IGC 2024
The 37th International Geological Congress 2024

IUGS
International Union of Geological Sciences

IGC 2024

The 37th International Geological Congress

Abstract Book

Busan, Korea
25-31 August 2024



www.igc2024korea.org

IGC 2024 Scientific Program

Plenary

T1. Sedimentary Geology

S1+S3. Continental Margin Sedimentology and Environment Change

- Oral 17
- Poster 43

S2: Black Shale Science and Economy

- Oral 76
- Poster 104

S4: Impact of volcanism on sedimentary systems

- Oral 125
- Poster 132

S5: Diagenesis and sedimentary environment

- Oral 135
- Poster 151

S6: Paleoenvironments of the early Paleozoic world

- Oral 177
- Poster 192

S7: General Topics in Sedimentary Geology

- Oral 196
- Poster 219

T2. Quaternary Geology

S1 Mapping the Quaternary geology: from detailed regional mapping campaigns to small- scale compilations

- Oral 271
- Poster 284

S2: Present Earth Surface Processes and Long-term Environmental Changes in East Eurasia

- Oral 288
- Poster 307

S3: Current and future directions in Quaternary chronostratigraphy

- Oral 315
- Poster 325

S4: A global perspective on the Neogene–Quaternary (Pliocene–Pleistocene) boundary

- Oral 329
- Poster 336

S5+S8: Geological Sea-level Proxies of Marine Isotopic Stage (MIS) 5 in the Asian Shorelines

- Oral 341
- Poster 353

S6: Youngest Quaternary (Meghalayan Stage) Speleothems and global Paleoclimate events

- Oral 363
- Poster 372

S7: New Advances in Paleolithic Sites and Early Human Settlement

- Oral 380

T3 Earth History and Stratigraphy

S1_Evolution of habitability of the early Earth Oral 409

- Oral 385
- Poster 397

S2: The Neoproterozoic-Lower Paleozoic stratigraphy, sedimentation, paleoclimate, chemostratigraphy and correlation of the Southwest and East Gondwana

- Oral 405
- Poster 412

S3: Evolution of Earth surface system from the Carboniferous to the Triassic

- Oral 423

S4+S5: The end-Permian mass extinction - state of knowledge and future advances

- Oral 442
- Poster 454

S6: Paleogeography of the Tethys Oceans

- Oral 459
- Poster 482

S7: Cretaceous Earth Dynamics and Climate in Asia (Joint Session of IGCP 679)

- Oral 502
- Poster 514

S8: General Topics

- Oral 522
- Poster 541

T4 Tectonophysics

S1: Eastern Asia tectonic evolution under the multi-plate convergent geodynamics during late Mesozoic

- Oral 574
- Poster 582

S2+S4: Intraplate tectonics and seismicity

- Oral 590
- Poster 602

S3: Deformation processes and texture analysis

- Oral 607
- Poster 620

S5: Structure, magmatism and evolution process of oceanic and marginal seas' lithosphere

- Oral 631
- Poster 643

S6_Active Tectonics and Earthquake Geology

- Oral 661
- Poster 670

S7_Tectonic evolution of modern and ancient orogens in 4D

- Oral 684
- Poster 698

S8: Subduction-related sedimentary basin evolution and lithospheric dynamics

- Oral 704
- Poster 711

S9: Deciphering complex plate tectonics from the ocean floor

- Oral 716
- Poster 720

S10+S13: Towards better understanding the origin of intraplate earthquakes in East Asia

- Oral 721
- Poster 727

S11: Geology and Tectonics of the Western Pacific Marginal Seas

- Oral 738
- Poster 754

S12: Deep Earth Exploration and Earth CT

- Oral 761
- Poster 776

T5 Planetary Sciences

S2+S1: Geological Exploration of Lunar and Martian Terrains

- Oral 785
- Poster 793

S3+S4: The interiors of the Earth, solar system planets, and exoplanets

- Oral 796
- Poster 805

S5+S6: Meteorites: Probing the Origins and Evolution of our Solar System

- Oral 809
- Poster 815

S7+S8: Planetary Habitability: From Extremophiles to Potential Life

- Oral 819
- Poster 826

S9+S10: Comparative Planetary Geology Studies

- Oral 828

S12+S11+S13+S14: Lunar Science and Exploration

- Oral 837
- Poster 841

T6 metamorphism

S1: Application of thermodynamic modelling in understanding the process of metamorphism

- Oral 856
- Poster 866

S2: Subduction zone fluids: mineralogical and geochemical effects and geodynamic consequences

- Oral 872
- Poster 891

S3: General Topics Oral 967

- Oral 921
- Poster 932

T7 Volcanology

S1: Large Igneous Provinces in Space and Time

- Oral 942
- Poster 960

S2+S5: Cretaceous Volcanism: Global Distribution Bearing on Tectonics of Continents and Oceanic Regions, K-T Boundary and Major Extinction

- Oral 971
- Poster 979

S3: Volcano Geology: role of field work on modern Volcanology

- Oral 997
- Poster 1003

S4: Volcanism on the Korean Peninsula

- Oral 1007
- Poster 1014

T8 Petrology

S1: Architecture and Thermal Structure of Translithospheric Magmatic Systems
- Oral 1021
- Poster 1031

S2: Granitoids and their enclaves
- Oral 1036
- Poster 1054

S3: Crust-Mantle interactions through time and the role of fluids
- Oral 1073
- Poster 1091

S4: Oceanic lithosphere evolution: crust-mantle geodynamics to melt processes and reservoirs
- Oral 1097
- Poster 1102

S5: Ophiolite: A window to the oceanic mantle across the geological time
- Oral 1104
- Poster 1119

S6: The petrological and related tectonic interpretations of Northeast Asia.
- Oral 1140
- Poster 1169

S7: General Topics
- Oral 1178
- Poster 1206

T9-Structural Geology

S1: 3D geological mapping: international status, barriers, and perspectives of geomodelling
- Oral 1224
- Poster 1241

S2_Shear Zone Tectonics
- Oral 1242
- Poster 1251

S3: Modern techniques for understanding faults and their effects on fault activity and fluid flow
- Oral 1262
- Poster 1273

S4: Fault damage zones in active and fossil faults
- Oral 1283
- Poster 1297

S5: Active faulting behavior, earthquake hazards zonation and urban prevention strategies: Field observation, data process and scene simulation
- Oral 1302
- Poster 1318

S7: Himalaya, Karakoram and Tibet: the geology and tectonics of a giant orogen
- Oral 1329
- Poster 1347

S8: From microscale to macroscale: multidimensional exploration in structural geology and tectonics
- Oral 1360
- Poster 1375

S9: Fault zones and fluid interactions, key structures for energy transition
- Oral 1387
- Poster 1403

S10: Geological architecture and active tectonics of Central and Eastern Himalayas
- Oral 1414
- Poster 1421

S11+S6: General Topics
- Oral 1423
- Poster 1441

T10 Geomorphology

S1+S6: Understanding Cover and its links with basement geology through Earth's history
- Oral 1457
- Poster 1463

S2: 'Landslides and climate changes' (IAG Co-Sponsored Session)
- Oral 1468

S4: Exploring high-resolution spatial and temporal data to resolve geologic and geomorphic processes
- Oral 1481
- Poster 1495

S5+S3: The role of climate, tectonics and surface processes in landscape evolution of the Himalayan-Tibetan orogen
- Oral 1505
- Poster 1522

T11-Paleontology and Paleoanthropology

S1_Cambrian Explosion and Co-evolution of environment Oral 1619
- Oral 1527
- Poster 1568

S2_The Evolution of Land Plants and Plant–Environment Interactions during Geological Time
- Oral 1576
- Poster 1591

S3_Ostracoda in Geology, the 5th Asian Ostracod Meeting (AOM)
- Oral 1600
- Poster 1614

S4: Paleocene-Eocene larger benthic Foraminifera, paleobiogeography and collision of Indian and Asian Plates
- Oral 1631
- Poster 1639

S5: Functional morphology and biomechanics in invertebrates: new ecological and evolutionary perspectives
- Oral 1640

S6: Early Palaeozoic faunas and palaeobiogeography of NE peri-Gondwana
- Oral 1647
- Poster 1672

S7: Recent advances in palaeontology from Asia (APA open session)
- Oral 1678
- Poster 1711

S8+S9: The floral diversity variation and palaeoenvironmental background across the terrestrial Triassic and Jurassic transition
- Oral 1715
- Poster 1721

S10: General contributions to Paleontology and Paleoanthropology
- Oral 1724
- Poster 1738

T12_Resource Geology and Economic Geology

S1_Resource Prospecting of Critical Metals and Economic Processing
- Oral 1754
- Poster 1766

S2_Exploration Targeting of Critical Metals
- Oral 1772
- Poster 1791

S3_Granitic Pegmatite-Hosted Critical Mineral Deposits
- Oral 1811
- Poster 1820

S4_Co-Ni mineralization mechanism related to sedimentary, metamorphic, magmatic and weathering processes
- Oral 1829
- Poster 1838

S5: Mining for a Better Energy Future: Sustaining the Supply of Critical Raw Materials
- Oral 1849
- Poster 1856

S7: Petroleum Enrichment and the Tethys Geodynamic System
- Oral 1861
- Poster 1888

S8: Metamorphic fluid mineralization and Ore Remobilization
- Oral 1928
- Poster 1952

S9_Promoting best practice in utilization of Geo resources (including Mineral, Water and Energy)
- Oral 1963
- Poster 1969

S10: Geo-Resources in Sustainable (Economic) Development
- Oral 1971
- Poster 1980

S11: Marine Mineral deposits, science, resources, technology, and environmental challenges, a look to the future
- Oral 1981
- Poster 2000

S12+S16: Novel approaches to modelling a sustainable and integrated minerals value chain
- Oral 2016
- Poster 2024

S13: Geometallurgy
- Oral 2030
- Poster 2036

S14_Ore-forming Magmatic Hydrothermal Systems: analysis of source to sink in deposit genesis
- Oral 2042
- Poster 2073

S15_Lithocaps and high sulfidation epithermal deposits
- Oral 2093

S17: Rare criticals metal geochemistry and mineral deposits
- Oral 2101
- Poster 2113

S18: Hydrodynamic studies of mineralization
- Oral 2126
- Poster 2134

S19: Mineralogy and Ore deposits in Alp-Himalaya belt
- Oral 2135

S20: Metallogeny and Geodynamics of East and SE Asia
- Oral 2142
- Poster 2162

S21: Uranium, thorium and related atomic energy minerals resources
- Oral 2170
- Poster 2186

S22: Iron Mineral System
- Oral 2197

S23: Navigating the Path to the Green Transition: Balancing Resource Extraction and Environmental Stewardship
- Oral 2204
- Poster 2213

S24+S6: HTHP geofluid-rock interactions, mass circulation and deep hydrocarbons in sedimentary basins
- Oral 2215
- Poster 2228

S25: Advances and Innovations in Uranium Exploration and Resource Evaluation. (A special session in memory of the late Dr. K. Kyser)
- Oral 2246

S26: General Topics
- Oral 2252
- Poster 2265

T13-Mineralogy

S2: Gemstone and Geological Formation
- Oral 2287
- Poster 2304

S3+S1+S5: Geochemistry, Isotopic Characteristics, and Geochronology of Gem deposits
- Oral 2312
- Poster 2319

S4: Environmental Mineralogy: From Understanding To Applicationr
- Oral 2331
- Poster 2347

S6: Silicate melts, magmas, and non-crystalline earth materials in Earth and Planetary Surfaces and Interior
- Oral 2357
- Poster 2368

S7: Gem materials
- Oral 2376
- Poster 2394

S8: General Topics
- Oral 2410
- Poster 2415

T14-Low Temperature Geohemistry

S1_Challenges and Opportunities of Global-Scale Geochemical Mapping (4th Arthur Darnley Symposium)
- Oral 2444
- Poster 2467

S2_Application of metal isotope fractionation in low temperature geochemistry
- Oral 2474
- Poster 2487

S3: Geochemical Signatures of Earth Surface Processes
- Oral 2491
- Poster 2498

S4+S5: New geochemical application of Rare Earth Elements and their Isotopes in low temperature geochemical environment
- Oral 2503
- Poster 2511

T15_Paleoclimate and Paleceanography

S1+S2: Paleoclimate and paleoceanography in the Ross Sea, Antarctica
- Oral 2514
- Poster 2520

S3: Recent developments in paleoclimatology
- Oral 2523
- Poster 2535

S4: General Topics
- Oral 2541
- Poster 2551

T16_Coastal, Marine and Lacustrine Geosciences

S1_Geohazard assessment from submarine landslides: a multi-stage approach
- Oral 2561
- Poster 2570

S2+S3: Coastal Environment Risk and its Influence on the Economic Development of a Country
- Oral 2571
- Poster 2577

S4: Beach sedimentary processes and mechanism
- Oral 2581
- Poster 2585

S5: Records of Climate and environmental change from lacustrine sediment
- Oral 2590
- Poster 2601

S6+S8: Sedimentation, sediment transport, and morphodynamics on the coastal system
- Oral 2612
- Poster 2620

S7: EMODNET-Geology's new standards revealing Earth's seabed geology
- Oral 2638
- Poster 2653

T17_Geoscience in Alpine and Polar Regions

S1+S4_Status of Himalayan Glaciers under the current climate change scenario
- Oral 2661
- Poster 2668

S2: Arctic evolution and climate changes during the Cenozoic
- Oral 2676
- Poster 2683

S3: Ice core science for alpine and polar ice cores
- Oral 2686
- Poster 2691

T18_Groundwater and Hydrogeology

S1: Microplastics and nanoplastics in soil and groundwater
- Oral 2694
- Poster 2699

S2: Groundwater Development for achieving food security and improving rural health in low- income countries
- Oral 2701
- Poster 2709

S3: Integrated use of groundwater and surface water resources keeping up with extreme droughts periods
- Oral 2723
- Poster 2729

S4: Eco-hydrological Process and its Effects in Karst Environment
- Oral 2731

S5: KRC Special session: Drought vulnerability of groundwater aquifer under climate crisis environment in S. Korea
- Oral 2743

S6: Groundwater and surface water interactions
- Oral 2749
- Poster 2761

S7: General Topics
- Oral 2771
- Poster 2782

T19 Geobiology

S1: Microbial carbonates through space and time
- Oral 2814

S2: Assessing the interplay of environmental and evolutionary controls in animal-substrate interactions through time
- Oral 2832
- Poster 2842

S3: Mid-Phanerozoic mass extinctions, recovery, extreme environmental events and integrated stratigraphic correlations
- Oral 2845
- Poster 2867

S4: General Topics
- Oral 2868
- Poster 2875

T20. Biogeochemical cycles

S3+S2. Local scale fluxes of carbon dioxide in urban environment: Sectorial emission and sequestration challenges
- Oral 2876
- Poster 2883

S4+S1. General Topics
- Oral 2884
- Poster 2889

T21. Environmental Geosciences

S1. Geoscience knowledge in Environment and Environmental Ecosystem
- Oral 2894
- Poster 2901

S3+S2. Anthropogenic contaminants in the environment
- Oral 2906
- Poster 2923

S4+S5: Emerging environmental pollutants, hazards, and energy resources and their associated human-natural system risks: Oral and postal presentation
- Oral 2949
- Poster 2957

T22. GIS and Remote Sensing

S1+S11. Remote Sensing of Global Resources with the New and Forthcoming Generation of Satellite Sensors
- Oral 2985
- Poster 2997

S2. Geoscience information, geological mapping and modelling
- Oral 3002
- Poster 3021

S5+S3+S6. Advances in GIS and remote sensing approach for geological hazards management
- Oral 3040
- Poster 3051

S7. Mapping the Way Forward: Advances in Applied Geoinformatics for Mineral Exploration
- Oral 3071
- Poster 3081

S8. Advances in AI and remote sensing approach for tidal flat monitoring
- Oral 3086
- Poster 3091

S9. Artificial Intelligence Methods Applied to Geological hazard using Remote Sensing and GIS
- Oral 3093

S10. Geoscience Information in the 2020s
- Oral 3097
- Poster 3105

T23. Seismology

S2+S1. Statistical Seismology and Episodic Events
- Oral 3112
- Poster 3116

S3. East Asia Earthquakes, Seismic Structure and Tectonics
- Oral 3117
- Poster 3133

S5. The 2023 M7.8 and M7.5 Kahramanmaraş, Turkey, Earthquake Sequence
- Oral 3146
- Poster 3163

S6. Investigating subsurface structures with dense seismic array: Theories and applications
- Oral 3170
- Poster 3178

S7. Site survey and seismic safety for nuclear installations (Sponsor Special Session)
- Oral 3191
- Poster 3198

S8+S4. General Topics
- Oral 3207
- Poster 3214

T24. Geophysics

S1. Fault detection and paleoseismology with near-surface geophysics
- Oral 3236
- Poster 3242

S2. Coupling of deep Earth and surface processes
- Oral 3246
- Poster 3257

S3. New Insights into the evolution of Deccan Volcanic Province and its seismic scenario
- Oral 3262
- Poster 3278

S6+S4+S5. Trending Machine Learning Applications in Oil and Gas Industry
- Oral 3284
- Poster 3290

S7. General Topics
- Oral 3292
- Poster 3299

T25. Geotechnology and Geophysical Exploration

S1. Advances in Geophysical Exploration Techniques for Resource Characterization
- Oral 3313
- Poster 3324

S2+S3. Geotechnology and its Applications in Geological Hazard Assessment and Monitoring
- Oral 3333
- Poster 3342

T26. Geoscience Education

S1. Geology Degrees Across the World – How are the Next Generation of Geologists Being Educated for the Geosciences of Tomorrow
- Oral 3348
- Poster 3355

S2. Exploring Geoscience Across the Globe: Special Session in Memory of Chris King
- Oral 3357
- Poster 3361

S4. International perspectives for natural disaster education
- Oral 3364

S5. Geoscience Education and Outreach for All: Techniques and Trends for Engaging Non- Specialist Learners
- Oral 3375
- Poster 3389

S6. Geoscience Education and Awareness
- Oral 3402
- Poster 3408

S7. Mitigating multi-hazard risks: perception, awareness and educational perspectives to cultivate a risk culture and strengthen disaster resilience in vulnerable communities
- Oral 3412

S8. International Perspectives on Earth Science Education
- Oral 3418
- Poster 3430

S9. General Topics
- Oral 3433
- Poster 3438

T27. Geoheritage, Geopark, and Geotourism

S1+S2. Heritage Stone: safeguarding the cultural and social legacy of rocks
- Oral 3448
- Poster 3464

S3. Geosites and Georoutes in the History of Geological Sciences
- Oral 3466
- Poster 3475

S4. Geoconservation and Geoheritage: geodiversity underpinning natural systems
- Oral 3478
- Poster 3506

S6. Geoscience in Geoheritage, Geoparks and Geotourism
- Oral 3521
- Poster 3539

S8. The Second 100 IUGS Geological Heritage Sites

- Oral 3552
- Poster 3581

S9. Global Geopark Network (GGN)/Geoparks and Society

- Oral 3583
- Poster 3593

S10. TRANSNATIONAL UNESCO GLOBAL GEOPARKS: The need and historical value of designating a transnational UNESCO Geopark in East Asia - focusing on Mount Baekdu and the Hantan River on the Korean Peninsula

- Oral 3606
- Poster 3613

S11. General Topics

- Oral 3615
- Poster 3619

T28. Forensic Geology and Medical Geology

S2+S1+S3. Medical Geology in Honour of Professor Olle Selinus (Special Session)

- Oral 3625
- Poster 3661

T29. Engineering Geology and Geomechanics

S2+S1. General Topics

- Oral 3674
- Poster 3689

T30. Urban Geology S2+S1. General Topics Oral 3934

- Oral 3708
- Poster 3717

T31. Geohazards

S1+S4. Surface faulting and near-fault earthquake hazard

- Oral 3718
- Poster 3727

S2. Outreach tools as a way to increase preparedness for geological hazards

- Oral 3743
- Poster 3750

S3. Geohazards: A global phenomenon and their Reduction Strategies

- Oral 3753
- Poster 3768

S5. Our Tasks on Global Submarine Geohazard issues to our future earth

- Oral 3770
- Poster 3783

S6+S7. Advances in Modeling and Simulation of Geological Disaster Problems

- Oral 3792
- Poster 3801

T32. Mitigation and Adaptation in Climate Crisis

S1+S2. Geoscience Contributions to Climate Change Mitigation Strategies

- Oral 3817
- Poster 3826

S3+S4. Offshore Monitoring Technology and its Application for CO2 Storage

- Oral 3835
- Poster 3843

T33. Big Data and Artificial Intelligence (AI) in Geoscience

S1+S2. Application of AI algorithms in natural hazards modelling Oral 4080

- Oral 3849
- Poster 3853

S3. Prediction of reservoir response using machine learning and data integration

- Oral 3860
- Poster 3864

S4. Data-driven or AI-driven Discovery in Geosciences

- Oral 3866
- Poster 3882

S6. Big Data and Artificial Intelligence (AI) in Geomodeling

- Oral 3908
- Poster 3917

S7+S5. General Topics

- Oral 3931
- Poster 3934

T34. Energy and Carbon Neutrality

S1. Geothermal energy, geoenergy, geopower, geoheat, earth energy

- Oral 3946
- Poster 3959

S2. Offshore renewable energy systems and submarine geohazards

- Oral 3964
- Poster 3970

S3. Assessment of innovation necessary for sustainable use of geothermal resources

- Oral 3971

S4+S6+S7. Critical Minerals Governance for Carbon Neutrality

- Oral 3982
- Poster 3986

S5. Unconventional Oil and Gas Resources & CO2 Geological Sequestration

- Oral 4000
- Poster 4029

T35. Geoscience and Policy

S2+S4+T22 S4. Geothermal energy, geoenergy, geopower, geoheat, earth energy

- Oral 4073
- Poster 4102

S3+S1+S6. Responsible Mining of Critical Minerals and the Importance of Environmental Justice

- Oral 4111
- Poster 4124

S5. Empowering women in geoscience for gender equality

- Oral 4127
- Poster 4132

T36. Management of Radioactive Resources and Waste

S1+S5. Advances in natural and engineering barriers for underground nuclear waste repositories
- Oral 4134
- Poster 4137

S2. Investigation and evaluation techniques related with nuclear power plants and waste disposal sites
- Oral 4150
- Poster 4159

S3. Transport of radionuclides in deep geological repositories and nuclear-related facilities
- Oral 4169
- Poster 4175

S4. Techniques for assessment and control of nuclide behavior in the HLW geological repository
- Oral 4180
- Poster 4188

T37. Deep-Time Digital Earth: IUGS DDE Sessions

S1. Evolution of life and biodiversity changes through deep time
- Oral 4195
- Poster 4214

S2. Quantifying plate tectonics and deformation in four dimensions
- Oral 4217

S3. Deep probing of 3D-4D lithospheric architecture and metallogenic processes
- Oral 4224
- Poster 4238

S4. Marginal Seas - Past and Future
- Oral 4245
- Poster 4261

S5. Knowledge & Data Co-boosted Discovery in the Co-Evolution of Minerals, Microbes and Environments
- Oral 4266
- Poster 4286

S6. Time Machine: Earth's deep-time geography -- data, reconstructions, challenges
- Oral 4290
- Poster 4309

S7. Geothermal Energy: Theory, Practice, and Global Opportunities
- Oral 4324
- Poster 4333

S8. Deep-time Digital Earth (DDE) – Progress, Challenges and Plans for 2024-2030
- Oral 4336
- Poster 4345

S9. Progress and Opportunities in Deep-time Paleomagnetism
- Oral 4348
- Poster 4357

S10. Geoscience Data Standards and Knowledge Graph
- Oral 4376
- Poster 4395

S11. Deep-time climate change – novel insights from paleoclimate modelling and the geologic record
- Oral 4411
- Poster 4418

S13+S14. Encouraging Early Career Scientists' (ECS) Engagement with DDE
- Oral 4422

T38. Anthropocene

S1. Anthropocene, History and the Geosciences: contributions to contemporary debates
- Oral 4430

S2. UNESCO IGCP 732 and the Stratigraphy of the Anthropocene
- Oral 4442
- Poster 4455

S3+S4. From the Holocene to Anthropocene - reading the geological and archaeological records of interplay between the nature and human
- Oral 4465
- Poster 4482

T39. Geoethics and Societal Relevance of Geosciences

S1+S2. GEOETHICS AT THE HEART OF ALL GEOSCIENCE: SERVING THE PUBLIC GOOD
- Oral 4494
- Poster 4516

T40. History of Geological Sciences

S1. History of women in the Geological Sciences: trailblazers, leaders and those in the shadows
- Oral 4520

S2. History of Geoscientific Travels in Asia and Beyond
- Oral 4532
- Poster 4553

S3+S4. General Contributions to the History of Geological Sciences
- Oral 4555
- Poster 4563

T41. Mathematical and Computational Methods for the Geosciences

S1. AI-driven mineral prospectivity mapping
- Oral 4570
- Poster 4592

S2. Fractals and Singularity in Geosciences
- Oral 4597
- Poster 4602

S3. Compositional data in geosciences: Methods and applications
- Oral 4606
- Poster 4615

S4. Geostatistical prediction and simulation for complex geological settings
- Oral 4618
- Poster 4642

S5. General Topics
- Oral 4646
- Poster 4658

T1 Sedimentary Geology

S1+3 Continental Margin Sedimentology and Environment Change		Session Chair: Scientific Program Committee			
Title	Presenter	Venue	Start	End	Page
Geochemistry and detrital zircon U–Pb geochronology of Neogene sedimentary rocks from offshore Bengal Basin, Bangladesh: Implications for provenance and tectonic setting	Julleh Jalalur RAHMAN	C105	2024-08-26 16:00	2024-08-26 16:15	17
Future drilling in Bengal Fan revealing the plateau uplift and its effects from the seafloor spreading to the climate change	Gang HU	C105	2024-08-26 16:15	2024-08-26 16:30	19
Cenozoic forearc and backarc basin-filling stratigraphy as an archive of tectonic controls on depositional styles and cycles along the north-western Pacific margins	Osamu TAKANO	C105	2024-08-26 16:30	2024-08-26 16:45	20
Geochemical Investigation in the Yellow Sea Reveals the Integration of the Modern Yellow River	Xiangtong HUANG	C105	2024-08-26 16:45	2024-08-26 17:00	22
Late Quaternary mineral magnetic record of the continental shelf sediments along the south-eastern coast of India: Implications for variations in the weathering and climate	RESHMA K V	C105	2024-08-26 17:00	2024-08-26 17:15	23
Continental weathering signal propogation in East Asian continental margins	Shouye YANG	C105	2024-08-26 17:15	2024-08-26 17:30	24
A long-term decline of δ26Mg values of clay-sized sediments in the past 430ka: the weakening of East Asian monsoon since the Mid-Brunhes Event?	Zhongya HU	C105	2024-08-26 17:30	2024-08-26 17:45	25
Re-examination the Sediments Provenance of the Eastern Sunda Slope Since the Last Deglaciation with Geochemical Methods	Junfei CHEN	C105	2024-08-26 17:45	2024-08-26 18:00	27
Holocene geomorphological evolution of a sediment-starved coastal embayment in response to sea level change: Insights from the Qing'ao Embayment, southern China	Fengling YU	C105	2024-08-27 08:00	2024-08-27 08:15	29
SEDIMENTATION AND GROWTH OF PROTEROZOIC CRATONIC BASINS: LESSONS FROM PURANA BASINS, INDIA	SHILPA PATIL PILLAI	C105	2024-08-27 08:15	2024-08-27 08:30	32
Glauconite a marker horizon for understanding paleoenvironment and depositional systems in the Mesoproterozoic Vindhyan Basin, Central India	Satya PRAKASH	C105	2024-08-27 08:30	2024-08-27 08:45	33
Extensive chemical weathering and its response to Quaternary glacialinterglacial cycles in the South China Sea: Evidence from Li isotope systematics	Fangbing LI	C105	2024-08-27 08:45	2024-08-27 09:00	35
Coupling of climate and catchment erosion in the Himalaya during the late Quaternary	Mohd AMIR	C105	2024-08-27 09:00	2024-08-27 09:15	36
Preliminary study on coupling between clinoform type and along-strike variability of shelf-edge stacking pattern	EUNHYUN CHO	C105	2024-08-27 09:15	2024-08-27 09:30	39
Inefficient burial of terrestrial organic carbon in deltas	Yonggui YU	C105	2024-08-27 09:45	2024-08-27 10:00	40
Development of submarine canyon from East Brazilian Passive Continental Margin	Daniela de Andrade MOREIRA	C105	2024-08-27 10:00	2024-08-27 10:15	41
The Chemical Weathering Record and its Responses to Climate Change and the Carbon Cycle: Insights from Sedimentary Records in Asian Marginal Seas over the Past 100,000 Years	Chao LI	C105	2024-08-27 10:15	2024-08-27 10:30	26
Marine to Continental transition in Chakrata to Rautgara Formation, Inner Lesser Himalaya (ILH), Uttarakhand, India	ALOK DEEP	C105	2024-08-27 10:30	2024-08-27 10:45	31
Relative Sea Level Controls and Depositional Dynamics in a Neoproterozoic rimmed shelf of Narji Limestone Formation, Kurnool Group, India: Insights from Facies Analysis and Isotope Signatures	RASIKH BARKAT	C105	2024-08-27 10:45	2024-08-27 11:00	37
Deep-water sedimentation controlled by interaction between bottom current and gravity flow: A case study of Rovuma Basin, East Africa	Jianan WU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	43
Li isotopic behaviors of particulate and dissolved load in the Changjiang (Yangtze River) Estuary	Chengfan YANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	44
Stratigraphic architecture of the Morondava Basin (western margin of Madagascar): geo-acoustic quantification from high-resolution multi-trace seismic data	Dhishna BULJORE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	46
Lacustrine environment evolution in the Mesozoic North Yellow Sea Basin, Eastern China: insight from the transition of Jurassic grey mudstones to Cretaceous red successions	REN WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	48
An improved FT-TRA system and its application to element analysis of sediments and foraminifera	Juan XU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	49
An improved understanding of the magnetic proxies of marine sediment in the South China Sea	Meinan SHI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	50
Paleoenvironmental reconstruction of the Colombian Maastrichtian Coals: Insights from facies analysis and coal petrology. Northern Andes	Juan SEBASTIAN GOMEZ NEITA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	51
Influence and model of deep hydrothermal solution on organic matter enrichment in fault basin	zhou FANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	53
Evolution of a small forarc basin associated with the change in the plate motion: an example of the Pliocene Kakegawa Group central Japan	HARUKI SONE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	55
Sedimentary facies and evolution of fluvio-estuarine depositional system during late Pleistocene to Holocene in the Nakdong valley, southeastern Korea	Seok-Hwi HONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	56

Title	Presenter	Venue	Start	End	Page
A modern tale of the Yellow River sand: insights from provenance analysis on detrital rutile trace elements and U-Pb ages	Yuan Shang	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	57
Continental crustal evolution revealed through sedimentary rocks: a case study from India	ESHA RAY	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	59
Isotopic fingerprinting of benthic dissolved iron cycling and iron sources in the Changjiang Estuary	Zhiwei HE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	61
Slope canyon evolution and its implications for gas hydrate accumulation in the northwestern Qiongdongnan Basin, South China Sea	Zigui Chen	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	63
Coupling of Source-sink System of Paleogene Enping Formation in Baiyun Sag	Zetong YU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	64
Microfacies and depositional environment of the Lower Jurassic Tagling Formation in the Spiti Valley of the Indian Himalayas	Ketan Avinash CHASKAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	66
Fine-grained turbidites in the southern Okinawa Trough and its implication for earthquakes activity over the past 700 years	Yang YAMIN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	67
Identification and Sedimentary Model of Shallow-water Deltas: A Case Study of the Funing Formation, Subei Basin, Eastern China.	Ziyi Yang	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	68
Stratigraphy and depositional history of the late Quaternary deposits in the inner shelf of the Korea Strait, SE Korea	Dong-Geun YOO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	69
Sandstone Petrography and Whole Rock Geochemistry of the Ashio Terrane, a Jurassic Accretionary Complex in Japan: Implications for Provenance and Tectonic Setting	Kyeongtae KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	70
Sandstone Petrography and Geochemistry of the Icheonri Formation in Gijang-gun, Busan: Implications for Provenance and Tectonic setting	Heeseon YANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	72
Detrital zircon U-Pb ages of the Cretaceous Icheonri Formation in the southeastern Gyeongsang Basin, East Asian continental margin: implications for the depositional age and provenance	Ga-Yeon KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	74
S2 Black Shale Science and Economy		Session Chair: Xingliang Zhang, Dong-Chan Lee			
Facies Dependency obvious - Carbon Isotopy fails to be a stratigraphic tool within Lower Toarcian (OAE)	Hans-Joachim ROEHL	C105	2024-08-28 09:30	2024-08-28 09:45	76
Sequence stratigraphy in the middle Ordovician shale successions, mid-east Korea: Stratigraphic variations and preservation potential of organic matter within a sequence stratigraphic framework	Uk Hwan BYUN	C105	2024-08-28 09:45	2024-08-28 10:00	78
Shale lithofacies classification criteria: discussion and application	Xinyu JIANG	C105	2024-08-28 10:00	2024-08-28 10:15	79
Coupling C-N-S-P-Fe systems to reveal bottom euxinia in ancient lakes: Implications on lake-water ventilation and paleowind orientation	Xubin WANG	C105	2024-08-28 10:15	2024-08-28 10:30	80
Analysis of the Differences in Diagenetic-Porosity Evolution of Organic-Rich Shale in the First Member of Qingshankou Formation, Central Depression, Songliao Basin	min YAN	C105	2024-08-28 10:30	2024-08-28 10:45	85
Differential enrichment of organic matter in saline lacustrine black shales: an example from the Chezhen Sag in Bohai Way Basin, China	ZHI CHAI	C105	2024-08-28 10:45	2024-08-28 11:00	88
Uranium and rare-earth elements in dictyonema shale of the Baltic sedimentary basin	TIMUR DIU	C105	2024-08-28 14:30	2024-08-28 14:45	87
Composition, concentrations and strategic resources of metals in Russian black shales (Volga and Baltic sedimentary basins)	TIMUR DIU	C105	2024-08-28 14:45	2024-08-28 15:00	83
The black shale distribution pattern on the Middle Yangtze Region, South China during Ordovician-Silurian transitional period	Chuanshang WANG	C105	2024-08-28 15:00	2024-08-28 15:15	96
Application of in situ Rb-Sr geochronology for dating of black shale	Zhongwu LAN	C105	2024-08-28 15:15	2024-08-28 15:30	93
Algal δ13C reveals variations in atmospheric CO2 during the Cambrian explosion	Chao Chang	C105	2024-08-28 15:30	2024-08-28 15:45	89
Lithofacies Characteristics and Sweet Spot Distribution of Lacustrine Shale Oil Reservoirs: A Case Study of the Second Member of the Kongdian Formation in the Cangdong Sag, Bohai Bay Basin	Yuan ZHAN	C105	2024-08-28 15:45	2024-08-28 16:00	103
The marine phosphorus crisis postponed the Cambrian radiation of animals	Kang-Jun Huang	C105	2024-08-28 16:15	2024-08-28 16:30	81
Sulfate-reducing microfossil Qingjiangonema from the early Cambrian black shale of South China	Xingliang ZHANG	C105	2024-08-28 16:30	2024-08-28 16:45	92
ORGANIC GEOCHEMICAL CHARACTERIZATION OF THE LOWER GONDWANA CARBONACEOUS SHALES OF THE EAST SIANG DISTRICT IN THE ARUNACHAL HIMALAYA, INDIA	DIPJYOTI BORSAIKIA	C105	2024-08-28 16:45	2024-08-28 17:00	90
Shale gas sweet spots comparison between marine shale and transitional shale of China	Qin ZHANG	C105	2024-08-28 17:00	2024-08-28 17:15	94
Sedimentary features and their hydrocarbon significance of lacustrine shale under different hydrodynamic conditions	Zhenglian PANG	C105	2024-08-28 17:15	2024-08-28 17:30	98
Research on Seismic Response Characteristics and Prediction Methods of Shale Lithofacies Assemblages in Jiyang Depression,Bohai Bay Bain,China	Zhengchun SHEN	C105	2024-08-28 17:30	2024-08-28 17:45	100
The Carnian Pluvial Episode(late Triassic) in northeastern Tethys: Lacustrine sedimentary records,petroleum geological significance from the Yanchang Formation,Ordos Basin, central China	Xiangbo Li	C105	2024-08-28 17:45	2024-08-28 18:00	102
Analysis of favorable lithofacies for the development of lamellar sparry calcite veins in Paleogene lacustrine black shale of Jiyang Depression, China	YUNJIAO ZHANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	104

Title	Presenter	Venue	Start	End	Page
In-situ heating-induced pore structure evolution in low-medium-maturity Paleogene lacustrine shale, Bohai Bay Basin, China: Insights from integrated experimental and numerical approaches	Guoshuai Bai	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	105
Evaluation of organic matter, thermal maturity and hydrocarbon potential of source rocks from southwest of Rwanda	THEOPHILE MUGERWA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	106
Coupling of nitrogen biogeochemical cycling and phytoplankton community structure before and after the Late Ordovician mass extinction in South China	Ruining HU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	107
Depositional environment and mineralization mechanism of the gaint Ortokarnash manganese carbonate deposit in the Western Kunlun Mountains	Bang-Lu Zhang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	108
OIL SHALE OF UZBEKISTAN - COMPLEX RAW MATERIALS OF MULTI-PURPOSE	MAKSUD ISOKOV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	110
Origin of Calcareous Concretion zone in the organic-rich Qusaiba Shale, Saudi Arabia	Mohamed Omar Abouelresh	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	112
The dominant lithofacies combination and genesis of the Kong2 shale in the Cangdong Depression of the Bohai Bay Basin	WEIHAO WEI LA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	113
Exploring CO2 Utilization Strategies in Shale: Enhancing Hydrocarbon Production, Sealing Efficiency, and Long-term CO2 Storage	Chioma ONWUMELU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	114
The development characteristics of continental shale laminae in China and its petroleum geological significance	Jiankang LU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	115
Sedimentary Characteristics, Distribution and Development Control Factors of Lower Cambrian Marine High Organic Matter Abundance Shale in Lower Yangtze Area	Jun WANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	117
senior engineer	baiyunfeng Yun-feng BAI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	121
Three-Dimensional Microstructure Analysis: Application of Confocal Laser Scanning Microscopy in the Study of Shale Oil Reservoir Spaces and Crude Oil Occurrence Characteristics in the Jurassic Shale	Xianda SUN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	123
Provenance and environmental factors controlling deposition of organic-rich facies in the Liard Basin of the Western Canada Sedimentary Basin	Hyeonji JEON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	119
S4 Impact of volcanism on sedimentary systems		Session Chair: Scientific Program Committee			
[Keynote] Reconstructing a hyaloclastite complex: the Aci Castello hyaloclastite sequence	Andrea DI CAPUA	C105	2024-08-28 08:00	2024-08-28 08:15	129
A record of mixed carbonate and volcanic sediments in the foothills of Zelee and Geyser carbonate banks (NW Madagascar)	Dhishna BULJORE	C105	2024-08-28 08:15	2024-08-28 08:30	125
Unravelling the Influence of Volcanism on Sedimentary Systems: Insights from the Early Paleozoic World	Eelika Kiil	C105	2024-08-28 08:30	2024-08-28 08:45	127
Influence of Volcanism on the Cretaceous Depositional Evolution of Alluvial Fans and Braided Rivers in the Western Qiantang Sag, East China Sea Shelf Basin	Kailong FENG	C105	2024-08-28 08:45	2024-08-28 09:00	130
Whole-rock geochemistry and Sm-Nd-Sr isotopes of Phanerozoic shales and mudstones from the Parnaíba Basin, NE Brazil: Insights for provenance shifts in a cratonic basin, related to Mesozoic volcanism	Claudio de Morisson VALERIANO	C105	2024-08-28 09:00	2024-08-28 09:15	131
Detection of Environmental Changes Post 2011 Puhyeue-Cordón Caulle Plinian Eruption Over 13 Years	Andrea DI CAPUA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	132
Petrological, Geochemical, and Depositional Characteristics of Early Proterozoic Tuffs of Gwalior Basin, Central India	SHIKHA DIXIT	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	133
Sedimentary processes around the volcanic U Island (Jeju Island, Republic of Korea)	Federica BARILARO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	134
S5 Diagenesis and sedimentary environment		Session Chair: Scientific Program Committee			
The features and mechanisms of coral reef carbonate weathering since Miocene: evidence from Yongle Atoll in the South China Sea	Yang YANG	C105	2024-08-27 14:30	2024-08-27 14:45	139
Selective Dolomitization and Its Influence on Reservoir Heterogeneity of the Lower Cambrian Longwangmiao Formation in Sichuan basin, South China	Xuefei YANG	C105	2024-08-27 14:45	2024-08-27 15:00	146
The Main Controlling Factors on the Evolution of the Cambrian Carbonate Platform in the Tarim Basin and Its Implications for the Distribution of Ultra-Deep Dolomite Reservoirs	Kehui Zhang	C105	2024-08-27 15:00	2024-08-27 15:15	148
U-Pb geochronology, REE on detrital zircons and clast counting of the Gualanday Group and its tectonic implications for the Eocene - early Oligocene northern Andes paleogeography	María Daniela MUÑOZ-GRANADOS	C105	2024-08-27 15:15	2024-08-27 15:30	149
Role of the initial texture of carbonates on dolomitization propagation from 4D Xray tomography	Nicolas Beaudoin	C105	2024-08-27 15:30	2024-08-27 15:45	143
Cyclicity related to solar activity in lacustrine organic-rich shales and their significance to shale-oil reservoir formation	Miruo LIN	C105	2024-08-27 16:00	2024-08-27 16:15	144
Diagenetic Evolution of Coal Beds in the Sabinas Basin, NE Mexico: Insights from Fluid Inclusions Geochemistry, and Stable Isotope (δ18O, δ13C, and δ 34S) Analysis	SUMIT MISHRA	C105	2024-08-27 16:15	2024-08-27 16:30	136

Title	Presenter	Venue	Start	End	Page
Chemofacies characterization of lacustrine shale based on machine learning classification: A case study from the Dongying Depression, Bohai Bay Basin, China	Guiang LI	C105	2024-08-27 16:30	2024-08-27 16:45	135
LITHOLOGICAL PROCESSES ON THE EXAMPLE OF THE DONETSK COAL BASIN OF UKRAINE	Volodymyr BARANOV	C105	2024-08-27 16:45	2024-08-27 17:00	141
Paleoenvironmental Conditions of the Huayacocotla Basin, Mexico, During the Late Jurassic: Implications for Mn accumulation	Joseph MADONDO	C105	2024-08-27 17:00	2024-08-27 17:15	145
Reservoir characteristics and formation mechanism of the Lower Cretaceous Laiyang Group deep-water tight sandstone in the Lingshan Island, Eastern China	Tongtong CHEN	C105	2024-08-27 17:15	2024-08-27 17:30	138
Impact of Abnormal Pressure and Thermal fluid activity on Pore Evolution and Reservior Quality- A Case Study of Sandstone Reservoir from the Paleogene Shallow Marine Gravity flow, Yinggehai Basin, the South China Sea	Jinglan Lan LUO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	151
Origin of dolomite in the Middle Permian Maokou Formation in eastern Sichuan Basin under the coupling constraints of hydrothermal and karstification	Ling ZHOU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	153
Controlling factors of tight sandstone reservoirs: A case study of the He 8 reservoir in the Ordos Basin	gaixia xia CUI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	155
Sedimentary Dynamics and Paleoenvironmental Signatures in the Witbank Coalfield, Main Karoo Basin of South Africa	Lindani Ncube	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	156
Diagenetic alterations induced by lamina-scale mass transfer and the impacts on shale oil reservoir formation in carbonate-rich shale of the Permian Lucaogou Formation, Jimusar Sag	Ke LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	158
Different Sedimentation, tectonism, diagenesis of ultra-deep tight sandstone reservoirs and its relationship with reservoir quality: a case study of Dabei Gas field in Kuqa Depression, Tarim Basin	Xiaotong XU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	159
Differential precipitation mechanism and their effects on the reservoir quality of alkaline diagenetic environment in the tight Middle Jurassic sandstone in the Central Sichuan Basin, SW China	DONG PING TAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	161
The coupling relationship between sandstone reservoir densification time and hydrocarbon charging time: A case study of the Yanchang Formation in South Ordos Basin, China	Zhen Wang	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	163
Mineral dissolution-precipitation mechanism in ultra-deep clastic rock reservoirs: a case study under the temperature and pressure background of Bashijiqike Formation of Kuqa Depression, Tarim Basin, China	Bing WU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	165
Diagenesis and reservoir quality prediction of Jurassic sandstones, central Junggar Basin, NW China	Penghui ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	166
The Characteristics and Genetic Mechanisms of the Lower Paleozoic Carbonate Reservoirs in South Yellow Sea Basin	Yu ZHENG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	167
Origin of the carbonate cements in the upper Miocene Huangliu Formation in the Ledong Area, Yinggehai Basin, China	xuezhe LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	169
Evidence of deep fluid activity in Jurassic tight sandstone reservoirs in the Northern Kuqa Depression	Yifan Zhang	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	171
Diagenesis and Evolution of lacustrine carbonate reservoir in the Upper part of the Fourth Member of the Shahejie Formation in the Gentle Slope Belt of the Bonan Sub-sag, Jiyang Sub-basin	Jie Yu DU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	172
Origin Mechanism and Favorable Area Prediction of Scale-Type High-Quality Carbonate Reservoirs in the South Yellow Sea Marine Basin, China	Ying GUO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	174
Characteristics and origin of multistage chlorites in tight sandstone reservoirs of the Upper Jurassic Qigu Formation in Yongjin Area, Junggar Basin, China	Xinyuan HUANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	175
Dolostone Petrology: Unveiling the past through a multi-method thin-section observation	Jino PARK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	176
S6 Paleoenvironments of the early Paleozoic world		Session Chair: Cristiano P. Galeazzi, Jusun WOO			
The Miaolingian Series (Middle Cambrian) in Southern Sweden: Astronomical forcing, biostratigraphy, and carbon isotope geochemistry.	Valentin Jamart	C105	2024-08-29 08:00	2024-08-29 08:15	178
Paleoclimate, provenance and depositional environment of Permo-Triassic sediments of Satpura Gondwana Basin, Madhya Pradesh, India.	Ranjit Khangar	C105	2024-08-29 08:15	2024-08-29 08:30	180
Detrital zircon geochronology of the basal Taebaek Group: Implications for regional scale provenance dynamics during the initial stage of the North China Platform	Donghyeok KANG	C105	2024-08-29 08:30	2024-08-29 08:45	182
Integrated Ichnological, Sedimentological and Geochemical Studies of the Cambrian Kunzam La Formation from Tidong Valley (Kinnaur), Himachal Himalaya: reconstructing the Northern Margin of the Indian Plate	Ranveer Negi	C105	2024-08-29 08:45	2024-08-29 09:00	183
Sedimentological and Geochemical Characterization of the Early Cambrian Eastern Yunnan, SW China	Xiaoxia PENG	C105	2024-08-29 09:00	2024-08-29 09:15	185
Spatial variation in carbonate carbon isotopes during the Cambrian SPICE event across the eastern North China Platform	ZHAOPENG WANG	C105	2024-08-29 09:15	2024-08-29 09:30	186

Title	Presenter	Venue	Start	End	Page
Floating astronomical time scale from the Upper Yangtze Region of South China suggests rapid paleoevnironmental variations during the Hirnantian glaciation	Hanyu ZHU	C105	2024-08-29 09:30	2024-08-29 09:45	188
Recycling of the Appalachian Signature in DZ U-Pb Records of Phanerozoic North America and Barriers to Transcontinental Sediment Transfer	Isaac ALLRED	C105	2024-08-29 09:45	2024-08-29 10:00	190
Stratigraphy and Carbonate Petrology of Permian Thitsipin Formation, Ywa-ngan Township, Myanmar: Implications for Depositional Environment	KYI MAW	C105	2024-08-29 10:00	2024-08-29 10:15	177
A dendrolite reef in a Cambrian siliciclastic environment, Sesong Formation, Taebaeksan Basin	Jusun WOO	C105	2024-08-29 10:15	2024-08-29 10:30	187
Provenance changes of the lower–middle Cambrian successions in the Taebaek Group, Korea: Environmental controls on source rock changes	Hyojong LEE	C105	2024-08-29 10:30	2024-08-29 10:45	189
Depositional environments of the Dongjeom Formation (upper Cambrian to lower Ordovician) in the Taebaeksan Basin in North China Platform: spatial heterogeneity of facies in wave-dominated shallow marine environments	Seungbeom AHN	C105	2024-08-29 10:45	2024-08-29 11:00	191
Preliminary study of spatiotemporal variability of sandstone compositions for early Paleozoic sandstones in the Bowers Terrane, northern Victoria Land, Antarctica	HONGWOO KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	192
Provenance of Detrital Zircons in Zealandia: Implications of a Musgrave Province Source and Potential Link to the MAPCIS Impact"	Daniel Patrick CONNELLY	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	193
Unveiling the geological significance of the Northern Gondwana glaciofluvial deposit: A geochemical approach by coupling rare-earth element and trace element geochemistry	Adhipa Herlambang Pamularso	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	194
Late Sinian-Early Paleozoic Lithofacies Paleogeographic Characteristics and Exploration Significance of the South Yellow Sea Basin, China	Ying GUO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	195
S7 General Topics in Sedimentary Geology		Session Chair: Sang Hoon LEE, Hyung Rae JO			
Sedimentation history and U-Pb detrital zircon age from Paleoproterozoic Mahakoshal back-rift basin developed during the evolution of Central Indian Tectonic Zone, India	ADITI SHARMA	C105	2024-08-29 14:30	2024-08-29 14:45	198
Petrographic and geochemical characteristics of Paleoproterozoic shales of the Limbunya Group: Implications on paleo-environment conditions.	Ananyaa Deepak	C105	2024-08-29 14:45	2024-08-29 15:00	202
Paleoweathering, Provenance and Tectonic Settings of Mesozoic Succession of Mundhan Dome (MD), Jhuran Formation, Kachchh, Western India: Insights from Petrography and Geochemistry	Poonam Rajeshbhai MANGTANI	C105	2024-08-29 15:00	2024-08-29 15:15	212
Temporal and spatial variations in sediment provenance in the Gunsan Basin, Yellow Sea	JUNHYUK SEO	C105	2024-08-29 15:15	2024-08-29 15:30	217
Tracking Middle and Late Jurassic environmental and sea-level changes in tropical Tethys Ocean	Antun HUSINEC	C105	2024-08-29 16:00	2024-08-29 16:15	200
The paleotectonic and paleogeography reconstructions of the Tarim basin during the Neoproterozoic	Bizhu HE	C105	2024-08-29 16:15	2024-08-29 16:30	196
Millennial scale marl-limestone rhythmites in the Middle Cambrian (500 My) Marjum Formation (Utah, USA) and their modulation by Milankovitch cycles	Damien PAS	C105	2024-08-29 16:30	2024-08-29 16:45	205
Paleoclimate evolution of the lower fourth sub-member of the Shahejie Formation in Niuzhuang Subsag during deposition	Rongkun LI	C105	2024-08-29 16:45	2024-08-29 17:00	215
Characterization and Development Patterns of Different Types of Karst Fracture-Cave Systems under Multi-Factor Controls: A Case Study of the Lungu 7 Area in the Tarim Basin.	Xiangbo ZHANG	C105	2024-08-29 17:00	2024-08-29 17:15	207
MODELING HYDROCARBON SYSTEMS USING AN EXAMPLE SOUTH TORGAY SEDIMENTARY BASIN (KAZAKHSTAN)	Araibek ZHIYENGALIYEV	C105	2024-08-29 17:15	2024-08-29 17:30	209
Formation of diamictite by fault-controlled redeposition of concretions	Dmitrii ALEKSANDROV	C105	2024-08-30 08:00	2024-08-30 08:15	204
Microbial induced sedimentary structures (MISS) from the Paleoproterozoic Gwalior basin, Central India	PRITAM PAUL	C105	2024-08-30 08:15	2024-08-30 08:30	206
Depositional characteristics of a braided river-type alluvial fan controlled by a small syndepositional fault	mingyue LI	C105	2024-08-30 08:30	2024-08-30 08:45	214
Depositional characteristics of Cretaceous carbonate tidal channels in southern Iraq	Zihao LIU	C105	2024-08-30 08:45	2024-08-30 09:00	216
RIVER SCALE AND CHANNEL PATTERNS IN THE ROCK RECORD	Cristiano GALEAZZI	C105	2024-08-30 09:00	2024-08-30 09:15	211
Campanian-Maastrichtian Paleoenvironmental and Sequence Stratigraphic Dynamics in the Southern Bida sub-basin, Nigeria: Insights from Sedimentology and Microfossils Studies.	Tope Shade ALEGE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	219
Northward subduction-accretion of the Bangong-Nujiang Meso-Tethys Ocean, Tibetan Plateau	Yiming LIU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	220
Deep marine siliciclastic sedimentation in a mélange zone: an example from the Late Cretaceous Fayah Formation in Batain Mélange, Northeastern Oman	IFTIKHAR AHMED ABBASI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	221

Title	Presenter	Venue	Start	End	Page
Proposal of new gravel shape indicator by the 3D principal component analysis of fluvial gravels and assessment of its accuracies in detecting the fluvial geomorphology	Tomoo YOKOYAMA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	223
Geochemical and statistical evaluation of Late Jurassic to early Cretaceous sandstones in the Bredasdrop sub-basin: Compositional signatures and provenance lithologies	Mogammad Yaaseen HENDRICKS	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	225
Detrital zircon U-Pb geochronology and geochemistry of Carboniferous sedimentary rocks from the Kharkhorin terrane, Central Mongolia	Erdenechimeg DAVAAJAV	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	227
Preliminary study of the Jurassic Bansong Group in the Yeongwol area	Sang-eon PARK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	229
Geochemistry and detrital zircon U-Pb geochronology of metasedimentary rocks of the Sergelen formation in Central Mongolia: Implications for their provenance and tectonic settings	Oyunchimeg TUMEN-ULZII	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	230
STATE OF THE ART OF THE JUMA FORMATION, ALTO TAPAJÓS GROUP, AMAZONAS STATE, BRAZIL: STRATIGRAPHIC REMARKS AND ITS IMPACT ON THE STUDY OF THE ALTO TAPAJÓS BASIN	Rodrigo Rodrigues ADORNO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	231
Mineralogy, and Trace and Rare Earth Element geochemistry of the Paleoproterozoic Karri Ironstone, Bijawar Basin, India: Implications for the genesis	Sushree Sangita PAL	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	233
Current-controlled sedimentation in the Charlie Gibbs Fracture Zone (North Atlantic)	Evgenia DOROKHOVA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	234
Contourite drifts in the South-Eastern Baltic Sea	DMITRY DOROKHOV	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	236
Comparison of Middle Permian sedimentary characteristics and stratigraphy in the northern and southern typical sag areas of the East Junggar Basin,North China	Keting Fan	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	238
Sedimentological characteristics and surface microtextures of quartz grains in modern sediments of the Hantan River, South Korea	Soyoung BAEK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	240
Source rock determination of detrital quartz grains by utilizing the Voigt peak separation of cathodoluminescence spectrum and fabric textures.	Naoya Miyashiro	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	241
Autogenic Oscillation of Grain-Size Transitions under Constant Sea-Level Rise-Flume experiment and Computational Modeling	Jaehyung LEE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	243
Geochemistry of Phosphatic Nodule within shale of Kopili Formation, Litang Valley, East Jaintia Hills, Meghalaya, India: Implications on Provenance	SHUBHAJIT KAR	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	244
Geochemistry and petrography of Middle Jurassic Nariinsukhait sandstone: Implications for paleoclimate and provenance	Baigalmaa NOROV	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	246
Retreat of the fan margin in an alluvial fan	Haein Shin	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	247
Pelagic carbonate sections across the Faraoni Oceanic Anoxic Event in the Umbria-Marche Basin (Apennines, Italy)	Xavier DEVLEESCHOUWER	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	248
Temperature Effects on Ripple Migration and Bedload Transport Rates: Flume experiments	Sejin KIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	250
Parvancorina :The anchor-shaped Ediacaran organism from Sonia Sandstone Formation of Marwar Supergroup, India	HUKMA RAM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	251
Quantitative characterization of 3D pore structures and percolation characteristics in bioturbated reservoir media based on x-ray micro-CT: a case study of the neogene sanya formation in the Qiongdongnan basin, northern south China sea	Yongbin NIU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	252
Identification characteristics of barrier sandstones of Benxi Formation in Ganquan-Fuxian area in the Ordos Basin China	Renhai PU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	253
Provenance and source area weathering of sandstones from the Tarkwaian group at the northeastern extent of the Paleoproterozoic Ashanti belt, Ghana: Constraints from petrography and geochemistry.	Victor SEDZIAFA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	254
The Sedimentary Characteristics of the Braided River Delta of the Triassic Lower Oil Group in the Block 9 area of the Tahe Oilfield	zhao lei	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	256
Three dimensional distribution characteristics of physical property with sedimentary depth in the Ulleung Basin of the East Sea: based on downhole logging data	Gil Young KIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	257
Characteristics of Mesozoic Reservoirs in Gaoqing Region	Xiaolong CHEN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	258
Sedimentary Characteristics and Controlling Factors of Biogenic Limestone in the Middle Part of the First Member of the Shahejie Formation, Shanghe area, Huimin Sag	Yu HU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	260
Effect of floodplain morphodynamics on channel avulsion: Outcrop observations of the Cretaceous Tando and Namyang basins in the mid-western part of the Korean Peninsula	Kyungjin LEE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	261
Characteristics of Mesozoic reservoir development in Gubei Sag	hongwei RANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	262
EPHEMERAL DEPOSITIONAL SETTING OF THE RED SANDSTONE IN THE SONIA FORMATION OF MARWAR SUPERGROUP, INDIA	PRAKASH BABU LAL	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	264
Provenance of sediments offshore northern Colombia as evidenced by detrital zircon U-Pb study of modern sediments (Magdalena River Delta and la Aguja Canyon)	Yamirka ROJAS-AGRAMONTE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	265

Title	Presenter	Venue	Start	End	Page
A high-resolution sequence stratigraphic framework of the Mississipian coastal system of the Poti Formation, Parnaíba basin, Brazil	Matheus DENEZINE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	267
Distribution and environment changes of sand ridges on the southern shelf of Korea	Eun-Je JEONG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	269
Stratigraphic and sedimentological study on the Pohang Basin, SE Korea	TAEYEON KIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	270
T2 Quaternary Geology					
S1 Mapping the Quaternary geology: from detailed regional mapping campaigns to small-scale compilations		Session Chair: Scientific Program Committee			
[Keynote] Biostratigraphical data to unravel and map the early Middle Pleistocene	Thijs VAN KOLFSCHOTEN	M218	2024-08-26 16:00	2024-08-26 16:30	280
Building the GIS of International Quaternary Map of Europe and Adjacent Areas (IQUAME2500): Connecting and Harmonising the European Quaternary Geology without Political Boundaries	Kristine E.C. ASCH	M218	2024-08-26 16:30	2024-08-26 16:45	271
A GIS Approach to Quaternary Glacial Geomorphology in Slovenia	Miloš BAVEC	M218	2024-08-26 17:00	2024-08-26 17:15	279
Evolution of Middle Ganga Alluvium In Parts of Ghaghara Sub- Basin, India Gajendra Nath Dwivedi* and Subodh Kr. Sharma. Lucknow and Nagpur**	Gajendra Nath Dwivedi	M218	2024-08-26 17:15	2024-08-26 17:30	282
Exploring Neotectonics and Seismicity during the late Quaternary in the vicinity of Gish fault in Darjeeling-Sikkim Himalaya through PGRS, MEQ, DGPS and OSL dating	RITU Pragya	M218	2024-08-26 17:30	2024-08-26 17:45	273
Mapping the retreat of the Laurentide Ice Sheet in the western Gulf of St. Lawrence (Eastern Canada)	Patrick Lajeunesse	M218	2024-08-26 17:45	2024-08-26 18:00	275
Reconstructing the glacial lakes of northern Quebec and Labrador (Canada) through field-based mapping and GIS modeling	Martin ROY	M218	2024-08-26 18:00	2024-08-26 18:15	277
The Geoscience of Wine: The influence of surficial geology on viticulture in Atlantic Canada	MITCH J MARACLE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	284
Snapshots of glacial forefields: mapping modern-day processes in central Chilean Patagonia	Paulina MEJÍAS OSORIO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	285
The Quaternary geological map production in Korea	Jin Cheul KIM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	286
S2 Present Earth Surface Processes and Long-term Environmental Changes in East Eurasia		Session Chair: Noriko Hasebe, Jin Cheul KIM			
[Keynote] Exploring Desert Margins: Interdisciplinary Insights into Climate Dynamics, Human Migration, and Environmental Change	HEMA ACHYUTHAN	M218	2024-08-27 14:30	2024-08-27 14:50	293
On acquisition of natural remanent magnetizations in tidal depositional setting: insight from a Holocene tidal mud sediment in the southwestern coast of the Korean Peninsula	Hyeon-Seon AHN	M218	2024-08-27 14:50	2024-08-27 15:05	288
Sea surface temperature variations at Shushi bay in Tsushima island over the last 3 ka	Sujeong PARK	M218	2024-08-27 15:05	2024-08-27 15:20	289
The environmental dynamics studied in Boontsagaan lake, southwestern arid Mongolia: lake sedimentation and catchment erosion	Noriko HASEBE	M218	2024-08-27 15:20	2024-08-27 15:35	290
Reconstruction of Sedimentary Environment on the Western Shelf of the South China Sea since the last deglaciation	Yang LI	M218	2024-08-27 15:35	2024-08-27 15:50	291
[Keynote] Sahara's surface transformation forced an abrupt hydroclimate decline and Neolithic culture transition in northern China	Hao LONG	M218	2024-08-27 16:05	2024-08-27 16:25	300
Luminescence Dating Holocene Sediments from the Mongolian Forest Steppe	Manfred FRECHEN	M218	2024-08-27 16:25	2024-08-27 16:40	295
Exploring palynofacies and sediment texture dynamics in subtropical floodplains along the Gomati River, Lucknow, India: Transition from Suburban to Urban Environments	POOJA TIWARI	M218	2024-08-27 16:40	2024-08-27 16:55	299
Typhoon variability during the Holocene in East Asia and its linkage to ENSO activity	Jaesoo LIM	M218	2024-08-27 16:55	2024-08-27 17:10	306
Taxonomic research on the Cenozoic gastropods from Qaidam Basin and their palaeoenvironmental significance	Tingting YU	M218	2024-08-27 17:10	2024-08-27 17:25	302
The Geological Evolution and Palaeoclimatic Significance of the Temburong Peatland, Brunei Darussalam	Adlina MISLI	M218	2024-08-27 17:40	2024-08-27 17:55	303
Insights into the Palaeoclimatic and Palaeoenvironmental Evolution of Brunei Darussalam through the Window of Tasek Merimbun Peatland	Basilios TSIKOURAS	M218	2024-08-27 17:55	2024-08-27 18:10	304
Age dating of lava plateau and paleolake sediments formed by dammed lava plateau in Yeoncheon, the center of Korean Peninsula	JIEUN KWON	M218	2024-08-27 18:10	2024-08-27 18:25	297
Sr-Nd isotopic composition of the Quaternary brown clay-silt sequences in the Jeongok Paleolithic site, Korea: Implication for sediment provenance	Hawon YUN	M218	2024-08-27 18:25	2024-08-27 18:40	301
Tracking the appearance of the first humans on the Jeongokri, Korea	Jin KIM	M218	2024-08-27 18:40	2024-08-27 18:55	305
Holocene landscape variations of a large shallow lake in East Asia: Interactions between climate, hydrology, and human beings	Yawen GE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	307
Uplift of the northeastern Tibetan Plateau leads to the extreme desertification in East Asia around 0.9 Ma	Xinbo GAO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	308
Limnological shift and droughts driven by monsoonal changes during the Holocene – insight from a diatom record from Biển Hồ maar lake, Central Highlands of Vietnam	Hoàn Đào-Trung	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	309

Title	Presenter	Venue	Start	End	Page
New data on the glacial history of the Southern Pamir	Mariia Efimova	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	310
Paleoenvironment evolution in the Weihe basin and its impacts on drainage systems of middle Yellow River since late Pliocene	Jingyun XIAO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	311
Incised-valley filling Sedimentation in response to Holocene Sea Level rise, Yeongil Bay, Southeastern Korea	Hyun Ho YOON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	312
Paleo-hydro environmental changes in Southeastern Mongolia from the Late Pleistocene to the Mid-Holocene: An analysis of lake sediment from Bayan Tohom Gobi	Sumin KANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	313
Reconfirmation of the dating of Jeju Island's Suwolbong Tuff	youjin WOO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	314
S3 Current and future directions in Quaternary chronostratigraphy		Session Chair: Martin J. Head, SPC			
Fluvial dynamics and climate change in a tropical river throughout the Late Quaternary (Kampar River, Sumatra, Indonesia)	Yuniarti YUSKAR	M218	2024-08-27 08:00	2024-08-27 08:15	317
Dating the base of the Upper Pleistocene in Chinese and Tajik loess by OSL and its association with climatostratigraphy and chronostratigraphy	Liping ZHOU	M218	2024-08-27 08:15	2024-08-27 08:30	319
A ~426 ka Antarctic methane jump at the onset of MIS 11 could mark a prospective second stage for the Middle Pleistocene Subseries	Martin J. James Head	M218	2024-08-27 08:30	2024-08-27 08:45	320
Date your late Cenozoic mud: New advances in applicability of the authigenic 10Be/9Be dating	Michal ŠUJAN	M218	2024-08-27 08:45	2024-08-27 09:00	323
CENOZOIC STRATIGRAPHY OF SOUTH AFRICA: CHALLENGES AND POSSIBILITIES	Greg A. Botha	M218	2024-08-27 09:00	2024-08-27 09:15	322
Electron Spin Resonance chronology and heavy minerals from the quaternary fluvial terraces of the Somme River (Northern France)	Rajib Kumar SAHA	M218	2024-08-27 09:15	2024-08-27 09:30	315
Unravelling the chronology of the infill of glacially overdeepened structures in the northern foreland of the European Alps.	Gustav FIRLA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	325
Inception of the European Ice Sheet revealed by cosmogenic nuclide dating in Lithuania: First results of the CosmoLith project	Michal ŠUJAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	327
S4 A global perspective on the Neogene–Quaternary (Pliocene–Pleistocene) boundary		Session Chair: Scientific Program Committee			
[Keynote] Paleoenvironmental changes across the Neogene–Quaternary boundary at the Monte San Nicola GSSP, near Gela, Sicily – an update of the international program GELSTRAT	Martin J. James Head	M218	2024-08-28 08:00	2024-08-28 08:15	331
'Nicola' bed deposition at the onset of the Quaternary ~2.58 Ma, Monte San Nicola, southern Sicily – geological background	Wieslawa RADMACHER	M218	2024-08-28 08:15	2024-08-28 08:30	329
Vegetation dynamics and climate changes during the Onset of Northern Hemisphere Glaciation: Insights from the Monte San Nicola Section (central Mediterranean)	Adele BERTINI	M218	2024-08-28 08:30	2024-08-28 08:45	333
Some problems of Pliocene – Pleistocene sediment studying at the East Siberian Sea according pollen data	Ekaterina NOSEVICH	M218	2024-08-28 08:45	2024-08-28 09:00	335
Climate variability and biotratigraphic constraints at the Neogene–Quaternary boundary at the Monte San Nicola type-section, Sicily	Adele BERTINI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	338
Palynological implications for paleoenvironmental changes in the continental shelf, southeastern Korea, during the Plio-Pleistocene climate transition	Yongmi KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	340
Hydrographic development of the northern South China Sea during the Pliocene–Pleistocene transition: The dinoflagellate cyst record of ODP Site 1148 – Preliminary results	Martin J Head	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	336
S5+S8 Geological Sea-level Proxies of Marine Isotopic Stage (MIS) 5 in the Asian Shorelines		Session Chair: Scientific Program Committee			
Continuous measurements in north China and culture experiments reveal the potential of leaf n-alkane carbon isotopes in paleoclimate studies	Guoan WANG	M218	2024-08-28 14:30	2024-08-28 14:45	341
Fire history of the Chinese Loess Plateau under extreme warming scenarios: a case study of the loess-paleosol sequence L5-S5	lian LIU	M218	2024-08-28 14:45	2024-08-28 15:00	342
Carbon cycle and carbon isotope fractionation during the snail assimilation process	xuefen SHENG	M218	2024-08-28 15:00	2024-08-28 15:15	343
Late Pleistocene and Holocene Landscape Evolution in the White River Badlands, Great Plains, USA	patrick albert burkhart	M218	2024-08-28 15:15	2024-08-28 15:30	345
Integrated multi-geochemical analysis for reliable 14C age of artificial carbonates	Zhanpeng Chen	M218	2024-08-28 15:30	2024-08-28 15:45	346
A newly revised record of relative sea-level changes in western Philippines, Southeast Asia during the past 125 ka deduced from uplifted coral reef terraces	Kathrine MAXWELL	M218	2024-08-28 15:45	2024-08-28 16:00	348
Hydroclimate changes during the Meghalayan Stage and its global teleconnection from Southern India	Upasana BANERJI	M218	2024-08-28 16:00	2024-08-28 16:15	350
EVIDENCES OF LATE-QUATERNARY SEA-LEVEL CHANGES IN CENTRAL KERALA, SOUTH INDIA	Shaima M	M218	2024-08-28 16:15	2024-08-28 16:30	352
Variability of leaf wax n-alkanes across gradients of environment and plant functional type in China	Yutao ZHOU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	353

Title	Presenter	Venue	Start	End	Page
Last and Holocene interglacial relative sea-level rises and coastal sedimentation in the Korean Peninsula	Woo Hun RYANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	354
New Geochronological Data on the Tatun Volcano Group in Northern Taiwan	Su-Chin CHANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	355
A modern pollen-climate dataset from South Korea for palaeoclimate reconstruction	Jaeyoung LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	356
Surface microtextures of quartz grains in soil of Chuncheon Basin	Eun-chae SHIN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	357
The preliminary study of reconstructing abrupt climate shift with speleothem in Korean Peninsula: a textural approach	Jungwon CHOI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	358
Where ice meets salt: A more than 800 m deep glacial basin in the European Eastern Alps (Salzkammergut region, Austria)	Clemens SCHMALFUSS	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	359
Millennial to seasonal trace element variability within stalagmite fluorescence banding during the Last Interglacial	Jihye KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	361
Paleoenvironmental evolution since the late Quaternary from core YZ02 in the South Yellow Sea	XIA LIAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	362
S6 Youngest Quaternary (Meghalayan Stage) Speleothems and global Paleoclimate events		Session Chair: Scientific Program Committee			
[Keynote] Holocene Meghalayan Stage Speleothem (Stalagmite) carbonate petrography and paleoenvironmental significance from Meghalayan and Lesser Himalayan caves, India	HEMA ACHYUTHAN	M218	2024-08-27 09:30	2024-08-27 09:45	367
Monsoon Mysteries Unveiled: Traversing Millennia Through Climate Reconstructions in Southern India	HEMA ACHYUTHAN	M218	2024-08-27 09:45	2024-08-27 10:00	363
Comparison between a stalagmite record and a peat record over the past 14 Ka from NE China: To what extend the proxies in stalagmite and peat records to reflect climate changes	Hong-Chun Li	M218	2024-08-27 10:00	2024-08-27 10:15	369
Reconstruction of Holocene Climatic Dynamics in the Western Himalaya: Speleothem Record	Jaishri BHATT	M218	2024-08-27 10:15	2024-08-27 10:30	365
Signatures of trace element variations in the Indian speleothem from the core monsoon zone during the late Holocene	Naveen GANDHI	M218	2024-08-27 10:30	2024-08-27 10:45	371
Meghalayan Stage Stalagmites , Indian Summer Monsoon and Paleoclimate records from Northeast India	POOJA BHARALI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	372
Seismic Impact on Speleothems and Cave Structures: Evidence for Major Earthquakes in the Central Himalaya	Jaishri Sanwal BHATT	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	374
Small mammal fossils from cave sediments and their use for palaeoenvironmental reconstructions. Potential and limitation	Lutz Christian MAUL	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	376
Past-WDs modeling using CMIP6 Paleoclimate Modeling Intercomparison Project (PMIP4) Experiments and Speleothems Over Hindukush Himalaya.	Pramod KUMAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	378
Evidence from southern India suggests that the Little Ice Age was not uniformly cold and dry across the globe.	ISHFAQ AHMAD MIR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	379
S7 New Advances in Paleolithic Sites and Early Human Settlement		Session Chair: Xuefeng Sun, SPC			
[Keynote] New Palaeolithic Explorations in Eastern Asia	Shixia YANG	M218	2024-08-28 09:30	2024-08-28 09:45	380
Early Holocene human in the Tengger Desert, northern China	xuefeng SUN	M218	2024-08-28 09:45	2024-08-28 10:00	381
New OSL dating reveals interactive migrations of Western and indigenous populations in north China corresponding to monsoonal fluctuations during the past 70-10 ka	JUNYI GE	M218	2024-08-28 10:00	2024-08-28 10:15	382
Discovery and research at Xuetangliangzi in the Yunxian hominin site, central China	Chengqiu LU	M218	2024-08-28 10:15	2024-08-28 10:30	384
T3 Earth History and Stratigraphy					
S1 Evolution of habitability of the early Earth		Session Chair: Ruimin Wang, SPC			
[Keynote] The expansion of marine eukaryotes in the early Neoproterozoic Era	Shuhai Xiao	C106	2024-08-26 16:00	2024-08-26 16:15	392
A tale of two widespread Proterozoic fossils: Chuaria and Tawuia assemblage from ~1.0 Ga rocks in North China	Ke PANG	C106	2024-08-26 16:15	2024-08-26 16:30	385
Discs from Tonian rocks in North China: Relating discoidal fossils with a central opening to worm-like annulated tubular fossils and their paleoecological and evolutionary implications	Guangjin LI	C106	2024-08-26 16:30	2024-08-26 16:45	387
Symbiotic fossils from the early Ediacaran in South China and their implication for lichenization and bio-weathering	Hanzhi Qu	C106	2024-08-26 16:45	2024-08-26 17:00	389
Stromatolites improved the habitability of Precambrian seafloor: Evidence from the molar-tooth structure in the Tonian Jiudingshan Fm., North China	Xubin WANG	C106	2024-08-26 17:00	2024-08-26 17:15	390
Large magnitude sulfur isotope mass independent fractionation indicating subaerial volcanism in 3.8 Ga	Ruimin WANG	C106	2024-08-26 17:15	2024-08-26 17:30	391
Abiotic Sulfur Cycling Model Across Deep Time	Javed Akhter MONDAL	C106	2024-08-26 17:30	2024-08-26 17:45	394
Unique Archean phosphorous cycle linked to submarine hydrothermal and biological activities	Takeshi KAKEGAWA	C106	2024-08-26 17:45	2024-08-26 18:00	393
What happened in Mesoarchean during earth history? Evidence from western Dharwar craton, southern India	Yan ZHAO	C106	2024-08-26 18:00	2024-08-26 18:00	395

Title	Presenter	Venue	Start	End	Page
Molybdenum isotope and oceanic redox evolution during the Cryogenian non-glacial period	Jin LI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	397
New discovery of rare 3.8 Ga crust in Labashan, eastern China: Petrogenesis and significance	Chunyan DONG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	399
Redox-stratified seawater during the GOE: Evidences from rare earth elemental and C-O isotopic compositions of Paleoproterozoic BIFs and carbonate rocks from the Taihua Group, North China Craton	Cai YUN LAN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	401
Preliminary observations of fulgurites: prebiotic sources of reduced phosphorus on early Earth	DongJun KIM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	402
The coming and going of banded iron formation	Bing SHEN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	403
Overlooked role of dissolved ferrous iron in the adsorption of phosphate by clay minerals: Implications for phosphorus cycling on the early Earth	Xing CUI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	404
Preservation of early life molecular signatures in a ~2.5 Ga banded iron formation, North China	Jingbo NAN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	400
S2 The Neoproterozoic-Lower Paleozoic stratigraphy, sedimentation, paleoclimate, chemostratigraphy and correlation of the Southwest and East Gondwana		Session Chair: Scientific Program Committee			
Cr-Cd isotopes track redox and nutrient conditions during the rise of biomineralizing organisms: The Ediacaran Taguatiya Guazú Fm., Paraguay	Fabricio CAXITO	C106	2024-08-27 08:00	2024-08-27 08:15	405
Ediacaran diamictites and glaciation in North China	Yongqing LIU	C106	2024-08-27 08:15	2024-08-27 08:30	407
Was there a palaeo-ocean in South China during the late Tonian to Cambrian? – Evidence from provenance variation across the Xiang-Gui-Yue Basin	Yang TIAN	C106	2024-08-27 08:30	2024-08-27 08:45	408
Discussion on a lectostratotype proposal for the Ediacaran Sete Lagoas Formation, Bambuí Group, Brazil	Matheus DENEZINE	C106	2024-08-27 08:45	2024-08-27 09:00	410
Ediacaran-Cambrian transition events in the peninsular India: Insights from isotope stratigraphy and geochronology of Bilara carbonates, Marwar Supergroup	Bivin GEORGE	C106	2024-08-27 09:00	2024-08-27 09:15	409
Orbitally-paced carbon-isotope excursion and sedimentary rate during the middle-late Cambrian	Jixuan WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	412
Multiple glacio-eustatic cycles through the Hirnantian (Late Ordovician) in South China: correlations between the nearshore and offshore outcrops	Chao LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	413
The sedimentary characteristics and stratigraphic framework of the Cryogenian in the northwestern Yangtze Craton	Xiaoshuai CHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	415
Sedimentology and timing of the Klipheuwel Group, South Africa – anatomy of a Cambrian-Ordovician failed rift in southwest Gondwana	Ruan Francois RAATH	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	417
Application of the Wavelet Transform coupled with Fischer plots and INPEFA in Sequence Stratigraphy	Yu ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	419
Geochronological constraints of high-grade metasedimentary rocks of the Italva and Costeiro basins: Reconstructing the Outer Magmatic Arc System of the ribeira belt, SE Brazil	Caroline de Araujo PEIXOTO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	421
S3 Evolution of Earth surface system from the Carboniferous to the Triassic		Session Chair: Scientific Program Committee			
The selection of the Global boundary Stratotype and section (GSSP) for the Carboniferous Moscovian Stage	Keyi HU	C106	2024-08-27 09:30	2024-08-27 09:45	423
The Middle-Late Pennsylvanian Event: timing and mechanism	Yixin WANG	C106	2024-08-27 09:45	2024-08-27 10:00	424
Phylogeny and paleobiogeography of the Carboniferous conodont genus *Gnathodus*	Wenqi WANG	C106	2024-08-27 10:00	2024-08-27 10:15	426
Farfield effects of the Hercynian orogeny on the sedimentary succession of the Arabian Plate	Michael Stephenson	C106	2024-08-27 10:15	2024-08-27 10:30	428
Revision of Idiognathodus sagittalis (Conodonta, Pennsylvanian): 2D- and 3D-based morphometrics	Yingjun PENG	C106	2024-08-27 10:30	2024-08-27 10:45	429
The chemical weathering trend of the Carboniferous to early Permian strata in the Naqing section, South China	Biao GAO	C106	2024-08-27 10:45	2024-08-27 11:00	431
Episodic marine anoxia during highly oxygenated Late Paleozoic icehouse	Jitao Chen	C106	2024-08-27 14:30	2024-08-27 14:45	432
Mercury isotope evidence for the linkage between volcanic activity and Early Permian Artinskian Warming Event	Chaosheng YUE	C106	2024-08-27 14:45	2024-08-27 15:00	433
Zinc isotopes as a tracer for global carbon cycling during the onset of late Paleozoic icehouse	Yutian ZHONG	C106	2024-08-27 15:00	2024-08-27 15:15	434
Tipping cascades in the onset of the Carnian Pluvial Episode (Late Triassic)	Bo WANG	C106	2024-08-27 15:15	2024-08-27 15:30	438
Chaotic Mars-Earth swings in precession of orbital perihelion revealed in Jurassic lake sequences, Junggar Basin, northwestern China	Yanan Fang	C106	2024-08-27 15:30	2024-08-27 15:45	440
Carbon isotope perturbations driven by volcanism during the Late Paleozoic Ice Age (LPIA)?	Zhihui ZHANG	C106	2024-08-27 16:00	2024-08-27 16:15	441
Volcanic activities, wildfires and the collapse of tropical rainforest ecosystems during the terrestrial end-Permian mass extinction in Southwest China	Hua ZHANG	C106	2024-08-27 16:15	2024-08-27 16:30	435

Title	Presenter	Venue	Start	End	Page
Sedimentary record of the Permian Yangtze Block breakup: Evidence from the Sichuan Basin	Xuanwei LIU	C106	2024-08-27 16:30	2024-08-27 16:45	436
The state of the art on the redefinition of the Devonian/Carboniferous Boundary	Markus ARETZ	C106	2024-08-27 16:45	2024-08-27 17:00	439
S4+S5 The end-Permian mass extinction - state of knowledge and future advances		Session Chair: Scientific Program Committee			
[Keynote] The end-Permian mass extinction: Progress and unexplained questions	Shuzhong SHEN	C106	2024-08-29 08:00	2024-08-29 08:15	452
Mass Extinctions & Fossil Preservation from Organic & Inorganic Geochemical Signals	Kliti Grice	C106	2024-08-29 08:15	2024-08-29 08:30	450
Stable sulfur isotope dynamics of reduced inorganic and organic sulfur phases recorded in the Permian-Triassic transition of the Meishan type section	Paul Greenwood	C106	2024-08-29 08:30	2024-08-29 08:45	449
Sea-level and temperature changes on the Late Permian mass extinction event	Guoqiang XU	C106	2024-08-29 08:45	2024-08-29 09:00	445
Did CO2 emissions from the Siberian Traps volcanism outpace silicate weathering following the end-Permian mass extinction?	Ying CUI	C106	2024-08-29 09:00	2024-08-29 09:15	446
Vapour pressure deficit, drought, flood, fires, and CO2 spikes during the Permian-Triassic life mass extinction	Gregory RETALLACK	C106	2024-08-29 09:30	2024-08-29 09:45	453
End-Permian continental vegetation collapse directly affected marine ecosystems; Evidence from Permian-Triassic successions of Australia.	Vivi Vajda	C106	2024-08-29 09:45	2024-08-29 10:00	448
Carbon isotopic excursions around the Smithian–Spathian boundary in southern Thailand	Kittichai TONGTHERM	C106	2024-08-29 10:00	2024-08-29 10:15	442
[Keynote] Astrobiological significance of Stromatolites and organic walled microfossils on early Earth : Evidence from Lesser Himalayan Proterozoic stromatolitic cherty carbonates of India	Shuzhong SHEN	C106	2024-08-29 10:15	2024-08-29 10:30	443
Stratigraphic position of various stromatolitic successions in Nepal Lesser Himalaya	Megh Raj DHITAL	C106	2024-08-29 10:30	2024-08-29 10:45	447
Proterozoic stromatolite-bearing host rocks for nickel and cobalt mineralization in western Nepal	Sunil LAMSAL	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	454
Identification and Significance of the Permian Guadalupian-Lopingian boundary in the northwestern margin of the Yangtze Craton	Xiaoqi FAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	455
Study of Meso-Neoproterozoic stromatolites and algal structures from the Lesser Himalayan carbonates of Nepal and their depositional environment	Basanta DEVKOTA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	456
Study of the Late Permian radiolarian fauna from the Heshan Formation in Laibin, Central Guangxi Province	XiaoXin Dong	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	457
Calcification of cell membranes: From ions to minerals	XIAO GAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	458
S6 Paleogeography of the Tethys Oceans		Session Chair: Scientific Program Committee			
[Keynote] The Permian-Triassic amalgamation in the Altaids-Tethysides interaction	Wenjiao XIAO	C106	2024-08-28 14:30	2024-08-28 14:45	467
Late Paleozoic sedimentary successions and basin structure variation of the Baoshan-Shan Block (China-Myanmar)	Xiaochi JIN	C106	2024-08-28 14:45	2024-08-28 15:00	478
The Złatne/Pieniny Basin as a part of the Alpine Tethys in Central and Eastern Europe	Jan Golonka	C106	2024-08-28 15:00	2024-08-28 15:15	459
The Tethyan Seaway during the Early to Middle Miocene – new data and a review	Werner E. Piller	C106	2024-08-28 15:15	2024-08-28 15:30	461
The base of the Maastrichtian at the Oslen-Krivodol Peritethyan reference section, Bulgaria: bioevents, isotope events and paleoceanography	Michael WAGREICH	C106	2024-08-28 15:30	2024-08-28 15:45	464
The opening time constraints of both Bangong-Nujiang Ocean and Neotethys Ocean: evidences from both stratigraphy and palaeobiogeography in the Qinghai-Tibet Plateau	Yichun ZHANG	C106	2024-08-28 15:45	2024-08-28 16:00	466
Early Triassic anachronistic microbial and pisoid-facies carbonates in the eastern Paleotethys	Katsumi Ueno	C106	2024-08-28 16:00	2024-08-28 16:15	469
Late Neoproterozoic–Cambrian eclogites and high-pressure granulites in the Central Qilian terrane (China) record the earliest subduction of Proto-Tethyan Ocean in the eastern Tethysides	Hao WANG	C106	2024-08-28 16:15	2024-08-28 16:30	471
Revisiting the Structure and Stratigraphy of the Bentong-Raub Suture Zone: Insights from Field Investigation and Geochemical Analysis	Norasiah Binti SULAIMAN	C106	2024-08-28 16:30	2024-08-28 16:45	474
A PALEOENVIRONMENTAL MODEL FOR THE RUS FORMATION: FACIES CHARACTERISTICS AND THEIR SEDIMENTARY ENVIRONMENTS	Osman Abdelghany	C106	2024-08-28 16:45	2024-08-28 17:00	475
Newly discovered Late Paleozoic magmatic rocks link to Paleo-Tethyan evolution in Hainan Island, South China	Lei WANG	C106	2024-08-28 17:00	2024-08-28 17:15	477
Subduction and Obduction-Scenario structural analysis of the Indosinian orogenic belt	Wei LIN	C106	2024-08-28 17:15	2024-08-28 17:30	472
Late Paleocene-middle Eocene calcareous nannofossils in western Tarim Basin	Xuejiao WANG	C106	2024-08-28 17:30	2024-08-28 17:45	462
Deciphering Miocene Geodynamics and Sedimentation in Eastern Turkey: Insights from Plate Tectonics and Basin Analysis	Erhan Gulyuz	C106	2024-08-28 17:45	2024-08-28 18:00	480

Title	Presenter	Venue	Start	End	Page
Quantifying the Late Jurassic post-rift subsidence trends of Alpine Tethys: Constraints on the passive margin stage of the Vienna Basin area, Austria	Eun Young LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	482
Flysch and mélange in the North-Eastern Part of the Alpine Tethys	Anna WAŚKOWSKA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	484
Paleogeograpy of the Tethys oceans in South-East Asia	KhuongThe HUNG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	486
Study on coal-bearing deposits of the Lower Gosau Subgroup (Turonian to Campanian) in the Northern Calcareous Alps, Austria: High-resolution insights into the paleoenvironment	xinxuan Xiang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	487
Final amalgamation processes of the southern Altaids: insights from the Triassic ophiolitic mélange in the eastern Tianshan-Beishan orogen (NW China)	Qigui MAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	488
Early Ordovician to Early Permian tectonic evolution of the northern Western Kunlun Orogen (NW China)	Miao SANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	490
Andean-type orogenic plateau as a potential trigger for Permian aridification of North China in northeast Pangaea	Dongfang SONG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	491
Late Paleozoic and Triassic clastic rocks in the Changning-Menglian Belt: insights into paleogeography of the Paleo-Tethys in western Yunnan, China	Jianbin ZHENG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	492
Zircon U-Pb age of an intermediate dike intruding into the Selenge igneous rock complex at the Jargalant Village, Northern Mongolia	Sukhbaatar PUREVDULAM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	494
The geochemical signature of the mafic rocks in the accretionary complexes of the western Khangai-Daur belt, Central Asian Orogenic belt, central Mongolia	BAYART NADMID	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	496
The last viscous coupling in the Neo-Tethys subduction plate interface	Zhou TAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	498
SEDIMENTARY RECORD OF A BASIN MARGINAL TO THE TETHYS OCEAN: THE CERGOWA BEDS (OUTER CARPATHIANS; OLIGOCENE)	Marek WENDORFF	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	500
High-resolution sequential thrust propagation in the Nepalese Himalaya: response to the Miocene anticlockwise rotation of the Indian plate	Rui LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	501
S7 Cretaceous Earth Dynamics and Climate in Asia (Joint Session of IGCP 679)		Session Chair: Gang Li, Taejin CHOI			
[Keynote] A synthesis of provenance studies of the Cretaceous Gyeongsang Basin, SE Korea and its tectonic implications for active continental margin in East Asia	Yong Il LEE	C106	2024-08-28 08:00	2024-08-28 08:30	504
Progress of IGCP 679: Cretaceous Earth Dynamics and Climate in Asia	Gang LI	C106	2024-08-28 08:30	2024-08-28 08:45	502
Vegetation response against environmental change during the Oceanic Anoxic Event 2 recorded by terrestrial plant biomarkers in sediments from the Tomamae (Hokkaido, Japan)	Masashi A. IKEDA	C106	2024-08-28 08:45	2024-08-28 09:00	508
A new Early Cretaceous bird shed new light on the evolution of avian cranial kinesis.	MIN WANG	C106	2024-08-28 09:00	2024-08-28 09:15	506
Stratigraphic, sedimentary and basin evolution and its chronological constraints on the transition from Yanliao biota to Jehol biota during the Late Meosozoic in North China	Yongqing LIU	C106	2024-08-28 09:15	2024-08-28 09:30	510
GEOCHEMICAL AND PALYNOLOGICAL ANALYSES OF THE KHOVIL COAL DEPOSIT, CHOIR-NYALGA BASIN, CENTRAL MONGOLIA	Nyamsambuu ODGEREL	C106	2024-08-28 09:45	2024-08-28 10:00	513
Development of a new silicate weathering index (RW) and its application to the Early Cretaceous strata distributed in East Asia	Tenichi CHO	C106	2024-08-28 10:00	2024-08-28 10:15	503
The sedimentological characteristics of the intermontane desert system in the Jurong Basin, South China and its relationship with the Late Cretaceous hot climate	Shuo CAO	C106	2024-08-28 10:15	2024-08-28 10:30	507
Cretaceous stratigraphy, paleogeography and major geological events in eastern Neotethys	Dangpeng XI	C106	2024-08-28 10:30	2024-08-28 10:45	512
Interpretations from detrital zircon geochronology of Lesser Himalaya strata, Nepal, regarding the Paleozoic-Mesozoic dispersal of Gondwana	Upendra BARAL	C106	2024-08-28 10:45	2024-08-28 11:00	505
Diverse microbially induced sedimentary structures (MISS) from the Cretaceous deposits of Korea: occurrences and paleoenvironmental implication	Hyun Joo KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	514
Mineral magnetic variations across an inland sea-way excursion around Late Maastrichian/Danian deposition of the Jhilmili intertrappean in the Deccan Volcanic Province, Mandla lobe, Madhya Pradesh, India.	Jyotibala SINGH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	515
Evaluation of the hinterland paleoweathering during the mid- to late-Cretaceous in Northwestern Kyusyu, Japan	Arisa NAKANO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	516
Interpretation of Cretaceous geomorphology in eastern China based on palynological data	Suping LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	517
Stable carbon isotope stratigraphy of the Tetori Group, Upper Jurassic to Lower Cretaceous siliciclastic shallow-marine to non-marine succession in central Japan: application for non-marine regional correlation	Mayuko KAMIMURA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	518
S8 General Topics		Session Chair: Scientific Program Committee			
Integrating geochemical and geochronological methods to improve geological mapping in Aus, Southern Namibia	Claudia MUTONGOLUME	C106	2024-08-29 14:30	2024-08-29 14:45	526

Title	Presenter	Venue	Start	End	Page
U–Pb Geochronology of Detrital Zircons from San Carlos Basin, Costa Rica: Evidence of Miocene Volcanism and Implications for the Precambrian and Paleozoic History of the Central American Isthmus	Martin Rojas Barrantes	C106	2024-08-29 14:45	2024-08-29 15:00	528
Research advances and a reference subdivision of the Meso-Neoproterozoic stratigraphy in China	Hongwei KUANG	C106	2024-08-29 15:00	2024-08-29 15:15	530
STRATIGRAPHIC REVISION OF AN EOCENE-MIOCENE CARBONATE-EVAPORITE SUCCESSION IN UAE-OMAN GUIDED BY SENTINEL-2 MULTISPECTRAL DATA ANALYSIS	Abdel-Rahman FOWLER	C106	2024-08-29 15:15	2024-08-29 15:30	534
Are Ordovician ferruginous ooids and microbialites indicators of cool-water realms and upwelling-active zones?	Xiaocong LUAN	C106	2024-08-29 15:30	2024-08-29 15:45	535
Meso-Neoproterozoic Simlipal Complex, Eastern India; an impact induced basin, post amalgamation of Singhbhum Craton and North Singhbhum Mobile Belt.	Jayaprakash Mohakul	C106	2024-08-29 15:45	2024-08-29 16:00	532
Provenance studies of the Cuyuja Unit in the Quebrada Yaguana, Napo-Ecuador	Christian ROMERO CÓNDOR	C106	2024-08-29 16:15	2024-08-29 16:30	538
Unravelling the Evolution of the Richtersveld Magmatic Arc: Insights from Integrated Regional Geological Mapping	Conrad GROENEWALD	C106	2024-08-29 16:30	2024-08-29 16:45	536
Continental migration does not conflict with the gyroscope	ZHAINA YERZHANOVA	C106	2024-08-29 16:45	2024-08-29 17:00	522
Expression of the Prague Event (Lochkovian-Pragian boundary) in the Carnic Alps (Italy and Austria)	Carlo CORRADINI	C106	2024-08-29 17:30	2024-08-29 17:45	525
Key findings of the geoscientific mapping in the Aukam Valley, Namaqua Metamorphic Complex, Southwestern Namibia	Ewereth MUVANGUA	C106	2024-08-29 17:15	2024-08-29 17:30	527
The South America Map of Orogens	Daniela MATEUS ZABALA	C106	2024-08-29 17:00	2024-08-29 17:15	520
When and how did the Sturtian glaciation begin? insights from the Shennongjia area, northern Yangtze Craton	Yuchong Wang	C106	2024-08-29 17:45	2024-08-29 18:00	540
Palynological variability within the Permian (Changhsingian) Umm Irna Formation (Jordan): implications for biostratigraphy and fluid flow character in alluvial formations	Michael Stephenson	C106	2024-08-29 18:00	2024-08-29 18:15	523
Factors affecting sequence structure and sequence-stratigraphic dynamics	Haoyuan LV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	541
Provenance of Late Precambrian quartzite- schist sequences of the western Central Asian Orogenic Belt	Nadezhda KANYGINA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	542
Vanadium isotope reveals the interval of marine oxygenation during early Cambrian, South China	Hao RAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	544
40Ar/39Ar ages from rocks of the southern part of the Mozambique Belt	Fátima Roberto Chaúque Nampete	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	545
Tectonics and Geodynamics of Antarctica	German LEICHENKOV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	546
Discovering Remnants of the Earliest Continents: 3.4 Ga Basement in the South West Terrane of the Yilgarn Craton and Implications for Archean Geodynamics	Catherine GILL	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	548
Picture Perfect Photogrammetry: mapping the remnants of long-gone glaciers in northern Namibia in unprecedented resolution	Ricarda WOHLSCHLÄGL	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	550
Modern ocean island basalt–like 182W signature in Paleoarchean mafic rocks: A negative μ182W endmember in the lower mantle	Qing-Feng MEI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	551
Sequence biostratigraphy of early Paleogene lignite-shale succession of western India: A case study on an integrated approach to Hydrocarbon Exploration	Shalini PARMAR	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	552
The Cadomian unconformity and the stratigraphy of the Neoproterozoic "Schist-Greywacke Domain" (Portugal)	Artur Abreu SÁ	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	554
Zircon U-Pb-Hf isotopic age of gneissic inlier of Aravalli Fold Belt, Rajasthan, India: evidences of Protracted crustal building events from Archean to Mesoproterozoic.	Krishnapriya BASAK	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	555
Lithostratigraphy, structure and metamorphic evolution of Naga Metamorphics, Nagaland, India	NEIPEKREIZO KESIEZIE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	556
In situ Rb–Sr age mapping of micas, feldspars, and clay minerals	DARWINAJI SUBARKAH	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	557
Archean continental crustal growth and reworking of the North China Craton: Constraints from zircon U-Pb age and Hf isotopic composition	Chunrong DIWU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	558
Updating the Cambrian Time Scale: A Bayesian approach	Valentin Jamart	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	559
PROTEROZOIC CARBONATITES IN THE SUL-RIOGRANDENSE SHIELD (SRS), SOUTH BRAZIL	Cimara Francisca MONTEIRO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	561
UNRAVELLING THE ORIGIN OF ALTERNATING FE- AND SI- LAYERS IN IRON FORMATIONS: A MULTISCALE RHEOLOGICAL INVESTIGATION	Elder YOKOYAMA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	563
The Portuguese (PT) version of the "International Chronostratigraphic Chart": a new approach	Manuel João LEMOS DE SOUSA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	564

Title	Presenter	Venue	Start	End	Page
Study on high-precision sequence stratigraphic characteristics and lake level variation trend: A case study of the lower part of the fourth Member of the Paleogene Shahejie Formation (Es4x) in the Niuzhuang Sub-sag	Zhaoxiang CHEN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	566
On the origin of continents: Insights from Archaean Terrains of Arctic Fennoscandia	Jaana HALLA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	568
Provenance analysis of the Tena Formation in the Anzu River, Puyo – Ecuador	Christian WLADIMIR ROMERO CÓNDOR	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	569
Geological and Geomorphological Mapping in Northern Luzon, Philippines using Field Data and Red Relief Image Map (RRIM)	CLOD ANNE VILLALUNA PUNZALAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	570
New data on the stratigraphy of the Middle and Upper Jurassic strata of northeastern Iran	Niki MAJIDIFARD	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	572
T4 Tectonophysics					
S1 Eastern Asia tectonic evolution under the multi-plate convergent geodynamics during late Mesozoic		Session Chair: Scientific Program Committee			
New insight into crustal exhumation induced by granitic intrusion following intracontinental contractional deformation: a possible model for Hohhot thermal upwelling-extensional structure, Inner Mongolia, north China	Yu ZHANG	C107	2024-08-29 14:30	2024-08-29 14:45	574
When did the Mongol-Okhotsk Ocean close?	Zhiyu YI	C107	2024-08-29 14:45	2024-08-29 15:00	576
Extensional Tectonics and North China Craton Destruction — insights from the Magnetic Susceptibility Anisotropy (AMS) of granite and Metamorphic Core Complex	Wei LIN	C107	2024-08-29 15:00	2024-08-29 15:15	577
Decoding the link between magmatic cyclicity and episodic extensional and contractional tectonics: insights from the Late Mesozoic granites of the eastern China	Lingtong MENG	C107	2024-08-29 15:15	2024-08-29 15:30	580
Late Cretaceous rapid uplift and denudation of northern Tibet and its climatic effects	Hao WU	C107	2024-08-29 15:30	2024-08-29 15:45	575
The Central Asian fold belt (CAOB): granite domes of the Erguna Massif as indicator of Mesozoic extension (evidence from the Trans-Baikal geotransect and parametric borehole of 2 600 m depth)	Ivan KUDRIAVTCEV	C107	2024-08-29 15:45	2024-08-29 16:00	578
The Lateral Accretionary Orogenic Process at Pangea's Conveyable Zone: Insights from the Borneo's Oldest Granitoids in Southeast Asia	Shan LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	582
Middle-Late Jurassic crustal shortening in the central–western North China craton in response to multi-plate convergence in the East Asia	Wei SHI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	583
Gondwanan Flood Basalts Linked Seismically to Plume-Induced Lithosphere Instability	Yanan SHI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	584
Late Jurassic true polar event revealed by paleomagnetic study in North China and its implication for regional tectonics and biota evolution in East Asia	PAN ZHAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	585
Cyclical and progressive destruction of the cratonic lithosphere of South China	Yang CHU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	586
Discussion on the Metallogenic Geological Body of the Qixiashan Pb-Zn Polymetallic Deposit in Jiangsu Province, China	Mingchao ZHANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	587
Mesozoic Uplift of the Dabashan and the Micangshan-Hannan Dome in the South Qinling Orogenic Belt determined by analysis of lithospheric flexure	Xiong XIONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	589
S2+S4 Intraplate tectonics and seismicity		Session Chair: Jin-Hyuck CHOI, Taehyung KIM			
The silent and slow active faults of Germany: results from paleoseismological trenching	Klaus REICHERTER	C109	2024-08-28 14:30	2024-08-28 14:45	600
Identification of seismic activity and basin inversion based on soft-sediment deformation structures: An example from SE Korea	Jinhyun Lee	C109	2024-08-28 14:45	2024-08-28 15:00	590
Intracrystalline deformation may explain the recurrence of small-magnitude tremors in an intraplate region- A case study from the Koyna-Warna Seismogenic Region, Western India	PIYAL HALDER	C109	2024-08-28 16:00	2024-08-28 16:15	596
Long-term patterns of paleo-earthquakes influenced by climate change on the Korean Peninsula	Man-Jae KIM	C109	2024-08-28 15:15	2024-08-28 15:30	592
New Constraints on the Active Tectonics of Gulf of Kuşadası, Western Turkey: Insights from a Comprehensive Offshore Survey	Gülsen Ucarkus	C109	2024-08-28 15:30	2024-08-28 15:45	593
Earthquake Geology of the Mogod Fault, Mongolia	Hankyung Bae	C109	2024-08-28 16:15	2024-08-28 16:30	598
Decoding Paleostress Conditions from the Morphology of Quaternary Volcanic Craters along the Western Branch of the East African Rift System: Implications for Volcanic Hazard Assessment	Francois HATEGEKIMANA	C109	2024-08-28 15:45	2024-08-28 16:00	595
Intraplate neotectonics and activity of thrust segment in the Ulsan fault, SE Korea	Kiwoong PARK	C109	2024-08-28 15:00	2024-08-28 15:15	591
Paleoseismic event timing and surface rupture scenarios on the Yangsan Fault, SE Korea	Taehyung KIM	C109	2024-08-28 16:30	2024-08-28 16:45	599

Title	Presenter	Venue	Start	End	Page
The Eastern English Channel (North of France) : Some examples of intraplate tectonics and seismicity	Virginie GAULLIER	C109	2024-08-28 16:45	2024-08-30 17:00	605
The Evaluation and Morphometric analysis of Active Tectonics in Zagros Folded Belt (ZSFB), West of Iran	SAMBIT PRASANAJIT NAIK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	602
Numerical modelling of tectonic stress and deformation of the Andaman Subduction Zone	Radheshyam YADAV	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	604
S3 Deformation processes and texture analysis		Session Chair: Munjae PARK, Sejin JUNG			
A study on petrofabrics of garnet in calc-silicate rocks in the Yeongnam Massif, South Korea	Seokyoung HAN	C107	2024-08-29 16:00	2024-08-29 16:15	607
Preliminary results of the deformation texture of diopside in serpentinite	Jungjin LEE	C107	2024-08-29 16:15	2024-08-29 16:30	608
Seismic anisotropy of slaty rocks: Unveiling the effect of the CPO on seismic properties	Victor CARDENES	C107	2024-08-29 16:30	2024-08-29 16:45	609
Deformation microstructures and seismic anisotropy of Yeoncheon amphibolites in the Imjingang Belt, South Korea	Sejin JUNG	C107	2024-08-29 16:45	2024-08-29 17:00	610
Chlorite dehydration in chlorite peridotite and implications for intermediate-depth earthquakes in subducting slabs	Haemyeong JUNG	C107	2024-08-29 17:00	2024-08-29 17:15	611
Lattice-preferred orientations of glaucophane, zoisite, and epidote in zoisite-epidote blueschist from Río San Juan metamorphic complex, Dominican Republic	Yong PARK	C107	2024-08-29 17:15	2024-08-29 17:30	612
All six typical olivine CPO types discovered in single research area and its seismic implications	Yilun Shao	C107	2024-08-29 17:30	2024-08-29 17:45	614
Differential Stress Affecting Preservation of Intergranular Coesite in UHP Rocks from the Dabie Shan: Ultra-microstructure Insights from TEM	Jinyu ZHENG	C107	2024-08-29 17:45	2024-08-29 18:00	615
Intracrystalline deformation microstructures in natural olivine with implications for stress estimation	Jian MA	C107	2024-08-29 18:00	2024-08-29 18:15	617
PROGRESSIVE STRAIN LOCALIZATION AND FLUID-ASSISTED DEFORMATION IN MANTLE EXHUMATION DURING RIFTING: PETROSTRUCTURAL CONSTRAINTS FROM THE ZABARGAD PERIDOTITES, RED SEA)	Marialine CHARDELIN	C107	2024-08-29 18:15	2024-08-29 18:30	618
Rheological inhomogeneities in the geodinamic structures of the earth' s crust	GENNADY ERMOLAEV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	620
Evolution of Deformation Microstructures and Fluid Inclusions in Peridotite Xenoliths beneath the Rio Grande Rift	Munjae PARK	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	622
Tectonic characteristics and petroleum geological significance of the CiCun fault	Jun YANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	623
Deformation microstructures of blueschists in Alpine Corsica, France, and implications for seismic properties in subducting oceanic crust	Seungsoon CHOI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	624
Petrofabrics and microstructures of phyllite from Geumseongri Formation, South Korea: Implications for seismic anisotropy	Seokyoung HAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	626
Microstructures of deformed granites and calc-silicate rocks in Yeoncheon, South Korea	Sena SIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	627
Lattice-preferred orientation and deformation mechanisms of amphibole in amphibolites from Jenner Headlands, Sonoma County, and Ring Mt., Marin County, California, U.S.A.	Junha KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	628
High-temperature shear initiation of subridge mantle: A microstructural study of peridotites from the Zhongba ophiolite, SW Tibet	ZHANG ZHEN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	629
Crystallographic preferred orientation and seismic anisotropy of minerals in glaucophane schist and eclogite from the Franciscan Complex of Jenner, California	Yoonhae HA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	630
S5 Structure, magmatism and evolution process of oceanic and marginal seas' lithosphere		Session Chair: Weiwei Ding			
[Keynote] Hydrothermal Feedbacks on Tectonics During Magma-Poor Rifting and Start of Oceanic Spreading	Marta PEREZ-GUSSINYE	C107	2024-08-28 08:00	2024-08-28 08:15	639
Deep Structure of the Southeast Asian Curved Subduction System and its Dynamic Process	Weiwei Ding	C107	2024-08-28 08:15	2024-08-28 08:30	631
Influence of Convergence Rate and Subduction Dip Angle on Island-Arc Magma Production	Yongliang BAI	C107	2024-08-28 08:30	2024-08-28 08:45	632
Structure and geodynamics beneath the Indian Ocean inferred from multimode surface wave tomography	Debasis MOHANTY	C107	2024-08-28 08:45	2024-08-28 09:00	634
Continental breakup of Marginal Seas in SE Asia	Jean-Claude RINGENBACH	C107	2024-08-28 09:00	2024-08-28 09:15	636
Detachment fault systems in the Northern South China Sea, insights into 3D tectonic segmentation of rifted margins	Shihao HAO	C107	2024-08-28 09:30	2024-08-28 09:45	638
Characterization of fault systems and implications on structural evolution of the northern Qiongdongnan Basin, South China Sea	Yu QIU	C107	2024-08-28 09:45	2024-08-28 10:00	640
The structure and spreading history of the South China Sea	Zhen SUN	C107	2024-08-28 10:00	2024-08-28 10:15	635
How could density contrast between magmatic rocks and bedrocks affect SDR formations?	Haibin YANG	C107	2024-08-28 10:15	2024-08-28 10:30	633

Title	Presenter	Venue	Start	End	Page
Development of detachment fault system associated with a mature metamorphic more complex: insight from the Kaiping Sag, northern South China Sea rifted margin	Gengbiao LI	C107	2024-08-28 10:30	2024-08-28 10:45	642
Geochemistry and petrogenesis of igneous rocks from the Yap forearc in the western Pacific: Implications for forearc magmatism	Ling CHEN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	643
The Oceanic crustal structure and the magmatic accretion history of the South China Sea	chenghui ZENG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	645
Oceanic crustal structures and characteristics of Syn-Spread Magmatism in the Central basin of the South China Sea	Haixuan SUN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	646
Possible Plume-Ridge Interactions during India-Madagascar Break-up	LACHIT SINGH NINGTHOUJAM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	647
New insights to slab interface and crustal structure in Sumatra subduction zone: constraints from novel receiver function analyses	Ling CHEN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	648
Constraining water flux in the Manila subduction zone with seismic data	Zhenteng WANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	650
Seismic and Gravity Data Analysis of Oceanic Core Complexes in the West Philippine Basin	Yanghui Zhao	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	651
Numerical Model of High-temperature Geothermal Based on Trans-crustal Magmatic System in Eastern Shandong Province	Jie LIU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	983
Rift architecture and evolution controlled by an exhuming and decapitating metamorphic core complex in the Kaiping Sag, northern South China Sea margin	WenDi LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	652
New data on the age of the basement of the Devonian Magnitogorsk island arc (the Southern Urals) according to the results of U-Pb LA-ICP-MS dating of zircons from tuffs of the Irendyk Formation	Ivan SOBOLEV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	653
Synrift and postrift thermal evolution of margins: a re-evaluation of classic models of rifting	Marta PEREZ-GUSSINYE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	655
USE OF MAGNETIC METHODS TO MODEL A GONDWANA SUTURE ZONE IN DEPTH: SOUTHEAST BRAZILIAN CONTINENTAL MARGIN	RAPHAELA LOPES DE ANDRADE SILVA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	656
Intrusive mantle flow induced by thermal heterogeneity during rift propagation	Min-seok JANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	658
S6 Active Tectonics and Earthquake Geology		Session Chair: J. Bruce H. SHYU, Jin-Hyuck CHOI			
[Keynote] Temporal clustering of large earthquakes along the central-eastern sections of the Altyn Tagh Fault, China	Yann KLINGER	C109	2024-08-29 14:40	2024-08-29 15:00	665
Fault Creep Promoted by the Regional Alignment of Fault Networks	Jaeseok LEE	C109	2024-08-29 15:00	2024-08-29 15:15	661
Fossil Earthquakes Preserved on Fossils: New examples from Taiwan	JIH-PAI LIN	C109	2024-08-29 15:15	2024-08-29 15:30	663
Evidence of Surface Rupture on Inherited Fault and its Implications for Intraplate Earthquakes in the Central Yangsan Fault, South Korea.	Sangmin HA	C109	2024-08-29 15:30	2024-08-29 15:45	664
A Study on Seismic Velocity Contrast along the Longitudinal Valley Fault System, Taiwan, Using Fault Zone Head Waves	Tzu-Chi Lin	C109	2024-08-29 15:45	2024-08-29 16:00	666
Persistent crustal CO2 degassing following the 2022 M6.8 Chihshang earthquake sequence, eastern Taiwan	Ching-Chou FU	C109	2024-08-29 16:15	2024-08-29 16:30	667
Tectonic Geomorphology and Paleoseismology of the East Solsona Basin Fault in Northern Luzon, Philippines	Noelynna Ramos	C109	2024-08-29 16:30	2024-08-29 16:45	669
Earthquake rupture features in near-surface regions, Korea	Youngbeom CHEON	C109	2024-08-29 16:45	2024-08-29 17:00	659
Frictional slips on artificial fault planes implicating periodic earthquakes along active tectonic plate boundaries	Insun SONG	C109	2024-08-29 17:00	2024-08-29 17:15	668
On the active faults around Gyeongju, Korea: a possible relationship with the 779 AD Gyeongju Earthquake and the Buddhist temples/pagodas in the Silla Dynasty (57 BC – 935 AD) as a 'Bibo Pungsu (Feng Shui theory)'	Chung-Ryul RYOO	C109	2024-08-29 17:15	2024-08-29 17:30	662
Neotectonic deformation and long-term behavior of Masjed-e Soleyman Dam, Iran	Arash Barjasteh	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	670
Multi-disciplinary active fault mapping in the central Gyeongju, SE Kore	Jinhyun lee	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	671
Aseismic, co-seismic, and post-seismic displacements on the September 2022 Guanshan and Chihshang earthquakes, in eastern Taiwan	Horng-Yue Chen	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	672
The characteristics of the Chihshang segment of the Longitudinal Valley Fault System, eastern Taiwan, assessed by historical aerial photo reconstructions	Tsz Yau Amundsen LAM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	673
Active shortening in the axial portion of the Andes in the northern end of the Chilean-Pampean flat slab triggered by sublithospheric controls	Sarah Ellen THOMAS	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	674
Quaternary reactivation and paleo-seismologic records along intrabasinal faults in the Miocene Janggi Basin, SE Korea	Jong-Won Han	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	676
Assessing Quaternary-active footwall splays in the Andean thrust front, Southern Precordillera, Argentina (32° 30' S - 68° 49' W)	Victoria Alvarellos	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	678
Active tectonics of the Yuli Fault in the central Longitudinal Valley area, eastern Taiwan	Yu WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	680
Wedge confinement; a brittle faulting process for the accommodation of active block movements in the interior of continents	Esmaeil SHABANIAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	681

Title	Presenter	Venue	Start	End	Page
A short review on geologic evidence of pre-historical large earthquakes in S. Korea	Jin-Hyuck CHOI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	682
Developing Fault Models for Seismic Hazard Assessment in Slow-Deforming Intraplate Regions: A Case Study of the Yangsan Fault, Korea	Taehyung Kim	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	683
S7 Tectonic evolution of modern and ancient orogens in 4D		Session Chair: Gideon Rosenbaum			
[Keynote] Subduction dynamics and overriding plate deformation	Wouter SCHELLART	C107	2024-08-26 16:00	2024-08-26 16:15	687
Space and time variability of styles of continental shortening: new insights from 3D seismic interpretation in the Jura fold and thrust belt	Miller Zambrano	C107	2024-08-26 16:15	2024-08-26 16:30	684
Along-strike change of erosion and sedimentation in the Longmenshan FTB, SE Tibetan Plateau, evidence from analogue experiments	Bin DENG	C107	2024-08-26 16:30	2024-08-26 16:45	688
Tectonic evolution of the Eastern Central Asian Orogenic Belt	Yongjiang LIU	C107	2024-08-26 16:45	2024-08-26 17:00	685
The formation of the Mongolian Orocline in Central Asia: slab-driven or overriding-plate-driven?	Pengfei Li	C107	2024-08-26 17:00	2024-08-26 17:15	689
Crustal Evolution and Mantle-Crust Interaction in the Paleoarchean: Insights from the Southern São Francisco Paleocontinent	Henrique BRUNO	C107	2024-08-26 17:15	2024-08-26 17:30	692
The Southern Segment of the Paleoproterozoic Minas-Bahia Orogen, SE Brazil: an example of a complete orogenic cycle	Monica Heilbron	C107	2024-08-26 17:30	2024-08-26 17:45	694
The architecture of ancient collapsed orogens: an integrated magnetotelluric-structural-seismic study of Paleoproterozoic Trans-Hudson orogen and its foreland	Sally Pehrsson	C107	2024-08-26 17:45	2024-08-26 18:00	696
Slab Subduction and Pull Link Magmatism at Active and Passive Continental Margins	Li-Qun DAI	C107	2024-08-26 18:00	2024-08-26 18:15	690
Slab segmentation, anomalous arc volcanism, and giant porphyry copper deposits in Indonesia	Gideon Rosenbaum	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	698
Exhumation of the Hogem Batholith, north-central British Columbia, Canada	Ruohong JIAO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	700
Orogenic Evolution and Plate Tectonic Significance of the East African Orogen of Turkana, N. Kenya	Morgan L. BLADES	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	701
Cenozoic uplift of Luxi Uplift and the Qinghai-Tibet Plateau and their geological significance	Fengdi GUO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	703
S8 Subduction-related sedimentary basin evolution and lithospheric dynamics		Session Chair: Zhongxian Zhao, Eun Young LEE			
[Keynote] The structure and breakup mechanism of the South China Sea: the feature of subduction related rifting	Zhen SUN	C107	2024-08-29 08:00	2024-08-29 08:30	704
Tectonic-controlled sedimentary basins in NE Iran	Mohammad Reza SHEIKHOLESLAMI	C107	2024-08-29 09:00	2024-08-29 09:15	705
The evolution of Eastern Paleotethys Ocean on Hainan Island, South China	Dai ZHOU	C107	2024-08-29 08:30	2024-08-29 08:45	706
The Late Cretaceous tectonic evolution of the Southern Central Andes: insights from the Malargüe area (36°S)	Matias BARRIONUEVO	C107	2024-08-29 08:45	2024-08-29 09:00	708
Degree of coupling in 3D multilayer lithospheric buckling: Implications for tectonic environments	Seok-Hyeon DO	C107	2024-08-29 09:15	2024-08-29 09:30	710
Sedimentation and subsidence history of the Gosau Group, Austria: Implications of Late Cretaceous subduction and sea level fluctuations	xinxuan Xiang	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	711
Late Cretaceous Tectonic and Paleogeographic Evolution of the Southern Central Andes: Insights from the Diamante Formation at 34°40'S	Federico Exequiel Martos	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	712
Structural evolution of Mud-intrusive and -extrusive System: Insights from 2D seismic reflection data of Makran Accretionary Wedge	SYED AHSAN HUSSAIN GARDEZI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	714
S9 Deciphering complex plate tectonics from the ocean floor		Session Chair: Jerome Dyment, Hanjin CHOE			
Long-range effects of mid-ocean ridge dynamics on earthquakes, magmatic activities, and mineralization events in plate subduction zones	Qiuming Cheng	C107	2024-08-29 09:30	2024-08-29 09:45	716
Unveiling the Evolution of the West Philippine Basin with Massive High-Resolution Seafloor Mapping Data	HANJIN CHOE	C107	2024-08-29 09:45	2024-08-29 10:00	717
World Digital Magnetic Anomaly Map (WDMAM) version 2.2 released	Jerome DYMENT	C107	2024-08-29 10:00	2024-08-29 10:15	718
Can an extraterrestrial body impact affect plate tectonics? The case of Chicxulub and the Yucatan Basin	Jerome DYMENT	C107	2024-08-29 10:15	2024-08-29 10:30	719
Investigating the Chemical Mechanism for Magnetization Reduction in Subducting Oceanic Crust through Hydrothermal Alteration of Magnetic Minerals	Sunhwa HONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	720
S10+S13 Towards better understanding the origin of intraplate earthquakes in East Asia		Session Chair: Eunseo CHOI, Sungho LEE			
[Keynote] Properties, nature and outlook of intraplate earthquakes in the eastern margin of Eurasian plate around the Korean Peninsula	Tae-Kyung HONG	C107	2024-08-28 14:30	2024-08-28 14:45	725
Inside the Central Cordillera of Colombia: La Línea Tunnel	Jorge GÓMEZ TAPIAS	C107	2024-08-28 14:45	2024-08-28 15:00	721
Understanding postseismic deformation patterns in the Korean Peninsula following the 2011 Tohoku-Oki earthquake: Insights from viscoelastic numerical simulations	Sungho LEE	C107	2024-08-28 15:00	2024-08-28 15:15	723

Title	Presenter	Venue	Start	End	Page
The critically stressed state of the earth's crust and the associated response to anthropogenic impact	Andrian Batugin	C107	2024-08-28 15:15	2024-08-28 15:30	724
Effect of postseismic deformation following Tohoku-Oki earthquake on the East Asian intraplate due to the strength of the East-Sea (Japan Sea).	Hyeon-Seob KIM	C107	2024-08-28 15:30	2024-08-28 15:45	726
Permian magmatism and Triassic and Jurassic metamorphism recorded at the western margin of Gondwana, Colombia	Jorge GÓMEZ TAPIAS	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	727
A review of the retroarc foreland metasediments associated with the Devonian-Mississipian west Patagonian magmatic arc, Argentina	Carlos Jorge Chernicoff	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	728
Newly dated Neoproterozoic-Cambrian Las Pacas Complex at the boundary between the Cuyania and Chilenia terranes, southern Mendoza province, Argentina	Carlos Jorge Chernicoff	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	729
A study on magnetization vector inversion modeling of Dokdo submarine volcanic body	SoonYoung CHOI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	730
Deciphering Fissure Dynamics: Magnetic Fabric Insights into Cretaceous Deccan's Volcanic Phenomena from N-S-T Dyke Swarms	GARIMA SHUKLA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	732
Cenozoic crustal thickness variations and surface uplift in the southeastern Tibetan Plateau: Insights from detrital zircon U-Pb geochronology and trace elements in the Gongga Shan region	Xiaoming SHEN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	734
Evidence of crustal scale fracture system in Central Indian Precambrian (Bastar) Craton, India: Inference from airborne magnetic data analysis and modelling.	AJIT SINGH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	736
S11 Geology and Tectonics of the Western Pacific Marginal Seas		Session Chair: Scientific Program Committee			
[Keynote] Trench kinematics and the opening of backarc basin	claudio faccenna	C107	2024-08-27 08:00	2024-08-27 08:15	752
ML-based volumetric conversion of 2D seismic sections for comprehensive seismic interpretation	Jun-Woo Lee	C107	2024-08-27 08:15	2024-08-27 08:30	738
Hyper-extended basins controlled by low-angle normal faults in Marginal Seas: 3D structure and tectono-sedimentary evolution	Geoffroy MOHN	C107	2024-08-27 08:30	2024-08-27 08:45	740
Cenozoic tectonic history of SE Korea during the evolution of the East Sea (Japan Sea)	Min-Cheol KIM	C107	2024-08-27 08:45	2024-08-27 09:00	742
Morphodynamic interaction between canyons and fans in a Basin and Range setting: the roles of tectonics, bedrock incision and alluviation	Gary PARKER	C107	2024-08-27 09:00	2024-08-27 09:15	743
Tectonic evolution and depositional environments of the southernmost continental shelf basins of Korea, the northern East China Sea	Seok Hoon YOON	C107	2024-08-27 09:15	2024-08-27 09:30	744
A novel coupled model for rift basin evolution: Integrating tectonics, sea-level cycles, and multiple sediment sources	Wonsuck KIM	C107	2024-08-27 09:30	2024-08-27 09:45	746
Depositional Age and Provenance of the Jeju Basin Sediments Inferred by Detrital Zircon U-Pb Geochronology	Taejin CHOI	C107	2024-08-27 09:45	2024-08-27 10:00	747
Subduction Initiation under the Neotectonic Regime of the Western East Sea (Sea of Japan) Margin	Jae-Hyuk LEE	C107	2024-08-27 10:00	2024-08-27 10:15	748
Characterization of Igneous Bodies around the Jeju Basin, the East China Sea: Igneous Stratigraphy and Tecto-Magmatic Implications	Yun-Hui JE	C107	2024-08-27 10:15	2024-08-27 10:30	750
The Distinctive History of the Attu region of the Western Aleutian Arc in the Western Pacific Region	Suzanne KAY	C107	2024-08-27 10:30	2024-08-27 10:45	751
Subduction Initiation process of a young marginal sea: a case study of the North Sulawesi subduction Zone	Tianyao HAO	C107	2024-08-27 10:45	2024-08-27 11:00	753
Geothermal characterization of the Western Pacific marginal seas	Shaowen LIU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	754
An Analysis of Karst Model and its Controlling Factors of Carbonate Buried Hill: A Case Study from the Weixinan Sag, Beibuwan Basin, South China Sea	Yanying LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	755
The Formation and Evolution of the Central Uplift in the South Yellow Sea Basin and Its Geological Significance for Oil and Gas	zhangjin CHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	756
Differential deformation characteristics and genetic mechanisms of the central uplift in the South Yellow Sea Basin,China	Qingxun WU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	758
Geochemistry and U-Pb chronology of Silurian clastic rocks from boreholes in the Yellow Sea, Western Pacific Marginal Seas: Geological data evidence that the Yellow Sea belongs to the Yangtze Block	LI ZHIQIANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	759
Thick-skinned tectonics in southern Ulleung Basin (East Sea) through gravity data analyses	Yoon-Mi KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	760
S12 Deep Earth Exploration and Earth CT		Session Chair: Scientific Program Committee			
Phanerozoic tectonic evolution and mineral system formation in East Asia	Xuanhua CHEN	C107	2024-08-30 13:50	2024-08-30 14:05	761
Adaptive mesh-free approach for gravity inversion	Yan LIU	C107	2024-08-30 14:05	2024-08-30 14:20	762
Multi-scale velocity structures of crustal-mantle beneath South China and its constraint on deep mineralization mechanism	Guoming JIANG	C107	2024-08-30 14:35	2024-08-30 14:50	766
New insights into asthenospheric flow beneath the Qinling Orogenic Belt and adjacent areas revealed by a three-dimensional Magnetotelluric study	Gaofeng YE	C107	2024-08-30 14:50	2024-08-30 15:05	768
The geodynamic process of the eastern Tibetan plateau revealed by a 3D structure extracted by the Wavegradiometry Method	Chuntao LIANG	C107	2024-08-30 15:05	2024-08-30 15:20	771
Intraplate thrust orogeny of the Altai Mountains revealed by deep seismic reflection	Lian-Feng Zhao	C107	2024-08-30 15:20	2024-08-30 15:35	773

Title	Presenter	Venue	Start	End	Page
Three-Dimensional Tomography: Unveiling the Tectonic and Mantle Dynamics Beneath the Mendocino Triple Junction	Ziqiang YANG	C107	2024-08-30 15:35	2024-08-30 15:50	775
Heterogeneous lithospheric mantle: A geophysical perspective	Irina ARTEMIEVA	C107	2024-08-30 15:50	2024-08-30 16:05	763
Cratons are not all that stable!	Hans THYBO	C107	2024-08-30 16:05	2024-08-30 16:20	764
Deep Researches of the North Eastern Eurasia: Russian geotransects – results and perspectives	Ivan KUDRIAVTCEV	C107	2024-08-30 16:20	2024-08-30 16:35	769
Study on the deep geological structure of the southern section of the Kyushu-Palau Ridge based on the combined gravity, magnetic and seismic inversion method	KE QIN	C107	2024-08-30 16:35	2024-08-30 16:50	774
Earth CT: Intergrating Deep Earth Profiles to Make Global Transections via Wide Open Collaboration	Qi ZHOU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	776
Seismic discontinuities in the Australian upper mantle: a Bayesian approach using receiver functions and multimode dispersion of surface waves	Kotaro TARUMI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	778
Three-dimensional thermal-rheological structure of East Asian continental lithosphere	Yujun SUN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	779
Upper-mantle velocity and anisotropy under the Mongol-Baikal region	Hanting WU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	780
Determining three-dimensional Vp/Vs model for the Longmenshan fault system and adjacent areas, Sichuan, China	Junjie HAO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	781
Lithospheric structure beneath the Hoh Xil block in the northern Tibetan Plateau revealed by deep seismic reflection profile	Zhanwu LU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	782
Film formation behavior of a hybrid silicate and its anti-hydration performance under a high-temperature environment	Mingyi Guo	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	783
Double-difference Seismic Tomography Using Variational Inference Method and its Application	Hao YANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	784
T5 Planetary Sciences					
S2+S1 Geological Exploration of Lunar and Martian Terrains		Session Chair: Michael Steven Phillips			
Far-IR spectrometer, MIRORES, for orbital ore prospecting on the Moon	Jakub CIAZELA	M316	2024-08-28 08:00	2024-08-28 08:15	786
Foundations for Lunar Landing Sites: Estimating the Bulk Density of Near-surface Lunar Regolith Through Cone Penetrometer Testing of Simulants	Michael LUCAS	M316	2024-08-28 08:15	2024-08-28 08:30	788
Lunar Dust Removal using a Gecko Roller	Charles Pett	M316	2024-08-28 08:30	2024-08-28 08:45	790
Spectrally Feldspathic Detections on Mars: A Review and New Discoveries	Michael PHILLIPS	M316	2024-08-28 08:45	2024-08-28 09:00	792
Structure, rheology, and evolution of the Martian lithosphere across the crustal dichotomy in and around the Tharsis-Valles Marineris provinces	Ratheesh Kumar RT	M316	2024-08-28 09:00	2024-08-28 09:15	785
Gale crater Mars – 3.7 billion years of Mars history from the Curiosity Mars Rover mission	Horton Newsom	M316	2024-08-28 09:15	2024-08-28 09:30	791
Estimation of Lunar Rock Strength: Integrating Regression Analysis and Machine Learning with Apollo Mission Data	Tae Young KO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	793
Volume estimation of specific types of Martian glaciers which may be related to the paleo-environment of Mars	AKIRA SAWADA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	794
S3+S4 The interiors of the Earth, solar system planets, and exoplanets		Session Chair: Takuo Okuchi, Jinhyuk CHOI			
The >3700 km long Great Dyke of Atla Regio, Venus: the longest traced individual dyke in the solar system	Hafida EL BILALI	M316	2024-08-28 09:30	2024-08-28 09:45	796
A role for iron hydrogenation in the layered redox processes of the post-giant impact Earth	Jinhyuk CHOI	M316	2024-08-28 09:45	2024-08-28 10:00	797
Formation and evolution of the protolunar disk	Razvan CARACAS	M316	2024-08-28 10:00	2024-08-28 10:15	799
Crustal extension due to dyke swarm emplacement: Influence on Venusian surface topography including the formation of annular rims/troughs characteristic of coronae	Richard ERNST	M316	2024-08-28 10:15	2024-08-28 10:30	802
Dyke swarm history and associated plume centres of Anala and Irnini Montes in Central Eistla Regio, Venus	AASTHA MISHRA	M316	2024-08-28 10:30	2024-08-28 11:00	800
In-situ high-pressure and high-temperature study of the Fe-S-O-H system: An implication for the thermal evolution of the Martian core	Jeongmin LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	805
Experimental seismic velocity measurements of chlorite and antigorite using the PE press	Nicholas Backhouse	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	806
Numerical simulation of planetary core formation using FEniCS Project for extending 3D modeling	Kyeong-Min LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	808
S5+S6 Meteorites: Probing the Origins and Evolution of our Solar System		Session Chair: Changkun Park			
Collisional erosion of planets recorded by lithium isotopes	Yingkui XU	M315	2024-08-28 08:00	2024-08-28 08:15	809
Petrochemical and shock heterogeneity in Shergotty achondrite	ARINDAM DUTTA	M315	2024-08-28 08:15	2024-08-28 08:30	810
Aluminium-Magnesium Ages of Evolved Achondrites	Zoltan VACI	M315	2024-08-28 08:30	2024-08-28 08:45	811
Maximizing the Value of Meteorite Data for Future Science	Kerstin Lehnert	M315	2024-08-28 08:45	2024-08-28 09:00	813
Chemical evidence for the melting of alkali feldspar in a lunar meteorite DEW 12007	Hyeong Gyu KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	815
Experimental Method for Measuring Cohesion of Regolith via Electrostatic Lofting	Charles T Pett	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	817
S7+S8 Planetary Habitability: From Extremophiles to Potential Life		Session Chair: Scientific Program Committee			

Title	Presenter	Venue	Start	End	Page
Ore prospecting in planetary analog using remote sensing data	Marta CIAZELA	M315	2024-08-28 09:30	2024-08-28 09:45	819
Iron's Role in Astrobiology: The Significance of Ferrihydrite in Martian Habitability	Adomas VALANTINAS	M315	2024-08-28 09:45	2024-08-28 10:00	822
Development of Early Microbial Communities within Newly Emplaced Lava in Iceland: A 3-Year Fixed-site Time-series Study	Nathan Hadland	M315	2024-08-28 10:00	2024-08-28 10:15	824
Geological evidence reveals a staircase pattern in Earth's rotational deceleration evolution	He HUANG	M315	2024-08-28 10:30	2024-08-28 10:45	820
Astrochronology and cyclostratigraphic analysis of Ordovician-Silurian transition —— Case study from JY11-4 borehole in Yangtze Block, Southern China	Shang YUE	M315	2024-08-28 10:15	2024-08-28 10:30	821
Profiling the lipidome of microbial communities in Icelandic and Azorean lava tubes	Joleen M CSUKA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	826
S9+S10 Comparative Planetary Geology Studies		Session Chair: Scientific Program Committee			
GEOLOGIC MAPPING OF LUNAR PYROCLASTIC DEPOSITS IN SINUS AESTUUM, RIMA BODE, AND MARE VAPORUM	Catherine Weitz	M211	2024-08-28 09:30	2024-08-28 09:45	828
Late Drainage Along Samara Valles, West of Jones Crater, Margaritifer Terra, Mars	John GRANT	M211	2024-08-28 09:45	2024-08-28 10:00	830
Enhanced bedrock weathering on Martian hillslopes with Recurring Slope Lineae (RSL)	Amit MUSHKIN	M211	2024-08-28 10:30	2024-08-28 10:45	831
Open mineral identification from CRISM hyperspectral data using an ensemble of Support Vector Machines and Extreme Value Theory	Sandeepan DHOUNDIYAL	M211	2024-08-28 10:45	2024-08-28 11:00	832
Terrestrial hot spring systems as repositories for biosignatures on Earth and Mars	Federica BARILARO	M211	2024-08-28 10:00	2024-08-28 10:15	834
From Jezero Crater to Nili Planum: Tracing the Subsurface Life Potential on Mars	Adomas VALANTINAS	M211	2024-08-28 10:15	2024-08-28 10:30	835
S12+S11+S13+S14 Impact crater, Lunar Science and Exploration		Session Chair: Jaesoo LIM			
(MAPCIS) Massive Australian Precambrian-Cambrian Impact Structure: evidences supporting confirmation for impact designation	Daniel CONNELLY	M311	2024-08-28 08:00	2024-08-28 08:15	837
Mineralogy and chronology of Ca-phosphates in the lunar meteorite SaU_169	Xiaochao CHE	M311	2024-08-28 08:30	2024-08-28 08:45	838
Light noble gases characteristics in Chang'E-5 lunar soil	Junjie LI	M311	2024-08-28 08:45	2024-08-28 09:00	840
Mapping the Geology of Venus as an Engagement Tool for Undergraduate Planetary Science Research	Katherine Janet Boggs	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	841
Platinum Group Element abundances and Re-Os isotopic composition of melt rock/breccia support the impact origin of the Simlipal structure, Singhbhum Craton, India	AJAY Kumar SINGH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	843
The application of ilmenite Crystal Size Distributions in experimental charges to understand the cooling rates of Apollo 11 basalts	Vanesa Mary C	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	845
Bridging Disciplines: A Feasibility Study on Integrating Mathematics and Geology in Education	Lujia PAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	847
Magnetic Susceptibility Instrument for Magnetically Inhomogeneous Granular Mixtures	Charles T Pett	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	849
COMPLEX MAGMA CHAMBER PROCESSES IN THE MOROKWENG IMPACT MELT SHEET, SOUTH AFRICA	SUMAN MONDAL	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	851
The temperature distribution in the mantle of the Moon based on geophysical data and evolutionary model	Ekaterina KRONROD	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	853
Decoding a complex geological record of the Yilgarn Craton using laterite iron crusts enriched with scandium	Daria LONGLEY	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	854
T6 Metamorphism					
S1 Application of thermodynamic modelling in understanding the process of metamorphism		Session Chair: Scientific Program Committee			
[Keynote] Phase equilibria computations in Metamorphic Petrology-Applications and limitations	Somnath Dasgupta	M315	2024-08-27 08:00	2024-08-27 08:15	865
Paleoproterozoic (2.01 Ga) high-pressure granulite facies metamorphism in the Central Zone of the Limpopo Belt (Eastern Botswana/South Africa): geodynamic implications	Reiner KLEMD	M315	2024-08-27 08:15	2024-08-27 08:30	856
Kyanite trace element zoning as a tool for gaining insights into the petrological evolution of migmatites	Sara Nerone	M315	2024-08-27 08:30	2024-08-27 08:45	858
H2O content variation in the metamorphic evolution of shear zones: a case from the Dora-Maira Massif (Western Alps)	Sara Nerone	M315	2024-08-27 08:45	2024-08-27 09:00	859
Indian Scientific Expedition to Bharati research base for constraining Metamorphic Evolution of Larsemann Hills, East Antarctica	ROSAN MALLIK	M315	2024-08-27 09:00	2024-08-27 09:15	863
Pre-Himalayan Metamorphism in the Lesser Himachal Himalaya: Insights from P-T pseudosection, U-Pb dating of zircon and monazite, and Sm-Nd garnet isochron	HIFZURRAHMAN -	M315	2024-08-27 09:15	2024-08-27 09:30	860
Petrogenesis of Maneswar Complex, Rengali Province, India: Implications for tectono-metamorphic evolution along craton-mobile belt margin	PRIYA PACHAURI	M315	2024-08-27 09:30	2024-08-27 09:45	861

Title	Presenter	Venue	Start	End	Page
Comparing qualitative and quantitative isopleth thermobarometry based on garnet composition	Sara Nerone	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	866
Phase equilibria and advanced thermobarometric modellings of Paleoproterozoic metapelites of NW Himalaya, India: Implication for its linkage with the Aravalli Supergroup	BIRAJA PRASAD DAS	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	867
PHASE EQUILIBRIA MODELLING AND PETROLOGY OF PELITIC GRANULITES IN SOUTHEASTERN NIGERIAN BASEMENT COMPLEX: INSIGHTS INTO THE EVOLUTION OF THE TRANS SAHARAN OROGENIC BELT.	Ifeoma Chinwendu AGHAEBITA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	868
Metamorphic P-T paths and timing of garnet-mica schists from the Mianlüe Tectonic Zone: Insight into the early Mesozoic collisional thickening of the South Qinling orogen, Central China	Sang Wan PAK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	869
P-T pseudosection and garnet diffusion modeling of phengite eclogite from Yuka terrane, North Qaidam	Rong-GuoHU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	870
S2 Subduction zone fluids: mineralogical and geochemical effects and geodynamic consequences		Session Chair: Scientific Program Committee			
[Keynote] Formation of abiotic H2 and CH4 in subduction zones	Renbiao TAO	M315	2024-08-27 14:30	2024-08-27 14:45	889
The processes of serpentinization in subduction zones: Reaction rates and hydrogen (H2) generation	Ruifang HUANG	M315	2024-08-27 14:45	2024-08-27 15:00	876
Fluid inclusions of ophicarbonates in Oman and Western Alps ophiolite and carbonation experiments of mantle minerals	Tatsu KAWAMOTO	M315	2024-08-27 15:00	2024-08-27 15:15	882
Hydrogen solubility of stishovite provides insights into water transportation to the deep Earth	Lei Kang	M315	2024-08-27 15:15	2024-08-27 15:30	878
The fate of methane in subduction zone fluids	Lijuan ZHANG	M315	2024-08-27 15:30	2024-08-27 15:45	888
The contribution of serpentinite to crust-mantle interaction and arc magma formation in subduction zones	Yi-Xiang CHEN	M315	2024-08-27 15:45	2024-08-27 16:00	872
Fluid-mediated Cu and Zn isotopic fractionation in subduction zones: Constraints from high pressure veins within eclogites in the Dabie Orogen	Jian HUANG	M315	2024-08-27 16:15	2024-08-27 16:30	885
Halogen cycling at the slab-mantle interface: constraints from metabasites from SW Tianshan, China	Zheng-Hua Pan	M315	2024-08-27 16:30	2024-08-27 16:45	884
Supercritical fluids in subduction zones and their geochemical effects	Ren-Xu Chen	M315	2024-08-27 16:45	2024-08-27 17:00	874
Magnesium isotope constraints on the role of recycled carbonate-rich sediments in the formation of ultrapotassic magmatic rocks at a continental arc setting	chen yu	M315	2024-08-27 17:00	2024-08-27 17:15	873
Imprints of eclogite-facies metasomatism in the North Balkhash ophiolite zone (Central Kazakhstan, west Central Asian Orogenic Belt)	Anfisa SKOBLENKO	M315	2024-08-27 17:15	2024-08-27 17:30	880
"Detrital" zircons in eclogite: their origin and implications for mass transfer	Taehwan KIM	M315	2024-08-27 17:30	2024-08-27 17:45	886
Subducted serpentinite contributes to the formation of arc lavas with heavy Mo isotopic compositions	Fu-Qiang DAI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	891
Deciphering the relative timing of deformation, recrystallization and fluid infiltration in the Dalrymple Amphibolite: Implications to the slab-mantle wedge interface	Gabriel Theophilus Vinalay VALERA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	892
Contributions of serpentinizing fluids to the low δ^{26}Mg isotopes of subduction zone fluids: Evidence from jadeitites and jadeite-rich rocks from the Rio San Juan complex, the Northern Dominican Republic	KUN CHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	894
Petrological and geochemical diversities of pyroxene pseudomorphs in ultramafic rocks originated from the mantle wedges: Insights into elemental transfer in slab-mantle interfaces	Takumi Wani	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	896
The genesis of metabasic rocks in the Yadong region of the Himalayan orogenic belt	XIN DONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	898
Serpentinization and deserpentinization of the mantle wedge at a convergent plate margin	ZHUANGZHUANG YIN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	900
Hydration of the deep mantle by slab-derived fluids: insights from arc-type hornblendites of eastern Arunachal Himalaya, NE India	Amrita DUTT	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	902
Fluid flow and isotopic inheritance in the subducted eclogitic crust recorded by in-situ Rb-Sr isotopes (North Balkhash ophiolite zone, Central Kazakhstan)	Sergei SKUZOVATOV	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	903
Mineral assemblage and temperature estimates of continent-derived metapelites and metapsammites in Sibuyan Island, Romblon, Philippines	John Kenneth Beran BADILLO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	905
Tectono-metamorphic events in the west central Philippines: Insights from the metamafic rocks of Tablas Island, Romblon	Andrew Exequiel Sanchez TABILOG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	907
Metamorphic complexes of western and central Mongolia	ERDENEJARGAL CHOINDONJAMTS	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	908
Geochemical evidence from coesite-bearing jadeite quartzites for large-scale flow of metamorphic fluids in a continental subduction channel	Xiao-Ying GAO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	909
The effect of argillization and opalization on the properties of andesites and basaltic andesites on the thermal fields of the Kamchatka Peninsula	Ilya BOLSHAKOV	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	910
Tracing the incipient melting P-T-t conditions of felsic gneiss in South Altyn Tagh: implications on the exhumation of deep subducted slabs	Yongsheng GAI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	912

Title	Presenter	Venue	Start	End	Page
The structure and transport properties of diopside supercritical fluid from machine learning potential	DONG WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	914
Subducted metasedimentary veneer impedes slab–arc carbon recycling	Jilei Li	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	915
Vein-induced carbonatitic metasomatism of eclogites in subduction zones: implications for carbon cycling and mantle isotopic heterogeneity	Weiqiang Ll	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	916
The mechanism for heavy Cr isotopes in some serpentinites and its implications	Ji SHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	917
Origin of fluid beneath the Noto peninsula, Central Japan: Stability of Lawsonite eclogite	Kazuaki OKAMOTO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	918
Four alkaline shifts of metasomatic reactions by a texture analysis for a garnet amphibolite at 1GPa and ~700°C in Oeyama Ophiolite, Japan	Riichi AKAI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	919
S3 General Topics		Session Chair: Scientific Program Committee			
Carboniferous, not Paleoproterozoic, eclogite-facies metamorphism in the northern North China Craton as revealed by in-situ garnet Lu-Hf and U-Pb geochronology	YAOQI YAN	M315	2024-08-26 16:00	2024-08-26 16:15	922
Low-pressure, high-temperature metamorphism in the central Mary Kathleen Fold Belt, north-eastern Australia: Tracking an anticlockwise P-T-t path by linking phase equilibrium modelling, microstructures, and in situ geochronology	Juergen REINHARDT	M315	2024-08-26 16:15	2024-08-26 16:30	924
Metamorphic age and potential heat source for the Buchan-type metamorphism in the Wilson Terrane, northern Victoria Land, Antarctica	Yoonsup KIM	M315	2024-08-26 16:30	2024-08-26 16:45	929
Pressure calibration of natural-quartz Raman spectra variation under hydrostatic condition	Kazuaki OKAMOTO	M315	2024-08-26 16:45	2024-08-26 17:00	930
Protracted crustal evolution of the Nigerian Basement Complex: Insights from Neoproterozoic tectono-magmatic overprint and protolith source analysis.	Chinedu Ibe	M315	2024-08-26 17:00	2024-08-26 17:15	921
Synchronous Paleocene (ca. 60 Ma) India-Asia collision indicated by high-pressure metamorphic rocks in the Himalaya	Yanling ZHANG	M315	2024-08-26 17:15	2024-08-26 17:30	926
Exsolution textures of Antiperthite and Mesoperthite in the Zhengjiapo BIF, Changyi Metallogenic Belt, North China Craton: evidence of UHT Metamorphic Overprint	Yanrong CHEN	M315	2024-08-26 17:30	2024-08-26 17:45	928
Fluid-fluxed anatexis of Paleoproterozoic granitic gneiss in the Yeongnam Massif, Korea	Yuyoung LEE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	932
Middle Permian high-pressure rocks preserved in the Southern Beishan Orogenic Belt, NW China: metamorphic evolution and tectonic implication	Wenxuan Li	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	934
Experimental evidence for the exsolution of kyanite from Al-bearing stishovite: Implications for ultra-deep subduction/exhumation of continental crust	Liang Liu	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	935
TIN ORE FORMATIONS OF ZIRABULAK-ZIAETDIN REGION OF UZBEKISTAN	Farrux Raxmatullayev RAXMATULLAYEV	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	937
The metamorphic events registered in the Santander Massif (Colombia)	Luis C.MANTILLA F.	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	938
METAMORPHIC EVOLUTION OF THE UBENDIAN BELT IN NORTHERN MALAWI	Ruth MUMBA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	940
Crustal Thermal transitions and the Rise of the Tibetan Plateau: From Amphibolite to Ultrahigh-Temperature Granulite Facies Crust since the Miocene	XIU-ZHENG ZHANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	941
T7 Volcanology					
S1 Large Igneous Provinces in Space and Time		Session Chair: Hafida EL BILALI			
[Keynote] Dyke swarms of the Indian Shield in space and time: characterizing Large Igneous Provinces, their plumbing system and likely mineral systems	Rajesh Kumar SRIVASTAVA	M316	2024-08-29 14:30	2024-08-29 15:00	947
Record of Archean Large Igneous Provinces (LIPs) and their mafic dyke swarms	Richard Everett ERNST	M316	2024-08-29 15:00	2024-08-29 15:15	954
Neoproterozoic (ca. 830 Ma) carbonatite dykes from Qianlishan in the western North China Craton and their tectonic and metallogenic	Shuan-Hong ZHANG	M316	2024-08-29 15:15	2024-08-29 15:30	944
A new ca. 2.49-2.46 Ga Silicic Large Igneous Province (SLIP) event in the Bastar craton, India	Amiya Kumar SAMAL	M316	2024-08-29 15:30	2024-08-29 15:45	946
Deciphering the Emplacement Mechanism of Paleoproterozoic Mafic Dyke Swarms in the Dharwar Craton: Insights from AMS and Fracture Analyses	SRINJOY DATTA	M316	2024-08-29 15:45	2024-08-29 16:00	945
A comprehensive geochemical study on mafic dyke swarms from the central-western Bastar craton, India, and their link with different Paleoproterozoic large igneous provinces of the Indian Shield	Ankur ASHUTOSH	M316	2024-08-29 16:00	2024-08-29 16:15	955
The Midcontinent Rift System LIP initiated passively — Evidence from diverse mantle source contributions during early rift development	Pete HOLLINGS	M316	2024-08-29 16:30	2024-08-29 16:45	949
Links between plume-generated LIPs and new ocean formation through	Hafida EL BILALI	M316	2024-08-29 16:45	2024-08-29 17:00	951
The Karoo large igneous province contains diamondiferous lamproites	Sebastian TAPPE	M316	2024-08-29 17:00	2024-08-29 17:15	959

Title	Presenter	Venue	Start	End	Page
Early Aptian volcanism of the Kerguelen LIP and its implications for the evolution of the proto-Indian Ocean	Eun Young Lee	M316	2024-08-29 17:15	2024-08-29 17:30	942
The effective elastic thickness of lithosphere for continental large igneous provinces	Qin WANG	M316	2024-08-29 17:30	2024-08-29 17:45	952
Revealing 2.4 LIP in the Belomorian province, Fennoscandian Shield: U-Pb ID-TIMS studies of baddeleyite and baddeleyite-zircon aggregates	Maria Alexandrovna SUKHANOVA	M316	2024-08-29 17:45	2024-08-29 18:00	957
Dyke swarms map of the Indian Shield on 1:25,00,000 scale	Amiya Kumar SAMAL	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	960
Petrological study of the Agulhas Plateau in the Southwest Indian Ocean: Results from core samples drilled during IODP Expedition 392	Kouki MORI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	961
First Report of Carbonate Antecrysts in the Newania Carbonatite, Rajasthan, India: Implications for Carbonatite Petrogenesis	Amritpaul SINGH	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	963
The areal extent of the Qiangtang-Panjal large igneous province	Wei Dan	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	965
Permian-Triassic silicic volcanic province of the West Siberian basin: Evidence for the temporal and genetic relationship with the Siberian Traps	Anton LATYSHEV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	966
Multiple mantle components for alkaline lavas of the Tuli basin, Karoo LIP	Osvaldo González-Maurel	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	967
Late Permian basalts in the eastern part of the Emeishan Large Igneous Province, SW China: Implications for plume–lithosphere interaction	Wenmin HUANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	969
The Late Mesozoic Volcanic Events and Metallogenic Basin Dynamics Mechanism in Eastern Shandong and Adjacent Seas	YanZHANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	956
S2+S5 Cretaceous Volcanism: Global Distribution Bearing on Tectonics of Continents and Oceanic Regions, K-T Boundary and Major Extinction		Session Chair: Scientific Program Committee			
Evidence of prolonged Aptian-Santonian magmatic pulses in the Indian Shield linked with the Marion mantle plume and its role in the breakup of India–Madagascar	Rajesh Kumar SRIVASTAVA	M316	2024-08-29 08:00	2024-08-29 08:15	971
Paleoenvironmental Constraints on Pleistocene Ice Sheets Informed by Glacio-Volcanic Deposits in Northeast Iceland	Cameron Essex	M316	2024-08-29 08:15	2024-08-29 08:30	973
Neoarchean volcanism in the Western Dharwar Craton, India: Petrology, Geochemistry and Tectonic Significance of BADR volcanics from Shimoga basin	Arpita KARMAKAR	M316	2024-08-29 08:30	2024-08-29 08:45	975
Recognition of Hidden Effusive Centers from the Emanating Pattern of Lava Tube and Channels in Deccan Volcanic Province of Western India	ANSHUMAN MISRA	M316	2024-08-29 09:00	2024-08-29 09:15	974
Development of New Concepts in Cretaceous Volcanism during Last Fifty Years in Peninsular India	K S MISRA	M316	2024-08-29 09:15	2024-08-29 09:30	977
Recent Evidence of the Evolution of Pleistocene Volcanism in the Northwestern End of the Central Volcanic Cordillera of Costa Rica, Central America.	Ana Sofia HUAPAYA R.P.	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	979
Block-and-ash flows deposit from 2015 at Volcán de Colima (Mexico): Textural and granulometric characterization as a tool in determining the dynamics and interaction with topography	Laura Fabiola HERNANDEZ	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	981
Post-2008 Eruption Volcanic Activities of Cerro Azul Volcano in the Galá pagos Archipelago Estimated Using Time-series InSAR	Seohyeon Kim	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	982
Temporal distribution of the Plagioclase Feldspars in ~1200 m thick lava flow sequence from Deccan traps borehole, Western Deccan Province	Shubham Bharat WAGHMARE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	984
Plio-Pleistocene rear-arc magmatic belt in the Southern Central Andes: the Varvarco Volcanic Field	Sofía Iannelli	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	985
Geochemistry of the Volcanic Rocks of the Central Northeast Foothills of the Tilarán Volcanic Arc, Costa Rica	Martin Rojas Barrantes	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	987
Records of lava-ice interactions during the Pleistocene in the Chiles volcano, Colombia-Ecuador border	CAMILA MARTINEZ	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	989
The Late Cretaceous explosive volcanism products in Bolnisi district and associated mineralization: Lesser Caucasus, Georgia	Nino POPKHADZE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	991
Geochemical and geochronological evolution of mafic-felsic volcanic rocks prior to the collision of India and Eurasia: Evidence from the northwestern Ladakh Himalaya, India.	Nongmaithem Lakhan SINGH	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	993
Radiogenic Sr, Nd, Hf and Pb isotope characteristics of Pumice from the Andaman Sea	Prabala Bhaskara RAMA MURTY	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	994
Tertiary and quaternary volcanism of the western part of Senegal: State of research and prospects	Raymond SAGNA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	995
S3 Volcano Geology: role of field work on modern Volcanology		Session Chair: Gianluca Groppelli			
GEOLOGIC MAP OF THE PLEISTOCENE VOLCANO OF MONTE AMIATA (SOUTHERN TUSCANY, ITALY)	Claudia Principe	M316	2024-08-29 09:30	2024-08-29 09:45	1000
Updated post 3 ka BP volcano-stratigraphy of Ulleungdo volcano, South Korea: insights into the Holocene post-caldera eruptions	Ho-Jun AHN	M316	2024-08-29 09:45	2024-08-29 10:00	1001

Title	Presenter	Venue	Start	End	Page
Monitoring magma chamber processes at silicic volcanoes through single zircon mineral chemistry and U-Pb ages in the Sabga Volcanic Complex, Cameroon Volcanic Line	Edith Etakah TIBANG	M316	2024-08-29 10:30	2024-08-29 10:45	997
Preliminary Study of Magma Mixing/Mingling in Pleistocene Volcanic Rocks of the Rakiraki Area, Viti Levu, Fiji	Kamal REGMI	M316	2024-08-29 10:15	2024-08-29 10:30	998
Carbon Isotope Fractionation in Silicate Melt: Window into Carbon	Hyunjoo LEE	M316	2024-08-29 10:45	2024-08-29 11:00	999
Volcano-tectonic activity of Pantelleria Island (Italy) and relationship with the Green Tuff emplacement	Gianluca Groppelli	M316	2024-08-29 10:00	2024-08-29 10:15	1002
Structure and composition of the Late Miocene Goderdzi Volcanic Complex, Lesser Caucasus, Georgia: implication for resurgent caldera formation	Miriani MAKADZE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1003
Correlation of proximal and distal deposits of a caldera-forming eruption based on the variation of juvenile materials: A case study of Toya Volcano, southwestern Hokkaido, Japan	Mitsuhiro Nakagawa	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1005
S4 Volcanism on the Korean Peninsula		Session Chair: Jinhuem PARK			
[Keynote] Hydrovolcanic activity in relation to Quaternary sea levels in Jeju Island, Korea	Young Kwan Sohn	M316	2024-08-30 08:00	2024-08-30 08:15	1008
Morphological analysis of volcanic cones and its implication to Quaternary tectonics of the Jeju Island (South Korea)	Francois HATEGEKIMANA	M316	2024-08-30 08:15	2024-08-30 08:30	1007
Dualistic Bubble Formation in Explosive Silicic Volcanism of Baekdusan	Gi-Bom KIM	M316	2024-08-30 09:15	2024-08-30 09:30	1013
Mantle degassing in South Korea	Hyunwoo LEE	M316	2024-08-30 09:00	2024-08-30 09:15	1012
Triggering of rapid ascent of magma and explosive eruption: The case for the Cretaceous Sinsudo Tuff in the Gyeongsang Basin, Korea	Yong-Un CHAE	M316	2024-08-30 08:30	2024-08-30 08:45	1009
Reconsideration of the magma plumbing system of the Suwolbong tuff ring, Jeju Island, Korea based on rigorous microscopic analysis	Sun Young GO	M316	2024-08-30 08:45	2024-08-30 09:00	1011
Evidence for an upper crustal melt lens beneath Baekdu/Changbaishan Volcano	James HAMMOND	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1014
Evidence for a localised upwelling beneath Baekdu/Changbaishan from seismic imaging and anisotropy	James HAMMOND	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1015
Eruptive and Emplacement Processes of the Namseongri Tuff, southern Jeju Island, Korea	Sunghyun KIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1016
A brief introduction of paleomagnetic and rock-magnetic applications for volcanological research in the Korean Peninsula	Hyeon-Seon AHN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1018
Variation of Eu isotope ratio in basaltic rocks in Jeju Island, Ulleung Island, Baekdu Mountain in Korea	Seung-gu LEE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1019
Three-dimensional resistivity structure of Nari Caldera on Ulleung Island, Korea.	Kiyeon KIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1017
T8 Petrology					
S1 Architecture and Thermal Structure of Translithospheric Magmatic Systems		Session Chair: Georg Zellmer			
[Keynote] Crystal Size Distributions (CSDs) in lava samples: a case study on Ruapehu volcano, Southern Taupo Volcanic Zone (STVZ), New Zealand.	Silvia Catalina MORENO ALFONSO	M216	2024-08-28 16:00	2024-08-28 16:15	1022
Plutonic Nature of a Transcrustal Magmatic System: Evidence from Ultrahigh Resolution Sr-Disequilibria in Plagioclase Microantecrysts from the Southern Taupo Volcanic Zone, New Zealand	Georg ZELLMER	M216	2024-08-28 16:15	2024-08-28 16:30	1021
Intense fractional crystallization dominated by amphibole in continental arc: A highly efficient way to generate felsic continental crust	JING RAN	M216	2024-08-28 16:30	2024-08-28 16:45	1023
Current understanding of lithospheric mantle evolution beneath Peninsular India	Sebastian Tappe	M216	2024-08-28 16:45	2024-08-28 17:00	1025
The role of lithospheric mantle in the formation of Earth's crust, gold and REE mineralization	Shanshan Li	M216	2024-08-28 17:00	2024-08-28 17:15	1027
Using mineral records to unravel magmatic roots beneath sibling volcanoes: A case study at Middle Sister and South Sister volcanoes, Oregon Cascades, USA	May Sas	M216	2024-08-28 17:15	2024-08-28 17:30	1029
Multi-component Magmas of Middle Sister and South Sister in the Three Sisters (Klah Klahnee) Volcanic Complex, Oregon Cascades, USA	May Sas	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1031
Petrologic study of the youngest stage lavas of Zao Volcano, NE Japan	Kanako OKI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1033
Maturation of continental arc crust via mush remobilization during magmatic flare-up	Long CHEN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1035
S2 Granitoids and their enclaves		Session Chair: Scientific Program Committee			
[Keynote] Petrogenesis of episodic volcanic-intrusive rocks in SE China: crystal-melt segregation and magma mixing	Xisheng XU	M216	2024-08-27 14:30	2024-08-27 14:45	1037
Genesis and Evolution of Zoned Magmatic Enclaves in Cretaceous Granitoid: A Case Study from Taejongdae, Busan	Mohammed S. M. Adam	M216	2024-08-27 14:45	2024-08-27 15:00	1036
Mafic magmatic enclaves in Zao Volcano Stage III products, NE Japan: Evidence of conversion of magma feeding system	Masao Ban	M216	2024-08-27 15:00	2024-08-27 15:15	1039
Variscan magmatism with linkage to slab-breakoff? Implication from age data and mineralogy in the Western Carpathians granitic rocks	igor Broska	M216	2024-08-27 15:15	2024-08-27 15:30	1040

Title	Presenter	Venue	Start	End	Page
Origin and evolution of Fe-Ti oxides in leucogranites of Muglib and Pangong regions of Ladakh Trans-Himalaya, India: Insights from textural and chemical features of manganoan-ilmenite and re-equilibrated biotite	Ravi Ranjan Kumar	M216	2024-08-27 15:30	2024-08-27 15:45	1042
Mafic-felsic magma interaction of granitoids and microgranular enclaves in Lohit Plutonic Complex, Arunachal Trans-Himalaya, Northeast India: constraint from field, petrography, mineralogy, geochemistry and U-Pb SHRIMP chronology.	DIEZENEINO MEYASE	M216	2024-08-27 15:45	2024-08-27 16:00	1044
Petrogenesis of Precambrian granitic suites around Ropp Complex: Constraints from zircon U-Pb-Lu-Hf Isotopes, mineral chemistry, and whole-rock geochemistry	Kayode Abdulgafar AMUDA	M216	2024-08-27 16:15	2024-08-27 16:30	1046
Geochemistry, zircon U-Pb geochronology, and Lu-Hf-O isotopes of Paleoproterozoic granite gneisses from Askot-Chiplakot klippe, Kumaun Lesser Himalaya, India: Insight into petrogenesis and evolution of north Indian continental lithosphere	Kapil Singh PANWAR	M216	2024-08-27 16:30	2024-08-27 16:45	1050
Magmatic evolution and geochronology of Mesoproterozoic A-type Darsi granite pluton from Nellore Schist Belt, Southeast India	NARSHIMHA CHINTHAPALLY	M216	2024-08-27 16:45	2024-08-27 17:00	1038
Microgranular enclaves in granitoids are products of mafic to hybrid magma globules mingled and undercooled into partly crystalline host granitoids: Distinct field and microstructural evidences from calc-alkaline granitoid complexes	Santosh KUMAR	M216	2024-08-27 17:00	2024-08-27 17:15	1048
Boundary issue of the Cretaceous granitoid realm in between the Karakoram terrane and the Ladakh magmatic arc along Shyok Suture Zone, Ladakh Trans-Himalaya, India	SITA BORA	M216	2024-08-27 17:15	2024-08-27 17:30	1052
***Geochemical signature of Tinkoto, Tiguida, Koulountou and Dioudioukounkou plutonic masses of the transitional zone between volcanic belt / Dialé basin (Kedougou-Kenieba Inlier South-Est Senegal/West Africa Craton*)**	MAME CODOU NDIAYE	M216	2024-08-27 17:30	2024-08-27 17:45	1053
Genesis of tonalite-granodiorite batholith during subduction to accretion period of the Altai orogen (NW China) and its implications for continental crustal growth	Jianjun ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1054
Silicic microgranular enclaves from the Port Mouton pluton of the Northern Appalachians: implications for the development of the peripheral plutons of the Meguma terrane	Greg Gregory SHELLNUTT	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1055
Geo-characterization of Late Cretaceous mafic microgranular enclaves and host granites: A case study in the Eonyang granite, South Korea	Hui Je JO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1056
Apatite geochemical indicators for magma mixing and fractional crystallization	BaoQuan ZHOU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1057
Early Cretaceous high-δ56Fe rhyolites in central Tibetan plateau: Insights into genesis of A-type magmas	Lu-Lu HAO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1059
Early Cretaceous fayalite- and ferrosilite-bearing rhyolitic porphyries and associated biotite-bearing rhyolitic porphyries from the Baishuizhai area, South China: high-temperature crustal melting and magmatic evolution	Xiao LIU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1060
Late Mesozoic high Ba-Sr granitoid in the Xiao Qinling area of Eastern Qinling Orogen, Central China: Petrogenesis and tectonic setting	Chengli ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1061
The extensional tectonic environment within the Urumieh-Dokhtar magmatic belt, NW Iran	REZA MONSEF	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1062
Granitoids of the north of the Urals: U-Pb geochronology (SIMS, LA-ICP-MS, ID TIMS) and isotope geochemical (OZrn, Sm-Ndwr, Lu-HfZrn) characteristics	Oksana Vladimirovna UDORATINA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1063
Formation and tectonic implication of the late Mesozoic Yunmengshan batholith, North China Craton: new constraints from zircon Hf-O isotopes and apatite geochemistry	Jin-Feng SUN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1065
Tectonic understanding of Syenites and Quartz Syenites from Peralimala and Angadimogar plutons, Kerala, India	SAI KRISHNA PRIYA VALLURI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1066
A Method for Calculating Magma Oxygen Fugacity with Uraninite in Granites	Jian GUO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1068
Petrogenesis of mafic enclaves hosted in the Zouzan pluton, Eastern Iran: Insight from the U-Pb zircon geochronology, whole-rock Nd-Sr isotopes, and elemental geochemistry of amphibole and apatite	Santosh KUMAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1070
An amphibolitic source for "adakitic" I-type plutons in continental collision zones	Qiwei LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1072
S3 Crust-Mantle interactions through time and the role of fluids		Session Chair: Sarajit Sensarma			
[Keynote] The Panjal Traps: a synthesis	Greg Gregory SHELLNUTT	M216	2024-08-27 08:00	2024-08-27 08:15	1090
Petrological and geochemical characteristics of the mafic-ultramafic complexes in the Bhavani Shear Zone, South India: implications for crustal evolution.	ABEENA PV	M216	2024-08-27 08:15	2024-08-27 08:30	1073

Title	Presenter	Venue	Start	End	Page
Geochemical characteristics of exsolved deep crustal aqueous fluid in a granitic system: Insights from the quartz reefs in the Bundelkhand craton, India	DIVYANSHI SHUKLA	M216	2024-08-27 08:30	2024-08-27 08:45	1075
Intra-volcanic chain B isotope variations: a case study from the Chilean Central Andes	Osvaldo González-Maurel	M216	2024-08-27 08:45	2024-08-27 09:00	1077
The ~2.5 Ga peraluminous monzo-granite (north-central India) with superchondritic Zr/Hf and OIB-like Nb/Ta: constraints for role of mantle fluid in crustal evolution and crust-mantle interactions	Sarajit Sensarma	M216	2024-08-27 09:00	2024-08-27 09:15	1078
Carbon-sulfur relationships in magmatic sulfide deposits: Implications for metal transfer between the mantle and crust	Shelby CLARK	M216	2024-08-27 09:15	2024-08-27 09:30	1080
Whole rock geochemistry and isotopic constraints on the mafic-ultramafic rocks of the Madawara Igneous Complex, Bundelkhand Craton (central	Abhishek Kumar PANDEY	M216	2024-08-27 09:30	2024-08-27 09:45	1084
Formation of amphibole rich selvege in high P mafic granulite and its relation with the regional hydration of CGGC	Somdipta CHATTERJEE	M216	2024-08-27 09:45	2024-08-27 10:00	1082
Melt inclusions study on Chamundi granite from southern India: Entrapment conditions and compositions	MOHD AQIB	M216	2024-08-27 10:00	2024-08-27 10:15	1088
PETROGENESIS OF MIGMATITES AND LEUCOGRANITE FROM MAIN CENTRAL THRUST ZONE IN AND AROUND MUNSIARI, KUMAUN HIGHER HIMALAYA	CHITRA JOSHI	M216	2024-08-27 10:15	2024-08-27 10:30	1086
New occurrence of carbonatite in the Kudakkal area of Pakkanadu-Mulakkadu Alkaline Complex, Tamilnadu, Southern India.	RAJENDRA PRASAD KANCHI	M216	2024-08-27 10:30	2024-08-27 10:45	1087
Molybdenum isotopes in intraplate basalts record slab-mantle interactions in Earth's deep mantle	WEI FANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1091
Geochemical characterization of Jonnagiri greenstone belt of eastern Dharwar craton, India: Insight into the crustal evolution of Jonnagiri greenstone terrane.	Saumyodeep DAS	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1092
Subduction of an oceanic plateau and its effect on magmatism through the analysis of melt inclusions: The case of the Hikurangi plateau subduction in the Kermadec arc	Raimundo Brahm	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1094
THE USE OF AEROHYPERSPECT DATA FOR THE DETECTION OF HYDROTHERMAL-METASOMATIC ROCKS AS INDICATORS OF SOLID MINERALS Kirsanov A.A. Lipiyainen K.L., Smirnov M.Yu., Kirsanov G.A., Khimchenko P.V., Tkachenko M.A. (Karpinsky Institute, St. Petersburg, RUSSIA)	Aleksaandr Andreevich KIRSANOV	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1095
S4 Oceanic lithosphere evolution: crust-mantle geodynamics to melt processes and reservoirs.		Session Chair: Scientific Program Committee			
[Keynote] Oceanic propagators and the formation of oceanic crust in divergent margins	Webster Ueipass Mohriak	M216	2024-08-28 17:30	2024-08-28 17:45	1097
Significance of Chrome-spinel chemistry in mafic-ultramafic rocks of Pauni and Taka areas, Western Bastar craton, Central India: Implication for their tectonic setting	RAJKUMAR MESHRAM	M216	2024-08-28 17:45	2024-08-28 18:00	1098
A Study on the Volatiles of Monogenetic Volcanoes, Jeju Island, South Korea	MINJAE KANG	M216	2024-08-28 18:00	2024-08-28 18:15	1100
Trindade-Martin Vaz Archipelago petrological evolutionary insights recorded in fassaitic greencore clinopyroxene and REE evolutionary trends	Anderson SANTOS	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1102
The geochemical nature of serpentinites from the Mashhad mafic-ultramafic complex as an evidence for Palaeotethys oceanic crust subduction in NE Iran	KOUROSH MOHAMMADIHA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1103
S5 Ophiolite: A window to the oceanic mantle across the geological time		Session Chair: Scientific Program Committee			
Microdiamonds in Oceanic Mantle and Continental Volcanic Rocks Provide Significant Clues for the Earth's Two-Way, Deep Recycling System	Jingsui YANG	M216	2024-08-28 08:30	2024-08-28 08:45	1108
Ophiolites in the westernmost South Tien Shan: geochemical characterization and tectonic settings.	Bakhtier NURTAEV	M216	2024-08-28 09:00	2024-08-28 09:15	1104
Tectono-magmatic and metamorphic development of Shyok Ophiolite Belt from Ladakh Trans-Himalaya, India: Insights from microstructures, phase petrology, and P-T trajectory	Ravi Ranjan Kumar	M216	2024-08-28 09:15	2024-08-28 09:30	1110
Investigating Ca-Mg ionic exchange in Macquarie Island unobducted abyssal serpentinites	Cesare ALBASIO LODI-CUSANI	M216	2024-08-28 09:30	2024-08-28 09:45	1111
The origin of the DUPAL anomaly in the Tethys mantle domain	XIJUN LIU	M216	2024-08-28 09:45	2024-08-28 10:00	1106
Melts of sediment in the mantle wedge of the Neoproterozoic Fuchuan Ophiolite and the mark of subduction initiation	Wei WANG	M216	2024-08-28 10:00	2024-08-28 10:15	1116
New Data on Ophiolites of Western Chukotka, Northeastern Eurasia	Tatiana PILITSYNA	M216	2024-08-28 10:15	2024-08-28 10:30	1117
Identification of ca. 520 Ma MOR-type ophiolite suite in the inner Cathaysia Block, South China: Evidence from shearing-type oceanic plagiogranite	Longming LI	M216	2024-08-28 10:30	2024-08-28 10:45	1113
Neo-Tethyan ophiolites of Iran: formation of nascent oceanic lithosphere above double subduction	Iman MONSEF	M216	2024-08-28 10:45	2024-08-28 11:00	1115
PGE geochemistry of Macquarie Island basaltic glasses and picrites	Gyuchan PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1119
Early Neoproterozoic oceanic crust fragments in the Lhasa Terrane, Tibet	Peiyuan HU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1120
Tectonized Neotethyan lithosphere in southeastern Tibet: Results of the Luobusa ophiolite drilling	XiangzhenXU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1121

Title	Presenter	Venue	Start	End	Page
Ophiolites record plume-ridge interaction and two-stage oceanic crust accretion of the Meso-Tethys Ocean in the Central Tibetan Plateau	Yue RANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1123
Mantle heterogeneity caused by melt addition to mid-ocean ridge peridotite: Evidence from the Mid-Ocean Ridge Taitao ophiolite, southern	Weiwei WU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1125
Exhumation of mantle peridotite in an embryonic oceanic basin at slow to ultraslow spreading ridge within the Dahomeyide belt in Ghana, West Africa	Daniel KWAYISI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1126
Tectonomagmatic evolution of mantle complexes of the North Balkhash and Dzhalair-Naiman ophiolite zones (central and south Kazakhstan, western part of the Central Asian Orogenic Belt)	Aleksandra MILYUKOVA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1127
Olivine fabric and tectonic evolution of Indus-Yarlung suture zone: Insight from the Indus-Yarlung ophiolitic peridotite in the Tibetan Plateau	YU YANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1129
Geochemical study of ultrahigh pressure serpentinites from Chinese southwestern Tianshan and its implications	Tingting SHEN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1130
Petrogenesis of chromitites in the Bulqiza ophiolite massif, Albania and its records of Ti metasomatism	Tian QIU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1131
A case for subduction initiation in the Proto-South China Sea? Insights from the volcanic geology, petrology, and geochemistry of the Southern Palawan ophiolite	Nikko Manaig BALANIAL	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1132
Juxtaposed Cenozoic and Mesozoic ophiolites in Palawan island, Philippines: Implications for the evolution of western Philippines	Betchaida PAYOT	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1134
Petrography and geochemistry of intrusive rocks in northern Zambales and Pangasinan: Constraints on the evolution of northern Luzon	Mariz Lacson ALCANCIA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1135
Subduction initiation beneath an attenuated continental margin: Insights from the Timor ophiolite	Yu-Chin Lin	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1137
The Ginebra Ophiolithic Complex: Origin and evolution of an Ophiolite in Colombia from geochemistry and U-Pb geochronology.	Jonathan Adolfo HERNANDEZ PRIETO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1138
S6 The petrological and related tectonic interpretations of Northeast Asia		Session Chair: Scientific Program Committee			
[Keynote] East Asian Blocks: From Breakup of Rodinia to Assembly of Pangea	Guochun ZHAO	M216	2024-08-29 08:00	2024-08-29 08:30	1140
Petrogenesis of the circum-cratonic Triassic syenite province from the North China	Xu LIU	M216	2024-08-29 08:30	2024-08-29 08:45	1151
Oceanic isolation of the Paleo-Tethys from the Panthalassa in the leadup to the Permian mass extinction: Consistent evidence from metamorphism in East Eurasia	lei Zhao	M216	2024-08-29 08:45	2024-08-29 09:00	1165
Triassic tectonic response of overriding North China block to the South China block continental deep subduction	Lingtong MENG	M216	2024-08-29 09:00	2024-08-29 09:15	1160
Zircon U–Pb ages and Lu–Hf isotopes of the Paleozoic Maizuru Granites, Southwest Japan: Implications for the tectonic correlation between the Proto-Japan and Northeast Asia	Kenta KAWAGUCHI	M216	2024-08-29 09:15	2024-08-29 09:30	1148
The review on the Permo-Triassic continental collision process in the Northeast Asia during the final amalgamation stage of Pangea supercontinent and the geological correlations between Korea, China, and Japan.	Chang Whan OH	M216	2024-08-29 09:45	2024-08-29 10:15	1142
Origin and evolution of the Maizuru Belt, Southwest Japan: Implications for the crustal rearrangement tectonics along the Northeast Asian continental margin	Kenta KAWAGUCHI	M216	2024-08-29 10:15	2024-08-29 10:30	1152
Paleozoic tectonic evolution of the Guryong Group from detrital zircon records: Implications for the tectonic affinity of the eastern Gyeonggi Massif, Korean Peninsula	Ji Wan JEONG	M216	2024-08-29 10:30	2024-08-29 10:45	1154
Petrogenesis and structural analysis of pillow-like metabasalt rocks in Shangying in North China Craton defines Neoarchean fore-arc ophiolitic mé lange in accretional wedge	Zhiyuan CHEN	M216	2024-08-29 10:45	2024-08-29 11:00	1166
Tectonic and metallogenic evolution of the North China (Sino-Korean) Craton and the connection to the East Asian Continent	Mingguo ZHAI	M216	2024-08-29 14:30	2024-08-29 15:00	1144
Early to Late Mesozoic Tectonic Evolution and Associated REE Mineralization in Southern Mongolia: A Comparative Study of the Mushgai-Khudag and Lugiin Gol REE Deposits	Otgon-Erdene DAVAASUREN	M216	2024-08-29 15:00	2024-08-29 15:15	1146
Geology of Northeast Asian depicted by the Tanlu fault	Peng PENG	M216	2024-08-29 15:15	2024-08-29 15:30	1164
Discovery of the Oldest Rocks in Eurasia and its Implication for the Origin of the First Crust on the Earth	Xiao-Fei Qiu	M216	2024-08-29 15:30	2024-08-29 15:45	1163
The tectonic evolution from the Archean to Triassic in the north central Gyeonggi Massif (Hongcheon-Chuncheon area) in the Korean Peninsula, and its application to the tectonic evolution of the North China Craton	min su Kang	M216	2024-08-29 15:45	2024-08-29 16:00	1168
Late Tonian (ca. 780–750 Ma) bimodal magmatism in the Ogcheon Metamorphic Belt, Korea, at the eastern margin of North China Craton	Moonsup Cho	M216	2024-08-29 16:15	2024-08-29 16:30	1150

Title	Presenter	Venue	Start	End	Page
lithofacies paleogeography of the Upper Cambrian-Lower Ordovician in Jiyang Sub-basin of North China Plate: An evolution driven by Huaiyuan movement, climate and see-level	Hao GUO	M216	2024-08-29 16:30	2024-08-29 16:45	1161
Ages, Geochemical Characteristics and Tectonic Environment of Mesozoic Diorites in the Central Sulu Orogenic Belt	Shikuo LU	M216	2024-08-29 16:45	2024-08-29 17:00	1158
Cretaceous two stage extensional tectonics in Northeast Asia and its geodynamics	Wei LIN	M216	2024-08-29 17:00	2024-08-29 17:15	1159
Early Paleoproterozoic magmatism in the southern Trans-North China Orogen	Xiaoping LONG	M216	2024-08-29 17:30	2024-08-29 17:45	1156
Cenozoic intracontinental tectonics of Mongolia: A synthesized review	Ulambadrakh KHUKHUUDEI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1169
Petrogenesis of Paleoproterozoic granitic gneiss in the Geumsan area, Korea, and its tectonic implications for Northeast Asia	Shuhan PAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1172
Geochronological and geochemical evidence of the Ordovician magmatism in the Lake Zone, Western Mongolia	Batkhishig Bayaraa	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1174
Reporting the geochronology of the igneous rocks of the southern Jeonju area, located in the southwestern part of the Okcheon metamorphic belt, Korea	Hawon YUN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1176
Six subduction-accretionary mafic zones identified in the Altai orogenic belt, Xinjiang, China	Liu YONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1177
High-temperature and high-pressure metamorphism and anatectic events in the Khondalite Belt	Shuhan PAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1170
S7 General Topics		Session Chair: Scientific Program Committee			
Carbonatization and silicification of ophiolitic ultramafic rocks and formation of gold-bearing listvenites in the Arabian-Nubian Shield	Mokhles Kamal AZER	M216	2024-08-30 08:00	2024-08-30 08:15	1179
Carbonatite, ultramafic breccia, syenite, and alkaline basalts from the igneous and sedimentary association of the Bolivian rift	Ramiro Matos	M216	2024-08-30 08:15	2024-08-30 08:30	1183
Determination of low-content Ti in zircon by LA-ICP-MS/MS	junlong NIU	M216	2024-08-30 08:30	2024-08-30 08:45	1189
Controlling Factors of Granite Chemical Diversity and Implications for Early Crustal Evolution: Migmatites from the Southwestern Daqingshan Complex, North China Craton	Xingzhou JIANG	M216	2024-08-30 08:45	2024-08-30 09:00	1190
Updates on the IUGS Task Force on classification and nomenclature of igneous rocks	Michele LUSTRINO	M216	2024-08-30 09:00	2024-08-30 09:15	1200
A tale of two metamorphic belts in eastern Taiwan: petrological characteristics	Chin-Ho TSAI	M216	2024-08-30 09:15	2024-08-30 09:30	1195
Revisiting the crustal growth of the eastern Central Asian Orogenic Belt: Insights from the Erguna Massif and Duobaoshan area	Chenyang SUN	M216	2024-08-30 09:45	2024-08-30 10:00	1202
Pb isotope disequilibrium in metasediment-derived granitic melts	Lingsen ZENG	M216	2024-08-30 10:00	2024-08-30 10:15	1184
An improved Faraday cup configuration for Sr isotopic analysis using LA-MC-ICP-MS and its applying on rich-REE apatite	Xirun Tong	M216	2024-08-30 10:15	2024-08-30 10:30	1199
The significance of isotopic decoupling in the mafic-ultramafic layered sequence of the Bushveld Complex, South Africa	Peace ZOWA	M216	2024-08-30 10:30	2024-08-30 10:45	1187
Chronology and geochemistry of Triassic sanukitoids in Funing area, South China: Implications for petrogenesis and geodynamic processes	Zhenglin LI	M216	2024-08-30 10:45	2024-08-30 11:00	1185
Petrogenesis of the Early to Middle Miocene Mafic Volcanism of the Huantraico Sequence, Argentina	Carina GRECO	M216	2024-08-30 13:45	2024-08-30 14:00	1197
Early-mid Cenozoic extensional arc volcanism of the North Patagonian and the Southern Central Andes (33-43°S)	Lucia FERNANDEZ PAZ	M216	2024-08-30 14:00	2024-08-30 14:15	1191
Chromite formation during the ascent of orthopyroxene-bearing magmas produced by incongruent melting of garnet + clinopyroxene + olivine assemblages in the upper mantle: An experimental investigation	Tahnee OTTO	M216	2024-08-30 14:15	2024-08-30 14:30	1204
Petrology and Geochemical Studies of late Cenozoic basic-intermediate volcanic rocks Southwest of Ghezel- Ozan (NW Iran)	Hamoon MEMARIAN	M216	2024-08-30 14:30	2024-08-30 14:45	1178
Signature of Himalayan Orogenesis in Quaternary Sediments, Lalmonirhat District, Bangladesh: Evidence from Petrography and Mineral Chemistry	ISMAIL HOSSAIN	M216	2024-08-30 14:45	2024-08-30 15:00	1181
Petrological characteristics of the volcanic rocks of the Pugo Formation and Zigzag Formation: Insights on the arc evolution of the Central Cordillera, Philippines	ARA JOY APONGAN ABATAYO	M216	2024-08-30 15:00	2024-08-30 15:15	1193
Petrological and geochemical characteristicsof a suite of calc-alkaline granite from Mercara Shear Zone, West Dharwar Craton, India: Implications for tectono-magmatic process from a paleo continental arc setting & evidence of deep crustal melting.	Rigzin NORBOO	M216	2024-08-30 15:15	2024-08-30 15:30	1196
Geochemistry and petrogenesis of Janga Iron-Copper skarn deposit, Kerman province	Maliheh NAZARI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1206
Eoarchean crustal evolution of the North China Craton revealed by U-Pb ages, trace elements and Hf-O isotopes of detrital zircons from the Caozhuang quartzite	Hao Wang	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1207
Petrological and geochronological characteristics of the Bargilt Fe deposit in Mongolia	OYUNGEREL SODNOM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1209

Title	Presenter	Venue	Start	End	Page
Petrography and Geochemistry of Metamorphic Rocks in Logbadjeck Quarries (Littoral Region, Cameroon): Environmental Impact	Nkeng Enstein FORCHENALLAH	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1210
Syn-collisional crust-mantle interaction in Himalayan passive continental margin: a response to lithospheric flexure	Lin MA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1212
Late Ediacaran Magmatic Activity in the Southern Dom Feliciano Belt (Northeastern Uruguay): Insights from U-Pb Zircon Dating and Hf Isotopic Composition of Dikes	Elena Peel	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1214
A Preliminary Study of the Geostandards of the Granites and Obsidians using Neutron Activation Analysis and Electron Probe Micro Analysis	JIN MI-EUN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1216
Episodic continental evolution of the paleo-Pacfic margin along East Gondwana	Giun HAN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1217
Sr–Nd–Hf isotope and trace-element constraints on the origin of the HIMU reservoir of mafic-ultra mafic intrusions, Pechenga Greenstone Belt: A Potential mantle plume source in the asthenosphere	Sakine MORADI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1218
Protolith and metamorphic ages of eclogites from the Eastern Alps	Ruihong Chang	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1220
Proterozoic Zircons in Neogene Semporna Peninsula volcanic rocks and its indication of ancient continental crust in Northeastern Borneo	In-Hye MOON	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1222
Age and Petrogenesis of appinite suites and high Ba-Sr granites in Chuncheon at the central Gyeonggi Massif, Korea	Tahnee OTTO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1223
T9 Structural Geology					
S1 3D geological mapping: international status, barriers, and perspectives of geomodelling		Session Chair: Philippe Calcagno			
[Keynote] Geomodelling by geological survey organisations: game changers, perspectives and challenges	Michiel Jan VAN DER MEULEN	C101	2024-08-27 08:00	2024-08-27 08:15	1235
Good Practices and Current Challenges of 3D Geological Modelling at the Czech Geological Survey	Ondřej ŠVAGERA	C101	2024-08-27 08:15	2024-08-27 08:30	1226
Construction of jurisdictional, federal, and multinational 3D geology to facilitate digital twins needed to address societal needs	Harvey Harvey Thorleifson	C101	2024-08-27 08:30	2024-08-27 08:45	1228
The Loop Project - an open-source platform for 3D geological modelling: towards better management of underground resources	Laurent AILLERES	C101	2024-08-27 08:45	2024-08-27 09:00	1229
LoopResources: Using structural frames for geostatistical simulations of geological resources.	Lachlan GROSE	C101	2024-08-27 09:00	2024-08-27 09:15	1231
Geomodelling in Europe: Sharing practices and open-sourcing tools among Geological Surveys	Laure PIZZELLA	C101	2024-08-27 09:15	2024-08-27 09:30	1232
3D Geological Modeling at BRGM (French Geological Survey)	Stephan Steuer	C101	2024-08-27 09:30	2024-08-27 09:45	1234
Heterogeneous internal architecture and engineering properties in an exhumed crustal scale strike-slip fault zone	Namgwon KIM	C101	2024-08-27 09:45	2024-08-27 10:00	1236
Germany 3D - Overview of 3D modelling activities of the German geological survey BGR	Stephan Steuer	C101	2024-08-27 10:00	2024-08-27 10:15	1238
Context is Everything: Leveraging a Common Reference Geological Model to Enhance Modeling Efficacy and Accuracy – A Case Study from Poland.	Zbigniew MALOLEPSZY	C101	2024-08-27 10:15	2024-08-27 10:30	1239
Role of basement tectonics and structural features in the seepage potential at the Cham –e Shir dam site, SW Iran	Arash Barjateh	C101	2024-08-27 10:30	2024-08-27 10:45	1224
Research on Key Technologies of 3D Geological Model Rendering in Cloud Environment	Yue SONG	C101	2024-08-27 10:45	2024-08-27 11:00	1225
Key Technologies for Geologic Modeling of Complex Fault Block Oil Reservoir	Xing DENG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1241
S2 Shear Zone Tectonics		Session Chair: Durga Prasanna MOHANTY			
Syn-kinematic granite emplacement in a transpressional corridor and its influence on the formation of dome-and-basin fold interference patterns	Gideon Rosenbaum	C101	2024-08-26 16:00	2024-08-26 16:15	1242
Shear Zones of Southern Granulite Terrane, India: Networks and complications	Durga Prasanna MOHANTY	C101	2024-08-26 16:15	2024-08-26 16:30	1247
Structural analysis of Riedel synthetic shears influenced by the thickness of the brittle layers: the lesson from analog modeling with PIV technique	Marilia Barbosa VENÂNCIO	C101	2024-08-26 16:30	2024-08-26 16:45	1259
Kinematic vorticity and deformation thermometry analyses of the exhumed mylonites from the Xiaohe ductile shear zone in the sourthern Xiaoqinling gold province, North China	Hui-Min MA	C101	2024-08-26 16:45	2024-08-26 17:00	1248
Stages of Shear Zone Evolution in an Isotropic Medium: An Account of Fluid Induced Rheological Transformation in ~2.6 Ga Bundelkhand Granitoids of India	SAYAN MAITY	C101	2024-08-26 17:00	2024-08-26 17:15	1243
Structural investigation in the Madurai Block of Southern Granulite Terrane, India: Insights from Shear Zones	JOHN DSOUZA	C101	2024-08-26 17:15	2024-08-26 17:30	1245
Deep crustal expressions of exhumed continental-scale fault zone systems: Shear zone nucleation and initiation on rheological boundaries	Shuyun CAO	C101	2024-08-26 17:30	2024-08-26 17:45	1250
Polyphase deformation derived from meso- and microstructural observations along the brittle-viscous shear zone in the Hamyang, Korea	Sang Yeol Bae	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1251
Importance of Mechanical Anisotropy on Strain Partitioning across a Transpressional Shear Zone (Okdong Fault) in Korea	Jinhyeon SO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1252

Title	Presenter	Venue	Start	End	Page
Strain partitioning and Construction of Wuliangshan Coherent Fault System in Biluoxueshan-Chongshan shear zone, SW Yunnan in China	QIANQIAN Guo	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1253
The role of long-lived shear zones in reconstructing the tectonic and deformational history of ancient active margin systems – the case of the Clarke River Shear Zone (NE Australia)	Raiza Toledo Rodrigues	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1255
Delineation of a new Crustal-Scale Shear Zone in the Northern Bundelkhand Craton: The ~E-W trending Datia Shear Zone	AISHWARYA MOHAN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1256
Middle-lower crustal flow response to the India-Eurasia collision: structural evidence from the Chong Shan tectonic belt within the Sundaland block	Xiaoyu Chen	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1258
Southern West African Craton Strain Field derived from integrated structural mapping approach : tectonic and kinematic significance of shear zones	Kalidou TRAORE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1260
EXTERNAL VS. INTERNAL REFERENCES FOR KINEMATIC ANALYSIS OF A TRANSPRESSIVE SHEAR ZONE	SUSHMITA BHATTACHARJEE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1261
S3 Modern techniques for understanding faults and their effects on fault activity and fluid flow		Session Chair: Ho Gong-Ruei			
[Keynote] Illuminating fault zone structures in depth by dense seismic array	Haijiang Zhang	C101	2024-08-29 08:00	2024-08-29 08:20	1268
100Ma of slip events in the core of the Highland Boundary Fault, Scotland: implications for earthquake slip.	Zoe SHIPTON	C101	2024-08-29 08:20	2024-08-29 08:35	1269
Analysis of Subsurface Fault Systems Using Audio-Magnetotelluric Surveys in the Western Ilan Plain of Northeast Taiwan	Ping-Yu CHANG	C101	2024-08-29 08:35	2024-08-29 08:50	1263
How good is your fracture model? Examining how interpreter experience and approaches affect fracture model variability.	Leila Evans	C101	2024-08-29 08:50	2024-08-29 09:05	1265
Exploring the significance of favourable and unfavourable structures in Orogenic gold deposits through a numerical modelling approach	SWARNENDU BHUYAN	C101	2024-08-29 09:05	2024-08-29 09:20	1267
Fluid flow characteristics based on topological analysis of a fracture system in Sinseondae area, Geoje Island, Korea	Goeun KIM	C101	2024-08-29 09:20	2024-08-29 09:35	1262
Fractured feldspar clast as paleostress marker	Tridib Kumar MONDAL	C101	2024-08-29 09:35	2024-08-29 09:50	1264
Quantitative evaluation of fault connectivity and its petroleum significance based on topological analysis: a case study from the well H area, southern Sichuan Basin	jingru zhao	C101	2024-08-29 09:50	2024-08-29 10:05	1270
The Role of Thermal Buoyancy on the Permeable Faults: Insights from the Lattice Boltzmann Models	Soojung AN	C101	2024-08-29 10:05	2024-08-29 10:20	1271
The Orogenesis and Metamorphic Fabrics in the Western Pacific Subduction Zones since late-Miocene, the rock recored from strike-slip to collision	Gong-Ruei HO	C101	2024-08-29 10:20	2024-08-29 10:35	1272
ROOTLESS ORE DEPOSITS OF TIEN-SHAN	GENNADY ERMOLAEV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1273
Mapping gas hydrate and fluid flow indicators: potential linkage with the occurrence of slope instability processes in the northern Bay of Bengal, offshore Bangladesh	Vanessa MONTELEONE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1275
Microstructure of the fault rock drill cuttings from the enhanced geothermal system site in Pohang, South Korea: evidence of frictional melting	Sejin JUNG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1277
Investigation of seismic and aseismic slip behavior of large thrust and strike-slip faults through the integration of structural mapping, microstructural characterization, thermometric and stable isotopic analyses and numerical simulations (Ligurian Alps, Italy; Carg Project)	Silvio SENO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1278
Heterogeneity of burial-related fracture networks and its effect on strata permeability: Insights from a volcano-sedimentary sequence in Wido Island, Korea	Sodam PARK	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1280
The impact of dykes and large planar surfaces in the connectivity of fractured basalts of the Paraná-Etendeka Province, Southern Brazil	Francisco TOGNOLI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1281
S4 Fault damage zones in active and fossil faults		Session Chair: Fabrizio Agosta			
[Keynote] Fossil traces of co-seismic fluid flow in seismically active fault zones: studying the past to understand the present and possibly predict the future.	Luca SMERAGLIA	C101	2024-08-29 14:30	2024-08-29 14:45	1285
Architecture and properties of active faults, insights from active faults in southern Spain	Anita Torabi	C101	2024-08-29 14:45	2024-08-29 15:00	1284
Geometric characterization of Baza and Galera active faults, Baza Basin, southern Spain	Ofelia SILIO	C101	2024-08-29 15:00	2024-08-29 15:15	1287
Architecture of active and fossil fault zones in sedimentary rocks: Lessons from integrated structural, geomechanical and mineralogical analyses	Abhisek BASA	C101	2024-08-29 15:15	2024-08-29 15:30	1289
Multidimensional structural analysis of the reservoir-scale fault damage zones flanking the eastern side of the High-Agri-Valley Basin, southern Italy	Fabrizio AGOSTA	C101	2024-08-29 15:45	2024-08-29 16:00	1294
Characteristics of fault zone structure and the relationship with hydrocarbon migration and accumulation: a case study of Qiongdongnan Basin, South China Sea	Yannan DU	C101	2024-08-29 16:00	2024-08-29 16:15	1296
The western central African passive margin seismicity	Hardy NKODIA	C101	2024-08-29 16:15	2024-08-29 16:30	1293
The Dauki fault zone architecture and its implications for the evolution of the Shillong Plateau, Meghalaya	Vinee SRIVASTAVA	C101	2024-08-29 16:30	2024-08-29 16:45	1291

Title	Presenter	Venue	Start	End	Page
Damage Asymmetry and Earthquake Rupture Propagation	Young-Seog KIM	C101	2024-08-29 16:45	2024-08-29 17:00	1283
Brittle Deformation History based on Kinematic Analysis in Igidae, SE Korea	유비 오	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1297
Fault reactivation and vein localization along dikes in granitic rock, Gyeongju, Southeast Korea	Sehyeon GWON	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1298
Structural heterogeneities in exhumed fault core: result from Great Glen Fault, Scotland	Namgwon KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1299
Controls of deep strike-slip fault on fractures in the Tarim Basin, Northwest China: Insight from finite element numerical simulation	Yichen SONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1300
Quantitative characterization method of ultra-deep strike-slip fault damage zone based on facies-controlled seismic inversion	Lu LIU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1301
S5 Active faulting behavior, earthquake hazards zonation and urban prevention strategies: Field observation, data process and scene simulation		Session Chair: Scientific Program Committee			
Earthquakes and neotectonics in cratonic Australia	Haibin YANG	C101	2024-08-27 14:45	2024-08-27 15:00	1303
Multi-phase non-coaxial orogenic growth: propagation of the Longmen Shan thrust belt on the eastern margin of the Tibetan Plateau	Zhicheng ZHOU	C101	2024-08-27 15:00	2024-08-27 15:15	1306
Hunting for an invisible Holocene fault beneath an urban region using historic aerial photos	Junjie REN	C101	2024-08-27 15:15	2024-08-27 15:30	1309
Progress of active fault surveying and its frontier problems in China	Xiwei XU	C101	2024-08-27 15:30	2024-08-27 15:45	1310
Probabilities Seismic Hazard Modeling inferred from the newest fault slip rates and its effect on the Landslide Risks in the Eastern Tibet Region	Jia CHENG	C101	2024-08-27 15:45	2024-08-27 16:00	1313
Irregular Earthquake Recurrence of the Northern Kongur Shan Extensional System, NE Pamir: Constraints from Multiple Paleoseismic Methods	Jin GE	C101	2024-08-27 16:00	2024-08-27 16:15	1315
Paleoseismic investigating understanding “Whether the historical 1505 central Himalaya earthquake produced surface rupture??”	Shreya Arora	C101	2024-08-27 16:15	2024-08-27 16:30	1316
Structural characteristics of thrust system in the piedmont zone of middle part of Longmen Mountains during the Indosinian period	Na ZHENG	C101	2024-08-27 16:30	2024-08-27 16:45	1302
Active Son-Narmada-South Fault as major threat to dams in central India	VAIBHAVA SRIVASTAVA	C101	2024-08-27 16:45	2024-08-27 17:00	1305
Surface Ruptures of the February 6, 2023 Earthquake Sequence, eastern Tü rkiye	Tim Kusky	C101	2024-08-27 17:00	2024-08-27 17:15	1307
Anatomy of intracratonic Gondwana rift basins of Peninsular India: An integrated gravity, magnetic and remote sensing approach	SWARNAPRIYA CHOWDARI	C101	2024-08-27 17:15	2024-08-27 17:30	1312
Transient response of semi-elliptical hill with an elliptical tunnel under blasting and seismic loading	Hao Luo	C101	2024-08-27 17:30	2024-08-27 17:45	1317
Morphotectonic studies and identification of active faults in Qazvin city up to a radius of 50 km from its center.	Maliheh Norouzi	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1318
New insight into the mechanism and evolution of HorseTail splay folds: A case study from the Huayingshan fold belt(South China)	Zhang-peng LIU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1319
Bonded nanoparticles restrengthen faults during earthquake slip	Jianhua HUANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1320
Seismogenic structures of the 2022 M6.1 Lushan earthquake and M6.0 Maerkang earthquake sequence in western Sichuan, China	Chuanyou LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1321
3D modeling and seismic capablity assessment of the east margin fault of Daxing uplift in North China Plain	Zhengfang LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1323
Evidence of Quaternary surface rupturing in the southernmost end of the Yangsan fault and deterministic seismic hazard assessment in the Busan metropolitan area	Hyunjee LIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1325
Mechanism analysis of underground powerhouse structure-stress-controlled collapse in fractured rock mass: microseismic monitoring and numerical investigation	Yuepeng SUN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1327
The Characteristics of Geostress Field and Fault reactivation analysis Assessment in the Cucumber Mountain Area, southern Sichuan Basin	Zifan Zhu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1328
S7 Himalaya, Karakoram and Tibet: the geology and tectonics of a giant orogen		Session Chair: Scientific Program Committee			
[Keynote] Utilizing Multi-Mineral Multi-System Petrochronology to Unravel the Tectonic Development of the Himalaya	John COTTLE	C101	2024-08-28 14:30	2024-08-28 14:45	1334
Deformation-Time Constraints on the South Tibetan Detachment System in the Cuona area, eastern Himalaya	Hanwen DONG	C101	2024-08-28 15:00	2024-08-28 15:15	1331
Spatial and temporal stress variations along a continental megathrust: case study of the Himalayan Main Central Thrust	Djordje GRUJIC	C101	2024-08-28 14:45	2024-08-28 15:00	1344
Constraining the evolution of shear zones in the Himalayan mid crust in Central Nepal: implications for the exhumation of the Himalayan metamorphic core	Rodolfo CAROSI	C101	2024-08-28 15:15	2024-08-28 15:30	1332
The geodynamics of long-term convergence, Indian continental subduction and indentation at the India-Eurasia collision zone	Wouter Pieter SCHELLART	C101	2024-08-28 15:30	2024-08-28 15:45	1335
Break-up of Pangaea and Gondwana Reflected in the Tectonics of the Eastern Himalayan Syntaxis	Neptune Srimal	C101	2024-08-28 15:45	2024-08-28 16:00	1337

Title	Presenter	Venue	Start	End	Page
COMPLEX THICK- AND THIN-SKINNED THRUSTING WITHIN THE NW QAIDAM BASIN, TIBET, CHINA – OR HOW TO SALT THE DESERT	Piotr KRZYWIEC	C101	2024-08-28 16:00	2024-08-28 16:15	1342
Wedge-scale deformation in the Himalaya through time	Malay MUKUL	C101	2024-08-28 16:15	2024-08-28 16:30	1343
Unveiling the Hidden Dynamics: A Comprehensive Exploration of the Greater Himalayan Out-of-Sequence Thrust and Active Faults in the Sutlej River Section, India	RAJKUMAR GHOSH	C101	2024-08-28 16:45	2024-08-28 17:00	1329
Himalayan Influence Tectonic and Exhumation history of the Shillong Plateau and Mikir Hills, NE-India: Constraints from Low-temperature Thermochronological Analysis	RAMESH CHANDRA PATEL	C101	2024-08-28 17:15	2024-08-28 17:30	1339
Tectonic collision of Indian-Asian plates and the evolution of Himalaya foreland basin	KUN YU	C101	2024-08-28 17:30	2024-08-28 17:45	1341
Effects of structural position on the progressive evolution of internal shear zones from the Himalaya: Insights into orogenic wedge evolution	Kathakali BHATTACHARYYA	C101	2024-08-28 18:15	2024-08-28 18:30	1346
Magmatic and metamorphic evolution of the Late Cretaceous Muslim Bagh Ophiolite, western Pakistan: Implications for ridge subduction after subduction initiation	Takeshi IMAYAMA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1347
Neo-Tethyan subduction records in West Sulawesi, Indonesia	Xiaoran Zhang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1348
Cenozoic kinematic evolution of the Qilian Shan, northern Tibetan plateau: implication for the intraplate deformation	Bing LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1349
Kinematics and deformation conditions of the Chongshan strike-slip shear zone on the southeastern Tibetan plateau	Wenyuan LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1350
K-Ar dating of authigenic illite-bearing fault gouge constraints on Cenozoic multiple reactivation of the Lancangjiang Fault, SE Tibetan Plateau and its Tectonic Implications	Kui TONG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1351
Structural analysis, Geochronology and Thermochronology studies of the middle segment of the Xianshuihe-Anninghe-Xiaojiang Fault system: Implications for multiple-stage growth of the SE Tibetan Plateau margin	Zhiwu LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1353
Mechanism for the Uplift of Gongga Shan in the Southeastern Tibetan Plateau Constrained by 3D Magnetotelluric Data	Feng JIANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1355
Cenozoic tectonomagmatic history of South Tibetan Detachment System (STDS), Dhauliganga valley, NW Himalaya	GARGI GIRISH DESHMUKH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1356
Development Process of the West Kunlun Orogenic Belt Under the Control of Tethyan Evolution: Constraints from Detrital Zircon U-Pb Chronology of the West Kunlun Foreland Belt	Yang GAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1358
S8 From microscale to macroscale: multidimensional exploration in structural geology and tectonics	Session Chair: Rodolfo Carosi, Takeshi Imayama, Shuyun Cao, Oliver Lacombe				
[Keynote] Multiscale modern structural geology in metamorphic basements: exploring processes from the map to the atomic scale	Michele Zucali	C101	2024-08-28 08:00	2024-08-28 08:15	1368
EBSD-based microstructural characterization of the (ultra-) high pressure eclogite and retrogressed amphibolite from the Tso Morari Crystalline Complex in Ladakh, India	Dripta DUTTA	C101	2024-08-28 08:15	2024-08-28 08:30	1360
Nanogeoscience：A developing interdisciplinary	Yiwen JU	C101	2024-08-28 08:30	2024-08-28 08:45	1362
The effect of inherited basement strike-slip structures on rift basin architecture: insights from analog modeling and PIV analysis	Marilia Barbosa VENÂNCIO	C101	2024-08-28 08:45	2024-08-28 09:00	1363
Long-term stability of the Siberian craton: from “hot anchor” to “cold anchor”	Qin WANG	C101	2024-08-28 09:00	2024-08-28 09:15	1364
Microscopic Kinematic Indicators in the Achankovil Shear Zone, South India and its Tectonic Implications	Pratheesh PRABHAKARAN NAIR	C101	2024-08-28 09:15	2024-08-28 09:30	1367
Influence of salt diapir on the fault activity of subsalt units in salt-bearing fold-and-thrust belts: insight from natural example and numerical simulation	Wei WANG	C101	2024-08-28 09:30	2024-08-28 09:45	1370
Site investigation in a tunnel for unrevealing earthquake nucleation or "Finding the needle in the haystack"	Alba ZAPPONE	C101	2024-08-28 09:45	2024-08-28 10:00	1373
Microscale to mesoscale structures to constrain shear zone kinematics, a case study from the Shillong Plateau, NE India	SURAJIT MISRA	C101	2024-08-28 10:00	2024-08-28 10:15	1366
Graphitic material in fault zones: Implications for tectono-thermal evolution and carbon cycle	Shuyun CAO	C101	2024-08-28 10:15	2024-08-28 10:30	1372
Geometric and kinematic characteristics of along the strike-slip fault system: An example from the Yongdong fault system in central part of the Korean Peninsula	Kim JUN-YEOP	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1375
Progressive evolution of a type II shear zone: the Ferriere-Mollières Shear Zone (Argentera Massif, Western Alps, Italy)	Matteo Simonetti	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1377
Newly identified fold-and-thrust structures in the Ulsan Block of the Cretaceous Gyeongsang Basin, SE Korea, and their formation timing	Hyewon LIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1379
HT-LP extensional shear zones in the Metamorphic core of the Himalaya: preliminary ages, strain and P–T conditions	Salvatore IACCARINO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1381

Title	Presenter	Venue	Start	End	Page
Mapping polycyclic and monocyclic basement's units, and their relationships with oceanic-derived units, in the Western Alps: preliminary data from the Northern Dora Maira Massif	Salvatore IACCARINO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1382
Structure characteristics and its insights on shale gas exploration: an example from the Luzhou area, southern Sichuan Basin, China	zhengshuo MIAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1386
Crustal tectonic fabric in the Iberian Variscan slate belt: strong seismic anisotropy of slaty rocks partially preserved during homoaxial re-folding	Victor CARDENES	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1384
S9 Fault zones and fluid interactions, key structures for energy				Session Chair: Luca Smeraglia	
[Keynote] Reconstructing past fluid migrations in fold-and-thrust belts and forelands using geochemistry	Nicolas Beaudoin	C101	2024-08-30 09:30	2024-08-30 09:45	1401
Distributed faulting and fault growth by segment linkage in stratigraphic multilayers	Rob BUTLER	C101	2024-08-30 09:45	2024-08-30 10:00	1390
Preliminary data on fluid flow along the seismically active Yangsan fault	Luca SMERAGLIA	C101	2024-08-30 10:00	2024-08-30 10:15	1392
Synkinematic hydrothermal silicification in active normal faults: implications on the permeability structure of silicified faults	Luigi BERIO	C101	2024-08-30 10:15	2024-08-30 10:30	1396
Fluids and deformation processes at shallow subduction megathrust: hints from ancient analogues	Francesca REMITTI	C101	2024-08-30 10:30	2024-08-30 10:45	1398
Permeability structures of fault zones in low porosity carbonates	Fabrizio AGOSTA	C101	2024-08-30 10:45	2024-08-30 11:00	1388
Multistage structural controls on hydrothermal vein system development in epithermal mineral deposits: A case study of the Tieluping Ag–Pb–Zn deposit, East Qinling, China	Xinming ZHANG	C101	2024-08-30 13:45	2024-08-30 14:00	1394
Scale-dependent fracture patterns and flow in low-enthalpy geothermal targets: the role of diagenesis and contingent nodes	Stephen Laubach	C101	2024-08-30 14:00	2024-08-30 14:15	1402
Deciphering fluid sources and pathways of hydrothermal Ba-F mineralisation in western Bastar craton, central India: Using mineral system approach by combining structure, fluid, Sr- and S-isotope geochemistry	Muduru Lachhana Dora	C101	2024-08-30 14:15	2024-08-30 14:30	1399
Structural diagenesis of deep-buried carbonates controlled by strike-slip faults: an example from the Sinian Dengying Formation in Central Sichuan Basin	Shangzi LIANG	C101	2024-08-30 14:30	2024-08-30 14:45	1387
Infiltration of illuvial clays along the near-surface slip zone	Youngbeom CHEON	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1403
The mechanism and its geological significance of Mesozoic red sandstone bleaching in Luxi block, North China Craton	Li LI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1404
Identification of fault that triggered the 2017 Mw 5.4 Pohang Earthquake using the geothermal borehole (PX-2) cuttings	Hyunjee LIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1406
Pseudotachylytes in Gyeongju City, Jiri Mountain, and Maemul Island of Southeastern Korea: Its Occurrence and Characteristics	Hee-Cheol KANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1408
Determining the timing of fault activity using fluid behavior characteristics	TAE-HO LEE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1410
Pressurization and injection of fault materials and fluids during the long-term seismic cycle, the intraplate Yangsan fault, SE Korea	Chang-Min KIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1411
Three-dimensional structural and parametric models focused on finding the leads for different applications connected with energy acquisition in NW part of Poland.	Rafał Laskowicz	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1412
S10 Geological architecture and active tectonics of Central and Eastern Himalayas				Session Chair: Scientific Program Committee	
Active fault mapping, structural framework, kinematics, and segmentation – An appraisal of the Chittagong Coastal Fault along the outer Indo-Burman Ranges	Md. Sakawat Hossain	C101	2024-08-30 08:00	2024-08-30 08:15	1416
Slab tear and its corresponding crustal deformation of subducted Indian lithosphere in the Eastern Himalayan Syntaxis region	Bo ZHANG	C101	2024-08-30 08:15	2024-08-30 08:30	1418
Landform Evolution of the Brahmaputra, Padma and Meghna interfluve, Bengal Basin, Bangladesh – A Pedological Approach	Md. Sharif Hossain KHAN	C101	2024-08-30 08:30	2024-08-30 08:45	1414
Investigating the relative roles of structural and mechanical (lithology, bed thickness) controls in fracturing in frontal thrust sheets: Insights from fracture characterization and attribute study, Eastern Himalaya, Sikkim	Kathakali BHATTACHARYYA	C101	2024-08-30 08:45	2024-08-30 09:00	1419
Petrotectonic framework of the Siwalik Group in northern part of the Chitwan Dun Valley, Central Nepal	Niraj Singh Thakuri	C101	2024-08-30 09:00	2024-08-30 09:15	1420
Miocene paleo-elevation constraints in the Tibetan Plateau: constraints of deuterium isotope from the Greater Himalayan Complex	Wentao GUO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1421
Mantle flow in the southeastern Tibet Plateau since the Eocene: From a geochemical perspective	Ziqing LI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1422
S11+S6 General Topics				Session Chair: Scientific Program Committee	
Internal characteristics and main influencing factors of buried hill faults in the south Fault zone of Zhu III sub-basin, Pearl River Mouth Basin, China	zedong LIU	C109	2024-08-30 14:30	2024-08-30 14:45	1425
Analogue Modeling of Rift Evolution in the Central Africa Bongor Basin: A Dynamical Analysis from Dual Rifting to Reversal Processes	Yanjie GAO	C109	2024-08-30 14:45	2024-08-30 15:00	1426
The exhumation history of Qiangtang Basin since the Cretaceous and its control of hydrocarbon accumulation	Qingqing LEI	C109	2024-08-30 15:00	2024-08-30 15:15	1427

Title	Presenter	Venue	Start	End	Page
Zircon U-Pb geochronology of the weathering crust from Permian Maokou Formation, Western Hubei Province and its indication for Emeishan volcanic activity	Yaxian GAO	C109	2024-08-30 15:15	2024-08-30 15:30	1428
Development Characteristics and Formation Evolution of Cambrian Strike-Slip Faults in the Gaoshiti-Moxi Area, Sichuan Basin, SW China	Ruifeng Wang	C109	2024-08-30 15:30	2024-08-30 15:45	1429
Structural characteristics and development model of fluid diapirs within the structural transition zone, northern South China Sea	Yang QIN	C109	2024-08-30 15:45	2024-08-30 16:00	1431
The impact of fracture development patterns under tectonic influence on hydrocarbon productivity in the Bozi-Dabei region	冠南 仲	C109	2024-08-30 16:00	2024-08-30 16:15	1433
Characteristics of the Meso-Cenozoic fracture system in the Xihu Sag and its control of the basin	Jinhang Zheng	C109	2024-08-30 16:15	2024-08-30 16:30	1434
Characteristics of Unconformity and its Control on Buried Hill Hydrocarbon Reservoirs: A Case Study from the Qiongdongnan Basin, South China Sea	Yanying LI	C109	2024-08-30 16:30	2024-08-30 16:45	1436
The in situ stress field and microscale controlling factors in the Bozhong depression, Bohai Bay Basin	Guanjie ZHANG	C109	2024-08-30 16:45	2024-08-30 17:00	1437
Characterization of the Deformation and Formation Evolution of Mud Diapir Structure in the Rel Del Rey Basin, Niger Delta	Jixin ZHANG	C109	2024-08-30 17:00	2024-08-30 17:15	1439
The development characteristics and genetic mechanisms of inversion tectonics in the northern part of the Yinggehai Basin	qingbo WU	C109	2024-08-30 17:15	2024-08-30 17:30	1440
New lithostructural map of the Doropo region, northeast Côte d'Ivoire: insight from structural and aeromagnetic data	ZIANDJEDE HERVE SIAGNE	C109	2024-08-30 17:30	2024-08-30 17:45	1423
Quantitative prediction of tectonic fracture in Puguang gas field based on stress genesis	Hui LI	C109	2024-08-30 17:45	2024-08-30 18:00	1424
GEOLOGICAL ANALYSIS OF THE DEVONIAN COMPLEX IN THE SOUTHERN PART OF THE CASPIAN BASIN (KAZAKHSTAN)	Aliya ABLIGAZIYEVA	C109	2024-08-30 18:15	2024-08-30 18:30	1438
Boundary effects in the evolution of the deformation and stress field of southern Andean plateau, southern central Andes (26°30´–27°30´S)	Rodrigo QUIROGA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1445
Fractal Dimension Analysis in Breccias of the Colombian Emerald Belts	Camilo Andrés BETANCUR	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1447
The 'fault-controlled-fluid' diapir in Yinggehai Basin : a new understanding based on OBN data	Chenxi Chen Ma	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1448
New understanding of the evolution and structural deformation of the northern Neuquén Andes (37-38°S)	Lucía JAGOE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1450
Thermokinematic 2D restoration of the Marañón Fold and Thrust Belt in the Andes along the Puchca Valley, Perú.	CRISTIAN MIGUEL MACHACA SARDON	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1452
New Understanding of Late Mesozoic Structural Deformation in the South Yellow Sea Basin and Its Significance for Oil and Gas Exploration	Huang ZHEN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1453
Effect of tectonic extrusion on the physical properties of clastic reservoirs*: *Based on physical simulation experiments	Yumeng Song	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1455
A Preliminary Study on the Sediment Source of the Maérzheng Formation in the Southern Margin of the East Kunlun Region, China	Lei PEI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1442
Tectonic significance of the Early Paleozoic ophiolite in the Central East Kunlun orogenic belt ， China	Lei Pei	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1443
Early Cretaceous lithospheric thinning of the North China craton: Insights from mantle-derived mafic dyke swarms in Jiaodong peninsula	Lei JI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1456
Analysis of effects of activities of Zahedan and Nosratabad faults on deformation and displacement dikes into zahedan poloton.(southeast of iran))	Zahra IRANI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1441
T10 Geomorphology					
S1+S6 Understanding Cover and its links with basement geology through Earth's history		Session Chair: Scientific Program Committee			
Neotectonics, geochemical dispersion processes and mineral exploration: linking basement and surface in regions of cover	Ignacio Gonzalez-Alvarez	M213	2024-08-30 13:50	2024-08-30 14:05	1457
Deciphering long-term geomorphological evolution through morphometric analysis of the Côa River drainage network (northeast Portugal)	Luca DIMUCCIO	M213	2024-08-30 14:05	2024-08-30 14:20	1458
The history of the most typical world's great rivers: the evolution of the Yangtze and Yellow rivers controlled by the Himalayan orogeny	Liankang YANG	M213	2024-08-30 14:20	2024-08-30 14:35	1460
Full-length Hiking Expedition along the Yellow River and Yangtze River, Discovery of Their earliest Sedimentary Layer, and Confirmation of a Complete Developmental Historical Profile	Liankang YANG	M213	2024-08-30 14:35	2024-08-30 14:50	1461
Danxia Landform research in China: Tectonic significance, fracture mechanisms and controlling factors	Fang REN	M213	2024-08-30 14:50	2024-08-30 15:05	1462
Controls of tectono-pluviometric forcing on landscape dynamics and seismicity in Java	Benjamin SAUTTER	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1463
Relationship between development periods of coastal sand dunes and climate-environmental factors	Min HAN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1464
Decadal and Millennium Scale Gully Expansion Rates, Mthatha, Eastern Cape, South Africa	Debbie Claassen	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1465

Title	Presenter	Venue	Start	End	Page
Karst morphologies in the foreland of the West-Congo belt, Republic of Congo: evidence of cone karst in the Madingou region	Nicy Tchiguina BAZEBIZONZA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1467
S2 'Landslides and climate changes' (IAG Co-Sponsored Session)		Session Chair: Scientific Program Committee			
Tackling Mediterranean Hurricanes through artificial intelligence in a near-future climate projection	Giovanni SCARDINO	M213	2024-08-30 08:00	2024-08-30 08:15	1468
Arctic landscape evolution in the warming climate of Svalbard: Permafrost degradation as a major driver of rock slide activity.	Dirk KUHN	M213	2024-08-30 08:15	2024-08-30 08:30	1471
Short-Term Climate Change (1981-2021) Impact on Landslide Events in South Sikkim, India	Ria NASKAR	M213	2024-08-30 08:30	2024-08-30 08:45	1473
Investigating the response of slow-moving landslides to climate and environmental changes in the Northern Apennines (Italy)	Vittoria VANDELLI	M213	2024-08-30 08:45	2024-08-30 09:00	1474
River bank falls of Anavilhanas extreme events in Negro river, Amazon state, Brazil	Cleide RODRIGUES	M213	2024-08-30 09:00	2024-08-30 09:15	1476
Detailed Survey and Quantitative Risk Assessment of Landslides in Mountainous Village: A Case Study in Jingyang Town, Hubei Province, China	Lei Liu	M213	2024-08-30 09:15	2024-08-30 09:30	1478
Impacts of rainfall-triggered landslides in New Zealand: déjà vu all over again	Martin Brook	M213	2024-08-30 09:30	2024-08-30 09:45	1479
Sea level rise and the 'hidden' landslides on the NW coast of Malta	Mauro SOLDATI	M213	2024-08-30 09:45	2024-08-30 10:00	1480
Climate change versus anthropic induced reactivation of slow-moving landslides in temperate environments	Mihai Niculiță	M213	2024-08-30 10:00	2024-08-30 10:15	1470
S4 Exploring high-resolution spatial and temporal data to resolve geologic and geomorphic processes		Session Chair: Scientific Program Committee			
Late Quaternary slip rate of the strike-slip faults on the eastern margin of the Qaidam Basin and its implication on the northeastern margin of the Tibetan Plateau	Guodong BAO	M213	2024-08-29 14:30	2024-08-29 14:45	1481
Optimization of InSAR based coseismic slip modeling for moderate earthquakes accounting for fore-aftershock sequence	Lejun LU	M213	2024-08-29 14:45	2024-08-29 15:00	1484
Field and UAV surveys of the northern Xainza rift, south-central Tibet: EW extension rates and earthquake hazard assessment	Marie-Luce CHEVALIER	M213	2024-08-29 15:00	2024-08-29 15:15	1485
Surface Rupture and Slip Distribution along the Chenghai fault mapped from airborne LiDAR data and its tectonic implications	Haomin Ji	M213	2024-08-29 15:15	2024-08-29 15:30	1486
Global basic landform mapping using 30-meter DEM for geologic and geomorphic research	Xingyu Zhou	M213	2024-08-29 15:30	2024-08-29 15:45	1488
Quantitative Assessment on Relative Tectonic Activity along Western Mae Chan Fault Zone, Northern Thailand	PICHAWUT MANOPKAWEE	M213	2024-08-29 15:45	2024-08-29 16:00	1490
Slip partitioning of the left-step Wulan segment along the right-lateral strike-slip Elashan fault	Jinrui LIU	M213	2024-08-29 16:00	2024-08-29 16:15	1492
Spatial Distribution and Regional Tectonic Significance of the Newly Discovered Kalawenguquan Fault in the Interior of the Tian Shan	Zhongtai HE	M213	2024-08-29 16:30	2024-08-29 16:45	1483
DATING ABANDONED ALLUVIAL SURFACES USING CALIBRATED MODELS OF GULLY INCISION	Amit MUSHKIN	M213	2024-08-29 16:45	2024-08-29 17:00	1493
Large-scale Traps Development and Hydrocarbon Accumulation along Transition Surfaces in Lacustrine Basin	Zhanlong Yang	M213	2024-08-29 17:00	2024-08-29 17:15	1494
New evidence of late Quaternary tectonic activity along the eastern margin of the Qaidam Basin	Zhikun REN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1495
Coseismic deformation of the 1976 Ms 7.3 Chaldiran earthquake in eastern Turkey measured by satellite imagery, in comparison with field measurements	Yu ZHOU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1497
Coseismic slip distribution of the 2023 earthquake doublet in Turkey and Syria from joint inversion of Sentinel-1 and Sentinel-2 data: An iterative modeling method for mapping large earthquake deformation	Jianlong Chen	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1498
Long-term influence of seismic activity on hot spring observation	Tian LEI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1499
Application of geological and geomorphological data in ground motion simulation	Jiangyi LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1500
A study on high-resolution 3D seismic velocity structure in southern Sichuan basin, China, using a local temporary network	Yang ZANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1501
Relationship between seabed geomorphology and flexural subsidence in the Sibari and Corigliano basin (Southern Italy)	Nora Markezic	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1502
Application of Acoustic Classification for Seabed Characteristics of Spratly Islands in the South China Sea	Yin Hsuan Liao	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1503
S5+S3 The role of climate, tectonics and surface processes in landscape evolution of the Himalayan-Tibetan orogen		Session Chair: Scientific Program Committee			
Investigation of the genesis and development of the late Pleistocene paleosols for the reconstruction of the geomorphic evolution of the loess deposits near Gorgan, Iran	Sahar MALEKI	M213	2024-08-29 08:00	2024-08-29 08:15	1505
Multi-phase drainage rearrangement in response to geodynamic mechanism transition in southeastern Tibet	YONG ZHENG	M213	2024-08-29 08:15	2024-08-29 08:30	1514

Title	Presenter	Venue	Start	End	Page
Tectonic Segmentation along the Himalayan Arc from Geomorphic Analysis and its implication on the Strength of the underthrusting Indian Lithosphere	Raj Sunil KANDREGULA	M213	2024-08-29 08:30	2024-08-29 08:45	1510
Geomorphological evidence of neotectonic activity in the Ganga-Brahmaputra plains: A review	CHINMAY DASH	M213	2024-08-29 08:45	2024-08-29 09:00	1515
Understanding the Long-Term Impacts of Human Activities and Climate Change on the Krishna-Godavari Delta through Remote Sensing	RESHMA KADAKATH NARANTHATTA	M213	2024-08-29 09:00	2024-08-29 09:15	1508
Mangroves ecosystem metamorphosis impacted by climate change in Indus Delta	Ping YIN	M213	2024-08-29 09:30	2024-08-29 09:45	1517
Sediment characteristics and carbon stock in mangroves of Mahanadi delta in western Bay of Bengal	KAKOLI BANERJEE	M213	2024-08-29 09:45	2024-08-29 10:00	1520
Identification and classification of the Salehyeh wetland sediments and assessment of possible contamination markers (toxic elements)	Nayerehsadat BAYAT GHIASI	M213	2024-08-29 10:00	2024-08-29 10:15	1507
The climate-tectonic interplay in Ladakh, NW Himalaya (India)-Records during the Quaternary Period	Binita PHARTIYAL	M213	2024-08-29 10:15	2024-08-29 10:30	1511
Quaternary Tectonism and Channel Migration in the Banas River, Western India M.R. Resmi and Manisha Gupta	Resmi M.R	M213	2024-08-29 10:30	2024-08-29 10:45	1519
Tectonic landforms and Morphometric analysis of the frontal part of the Belt of Schuppen: Focus on Naga Thrust	SENTISENLA JAMIR	M213	2024-08-29 10:45	2024-08-29 11:00	1513
Sustainable Habitability of the Mountain Valley Systems under Emergent climatic transition: A case of the Himalaya	Satish Jagdeo SANGODE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1522
The Ganga Plain rupture cyclicity deduced from the terminal fans; and its coherency with the Himalayan earthquake cycles	PITAMBAR PATI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1523
The enigmatic Sarasvati River: Unravelling the mystery through space and time-A multidisciplinary approach	HARSH TEWARI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1524
Comparative analysis of sea level changes along the South Sea coast in South Korea during the Holocene Thermal Maximum	JUNGHYUNG RYU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1526
T11 Paleontology and Paleoanthropology					
S1 Cambrian Explosion and Co-evolution of environment		Session Chair: Scientific Program Committee			
[Keynote] Isoxys volucris from the lower Cambrian Sirius Passet lagerstätte: a spiny solution to avoid predators	Arne Thorshøj NIELSEN	C201-202	2024-08-27 08:00	2024-08-27 08:15	1560
Kuanchuanpu biota – An early Cambrian Orsten-type Lagerstätte yielding the earliest ecdysozoan body fossils	Huaqiao ZHANG	C201-202	2024-08-27 08:15	2024-08-27 08:30	1527
Adaptive specialization of hexactinellid sponges from the early Cambrian black shales of southern China	Hao YUN	C201-202	2024-08-27 08:30	2024-08-27 08:45	1528
Cambrian small skeletal fossil bioprovinces and their application to test paleogeographic models	Michael STEINER	C201-202	2024-08-27 08:45	2024-08-27 09:00	1531
Chronology of the Ediacaran-Cambrian Boundary：Discussion with new data from Aksu area of Xinjiang Province, China	Ben YANG	C201-202	2024-08-27 09:00	2024-08-27 09:15	1533
TriBE: An international working group dedicated to understanding the early Palaeozoic dispersal and radiation of trilobites, and first results on trilobite palaeobiogeographical patterns	Harriet Bethany B. DRAGE	C201-202	2024-08-27 09:15	2024-08-27 09:30	1538
Crown group sponges from the Nama Group of Namibia, and the evolution of spiculogenesis across the Ediacaran-Cambrian transition	Alex George LIU	C201-202	2024-08-27 09:45	2024-08-27 10:00	1540
Ediacaran chronostratigraphy: falling into place or falling into pieces?	Dmitrii GRAZHDANKIN	C201-202	2024-08-27 10:00	2024-08-27 10:15	1542
Preservation of arthropods and microbes in Cambrian Orsten Lagerstätten	Nikita SOZONOV	C201-202	2024-08-27 10:15	2024-08-27 10:30	1544
Putative soft-bodied structures in early Cambrian Orsten-type fossil lagerstätten of the Yangtze Platform	Yuqian CHEN	C201-202	2024-08-27 10:30	2024-08-27 10:45	1552
The structural diversity of mollusk shells in early Cambrian	Luoyang LI	C201-202	2024-08-27 10:45	2024-08-27 11:00	1554
Systematics of the Redlichiidae (Redlichiida, Trilobita) and related groups	Zhixin SUN	C201-202	2024-08-27 14:30	2024-08-27 14:45	1541
The anterior sclerite in early arthropods	Mengxiao YU	C201-202	2024-08-27 14:45	2024-08-27 15:00	1537
Ventral Morphology and Their Ecological Implications of Two Xandarellids from Chengjiang Biota, China	Maoyin ZHANG	C201-202	2024-08-27 15:00	2024-08-27 15:15	1535
3D morphologies of the early Cambrian Chengjiang arthropods	Yu LIU	C201-202	2024-08-27 15:15	2024-08-27 15:30	1534
Spatially and temporally dynamic marine redox state through late Ediacaran-early Cambrian: evidence from carbonate I/Ca proxy	Ruliang HE	C201-202	2024-08-27 15:30	2024-08-27 15:45	1536
Morphological comparison with Cambrian relatives reveals the evolution of tardigrades	Ji-Hoon Kihm	C201-202	2024-08-27 15:45	2024-08-27 16:00	1557
Evolution in Polar Ecosystems: The Early Ordovician of Morocco and France	Gaëtan JM POTIN	C201-202	2024-08-27 16:15	2024-08-27 16:30	1556
Cambrian Burgess Shale-type fossil Lagerstätten of North China	Pingli WANG	C201-202	2024-08-27 16:30	2024-08-27 16:45	1555
Complete radiodonts from the early Cambrian Chengjiang fauna: implications on radiodont evolution	Han ZENG	C201-202	2024-08-27 16:45	2024-08-27 17:00	1549
A tiny Cambrian euarthropod illuminates the early evolution of mandibulates	Yao Liu	C201-202	2024-08-27 17:00	2024-08-27 17:15	1548
Taxonomic revision of Dickinsonia Sprigg	Nikita SOZONOV	C201-202	2024-08-27 17:15	2024-08-27 17:30	1546
Continental weathering during the Great late Ediacaran Glaciation revealed by Mg isotope	TIANZHENG HUANG	C201-202	2024-08-27 17:30	2024-08-27 17:45	1567

Title	Presenter	Venue	Start	End	Page
Phosphatised calcified cyanobacteria at the terminal Ediacaran and the earliest Cambrian transition stage: Response to the paleoenvironment	Xiao MIN	C201-202	2024-08-27 17:45	2024-08-27 18:00	1530
Preliminary study on Cambrian shell fossils from the Xiweikou Section in Yuncheng, Shanxi , China	Zhao Wang	C201-202	2024-08-28 08:00	2024-08-28 08:15	1558
Comparison of mineralized skeleton and microstructure of early Cambrian tubular animals	Jingliang ZHAO	C201-202	2024-08-28 08:15	2024-08-28 08:30	1562
Shallow water fauna from deep-water deposits, in the Zhaolaoyu Formation, late Ordovician at Fuping area, southern Ordos Basin	Caibin ZHANG	C201-202	2024-08-28 08:30	2024-08-28 08:45	1564
Evolutionary significance and biological affinities of Ediacaran to Cambrian tubular fossils	Yuze WANG	C201-202	2024-08-28 08:45	2024-08-28 09:00	1565
Did ctenophores construct colonies in the Ediacaran?	Vladislav DESIATKIN	C201-202	2024-08-28 09:30	2024-08-28 09:45	1550
Characterisation of Carbon isotope of the Cambrain Jialao Formation, Jianhe County, Guizhou Province, China	Zhen LI	C201-202	2024-08-28 09:45	2024-08-28 10:00	1559
Morphogenesis simulations unravelling novel recognition biases in Paleozoic trilobite injuries	Xiaoyong YAO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1568
Isolated radiodont mouths: case study of two unique oral cones from the Fezouata Shale Formation (Early Ordovician, Morocco).	Gaëtan JM POTIN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1569
Modularity and fluctuating asymmetry in the early Cambrian trilobite Protoryctocephalus arcticus from the 'Tsinghsutung' Formation, South of China	Esteve JORGE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1571
Taxonomy and Morphology of Choia from the Qingjiang Biota	Laiyuan Wu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1573
New artiopodan euarthropods from the Chengjiang fauna (Cambrian, Stage 3) at Malong, Yunnan, China	Yuyan ZHU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1574
Ecological and environmental implications of predatory groups in the Cambrian Guanshan Biota	Deguang JIAO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1575
S2 The Evolution of Land Plants and Plant–Environment Interactions during Geological Time		Session Chair: Jinzhuang Xue			
[Keynote] In situ preservation enhances systematic study: a case in research of the Wuda Tuff Flora, Inner Mongolia	Jun WANG	M218	2024-08-29 08:00	2024-08-29 08:15	1582
Mineralogical characteristics of pedogenic carbonates in Devonian paleosols and their environmental implications	jingru LUO	M218	2024-08-29 08:15	2024-08-29 08:30	1576
Biomarkers in fossil resins (ambers) – diversification and application	Paweł Kosakowski	M218	2024-08-29 08:30	2024-08-29 08:45	1589
Devonian coevolution of forests and tetrapods	Gregory RETALLACK	M218	2024-08-29 08:45	2024-08-29 09:00	1577
A preliminary study of three vascular plants from the Middle Devonian Haikou Formation of Qujing, Yunnan Province, China	Gaofeng ZHENG	M218	2024-08-29 09:00	2024-08-29 09:15	1578
Coupling relationship between radiation of early vascular plants and the long-term water cycle	Jinzhuang XUE	M218	2024-08-29 09:15	2024-08-29 09:30	1579
The cycle of S element in pyrite from Carboniferous bauxite in South china	Yulei CHEN	M218	2024-08-29 09:30	2024-08-29 09:45	1581
The Middle-Late Triassic Boundary Extinction: Palynological evidence	Yuewu SUN	M218	2024-08-29 09:45	2024-08-29 10:00	1584
New material of Radula heinrichsii (Radulaceae, Porellales) from mid-Cretaceous Myanmar amber	Xiangbo SONG	M218	2024-08-29 10:00	2024-08-29 10:15	1585
Tracking Darwin's climbing plants in a 298 Ma swampy forest	ZHOU WEIMING	M218	2024-08-29 10:15	2024-08-29 10:30	1586
Eusporangiate Fern from the Early Permian Peat-forming Forest in Wuda, Inner Mongolia, China	Dandan LI	M218	2024-08-29 10:30	2024-08-29 10:45	1587
Palaeodepositional environment, implications of Glossopteris flora, and organic matter characteristics from Early Permian Period, Karo OCM, East Bokaro Coalfield, Damodar Basin, India	Suraj Kumar SAHU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1591
Organo-floral characteristics of the Jagannath coal mine (Talcher Coalfield) from Mahanadi Basin: Implications to Paleoecology, Paleovegetation and depositional settings	DEVESHWAR PRAKASH MISHRA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1593
Vegetation and climate oscilations during MCO/MCT in Central and Eastern Paratethys	Marianna Kováčová	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1594
Palynofloral Succession on the Cretaceous-Paleogene Transition in Northeast China	Yuewu SUN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1595
Middle-Late Permian Palynofloras in lacustrine-pluvial fan depositional system in Junggar Basin, northern Xinjiang, China	Yuewu SUN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1597
The Leaf Fossils of Tuff Units in Metro Manila and Rizal, Philippines	Andrea Pamintuan	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1599
S3 Ostracoda in Geology, the 5th Asian Ostracod Meeting (AOM)		Session Chair: Yaqiong Wang			
[Keynote] Time Machine Biology: ostracod examples	Moriaki YASUHARA	C201-202	2024-08-26 16:10	2024-08-26 16:30	1605
Late Ordovician ostracods of Valcour Island, New York State, USA	Yichi ZHANG	C201-202	2024-08-26 16:30	2024-08-26 16:45	1606
Late Devonian benthic ostracods from South China and their response to the Frasnian–Famennian event	Junjun SONG	C201-202	2024-08-26 16:45	2024-08-26 17:00	1604
Exceptional preservation of reproductive organs and giant sperm in the Cretaceous ostracods	He WANG	C201-202	2024-08-26 17:00	2024-08-26 17:15	1601

Title	Presenter	Venue	Start	End	Page
Cretaceou stratigraphy and ostracod funa in the Songliao Basin, NE China	Dangpeng XI	C201-202	2024-08-26 17:15	2024-08-26 17:30	1613
Ostracod Faunas from the Early Cretaceous Liupanshan Group (Pingliang, NW China): Implications for Biostratigraphy and Palaeoenvironment	Yaqiong WANG	C201-202	2024-08-26 17:30	2024-08-26 17:45	1600
[Keynote] Phenotype Puzzle: Challenges in Paleontological Studies	Yanhong PAN	C201-202	2024-08-26 18:00	2024-08-26 18:20	1602
A review of non-marine ostracod faunas from the Cretaceous Gyeongsang Basin, South Korea	Byung-Do CHOI	C201-202	2024-08-26 18:35	2024-08-26 18:50	1603
Distribution and community structure of ostracods across the Isthmus of Panama	Kk Aye	C201-202	2024-08-26 18:50	2024-08-26 19:05	1607
Ecological Impact of the Suez Canal: Distribution and Diversity of Invasive Ostracods in the Mediterranean Sea	Lalita WEERACHAI	C201-202	2024-08-26 19:05	2024-08-26 19:20	1608
Testing the deep-sea glacial disturbance hypothesis as a cause of low, present-day Norwegian Sea diversity	Anna JÖST-KIM	C201-202	2024-08-26 19:20	2024-08-26 19:35	1611
OSTRACOD ASSEMBLAGES OF THE MIDDLE MIOCENE TRANSGRESSIVE SEDIMENTS IN THE CARPATHIAN FOREDEEP (JAWORZNO, SW POLAND; THE CENTRAL PARATETHYS)	Zbigniew Jan ZIAREK	C201-202	2024-08-26 19:35	2024-08-26 19:50	1609
No-marine Ostracod fauna from the Early Cretaceous Jinchuan Formation of the Ordos Basin: Taxonomy and Biostratigraphy	Yaqiong WANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1614
Geochronology and biostratigraphy study on the Early Cretaceous basins in the Jilin region, northeastern China	Yu-Ting ZHONG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1615
Holocene hydroclimate changes in the source area of the Yellow River inferred from ostracod assemblages and their isotopes in Lake Gyaring	Xiangzhong LI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1617
PALEOZOOGEOGRAPY OF THE LOWER CREATACEOUS QUIRICÓ FORMATION, SÃO FRANCISCO BASIN, MINAS GERAIS STATE, BRAZIL: A STUDY BASED ON LIMNIC OSTRACODS	Amanda MOREIRA LEITE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1618
Holocene ostracod assemblages and paleo-water depth from a raised beach sediment near Lake Suribachi-Ike, East Antarctica	Satoshi SASAKI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1620
Reconstructing Global Diversification Pattern of Non-marine Cypridoidea from Fossil Occurrence Data	Wonseop LIM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1621
A new record of Notodromadidae (Ostracoda) from southern Thailand: preliminary result	Anisong Chitnarin	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1622
Spatiotemporal changes of Ostracoda and paleoenvironment in brackish Lake Nakaumi (SW Japan) in relation to climatic and anthropogenic influences since the Little Ice Age	Toshiaki IRIZUKI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1623
PALEOZOIC OSTRACODS FROM MONGOLIA	Yarinpil ARIUNCHIMEG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1625
PLIOCENE NON-MARINE OSTRACODS FROM THE SHARGA BASIN	Belgutei BOLD	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1627
NON MARINE OSTRACODA FROM THE CRETACEOUS OF THE TSOGT-OVOO BASIN IN MONGOLIA	Jalbaa UNDARIYA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1628
The study of AI deep learning Yolov5 algorithm analysis for distinguish Ostracoda in meiofauna microscope pictures	Hyunsu YOO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1630
S4 Paleocene-Eocene larger benthic Foraminifera, paleobiogeography and collision of Indian and Asian Plates		Session Chair: Yaqiong Wang			
Paleocene-Eocene Larger Benthic Foraminifera from Meghalaya and Indo – Myanmar Orogenic belt of Eastern Tethys, India, collision of Indian –Asian plates and global paleobiogeography	VINOD TEWARI	M218	2024-08-29 14:30	2024-08-29 14:45	1631
[Keynote] Larger Benthic Foraminifera: Valuable Proxies in Biostratigraphic Evaluation of Paleogene Carbonate and Siliciclastic Sequences in Indian Petroliferous Basins	VINOD TEWARI	M218	2024-08-29 14:45	2024-08-29 15:00	1637
Foraminiferal assemblage and palaeoenvironmental reconstruction of early Eocene Umlatodoh Limestone form south Shillong Shelf: Signature of ETM2?	T. Ngamlengin Haokip	M218	2024-08-29 15:00	2024-08-29 15:15	1633
LARGER BENTHIC FORAMINIFERA (LBF) BIOSTRATIGRAPHY OF PALEOCENE – EOCENE SEDIMENTS IN PARTS OF ASSAM SHELF OF ASSAM AND ASSAM ARAKAN BASIN WITH REFERENCE TO DEPOSITIONAL ENVIRONMENT	KALPANA KALITA	M218	2024-08-29 15:15	2024-08-29 15:30	1635
Biostratigraphy Bentic Foraminifers of Triassic- Jurassic boundary in Zagros Basin (SW Iran)	Vahid AHMADI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1639
S5 Functional morphology and biomechanics in invertebrates: new ecological and evolutionary perspectives		Session Chair: James Nebelsick			
[Keynote]Distinct causes underlie double-peaked trilobite cephalon disparity, but this disparity is unrelated to exoskeleton moulting behaviour	Harriet Bethany DRAGE	C201-202	2024-08-28 15:45	2024-08-28 16:00	1642
[Invited] Exploring patterns of adaptive evolution across the Cambrian trilobite radiation	James Dougal HOLMES	C201-202	2024-08-28 14:00	2024-08-28 14:15	1646
Insights into raphiophorid trilobite glabella spine as a sensory organ for collective behaviour	Esteve JORGE	C201-202	2024-08-28 15:00	2024-08-28 15:15	1640
Enrolment in trilobites: insights for development and phylogeny	Esteve JORGE	C201-202	2024-08-28 15:30	2024-08-28 15:45	1641
Computational fluid dynamics simulation indicates morphological selection of the Upper Ordovician graptolite dicranograptids by hydrodynamics	Wenhui Wang	C201-202	2024-08-28 15:15	2024-08-28 15:30	1644
Biomechanics of the echinoid skeleton and its relevance to ecological reconstructions and preservation potentials in the fossil record	James NEBELSICK	C201-202	2024-08-28 14:30	2024-08-28 14:45	1645

Title	Presenter	Venue	Start	End	Page
[Keynote] Integrative Ordovician stratigraphy of China: a critical constraint on orogenies and palaeogeographical evolution of NE peri-Gondwana	Yuandong ZHANG	C201-202	2024-08-28 14:15	2024-08-28 14:30	1661
S6 Early Palaeozoic faunas and palaeobiogeography of NE peri-Gondwana		Session Chair: Scientific Program Committee			
The Ordovician radiolarians from Qilian Orogenic Belt	Hui LUO	C201-202	2024-08-28 14:45	2024-08-28 15:00	1666
Uppermost Darriwilian radiolarians from the lower part of Wulalike Formation, NW Ordos Basin, North China	Xuejin WU	C201-202	2024-08-29 10:00	2024-08-29 10:15	1665
New techniques for studying the morphology of chitinozoan plugs	Yan LIANG	C201-202	2024-08-29 10:15	2024-08-29 10:30	1663
The global distribution of Upper Ordovician acritarchs	Kui YAN	C201-202	2024-08-29 10:30	2024-08-29 10:45	1653
The Ordovician-Silurian boundary deposits in northwestern Tarim, Xinjiang: the Xikeer bed (new unit) and its implications	Yuchen ZHANG	C201-202	2024-08-29 10:45	2024-08-29 11:00	1657
[Keynote] Methods for β-level paleobiogeography using dendrogram and cladogram	Dong-Chan LEE	C201-202	2024-08-29 14:30	2024-08-29 14:45	1648
New insights into the Great Ordovician Biodiversification Event: Evidence from the Early Ordovician Liexi Fauna	Xiang Fang	C201-202	2024-08-29 14:45	2024-08-29 15:00	1650
Latest Ordovician graptolite fauna of the Wufeng Formation in South China	Qing CHEN	C201-202	2024-08-29 15:00	2024-08-29 15:15	1660
Silurian conodonts from western Yunnan and Xizang (Tibet), China	Zhongyang CHEN	C201-202	2024-08-29 15:15	2024-08-29 15:30	1664
Early Darriwilian evolution of North China conodont bioprovince: insights from sedimentology and conodont biostratigraphy	Sehyun Cho	C201-202	2024-08-29 15:30	2024-08-29 15:45	1668
The Middle Ordovician Bivalves from Dali, Yunnan Province, SW China and their palaeogeographic significance	Yong WANG	C201-202	2024-08-29 15:45	2024-08-29 16:00	1647
Middle–Late Ordovician cephalopod fauna from southern Xizang (Tibet) and its palaeogeographic implications	Jiaqi SONG	C201-202	2024-08-29 16:00	2024-08-29 16:15	1649
Early Paleozoic reef evolution in the Taebaek and Yeongwol groups, Korea: Insights into the peri-Gondwanan reef development	Jeong-Hyun LEE	C201-202	2024-08-29 16:30	2024-08-29 16:45	1671
A distinctive type in the earliest Phanerozoic reef pattern: calcimicrobial-cement reefs from the Cambrian Series 2 Xiannüdong Formation, China	Daecheol KIM	C201-202	2024-08-29 16:45	2024-08-29 17:00	1651
Oldest stromatoporoid reefs are found in South China	Juwan JEON	C201-202	2024-08-29 17:00	2024-08-29 17:15	1655
Mollusk-dominated skeletal contributions during the Great Ordovician Biodiversification Event (GOBE) in the Darriwilian Sino-Korean Block	Myung-Jun Seo	C201-202	2024-08-29 17:15	2024-08-29 17:30	1670
Paleozoic oxygenation event - evidence from late Silurian tubular trace fossils in South China	Yuxuan WANG	C201-202	2024-08-29 17:30	2024-08-29 17:45	1659
The last episode of coral-stromatoporoid biostromes and faunal changes across a Devonian-Carboniferous Boundary section of South China	Kun LIANG	C201-202	2024-08-29 17:45	2024-08-29 18:00	1667
Recovery of the earliest Silurian paleo-ocean: coupling evidence from both benthos and redox conditions in South China	Wenhui Wang	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1672
First report of Late Ordovician sponge spicules assemblage from the Yangtze Platform, South China	Lixia LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1673
Carbon isotope stratigraphy of the Lower Ordovician Dumugol Formation: Implications for global correlation	Eunsoo LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1675
Biogeographic shifts of marine invertebrates during the Ordovician-Silurian transition	shasha LIU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1676
Graptolite biostratigraphy of the Ordovician Wulalik Formation in western margin of North China	Huaqing WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1677
S7 Recent advances in palaeontology from Asia (APA open session)		Session Chair: Yongdong Wang, Byung-do CHOI			
[Keynote] New record of the conifer wood taxon Brachyoxylon from the Middle Jurassic in southwestern China, and a global survey of paleobiogeography of the Mesozoic Brachyoxylon occurrences	Yongdong WANG	C201-202	2024-08-30 08:00	2024-08-30 08:15	1692
The first record of the genus Prosantorhinus (Perissodactyla: Rhinocerotidae) of East Asia	Danhui SUN	C201-202	2024-08-30 08:15	2024-08-30 08:30	1683
Deciphering the Evolutionary Dynamic of Melanosomes in Mammalian hair	Xin LI	C201-202	2024-08-30 08:30	2024-08-30 08:45	1681
Evolution and dispersal of vertebrates in the Tibetan Plateau and surrounding regions	Tao DENG	C201-202	2024-08-30 08:45	2024-08-30 09:00	1679
Fossil evidence reveals sexual dimorphism in Anchiornis huxleyi	Yibo Zhou	C201-202	2024-08-30 09:00	2024-08-30 09:15	1678
Four endemic taxa of chondrichthyans from the Late Ladinian (Middle Triassic) of Guizhou and Yunnan Provinces, South China	Siyan ZHAO	C201-202	2024-08-30 09:15	2024-08-30 09:30	1693
Stromatoporoids from Upper Ordovician rocks of southern Kazakhstan and their palaeobiogeographical implications	Juwan JEON	C201-202	2024-08-30 09:30	2024-08-30 09:45	1688
The oldest pig-nose turtle (Carettochelyidae) in the Early Cretaceous of South Korea	Minguk KIM	C201-202	2024-08-30 09:45	2024-08-30 10:00	1707
The oldest Gondwanan record of durophagous shark Strophodus Agassiz, 1838 (Hybodontiformes) from the Kachchh Basin, western India	Suraj Bhosale	C201-202	2024-08-30 10:00	2024-08-30 10:15	1702
Fossil insects from China: a review	Diying HUANG	C201-202	2024-08-30 10:15	2024-08-30 10:30	1698
The review of Protopsyllidioidea in China	Xinneng LIAN	C201-202	2024-08-30 10:30	2024-08-30 10:45	1697
Revision of Mesopsyche and description of new species of Turbidapsyche gen. nov., from the late Middle Triassic Tongchuan entomofauna: taxonomic and paleogeographic implications	Xinneng LIAN	C201-202	2024-08-30 10:45	2024-08-30 11:00	1695
New Umenocoleidae (Dictyoptera) from the Jinju Formation, South Korea	SooBin LEE	C201-202	2024-08-30 14:00	2024-08-30 14:15	1694

Title	Presenter	Venue	Start	End	Page
Molecular taphonomy of Oligocene marine mammal bones from Hokkaido, Japan	Raman UMAMAHESWARAN	C201-202	2024-08-30 14:15	2024-08-30 14:30	1684
Multidirectional "shuttle dispersal" model and human origins	Xijun NI	C201-202	2024-08-30 14:30	2024-08-30 14:45	1686
Shells for understanding Hong Kong subtidal ecosystem history: a conservation baseline	Pedro Juliao JIMENEZ	C201-202	2024-08-30 14:45	2024-08-30 15:00	1690
The lower Barremian Bkassine (Lebanon) dysodile Konzentrat and Konservat-Lagerstätte: Insights on the fossil continental assemblages and reconstruction of the depositional environment	Diying HUANG	C201-202	2024-08-30 15:00	2024-08-30 15:15	1700
Memorial of Prof. Martin G. Lockley: The Dinosaur and Pterosaur Tracks of the Korean Peninsula	Min HUH	C201-202	2024-08-30 15:15	2024-08-30 15:30	1703
The earliest calcareous peyssonneliacean red algae fossils from Ordovician: systematics, evolutionary and paleoecological significance	weiling ZHUANG	C201-202	2024-08-30 15:30	2024-08-30 15:45	1705
DISCOVERY AND GEOLOGICAL SIGNIFICANCE OF PHOSPHATIZED ANIMAL RESTING EGG FOSSILS IN THE CHANG 73 MEMBER, YANCHANG FORMATION, ORDOS BASIN	Dexiang GAN	C201-202	2024-08-30 15:45	2024-08-30 16:00	1708
New discoveries of the fossil lampreys from the Yanliao and Jehol Biotas, North China	Feixiang Wu	C201-202	2024-08-30 16:00	2024-08-30 16:15	1710
Early Cambrian evaporite deposits in the North China Craton and their event stratigraphic, paleogeographic, and paleoenvironmental implications	Bin WAN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1711
Taxonomy and taphonomy of fossil fish scales from the Lower to Middle Miocene of eastern part of Shimane Prefecture, Japan	Mami HAMADA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1712
Phylogeny of the Trigonioididae	Seong Young YANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1713
New insights into pterosaur cranial anatomy: X-ray imaging reveals palatal structure and evolutionary trends	He CHEN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1714
S8+S9 The floral diversity variation and palaeoenvironmental background across the terrestrial Triassic and Jurassic transition		Session Chair: Scientific Program Committee			
Tracing Palaeo-Gaseous Mercury Variations through Fossil Plants: Preliminary Analysis of Mercury Concentration Data in Extant *Ginkgo* and Extinct Ginkgoaleans	Li Zhang	C201-202	2024-08-29 08:00	2024-08-29 08:15	1715
Mesozoic Climate change and CO2 concentration variation - paleobotanical evidence from China	Yongdong WANG	C201-202	2024-08-29 08:15	2024-08-29 08:30	1716
The linkage between Carnian Pluvial Episode and volcanism recorded by mercury anomalies in South China	Qing LI	C201-202	2024-08-29 08:30	2024-08-29 08:45	1717
The Mesozoic vegetation of Madagascar and the Jurassic vegetation of the Mahajanga Basin, northwestern Madagascar	Vivi Vajda	C201-202	2024-08-29 08:45	2024-08-29 09:00	1718
Atypical element accumulation in fossil leaves from the end-Triassic of Northern Hemisphere	Susan NEHZATI	C201-202	2024-08-29 09:00	2024-08-29 09:15	1720
First fossil foliage record in the red beds from the Upper Jurassic in the Sichuan Basin, southern China	Yongdong WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1721
Early Jurassic plants response to the Toarcian Ocean anoxic event in the Ordos Basin, China	Yunfeng LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1722
Preliminary report on pterosaur track from the Cretaceous Jindong Formation, Gyeongsang Supergroup, Goseong County, South Korea	Hyeokpyo JEON	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1723
S10 General contributions to Paleontology and Paleoanthropology		Session Chair: Rowan Martindale			
NaOH solution: a novel approach to extract microfossil trapped in cherts	Manuel RIGO	C201-202	2024-08-28 16:00	2024-08-28 16:15	1725
A new research on ultra-large ichthyosaur-Himalayasaurus tibetensis	Qinghua SHANG	C201-202	2024-08-28 16:15	2024-08-28 16:30	1730
New Pachymeridiidae (Insecta: Heteroptera: Pentatomomorpha) fossils from the Jinju Formation (Lower Cretaceous), South Korea	Jun-Hyeok JANG	C201-202	2024-08-28 16:30	2024-08-28 16:45	1732
CENOZOIC BIOSTRATIGRAPHY APPROACH FROM EQUATORIAL CARBONATE PLATFORM OF BRAZIL	Orangel AGUILERA SOCORRO	C201-202	2024-08-28 16:45	2024-08-28 17:00	1733
Paleobiodiversity of the Tamengo and Guaicurus formations (Ediacaran-Cambrian boundary strata, Brazil): paleoecological, paleogeographic and biostratigraphic implications	Rodrigo ADORNO	C201-202	2024-08-28 17:00	2024-08-28 17:15	1735
New Record of Elasmobranch (shark) fauna from the early Miocene (Aquitanian) of Kachchh Region (western India): Palaeoenvironmental and Palaeobiogeographic significance	Ketan CHASKAR	C201-202	2024-08-28 17:15	2024-08-28 17:30	1737
Neocomian ammonites from Talesh region (NW Alborz Mountains, Iran)	MAHMOUDREZA Majidfard	C201-202	2024-08-28 17:30	2024-08-28 17:45	1724
Study of Quaternary Radiolaria from the Core ABP-06, Station II, Section 1, Central Indian Ocean	DEEKSHA BOHRA	C201-202	2024-08-28 17:45	2024-08-28 18:00	1726
Ecological impacts of the Early Jurassic climate crises	Sinjini SINHA	C201-202	2024-08-28 18:00	2024-08-28 18:15	1727
Cranial elements of Temnospondyl from the Middle Triassic of Satpura Basin, Madhya Pradesh, India.	Savita Nilkanth CHAURPAGAR	C201-202	2024-08-28 18:15	2024-08-28 18:30	1729
Traces of Predatory Drilling Behavior on Middle to Late Pliocene Mollusc Fossils from Santo Domingo, Ilocos Sur, Northern Philippines	David Cabahug POLICARPIO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1738
Response of foraminifers to the Hangenberg mass extinction during the Devonian-Carboniferous transition in South China	Yang SHEN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1739

Title	Presenter	Venue	Start	End	Page
Bone Histology of the Sabertooth *Smilodon populator* and *Puma concolor* from Brazil	Virginia Silva Maciel	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1740
Pleistocene-Holocene Molluscan Fossil Assemblage and Paleoenvironment Analysis of the Damortis Uplifted Marine Terrace Sequence in Santo Tomas, La Union, Philippines	John Paul Martinez Mondala	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1741
Thermal maturity and taxonomic insights from palynomorph coloration: Preliminary results for the immature sediments of the Cretaceous, Yezo Group	Maho HAYAKAWA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1742
OPal: Open Palaeontology – a community-driven diamond open access journal with preregistration	Harriet Bethany DRAGE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1744
METHODOLOGICAL DEVELOPMENT FOR EXTRACTING THREE-DIMENSIONAL SPECIMENS OF CLOUDINA LUCIANOI (BEURLEN E SOMMER, 1957)	Rodrigo Rodrigues ADORNO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1745
***Glossifungites* : Tracing the Subterranean Artistry of Ancient Ecosystems from the Baisakhi Formation of Jaisalmer Basin, Rajasthan, India**	ANSHUL HARSH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1749
Miocene vertebrates of Kutch, Gujarat, India: An implication on Indian-Asian post collision faunal diversification and paleobiogeography	Kongrailatpam Milankumar SHARMA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1750
Discovery of the *Fictovichnus* from the Fatehgarh Formation of Barmer Basin from India	PAWAN KUMAR	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1752
Microconchid-cement reefs from the Visean of Belgium	Jeong-Hyun LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1753
Growth behaviour and palaeoecological role of microproblematica Palaeoaplysina in the Late Carboniferous to the Early Permian of Svalbard	Juwan JEON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1747
T12 Resource Geology and Economic Geology					
S1 Resource Prospecting of Critical Metals and Economic Processing		Session Chair: Scientific Program Committee			
PERSEPHONE – Autonomous Exploration and Extraction of Deep Mineral Deposits	Marko KOMAC	C203-204	2024-08-26 16:00	2024-08-26 16:15	1754
Gallium distribution and enrichment in skarn iron deposits: Insights from the Zhuchong deposit, Eastern China	Wang FANGYUE	C203-204	2024-08-26 16:15	2024-08-26 16:30	1756
Geochemical characterization of Rare Earth Elements and Rare Metal Potentials, Neoproterozoic, Peralkaline rhyolite of Malani Igneous Suite, Jodhpur, District, Rajasthan	Mukesh Kumar MISHRA	C203-204	2024-08-26 16:30	2024-08-26 16:45	1760
The Main Type, Characteristics And Genesis of Brine Li Deposits in China's Continent	Chenglin LIU	C203-204	2024-08-26 16:45	2024-08-26 17:00	1763
Carbonatites and their potentiality for Niobium mineralisation in Central block of eastern Ambadungar: Indicated Resource for critical mineral	BIJAY KUMAR DAS	C203-204	2024-08-26 17:00	2024-08-26 17:15	1757
Unlocking the Exploration Potential of Critical Minerals in South Korea	Andrew Kim	C203-204	2024-08-26 17:15	2024-08-26 17:30	1761
Geochemical Variations of Critical Elements in Angouran Zn-Pb Deposit, Iran: Insights from New La-ICP-MS Analysis	Mohammad AMINI	C203-204	2024-08-26 17:30	2024-08-26 17:45	1765
FUTURAM: Developing methodologies for mining waste characterisation	Anna LADENBERGER	C203-204	2024-08-26 17:45	2024-08-26 18:00	1758
The Critical Metal Potential of Pb-Zn Deposits in the Canning Basin: A case study of Goongewa, Lennard Shelf	Jenna McGovern	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1766
ECONOMIC COOPERATION BETWEEN SOUTH KOREA AND UZBEKISTAN ON CRITICAL METALS.	NAVRUZBEK JAHONGIR UGLI JURABEKOV	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1767
Phoscorite as a possible source for phosphate and REE: A first report from Chaitma Alkaline Province, Korba district, Chhattisgarh.	NIBIN G TOM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1768
The study of Critical Raw Materials in the Czech Geological Survey	Anna VYMAZALOVA MAITI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1770
A review of China's resources of lithium in coal seams	chao LIU	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1771
S2 Exploration Targeting of Critical Metals		Session Chair: Scientific Program Committee			
New developments for minerals discovery in the 21st century	Sandra Occhipinti	C203-204	2024-08-27 14:30	2024-08-27 14:45	1772
The evolving potential of the Australian REE ecosystem	Ignacio Gonzalez-Alvarez	C203-204	2024-08-27 14:45	2024-08-27 15:00	1774
Detailed exploration targeting of LCT pegmatite deposits in the central-part of Rajasthan, India	Alok PORWAL	C203-204	2024-08-27 15:00	2024-08-27 15:15	1777
Uranium Exploration targeting in the Mineral System Approach	Patrick LEDRU	C203-204	2024-08-27 15:15	2024-08-27 15:30	1780
Geochemical vectors to LCT pegmatites: the compositional data analysis approach.	Bijal Chudasama	C203-204	2024-08-27 15:30	2024-08-27 15:45	1783
Discovery of Ion-Adsorption Rare Earth Element Deposits by Geochemical Exploration in Southwestern China	ZHOU JIAN	C203-204	2024-08-27 15:45	2024-08-27 16:00	1776
Cassiterite trace element discrimination plots for critical mineral exploration	Avish Avnith KUMAR	C203-204	2024-08-27 16:15	2024-08-27 16:30	1786
A Preliminary Overview of the Metallogenetic Provinces of Southern Angola	Enrique Merino Martinez	C203-204	2024-08-27 16:30	2024-08-27 16:45	1778

Title	Presenter	Venue	Start	End	Page
Indonesian Critical Mineral and Energy Transition	Muhammad Wafid AGUNG NOVIANTO	C203-204	2024-08-27 16:45	2024-08-27 17:00	1782
Critical-metal related alteration mineral mapping using hyperspectral data: A new approach using ensemble of Support Vector Machines and Extreme Value Theory	Sandeepan DHOUNDIYAL	C203-204	2024-08-27 17:00	2024-08-27 17:15	1784
Regional-scale exploration targeting of Rare Earth Elements associated with carbonatite-alkaline complexes: a comprehensive prospectivity study in northwestern India	Malcolm Aranha	C203-204	2024-08-27 17:15	2024-08-27 17:30	1787
Exploration targeting of northern Finland for CRMs hosted in ultramafic-mafic orthomagmatic intrusions	Malcolm Aranha	C203-204	2024-08-27 17:30	2024-08-27 17:45	1789
Criteria for forecasting and assessment of tin-tantalum-lithium mineralization in Eastern Kazakhstan	NataLya ZIMANOVSKAYA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1791
Machine learning approach to predict distribution of critical elements : REE + Y contents in the Iranian karst-type bauxite deposits	Giovanni MONGELLI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1793
LocatOre: Mineral Exploration and Vectoring Software	Stephen Alexander COOKE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1795
The characteristics and use of calcrete as a sample medium for gold exploration in the Karibib area	NAILOKE SHALI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1796
GEOLOGICAL INVESTIGATION OF THE CHIMBIYA NIOBIUM-TANTALUM (Nb-Ta) ANOMALY IN KASUNGU DISTRICT, CENTRAL MALAWI.	Chrispin Ngwata	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1797
Mafic ultramafic rocks around Bachihalli-Hulihalli area, Holenarsipur Schist Belt, Western Dharwar Craton, South India: indications for Zn rich environment	KALYAN PAL	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1799
Analysis of Lithium-Bearing Pegmatite Mineral System in the Alvand Plutonic-Metamorphic Complex, Western Iran	Majid Keykhay-Hosseinpoor	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1800
Possibility of lignite coal deposits of South Korea as an unconventional REE deposit; preliminary case study of Gyeongju-Yeongil coal field	Woohyun CHOI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1801
Mineral resources exploration in SW Angola (PLANAGEO Project)	Iván MARTÍN-MÉNDEZ	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1803
Structural control on gold mineralisation in the Ngubevu area (South Africa) inferred from micro-scale to regional-scale spatial analysis	Nolukholo Sinovuyo Busakwe	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1805
Geology and Copper-Sulphide mineralisation within the Mutale area, Soutpansberg Group, South Africa	Thangeni Mphanama	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1806
Identifying target areas for copper mineralization using ASTER and geochemical data in Musina Area, Limpopo Mobile Belt, South Africa	Humbulani Rejune MUNDALAMO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1807
Reconnaissance Phase of Chromite Potential in Iran	SHAFIGHEH TARKIKORDEDEHI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1808
Quantitative Data for Geochemical Exploration of critical elements: The Contribution of Handheld LIBS	Naila MEZOUED	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1810
S3 Granitic Pegmatite-Hosted Critical Mineral Deposits		Session Chair: Scientific Program Committee			
[Keynote] Lithium pegmatites of Africa - a review	Kathryn Goodenough	C203-204	2024-08-27 09:30	2024-08-27 09:45	1819
Ore deposits of critical minerals in Indian granitic pegmatites	Yamuna SINGH	C203-204	2024-08-27 09:45	2024-08-27 10:00	1811
The legacy of Petr Černý in the study of granitic pegmatites	Tania MARTINS	C203-204	2024-08-27 10:00	2024-08-27 10:15	1816
Multidisciplinary Approach to Exploring for Rare-Element Pegmatites in Western Australia	Paul DUURING	C203-204	2024-08-27 10:15	2024-08-27 10:30	1817
New age data for the rare metal pegmatites of the East Sayan rare metal belt	Anna IVANOVA	C203-204	2024-08-27 10:30	2024-08-27 10:45	1812
Deep Learning Application in Predictive Mineral Targeting of Southwestern Uganda: Leveraging Airborne Magnetic and Radiometric Data	Christopher ALEXIS	C203-204	2024-08-27 10:45	2024-08-27 11:00	1814
Rare metal potential of North-Western Kalba (Eastern Kazakhstan)	Tatyana Oitseva	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1820
Pressure relevance of pegmatite melt evolution: new insight about melt-melt-fluid immiscibility imprinted in pegmatite quartz	Woohyun CHOI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1822
Mineralogical and geochemical properties of the pegmatite zircons: Implications for the formation of immiscible melt and fluid during pegmatite evolution	Youseong Lee	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1823
Metallogenesis of superlarge W-Cu ore systems in South China: Exampled by Zhuxi and Dahutang ore deposits	Xiaofei PAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1824
The use of lithium as a Critical Mineral in Granitic Pegmatite	Alla DIAW	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1826
Genesis of the Koktokay pegmatitic rare-metal deposit (Altai, China): Constraints from the newly-recognized Triassic rare-metal leucogranite	Ping SHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1827
S4 Co-Ni mineralization mechanism related to sedimentary, metamorphic, magmatic and weathering processes		Session Chair: Scientific Program Committee			
[Keynote] Origin of Cu-Co mineralization in the Central African Copperbelt: Neoproterozoic syn-sedimentary-diagenetic processes overprinted by Pan-African orogenic mineralization events	Huimin SU	C203-204	2024-08-27 08:00	2024-08-27 08:15	1829

Title	Presenter	Venue	Start	End	Page
Major types of Co-Ni deposits and their exploration in China	Shao-Yong JIANG	C203-204	2024-08-27 08:15	2024-08-27 08:30	1832
Unlocking critical metal resources from the Avebury metasomatic Ni sulfide deposit, Western Tasmania, Australia	JOSE LUIS BARILLAS DIAZ	C203-204	2024-08-27 08:30	2024-08-27 08:45	1833
Resource Potential Evaluation of Magmatic Cobalt and Nickel in the East Kunlun Metallogenic Belt, Northwest of China	Feng ZHANG	C203-204	2024-08-27 08:45	2024-08-27 09:00	1835
Occurrence patterns and controlling factors of Co in the world-class Panzhihua Fe-Ti oxide deposit, SW China: implications for Co mineralization	Banxiao RUAN	C203-204	2024-08-27 09:00	2024-08-27 09:15	1836
Geochemical anomalies related to cobalt-nickel mineralization in the Eastern Kunlun Orogen, China	Yue LIU	C203-204	2024-08-27 09:15	2024-08-27 09:30	1831
Mineralization of Ni-Co and other critical metals in Early Cambrian black shales in the Yangtze Block of South China	Jing-Hong YANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1838
Platinum Group Elements and associated magmatic sulfide mineralization in the Tantalite Valley Complex, Southern Namibia	Daniel Reuben Ferreira	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1840
Linking Selective Alteration, Mineral Compositional Zonation and Sulfide Melt Emplacement in Magmatic Ni-Cu Sulfide Deposits	Mengmeng Cui	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1842
Ni-PGE enrichment in the Jaguar and Jatobá IOCG deposits, Carajás district, Brazil	Yuri Tatiana CAMPO RODRIGUEZ	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1843
Geology and cobalt occurrence of the Cihai iron-cobalt deposit, eastern Tianshan, Xinjiang, China	Wei MEI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1845
The origin and mineralization processes of the Dulenggou copper-cobalt deposit in Eastern Kunlun metallogenic belt, western China	Wei WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1846
Mineralogy and geochemistry of nickel laterite deposit in the Acoje block of the Zambales ophiolite, Philippines	Akane ITO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	1847
S5 Mining for a Better Energy Future: Sustaining the Supply of Critical Raw Materials		Session Chair: Tunde Muritala ARISEKOLA			
CRM-geothermal: Raw materials from geothermal fluids	David Govoni	C102	2024-08-30 08:00	2024-08-30 08:15	1852
Resource potential of Russian Federation for critical raw materials. Lithium factor	Oleg KAZANOV	C102	2024-08-30 08:15	2024-08-30 08:30	1851
Certification of Competencies in Geosciences in Africa: Facts, Fictions, Geopolitical Considerations and African Union Perspectives	Tunde ARISEKOLA	C102	2024-08-30 08:30	2024-08-30 08:45	1854
AfricaMaVal – Building Africa-EU partnerships on sustainable raw materials value chains: focusing on business network with upstream and downstream companies	Marko KOMAC	C102	2024-08-30 08:45	2024-08-30 09:00	1849
Major global producers of critical minerals in extraction and processing stages	JI WON MOON	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1856
Rare Earth Elements and Yttrium (REY) enrichment in mining wastes from Tinto river area (SW Spain)	Francisco Javier González	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1857
Serpentinization in the Malawi Rift- a potential to power the energy transition.	Chikumbutso Cyril KAMBILONJE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	1859
S7 Petroleum Enrichment and the Tethys Geodynamic System		Session Chair: Scientific Program Committee			
[Keynote] Hydrocarbon enrichment in basins influenced by Tethyan evolution: A comparative analysis of the Persian Gulf Basin and the Sichuan Basin	Zhiliang HE	C203-204	2024-08-28 09:30	2024-08-28 09:45	1863
Differential hydrocarbon accumulation and enrichment in the northern Kuqa foreland basin, western China	Xinzhuo Wei	C203-204	2024-08-28 09:45	2024-08-28 10:00	1861
The Impact of Tethys Evolution on Petroleum Accumulation in Kuqa, Papua, and Zagros Foreland Basins	shunqi CHAI	C203-204	2024-08-28 10:00	2024-08-28 10:15	1870
The trace metal content in oils: a global approach	Svetoslav GEORGIEV	C203-204	2024-08-28 10:15	2024-08-28 10:30	1875
Geochemical characteristics, genetic types and sources of gas accumulations in the northern Jizhong Subbasin, Bohai Bay Basin, eastern China	NIAN LIU	C203-204	2024-08-28 10:30	2024-08-28 10:45	1908
Main Features and Controlling Factors of Hydrocarbon Basins in the eastern Tethys Tectonic Domain	Xiaowei FU	C203-204	2024-08-28 10:45	2024-08-28 11:00	1869
Characteristics and Resource Potential of East Indonesia Basin Group in Eastern Tethys: A Comprehensive Assessment	Shijie ZHAO	C203-204	2024-08-28 14:30	2024-08-28 14:45	1867
Two-stage oil accumulation in the Ediacaran Dengying Formation at central Sichuan Basin: Insights from dolomite U-Pb and pyrobitumen Re-Os dating	Bin DENG	C203-204	2024-08-28 14:45	2024-08-28 15:00	1866
Organic petrological and geochemical characteristics of lower Paleozoic marine shale	Sherry (Xiaowei) Zheng	C203-204	2024-08-28 15:00	2024-08-28 15:15	1883
Structure and Stratigraphic Architecture of Lake Edward Basin, Uganda: Implications for Petroleum System Analysis	Lauben TWINOMUJUNI	C203-204	2024-08-28 15:15	2024-08-28 15:30	1882
A machine learning method reveal the variations of organic matter enrichment mechanisms of freshwater vs. saline lacustrine oil shales driven by paleoclimate	Man LU	C203-204	2024-08-28 15:30	2024-08-28 15:45	1874
Structural characteristics and evolution processes of intracratonic strike-slip faults: A case from the Gaoshiti-Moxi area, central Sichuan Basin, SW China	Qingqi ZHAO	C203-204	2024-08-28 15:45	2024-08-28 16:00	1881
Post-rifting uplift and inversion of intra-plate basin: implication from the Doseo basin, Central Africa	Yifan SONG	C203-204	2024-08-28 16:15	2024-08-28 16:30	1865

Title	Presenter	Venue	Start	End	Page
Charging and leakage of natural gas in the YL13-1 structure, Qiongdongnan Basin	Yongbin QUAN	C203-204	2024-08-28 16:30	2024-08-28 16:45	1872
Genetic mechanism and pore evolution of deeply-buried high-quality conglomerate reservoirs of the Paleocene Kongdian formation, Bozhong Depression, Bohai Bay basin	Xiaojun PANG	C203-204	2024-08-28 16:45	2024-08-28 17:00	1877
Integration of Rock physics and Geological processes in reservoir Properties Characterization. A case study applied on Plutonio Field of the West African Congo Basin	Mukhtar HABIB	C203-204	2024-08-28 17:00	2024-08-28 17:15	1879
GASEOUS ANOMOLIES FOUND IN AGRICULTURE FIELD AROUND SAGAR Distt., SOUTHERN FRINGES OF BUNDELKHAND REGION, MADHYA PRADESH. INDIA	AKANKSHA SAHU	C203-204	2024-08-28 17:15	2024-08-28 17:30	1885
Characteristics of effective fracture development in deep-ultra-deep reservoirs and its impact on gas reservoir productivity	Xixue ZHANG	C203-204	2024-08-28 17:30	2024-08-28 17:45	1886
Petroleum system development in the Iranian Zagros Basin in response to the Neo-Tethys evolution	Tianhou LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1888
Hydrocarbon charging process and phase evolution in the lower to middle Jurassic in Qiudong Sag, Turpan-Hami Basin, NW China: A response under the closure of the Paleo-Tethys Ocean	Shuxin QIN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1890
Characteristics and control factors of high poroperm carbonate reservoir of Mishrif Formation in the United Arab Emirates	Beiwei LUO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1892
Influence of multi-stage volcanic events on the Late Cretaceous-Paleogene reservoirs and its geological significance in the northern Central Myanmar Basin	Zengyuan Zhou	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1894
Segmented activity of the Shuntuoguole Low Uplift strike-slip fault zone and its impact on oil and gas charge events: Constraints from calcite veins containing hydrocarbon inclusions	Mengting HANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1895
Multiple hydrocarbon accumulation model around Sangtamu fault zone in Lunnan area, Tarim Basin	GANG PENG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1896
Hydrocarbon complex formation model around the periphery of the Lunnan fault zone in the Lunnan area of the Tarim Basin	Maogeng TIAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1898
In-Situ U-Pb Dating and Geochemical Characterization of Multi-Stage Calcite Cementation in the Upper Cretaceous Mishrif Formation, Mesopotamian Basin, Iraq: Constraints on Diagenetic, and Paleo-Oil Filling Events	HUAN WANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1900
Main Controlling Factors on Cambrian Dolomite from the Tarim basin, northwest China: implications for Ultra deep Reservoir	Xuelian YOU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1902
The hydrocarbon charging history and accumulation model of deep buried carbonate reservoirs in Yuqi area, Tarim Basin, Northwestern China	Zhiyi TIAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1904
The basic model and controlling factors of hydrocarbon enrichment in deep buried carbonate reservoirs: A case study of Tuoputai area in the Tarim Basin, Northwest China	Honglei XIE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1906
Geological structure of the Cenozoic strata of the Fergana region in the light of oil and gas prospects	Radjabov SHUKHRAT	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1909
Reunderstanding Of Hydrocarbon Generation Evolution And Hydrocarbon Generation Potential Of Lower Cambrian Source Rocks In Tarim Basin	Shiyang ZHOU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1911
Cretaceous prototype basins, lithofacies paleogeography of Tethys region and their controlling on oil and gas accumulation	Tongfei HUANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1912
Geochemical characteristics and accumulation model of natural gas in the Cenozoic Bohaibay basin	Bo Yang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1914
Influence of tectonic activity on petroleum enrichment：Take organic-rich shale reservoirs for example	xiaoshi LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1915
Ancient alkaline lacustrine formation mechanism and distribution characteristic of Fengcheng Formation in Junggar Basin, Northwestern China	Yunxian FENG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1916
Two pulsed activities of the Emeishan large igneous province in southwestern China inferred from dolomite U-Pb geochronology and significance	Di XIAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1918
Discovery, formation, and significance of the basement ancient uplift in the South Yellow Sea Basin	Qingxun WU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1919
Discovery and Geological Significance of Ancient Crystalline Basement in the South Yellow Sea Basin, Eastern China	Jian REN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1920
Discovery of Early Paleozoic “Rifting Troughs” in the South Yellow Sea and Its Significance for Oil and Gas Exploration	Jian REN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1921
New evidence of post Indosinian tectonic evolution in the South Yellow Sea Basin in eastern China	Jian REN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1922
Characteristics and Petroleum Geological Significance of Neoproterozoic Granite in the South Yellow Sea Basin, China	Ying GUO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1923
The relationship between Structural Fracture Development and Hydrocarbon Accumulation in the Foreland Basin under the Tethys Evolution: Examples from the Kuqa Foreland Basin	LI SHANMING	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1925

Title	Presenter	Venue	Start	End	Page
Research on the genesis and characterization methods of non-horizontal fluid surface in oil and gas reservoirs in the Middle East	XIAO DU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1926
Bedding-parallel stylolites as a proxy for the sealing capacity of deep-burial carbonate cap rocks in the Tarim Basin, NW China	Jun WU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1927
S8 Metamorphic fluid mineralization and Ore Remobilization		Session Chair: Scientific Program Committee			
[Keynote] Metamorphic fluids and varieties of orogenic-type gold mineralisation	Andrew TOMKINS	C102	2024-08-29 14:30	2024-08-29 14:50	1948
[Invited] A predictive exploration framework for primary and metamorphosed IOCG and affiliated critical and precious metal deposits in Metasomatic iron and alkali-calcic mineral systems	Jean-Francois MONTREUIL	C102	2024-08-29 14:50	2024-08-29 15:10	1943
The orogenic Mo deposit overprinted by gold mineralization	Nuo LI	C102	2024-08-29 15:10	2024-08-29 15:25	1928
Metamorphic fluids and orogenic-type gold mineralization	Richen Zhong	C102	2024-08-29 15:25	2024-08-29 15:40	1929
The lithium behavior of during prograde metamorphism: implications for optimal crustal sources for mineralization	Ming XIAO	C102	2024-08-29 15:40	2024-08-29 15:55	1931
Protracted gold mineralization in the southern part of the Mozambique Belt: Evidence from the Nanlia and Makorongo prospects, northeastern Mozambique	Manuel NOPEIA	C102	2024-08-29 15:55	2024-08-29 16:10	1939
Orogenic gold mineralization in the Huangling region and its intimate tectonic linkage to the Neoproterozoic orogeny of South China	Huimin WANG	C102	2024-08-29 16:25	2024-08-29 16:40	1937
The polyphase development of gold mineralization in the Kibali gold district: Insights derived from the analysis of pyrite.	Yann Waku Mpaka	C102	2024-08-29 16:40	2024-08-29 16:55	1945
Sulfur and iron isotope constraints on the source of ore-forming materials of the Xiajiadian sediment-hosted gold deposit, China	Xu-Yang LIU	C102	2024-08-29 16:55	2024-08-29 17:10	1946
Base metal mineralisation at Agnigundala Sulphide Belt and deformation stages in Nallamalai Fold Belt, Cuddapah Basin, India	MOHD QAIM RAZA	C102	2024-08-29 17:10	2024-08-29 17:25	1950
Syn-metamorphic remobilization of stratabound Zn and Pb: a case study on the Jiashengpan deposit in northern China	Chang YU	C102	2024-08-29 17:25	2024-08-29 17:40	1941
Metal origin and redistribution of cobalt in the ore-forming fluid of sediment-hosted stratiform Cu-Co deposits: Evidence from geochemistry of sulfides from the Shizishan deposit, SW China	Wenbo LI	C102	2024-08-29 17:40	2024-08-29 17:50	1933
Saline fluids drive Cu mineralization in the Precambrian metasediments in the Trans-North China Orogen	Hong-Rui Fan	C102	2024-08-29 17:50	2024-08-29 18:05	1935
The origin of the pyrite-pyrrhotite veins at Rampura Agucha, India.	Don CHATTERJEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1952
Evolution of the metamorphic fluid in the ca. 1.89 Ga augen orthogneiss from the East European Craton	Laurynas Š ILIAUSKAS	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1953
REE and Nb remobilization during post-ore metamorphism of the giant Bayan Obo deposit	Long HAUNG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1955
In situ major, rare earth elements and U-Pb ages of apaite from orogenic Dongkeng gold deposit, Yunkai Massif, South China: implications for mineralization	Guozheng ZHANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1956
Study on the Geochronology and Geochemistry of concealed granite in Tongmukeng Tin deposit in Yunshan, Jiangxi province	MENGQI JIN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1958
Deposit-scale controls of disseminated-type orogenic gold mineralization in high-grade metamorphic turbidites from the Damara belt, Namibia.	Josia Shilunga	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1960
Geochronological and sulfide geochemical evidence for gold mineralization related to post-collisional magmatism in the Wulonggou goldfield of the East Kunlun Orogen, northern Tibet	Qilin WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1961
Fluid Inclusion Characterization of the Quartz Vein in Mineralized Banded Iron Formation of Hiriyur Formation, Dharwar Craton	MANJU SATI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	1962
S9 Promoting best practice in utilization of Geo resources (including Mineral, Water and Energy)		Session Chair: Asim Amitabh Pradhan			
[Keynote] Pyrophyllite as substitute raw material for future Industrial Development in India	ASIM PRADHAN	C104	2024-08-26 16:00	2024-08-26 16:15	1965
Synthesis of Kudremukh Iron Ore Mine Tailings based on Geopolymer Aggregates using Fly ash as Precursor in Construction Industry	Ramaraju H K	C104	2024-08-26 16:15	2024-08-26 16:30	1964
Ultrasonic Leaching: A Green Leaching Technology of Clay-Type Lithium Resources in Salt Lakes	KAISHENG XIA	C104	2024-08-26 16:30	2024-08-26 16:45	1968
UNLOCKING HIDDEN RICHES: NEW METHODS FOR REPURPOSING MINING WASTE IN UZBEKISTAN	Shukhrat Rayimovich SHUKUROV	C104	2024-08-26 16:45	2024-08-26 17:00	1963
Assessing the Impacts of Coal Mining on water quality in the Talcher Region, Angul District, Orissa, India	ARUN NAIK	C104	2024-08-26 17:00	2024-08-26 17:15	1967
The Role of Pyrophyllite in Advanced Materials: A Critical Review of Current Trends	BISWANATH SAHOO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1969
Exploration of geothermal resources by using geophysical method in the north of Changbaishan Mountain	Yan Wu GUAN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	1970
S10 Geo-Resources in Sustainable (Economic) Development		Session Chair: Prabodha Ranjan Sahoo			
[Keynote] Geo-Resources in Sustainable Development	AFIA AKHTAR	C203-204	2024-08-28 08:00	2024-08-28 08:15	1976

Title	Presenter	Venue	Start	End	Page
Geological and technogenic support of the combined exploitation and preservation of the environment during the development of ore deposits.	Marat BITIMBAYEV	C203-204	2024-08-28 08:15	2024-08-28 08:30	1973
Integrated and Multidisciplinary geoscientific mapping of the Limpopo Greenstone Belts, South Africa	Ndivhuwo Cecilia Mukosi	C203-204	2024-08-28 08:30	2024-08-28 08:45	1978
Hydrocarbon prospect in parts of the Nagapattinam sub-basin in the Cauvery Basin, deciphered from the biostratigraphy and source rock characterization	Ashish SARKAR	C203-204	2024-08-28 08:45	2024-08-28 09:00	1971
Push and Pull factors as predictors of entrepreneurial dynamics in artisanal and small-scale mining: a case study on industrial mineral exploitation in South Africa	Ndivhudzannyi Rembuluwani	C203-204	2024-08-28 09:00	2024-08-28 09:15	1975
Effects of foreign direct investment and Belt and Road Initiative on the mining industries in the ASEAN countries	JI WON MOON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	1980
S11 Marine Mineral deposits, science, resources, technology, and environmental challenges, a look to the future		Session Chair: Scientific Program Committee			
The distribution of platinum in ferromanganese crusts and nodules at different depth of the Suda Guyot, Western pacific	Yanhui DONG	C203-204	2024-08-29 08:00	2024-08-29 08:15	1981
Microstratigraphic characterization of mineral diversity of hydrogenetic ferromanganese crusts in the Northwestern Pacific seamounts.	Akira USUI	C203-204	2024-08-29 08:15	2024-08-29 08:30	1983
Seabed mining for a sustainable future	Fani SAKELLARIADOU	C203-204	2024-08-29 08:30	2024-08-29 08:45	1984
Contribution of Multiple Metal Sources to the Formation of Hydrothermal Chimney and Mound in the Mirae-2 Vent Field, Central Indian Ridge	Sun Ki CHOI	C203-204	2024-08-29 08:45	2024-08-29 09:00	1987
Brothers volcano submarine hydrothermal system: upper parts of a porphyry Cu system	Cornel DE RONDE	C203-204	2024-08-29 09:00	2024-08-29 09:15	1988
Morphology-Driven Magnetic Properties in Coastal Ferromanganese Concretions	Joonas WASILJEFF	C203-204	2024-08-29 09:15	2024-08-29 09:30	1990
Morphological Diversity and Its Influence on Geochemical Properties of Ferromanganese Concretions from the Baltic Sea	Joonas VIRTASALO	C203-204	2024-08-29 09:30	2024-08-29 09:45	1992
Mapping and studying the European seabed minerals for sustainable development	Francisco Gonzalez	C203-204	2024-08-29 09:45	2024-08-29 10:00	1993
New Developments of the Seabed Mineral Resources Research on the Norwegian Continental Shelf	Harald Brekke	C203-204	2024-08-29 10:00	2024-08-29 10:15	1995
Towards the first licensing round for seabed minerals on the Norwgian continental shelf - a knowledge-based and stepwise approach	Harald Brekke	C203-204	2024-08-29 10:15	2024-08-29 10:30	1997
In-situ monitoring reveals the vertical stratification characteristics of sediment plume in deep-sea mining	zhihan Fan	C203-204	2024-08-29 10:30	2024-08-29 10:45	1999
A first estimation of resource abundance in the Korea CFC contract area	Gyuha HWANG	C203-204	2024-08-29 10:45	2024-08-29 11:00	1986
In-situ Geotechnical Properties of Abyssal Sediments and Implications for Polymetallic Nodule Mining	Zhenggang LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2000
Quantifying the rare earth element enrichment process of bioapatite in deep-sea REY-rich sediments	Hao Wang	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2002
Hydrothermal activity within seafloor hydrothermal vent fields along the Southwest Indian Ridge	Weifang YANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2004
Potential Impact of Polymetallic Nodules Deep Sea Mining on the World Commodity Markets	Anna LAPTEVA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2005
MARINE PLACER OCCURRENCES AND ASSOCIATED CRITICAL RAW MATERIALS IN RIAS BAIXAS (NW SPAIN)	Francisco González	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2007
Magnetite concentration in serpentinite from the Central Indian Ridge, a tracer of natural H2 formation	Wonnyon KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2009
The comparative analysis of rare earth oxide amount in terrestrial ore deposits and deep-sea sediments	Hyosang KWON	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2010
Depth-dependent variations in paleoceanographic records of the ferromanganese nodules in the Arctic Ocean: High-resolution Raman spectroscopic study	Sangmi LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2011
Baltic Sea ferromanganese concretion growth rates and conditions in laboratory experiment	Renata MAJAMÄKI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2012
Cobalt-rich Ferromanganese Crusts from the Southwest Canary Islands Seamounts: Mineralogy and Geochemistry of Strategic and Critical Elements	Egidio Marino	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2014
S12+S16 Novel approaches to modelling a sustainable and integrated minerals value chain		Session Chair: Lequn ZHANG			
[Keynote] Fundamentals Enabling Integrated Mining Value Chains	Kerry TURNOCK	C104	2024-08-27 08:00	2024-08-27 08:15	2022
Bayesian linear regression with Gaussian mixture likelihood for outlier detection of metal grades	Yufu NIU	C104	2024-08-27 08:15	2024-08-27 08:30	2016
Multiscale variance prediction of metal grade for sortability assessment of bulk ore sorting in Cu deposit	Yufu NIU	C104	2024-08-27 08:30	2024-08-27 08:45	2017
Enhancing named entity recognition in geoscience by using a domain-specific schema	Sandra Paula VIILLACORTA CHAMBI	C104	2024-08-27 08:45	2024-08-27 09:00	2018
Identifying and Quantifying Indirect Trade Flows of Commodities	Jamie BRAINARD	C104	2024-08-27 09:00	2024-08-27 09:15	2019

Title	Presenter	Venue	Start	End	Page
Leveraging Bayesian Hierarchical Models to Mitigate the Impact of Mineral Exploration Uncertainty on the Mineral Value Chain	Lequn ZHANG	C104	2024-08-27 09:15	2024-08-27 09:30	2020
Overview of key Mineral requirements in the era of Intelligent vehicles: taking Software-defined vehicles as an example	Zizhan CHEN	C104	2024-08-27 09:30	2024-08-27 09:45	2023
Quantitative assessment of exploration criteria: A case study from the Yilgarn Craton in Western Australia	Mosayeb KHADEMI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2024
Phosphogypsum stacks from Năvodari (Romania) as secondary resource	Aurora Maruta IANCU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2025
Geochemical fingerprinting of Cobalt and Nickel along the battery value chain: coupled information from trace elements and sulfur isotopes	Yuan Shang	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2027
Soil organic matter loss due to anthropogonic activities in settlement area in Forest steppe and Gobi region of Mongolia	Telmen TURMUNKH	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2029
S13 Geometallurgy		Session Chair: Raimon Tolosana-Delgado			
Geometallurgy for the Energy Transition	Kathryn Goodenough	C102	2024-08-28 14:30	2024-08-28 14:45	2030
Combination of geostatistical ore grade, RQD, and lithotype models for geometallurgical optimization of a tin deposit	Sylvie RAHARISOLONJANAHARY	C102	2024-08-28 14:45	2024-08-28 15:00	2033
A 2D predictive geometallurgical model of a tailings storage facility	Raimon TOLOSANA-DELGADO	C102	2024-08-28 15:00	2024-08-28 15:15	2034
Machine learning assisted geostatistical modelling of geometallurgical domains	Ute MUELLER	C102	2024-08-28 15:15	2024-08-28 15:30	2035
The processing behaviour of the sphalerites from the Big Syncline deposit, South Africa	Gloria Boikanyo MOTLOBA	C102	2024-08-28 15:30	2024-08-28 15:45	2031
Analyzing Refractory Gold and Deleterious Elements in Historical Witwatersrand Tailings: Implications for Gold Extraction Strategies	Steve Jason CHINGWARU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2036
ROLE OF IN-SITU TECHNIQUES IN IRON ORE MINERAL BENEFICIATION	P V SUNDER RAJU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2037
Forms of ore bodies in the Pirmirab mine	Anzor MAKHAMMATOV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2039
Refractory gold ore characterization of the Bonanza-Sandy vein system, Maco Mine, Masara Gold District, Eastern Mindanao, Philippines	JILLIAN AIRA GABO-RATIO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2041
S14 Ore-forming Magmatic Hydrothermal Systems: analysis of source to sink in deposit genesis		Session Chair: Scientific Program Committee			
[Keynote] Facts and myths about orthomagmatic ore deposits	Vadim Kamenetsky	C102	2024-08-27 08:00	2024-08-27 08:15	2067
Controls on the formation of porphyry Mo, Cu and Au deposits in the Qinling Orogenic Belt, central China	Li TANG	C102	2024-08-27 08:15	2024-08-27 08:30	2042
Investigating Chodarchay porphyry-epithermal deposit, NW Iran: Using EPMA and fire-assay minor/trace element data	Majid GHADERI	C102	2024-08-27 08:30	2024-08-27 08:45	2045
Iron-oxide apatite deposits formed by accumulation of magmatic hydrosaline liquids	Xin-Fu ZHAO	C102	2024-08-27 08:45	2024-08-27 09:00	2050
Lead-lead dating reveals Permian granite-induced high-grade niobium mineralization at Bayan Obo	Lan YANG	C102	2024-08-27 09:00	2024-08-27 09:15	2052
Overlapping Alkalic Porphyry Cu-Au and Magnetite-Apatite mineralization in the Iron Mask Batholith, British Columbia, Canada	Andres Felipe GONZALEZ DURAN	C102	2024-08-27 09:15	2024-08-27 09:30	2054
Recycled fluids in magmas of continental-collisional porphyry Cu deposits: Insights from mercury isotopes	Bo XU	C102	2024-08-27 09:30	2024-08-27 09:45	2055
Evolution of pyrite and Cu-Fe-sulphides in the Olympic Dam Cu-U-Au-Ag deposit, South Australia: Evidence from micron-scale EBSD study coupled with LA-ICP-MS analysis	Samuel King	C102	2024-08-27 09:45	2024-08-27 10:00	2058
Oligocene magmato-tectonic events influential in the development of Pb-Zn, Ag and Au mineralization at the Plomosas deposit, southwestern Sierra Madre Occidental, Mexico	Paula MONTOYA LOPERA	C102	2024-08-27 10:00	2024-08-27 10:15	2062
Three-stage niobium mineralization at Bayan Obo, China	Yan YU	C102	2024-08-27 10:15	2024-08-27 10:30	2063
Mineralization and remobilization of heavy rare earth elements in carbonatite rocks: insights from in situ elemental and Sr–S isotopic compositions of sulfate minerals	Si-Qi LIU	C102	2024-08-27 10:30	2024-08-27 10:45	2064
Origin of fluids in the Lancangjiang tin belt, southwestern Yunnan, China: evidence from trace elements and boron isotopic compositions of tourmaline	Yiting ZHU	C102	2024-08-27 10:45	2024-08-27 11:00	2044
[Keynote] Rare metal deposits related to magmatic hydrothermal processes in China	Shao-Yong JIANG	C102	2024-08-27 14:30	2024-08-27 14:45	2048
Cl-rich hydrothermal fluid interaction for scapolite formation in copper deposits of Aravalli-Delhi Fold belt, western India	Prabodha SAHOO	C102	2024-08-27 14:45	2024-08-27 15:00	2061
Investigation of mineralogy, geochemistry, and fluid inclusions of the Ghalozendan iron deposit, Azerbaijan province, NW Iran	Soqra RASTI	C102	2024-08-27 15:00	2024-08-27 15:15	2066
Open System Boiling of Saline Fluids form Salt-rich Ionic Melts: implications for formation of some IOA-IOCG systems	David LENTZ	C102	2024-08-27 15:15	2024-08-27 15:30	2071

Title	Presenter	Venue	Start	End	Page
The role of magmatic sulfide floatation in the formation of seafloor massive sulfide deposits: Insights from the Fatu Kapa volcano in the NW Lau back-arc basin	Jung-Woo PARK	C102	2024-08-27 15:30	2024-08-27 15:45	2070
Paleoarchean volcanogenic massive sulfide (VMS) mineralization in the Nondweni Greenstone Belt, Kaapvaal craton: Direct links to submarine felsic eruptions, not to komatiites	Sebastian TAPPE	C102	2024-08-27 15:45	2024-08-27 16:00	2069
Magmatic initial and saturated water thresholds determine copper endowments: insights from apatite F-Cl-OH compositions	Yingcai SUN	C102	2024-08-27 16:15	2024-08-27 16:30	2068
GENETIC CLASSIFICATION OF SAUSAR GROUP, CENTRAL INDIA: A HOLISTIC APPROACH	SANJOY KUMAR SARKAR	C102	2024-08-27 16:30	2024-08-27 16:45	2043
Magmatic-Hydrothermal Evolution at the Kuh-e Janja Porphyry Cu-Au Deposit, Southeastern Iran: Relative Timing of Hypogene Cu Mineralization from Vapor-Like, Near-Critical Density, Single-Phase Fluids	Majid SOLEYMANI	C102	2024-08-27 16:45	2024-08-27 17:00	2046
FELSIC VOLCANIC HOSTED COPPER-GOLD MINERALIZATION AT MUNDIYAWAS-KHERA AREA, ALWAR BASIN, WESTERN INDIA: A PROSPECTIVE MODEL FOR EXPLORATION	ISRAIL KHAN	C102	2024-08-27 17:00	2024-08-27 17:15	2056
Jurassic-Cretaceous W-Sn polymetallic ore formation and exhumation in South China: Tectonic-magmatic-metallogenic models	Huan LI	C102	2024-08-27 17:15	2024-08-27 17:30	2060
Geological aspects of the Manto type copper deposits in the Sabzevar metallogenic zone, NE Iran	Susan EBRAHIMI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2073
Practical assessment of ore-magmatic systems of Greater Altai	Oxana KUZMINA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2075
Regularities of formation, prognostic criteria of gold-sulphide formation deposits in East Kazakhstan	Marina MIZERNAYA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2076
New evidence for the intrusion-related gold deposit origin of Luanjiahe deposit in Jiaodong Peninsula, China	Xiaofeng Yao	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2078
Caledonian Granites in the Longhua Ni-Co Deposit, South China : Tectonic Setting and Its Relationship with Mineralization	Hejun TANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2080
The critical mineral potential of the Kennedy Igneous Association: Petrogenesis, tectonic setting, and metallogeny	JONGHYUN LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2082
Sulfur and lead isotope geochemistry of granitoid rocks in the Taebaeksan Mineralized District, South Korea	Byeongyong YU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2084
The Genesis of the San Francisco Manganese Deposits, Jalisco, Mexico: Geological Insights and Mineralogical Signatures	Genesis RAMOS GARCIA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2085
Cathodoluminescence, trace element and fluid inclusion studies of the ginguro-bearing crustiform veins in the Hokuryu Ag-Au deposit, Hokkaido, Japan	Omar SOBERANO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2087
Hyper-enrichment of gold via quartz fracturing and growth of polymetallic melt droplets: example from the Xiaoqinling lode gold district, central China	Wei Jian	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2088
Fluid Evolution of the Wunugutushan Porphyry Copper-Molybdenum Deposit in Inner Mongolia: Insights from Quartz Fluid Inclusions and Muscovite Compositional Studies	Xiangkai CHU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2089
New geochronological constraints on the giant Nurkazgan porphyry Cu-Au deposit, Central Kazakhstan	Haoxuan FENG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2091
S15 Lithocaps and high sulfidation epithermal deposits		Session Chair: Peter Hollings			
Geology, alteration and mineralization of the Pemberton Hills porphyry system, Canada: anatomy of a lithocap	Pete HOLLINGS	C102	2024-08-26 16:30	2024-08-26 16:45	2093
Nature and Characteristics of Gold Deposit of Bhitar Dari Area of Gorumahisani-Badampahar Greenstone Belt of Iron Ore Group, East Singhbhum District, Jharkhand, India.	PANKAJ KUMAR	C102	2024-08-26 16:45	2024-08-26 17:00	2095
The formation of gold-rich goethite and hematite in an epithermal gold deposit	Feng-Xia HUANG	C102	2024-08-26 17:00	2024-08-26 17:15	2097
Alunite and pyrite mineral chemistry vectoring to high-grade Au-Ag orebodies associated with the Martabe lithocap in Sumatra arc, Indonesia	Wei Hong	C102	2024-08-26 17:15	2024-08-26 17:30	2099
S17 Rare criticals metal geochemistry and mineral deposits		Session Chair: David Lentz			
Extreme low-T fractionation of felsic magmas and implications for rare-metal deposit genesis: analysis of regional thermal considerations and internal high heat production	David LENTZ	C102	2024-08-28 16:00	2024-08-28 16:15	2110
South African coal and coal by-products as potential alternative sources for rare earth elements: A case study of the Ermelo, Soutpansberg, Tuli, Utrecht and Waterberg coalfields	Christopher Baiyegunhi	C102	2024-08-28 16:15	2024-08-28 16:30	2101
The volcanic-hosted beryllium deposits in eastern China: Tectonic setting, Ages and Metallogenic potential	Xiaofeng LI	C102	2024-08-28 16:30	2024-08-28 16:45	2102
The chemical composition of helvine-group minerals and implications for the genesis of beryllium deposit: cases studies from Dawan, Qidushan and Taoxikeng deposits, southeast China	Yiting ZHU	C102	2024-08-28 16:45	2024-08-28 17:00	2103
Li-Rb-Cs mineraliztion of granite-pegmatite in the Gyirong-Nyalam region, Tibet and its significance	Fangyang HU	C102	2024-08-28 17:00	2024-08-28 17:15	2104
A preliminary study on the beryllium mineralization in the southern Great Xing'an Range, northeastern China	Yu-Sheng Zhu	C102	2024-08-28 17:15	2024-08-28 17:30	2105

Title	Presenter	Venue	Start	End	Page
Volcanic-hosted hydrothermal rare earth element (REE) mineralisation, West Musgrave Province, Australia	Ben James Kimpton	C102	2024-08-28 17:30	2024-08-28 17:45	2112
Rare metal (REE, Nb, Ta) deposits hosted by carbonatite and alkaline complexes: A Canadian perspective	Anne-Aurélie Sappin	C102	2024-08-28 17:45	2024-08-28 18:00	2108
Rare Metals in Coals of Far East of Russian: Concentrations & Resources in Coal deposits	VLADIMIR ILICH VYALOV	C102	2024-08-28 18:00	2024-08-28 18:15	2106
In-situ U-Pb Dating of Apatite in Heima Pegmatite-hosted Lithium Deposit, West Yunnan	Yong YU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2113
Mineralogy of the REE-rich carbonatite complexes in Khotgor, South Mongolia	Bingbing GAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2115
Zircon and cassiterite U-Pb geochronology, Hf isotopes and geochemistry characteristics of Xianglushan rubidium-rich granite complex and its geological significance, northeast Guangxi , China	Yupeng HUO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2117
Allanite crystallization inhibits economic rare earth element mineralization in carbonatites.	SOURAV BHATTACHARJEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2119
Modification of magmatic-hydrothermal tin deposits by ductile shearing: Example of the Jiufeng and Nandaoao tin deposits of northern Guangxi, south China	ZuoHai FENG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2121
THE ZONE OF JUNCTION OF OIL AND GAS BEARING STRUCTURES AND URANIUM PROVINCES	Rakhimjan TURSUNMETOV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2123
Beryl chemistry as a compositional framework for prospecting of rare-metal pegmatites in Nepal Himalaya	SUSHMITA BHANDARI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2125
S18 Hydrodynamic studies of mineralization		Session Chair: Scientific Program Committee			
Cycling of Uranium (U)-polymetals in Earth System and its Effect on Mineral Resources and Environment	Deru XU	C104	2024-08-27 14:30	2024-08-27 14:45	2126
Hydrodynamic relationships between shallow and deep parts of mineralization systems and implications for deep mineral exploration	Guoxiang Chi	C104	2024-08-27 14:45	2024-08-27 15:00	2128
Hydrodynamics of the Xiangshan volcanic-type uranium deposits in Jiangxi Province, South China	Zenghua LI	C104	2024-08-27 15:00	2024-08-27 15:15	2130
Genetic association between carbonates and gold precipitation	Teng Deng	C104	2024-08-27 15:15	2024-08-27 15:30	2131
Numerical modeling of the formation of ore shell by ore-forming materials enrichment in porphyry copper deposits	Changhua XIE	C104	2024-08-27 15:30	2024-08-27 15:45	2133
The influence of basin fluid activity on the mineralization process of sandstone-type uranium deposits	Taping He	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2134
S19 Mineralogy and Ore deposits in Alp-Himalaya belt		Session Chair: Shohreh Hassanpour			
Low-crustal juvenility and continental-slab shallow subduction control the formation of post-collisional porphyry Cu systems in east Tibet	Zengqian HOU	C203-204	2024-08-29 14:30	2024-08-29 14:45	2137
Deep process and lithospheric architectural control of Cu-REE mineralization in the Gangdese and Sanjiang collisional belts	Rui WANG	C203-204	2024-08-29 14:45	2024-08-29 15:00	2140
Porphyry Copper Deposits Main Characteristics in Iran	Maryam AHANKOUB	C203-204	2024-08-29 15:00	2024-08-29 15:15	2141
The Characteristics and Origin of Barite in the Giant Mehdiabad Zn–Pb–Ba Deposit, Iran	Yingchao LIU	C203-204	2024-08-29 15:15	2024-08-29 15:30	2135
W-Mo porphyry deposit Ochtiná-Rochovce (Western Carpathians, Slovakia) - lithological and mineralogical characterization	Peter Koděra	C203-204	2024-08-29 15:30	2024-08-29 15:45	2138
S20 Metallogeny and Geodynamics of East and SE Asia		Session Chair: Khin Zaw			
Multiple mineralization and geodynamics of the Nanyangtian tungsten deposit, SW China: Constraints from structural deformation and geochronology	Da ZHANG	C102	2024-08-28 08:00	2024-08-28 08:15	2149
Copper skarn mineralization related to reduced monzodioritic magma at the Huanren deposit, northeastern China	Hegen Ouyang	C102	2024-08-28 08:15	2024-08-28 08:30	2147
Gold Deposits of the Jiaodong Peninsula, Eastern China	Kunfeng QIU	C102	2024-08-28 08:30	2024-08-28 08:45	2151
Magmatic history in the Suyoc prospect: Implications to hydrothermal mineralization in the Mankayan Mineral District, north Luzon, Philippines	JILLIAN AIRA GABO-RATIO	C102	2024-08-28 08:45	2024-08-28 09:00	2157
Geodynamics of Late Mesozoic giant decratonization-related gold mineralization in the North China Craton	Jin-Hui YANG	C102	2024-08-28 09:00	2024-08-28 09:15	2146
Bimodal volcanism and massive sulfide deposition in the mid-Miocene Hokuroku Rift of NE Japan	Andrea Agangi	C102	2024-08-28 09:15	2024-08-28 09:30	2158
Role of chalcophile element fertility in the formation of post-collisional porphyry Cu deposits in the eastern Tethyan domain	Hongda Hao	C102	2024-08-28 09:30	2024-08-28 09:45	2161
Magma fertility of the Wuntho–Popa arc belt: implication for porphyry Cu mineralization in Myanmar	Jing-Jing Zhu	C102	2024-08-28 09:45	2024-08-28 10:00	2160
Eruption Style, Mineralization and Geohazard of Mt Popa Volcano, central Myanmar	Khin ZAW	C102	2024-08-28 10:00	2024-08-28 10:15	2144
Geodynamic settings of formation and metallogeny of gold in the Altai-Sayan folded area (Southern Siberia)	Alexandr CHERNYKH	C102	2024-08-28 10:15	2024-08-28 10:30	2142
Exploration Potential of Antimony Deposits in Myanmar: Insights from Fluid and Stable Isotope Geochemistry of the Lyhamyar Sb Deposit, Eastern Myanmar	Aung Min OO	C102	2024-08-28 10:30	2024-08-28 10:45	2152

Title	Presenter	Venue	Start	End	Page
Mineralogy, Geochemistry, and Origin of Green Jasper in Northeastern Region of Cambodia	Seang Sirisokha	C102	2024-08-28 10:45	2024-08-28 11:00	2154
Characteristics and Timing of Migmatite Structures Exposed along the Kyaikkhami Beach area, Thanbyuzayat Township, Mon State, southern Myanmar	Zin Mar OO	C102	2024-08-28 11:00	2024-08-28 11:15	2155
Origin of pegmatite-related gem deposits, northwestern part of Pyetkaywe Batholith, Myittha Townships, Mandalay Division, Myanmar	Yin Yin MYINT	C102	2024-08-28 11:15	2024-08-28 11:30	2156
U–Pb and Hf-isotope analysis of zircons and Molybdenite Re-Os Dating in Gao'aobei Tungsten-molybdenum Ore, Southern Hunan Province , South China	Yanbin WANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2162
U-Pb geochronology, trace elements and Sr-Nd isotope geochemistry of the gold deposit in the Rangnim Massif, North Korea: a model for hydrothermal ore genesis	LEI XU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2163
Biogenic mediated pyrite formation in the Shinyemi Skarn Fe polymetallic deposit, South Korea	Naing Aung KHANT	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2165
Geochemical characteristics of antimony and tungsten mineralization of the Doi Ngom deposit, northern Thailand	Karn Phountong	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2166
Linking two types of breccia bodies to sedimentary rock-hosted stratiform copper (SSC) and iron oxide-copper-gold (IOCG) deposits in the Kangdian metallogenic belt, SW China	Xue-Qing YIN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2167
Robust age constraints on the Carlin-type gold and Skarn-type W deposits in the Youjiang basin of China: Implications for their genetic linkage and future exploration	WEI GAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2168
Metal sources of sediment-hosted antimony deposits: Evidence from antimony isotopes	Shanling FU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2169
S21 Uranium, thorium and related atomic energy minerals resources		Session Chair: Deepak Kumar Sinha			
[Keynote] Unusual multi-metallic uranium deposits in India: Their potentialities.	DEEPAK SINHA	C102	2024-08-29 08:00	2024-08-29 08:30	2171
Analysis and prediction of supply guarantee for the development of world nuclear power	SONG Jiye	C102	2024-08-29 08:30	2024-08-29 08:45	2185
A new exudation metallogenic model for uranium deposit in the red-mottled sedimentary sandstone system in northern basins of China	Ziying LI	C102	2024-08-29 08:45	2024-08-29 09:00	2174
Late Cretaceous-Cenozoic tectonic-sedimentary evolution and U-enrichment in the southern Songliao Basin	Shaoyi WANG	C102	2024-08-29 09:00	2024-08-29 09:15	2182
Trapping of uranium by organic matter within sandstones during mineralization process: A case study from the Shuanglong uranium deposit, China	Fan Zhang	C102	2024-08-29 09:15	2024-08-29 09:30	2170
Trans-strata mineralization of sandstone-hosted uranium deposits triggered by neotectonics	Yinhang CHENG	C102	2024-08-29 09:30	2024-08-29 09:45	2183
Sandstone-type uranium deposits hosted in the aeolian sandstone: Taking an example of the Pengyang-Jingchuan deposit in the Ordos Basin, China	YIN CHEN	C102	2024-08-29 10:00	2024-08-29 10:15	2172
Determination of radon exhalation rate of uranium ore samples from sandstone-hosted uranium deposits	Nanping WANG	C102	2024-08-29 10:15	2024-08-29 10:30	2184
Analysis on Uranium Metallogenic Conditions and Prospect Review of the Langka-Daladi Aera in Eastern Part of Southern Margin of Yili Basin, North China	SONG JI Jiye	C102	2024-08-29 10:30	2024-08-29 10:45	2176
Genesis of high-grade uranium deposits in Motianling Neoproterozoic granites from northern Guangxi Province, South China: Constraints from in situ micro-chronology, sulfur isotope and trace elements analysis	Yongjian WANG	C102	2024-08-29 10:45	2024-08-29 11:00	2177
Uranium mineral systems in Brazil	Hugo POLO	C102	2024-08-29 11:00	2024-08-29 11:15	2180
Uranium mineralization age constraint by indirect dating of syn-ore gangue minerals: a case study from a Na-metasomatite uranium deposit in Northwest China	Jun ZHONG	C102	2024-08-29 11:15	2024-08-29 11:30	2179
Thorium and Uranium ore occurrences of Georgia (The Caucasus): A comparative analysis and Prospects	Avtandil OKROSTSVARIDZE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2186
Occurrence and geochemical characteristics of uraniferous soil in Maninsan area, South Korea	Jinah Lim	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2188
Mineralogy of residual and redeposited uranium in the boreholes of in-situ leaching uranium mining	Anna Vladimirovna SASHCHENKO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2189
New frontiers of multi-scale uranium exploration in Brazil. Case studies: Rio Cristalino and Itataia regions.	Isabelle Cavalcanti Corrêa de Oliveira SERAFIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2191
Research on the verification method of weak information of airborne gamma spectrometry for sandstone-type uranium exploration	LIANCHENG SHI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2193
A Study on the Uranium-Radium Equilibrium Coefficient of Barun Sandstone-Hosted Uranium Deposit, Inner Mongolia	Aimin PENG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2195

Title	Presenter	Venue	Start	End	Page
Types and spatiotemporal distribution characteristics of uranium deposits in China	Yuqi CAI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2196
S22 Iron Mineral System		Session Chair: Scientific Program Committee			
BIF-hosted iron ore: A mineral system review	Steffen HAGEMANN	C203-204	2024-08-29 16:00	2024-08-29 16:15	2202
The complex origin of the Proterozoic Varena Iron Ore deposit in the SW East European Craton, southern Lithuania: implications from microstructures, mineral chemistry and isotope study	Grazina SKRIDLAITE	C203-204	2024-08-29 16:15	2024-08-29 16:30	2197
Mineralogy, mineral chemistry, and Fe-O isotope geochemistry of IOA-style mineralization and wall-rock alteration at the Yangyang deposit in the central-eastern Korean Peninsula	Heonkyung IM	C203-204	2024-08-29 16:30	2024-08-29 16:45	2199
Timing of iron skarn mineralization by U-Pb dating of Ca-Fe garnets	Ekaterina SALNIKOVA	C203-204	2024-08-29 16:45	2024-08-29 17:00	2201
S23 Navigating the Path to the Green Transition: Balancing Resource Extraction and Environmental Stewardship		Session Chair: Christopher Keane			
[Keynote] Envisioning 2050: Strategic Scenarios for the Global Raw Materials Landscape	Christopher KEANE	C203-204	2024-08-30 08:00	2024-08-30 08:15	2205
Mining to meet the challenge of Net Zero	David MANNING	C203-204	2024-08-30 08:15	2024-08-30 08:30	2206
Mechanochemical processing of silicate rocks to trap CO2	Zoe SHIPTON	C203-204	2024-08-30 08:30	2024-08-30 08:45	2212
High-tech metals are key elements for future technologies – What are the challenges and how are their global market situations ?	Volker STEINBACH	C203-204	2024-08-30 08:45	2024-08-30 09:00	2204
Critical raw materials extraction in environmentally protected areas	Vitor Correia	C203-204	2024-08-30 09:00	2024-08-30 09:15	2208
Ukrainian Salt Sector: Strategy for Post-War Recovery, Sustainable Development, and Advancement of Salt Resources as Input in Green Transition Technologies	Larysa BOSEVSKA	C203-204	2024-08-30 09:15	2024-08-30 09:30	2210
Mineral resource abundance index: Towards responsible cosmetic ingredients and use of minerals in downstream industries	Nicolas CHARLES	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2213
S24+S6 HTHP geofluid-rock interactions, mass circulation and deep hydrocarbons in sedimentary basins		Session Chair: Scientific Program Committee			
[Keynote] Mixing processes and patterns of fluids in alkane-CO2-water systems under high temperature and high pressure—Microscopic visual physical thermal simulations and molecular dynamics simulations	Guanghui YUAN	C203-204	2024-08-30 09:30	2024-08-30 09:45	2219
Diagenetic Processes and Low-Permeability Tightening Mechanisms of Reservoirs in the Paleogene Deep Layers under High-Temperature and High-Variability Conditions in the Baiyun Sag, Pearl River Mouth Basin	Xiaoyang Zhao	C203-204	2024-08-30 09:45	2024-08-30 10:00	2220
Lamina-scale diagenetic mass transfer in lacustrine organic-rich shales and the impacts on shale oil reservoir formation	Kelai Xi	C203-204	2024-08-30 10:00	2024-08-30 10:15	2218
Fluid-rock interaction of deep hydrothermal fluids and its reservoir response in carbonate rocks: A case study from the Ordovician in the Tarim Basin	Jian WANG	C203-204	2024-08-30 10:15	2024-08-30 10:30	2226
Research on exploration technology of sandstone-type uranium deposits in Erlian Basin based on airborne magnetic, aeroradiomeairborne gamma spectrometry and gravity surveys	LIANCHENG SHI	C203-204	2024-08-30 10:30	2024-08-30 10:45	2224
Origin of carbonate cements and their control on sandstone reservoir quality in the First Member of the Eocene Shahejie Formation, Bohai Sea, East China	Xiaojun PANG	C203-204	2024-08-30 10:45	2024-08-30 11:00	2215
Influence of diagenetic fluid on glutenite reservoirs: a case study of the Junggar Basin, China	Zhiguo MAO	C203-204	2024-08-30 11:00	2024-08-30 11:15	2217
Oxidation of hydrocarbons in deep strata of continental sedimentary basins: Evidences, mechanism, and geological implications	Xun KANG	C203-204	2024-08-30 11:15	2024-08-30 11:30	2222
The influence of microscopic petrological characteristics on fracability of tight sandstone in the Yanchang Formation of the Longdong Area, China	Xiaoming SHI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2228
Impact of CO2 influx on sandstone reservoir quality: A case study of the Quantou Formation, southern Songliao Basin, China	Zheng Cao	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2229
Characteristics and origin of deep and ultra-deep high-quality clastic reservoirs in the steep slope zone of the Minfeng sub-sag, Dongying Sag, China	Jiageng LIU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2230
Study on the Main Controlling Factors of Effective Reservoirs in Tight Beach Bar Sand Oil Reservoirs in the Dongying Depression	Huafeng ZHANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2232
Mixing processes of the oil-water-CO2 systems in different fluid phases: Insights to CO2 sequestration in depleted hydrocarbon reservoirs	Zihao JIN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2234
Study on Diagenetic Fluids and Reservoir Evolution of Near Source Glutenite Reservoirs, Bozhong Depression Paleogene	Jin HU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2236
Synergistic diagenesis and shale oil enrichment patterns in the Chang 73 sub-member of Triassic Yanchang Formation in the Ordos Basin	Xiaobing NIU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2238
The impact of burial dissolution on the development of ultra-deep fault-controlled carbonate reservoirs: Insights from high-temperature and high-pressure dissolution kinetic simulation	Xiaolin TAN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2239

Title	Presenter	Venue	Start	End	Page
The Stability of the CO2-H2O-Dawsonite-Bearing Sandstone Reaction System: Experimental Study And Thermodynamic Simulation	Kaining WANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2240
The use of Airborne Geophysics in Mineral Exploration	Alla DIAW	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2242
Superimposed transformation by multiple types of fluids during diagenesis in ultra-deep carbonate reservoirs	Leilei Yang	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2244
S25 Advances and Innovations in Uranium Exploration and Resource Evaluation. (A special session in memory of the late Dr. K. Kyser)		Session Chair: Adrienne Hanly			
[Keynote] IAEA activities supporting capacity building and innovations in uranium resources, processing and mining	Adrienne Hanly	C104	2024-08-27 16:00	2024-08-27 16:30	2251
Significant Progresses and Prospects in Innovation of Uranium Geology in China Since 2000	Mingkuan QIN	C104	2024-08-27 16:30	2024-08-27 16:45	2249
Progress in the extraction and integration of uranium mineralization information in the basin	Yu RENG-AN	C104	2024-08-27 16:45	2024-08-27 17:00	2250
The relationship between Meso–Cenozoic tectonic-fluid evolution and sandstone type uranium mineralization in Kuqa Depression, Tarim Basin, western China	NIAN LIU	C104	2024-08-27 17:00	2024-08-27 17:15	2248
The role of transient processes in the generation of giant uranium deposits	Patrick LEDRU	C104	2024-08-27 17:15	2024-08-27 17:30	2246
S26 General Topics		Session Chair: Scientific Program Committee			
Ore mineralization of some gold deposits of Mongolia: Gold mineralization linking to the crystal forms	MUNGUNTULGA PUREVSUREN	C203-204	2024-08-30 13:45	2024-08-30 14:00	2252
Nanoparticles Observed by TEM from Gold, Copper-Nickel and Silver Deposits and and Their Significance for Mineral Exploration in Covered Terrains	Bimin ZHANG	C203-204	2024-08-30 14:00	2024-08-30 14:15	2263
Sources of dissolved solutes and physico-chemical conditions of fluorite (± barite) mineralisation at Dongargaon, India: Constraints from geochemical study of bulk rock and hydrothermal minerals	PANKAJ VAIDYA	C203-204	2024-08-30 14:15	2024-08-30 14:30	2259
Reinterpretation and 3D visualization of Pine Creek Orogen (NT, Australia)	Gemma Mitjanas	C203-204	2024-08-30 14:30	2024-08-30 14:45	2258
Analysis of the Safety Situation of Potash Resources in China and Suggestions for Global Cooperation	YAN ZHANG	C203-204	2024-08-30 14:45	2024-08-30 15:00	2264
Ultramafic-Hosted Magnesite Deposits in Southern Peninsular India: Spectral and Stable Isotopic Insights	HARITHA A	C203-204	2024-08-30 15:00	2024-08-30 15:15	2261
The role of mineral-related industries in Chinese industrial pattern	Weidong LI	C203-204	2024-08-30 15:15	2024-08-30 15:30	2253
Simulation Analysis of Supply Crisis Propagation Based on Global Nickel Industry Chain	Xingxing WANG	C203-204	2024-08-30 15:30	2024-08-30 15:45	2254
GEOLOGICAL-GEOCHEMICAL MODEL OF THE DAUGYZ GOLD DEPOSIT (SOUTHERN TIEN SHAN, CENTRAL KYZYLKUM)	JAKHONGIR MOVLANOV	C203-204	2024-08-30 15:45	2024-08-30 16:00	2255
Research on the impact of global mineral trade structure on national economy	XIAN XI	C203-204	2024-08-30 16:00	2024-08-30 16:15	2257
First row transition metals deportment in Cretaceous karst bauxite: the case of the southern Italy and Sardinia Island deposits	Giovanni MONGELLI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2265
Potential Natural Hazards of Mineral Facility and Effect of Mineral Production Using Geospatial Data for Asia-Pacific Region	Jaewon CHUNG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2267
The impact of oil decoupling between EU and Russia on the pattern of global oil trade under the Russia-Ukraine military conflict	Xiu WANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2268
Copper-Gold Mineralization in a Covered Basement Complex of North Delhi Terrane, Rajasthan: Implication towards Mineral Potential of Basement Rocks	Arindam MISRA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2269
Genesis of Gold mineralization in Sonakhan Greenstone Belt, Bastar Craton, India: constraints with fluid inclusion studies.	Sathyavani C	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2271
Combined Study of Gold-Bearing Arsenopyrite of Orogenic Gold Deposits: High Resolution 3D X-ray Computed Tomography, LA-ICP-MS and EMPA Analyses	Evgeny NAUMOV	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2273
The National Geological Plan of Angola (PLANAGEO)	José GARCÍA LOBÓN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2275
Mineral chemistry of tourmaline associated with the Zawar Zn-Pb deposit, Rajasthan, India	ARKODEEP SENGUPTA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2276
Development Characteristics and Preservation Mechanism of Primary Pores in Ultra-deep Cretaceous Reservoirs in the Kelasu Structural Belt of the Kuqa Depression	Shilong LI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2277
Characteristics of Source Rocks and Formation of Reservoir Bitumen in Yinchuan Graben, Ordos Basin, China	Qingmeng FU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2279
Cross-layer propagation of natural fractures in finely laminated shale	huawei LI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2280
Fluid migration through an intensively overpressured diapir in the Yinggehai Basin, South China Sea	zhifeng GUO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2281
New Re-Os molybdenite age for the Erdenetiin Ovoo Cu-Mo ore field, North Mongolia	Baatar MUNKHTSENGEL	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2282
Element Distribution and REE Dispersal in Sandstone-Hosted Copper Mineralization within Oligo-Miocene Strata, NE Iran: Insights from Lithostratigraphy and Mineralogy	MOSTAFA FEIZ	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2284

Title	Presenter	Venue	Start	End	Page
Relationship between vegetation canopy and selected ore bodies of Iran	Shahindokht ABOLMAALI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2286
T13 Mineralogy					
S2 Gemstone and Geological Formation		Session Chair: Chakkaphan SUTTHIRAT, Youngchool Kim			
A New Approach for Detecting Heat Treatment of Sapphire	Teerarat PLUTHAMETWISUTE	C104	2024-08-28 08:00	2024-08-28 08:15	2287
Ageing Characterization and Origin Traceability of archaeological amber artifacts via FTIR spectroscopy and Pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS)	Yan LI	C104	2024-08-28 08:15	2024-08-28 08:30	2290
Chemical Composition and origin of color in Black and Black Cyan Nephrite from Margou Deposit, Qiemo county, Xinjiang, China	Ting FANG	C104	2024-08-28 08:30	2024-08-28 08:45	2292
The Structure of Natural Opal-A: An Insight through Synchrotron X-ray Diffraction and Pair Distribution Function Analysis	Seungyeol LEE	C104	2024-08-28 08:45	2024-08-28 09:00	2293
Fast identification of imitation pearls against cultured pearls using hyper near-infrared spectroscopy	JINHEE LEE	C104	2024-08-28 09:00	2024-08-28 09:15	2296
Unusual mixed characteristics of sapphires from magmatic deposits in Muling, Northeast China	Yimiao Liu	C104	2024-08-28 09:15	2024-08-28 09:30	2297
Beyond Jewelry: The Quantum Realm of Diamonds	Hyunmin CHOI	C104	2024-08-28 09:30	2024-08-28 09:45	2298
The Special Color Effect in “Chameleon” Amber and its main Fluorescence Component	Yan LI	C104	2024-08-28 09:45	2024-08-28 10:00	2299
Chemistry defect, the clue to understand colorations in gem corundum varieties and more	Pornsawat WATHANAKUL	C104	2024-08-28 10:00	2024-08-28 10:15	2302
Unusual Synthetic Overgrowth on Natural Rose-Quartz Crystal Aggregate	Thanapong LHUAAMPORN	C104	2024-08-28 10:15	2024-08-28 10:30	2295
The color center of beryllium-treated blue sapphires	Natthapong MONARUMIT	C104	2024-08-28 10:30	2024-08-28 10:45	2301
Observation of characteristics of synthetic diamonds in ultraviolet illuminating	EUNOK JO	C104	2024-08-28 10:45	2024-08-28 11:00	2300
ANCIENT NEPHRITE QUARRY NEWLY DISCOVERED: CHARACTERIZATION OF NEPHRITE FROM SANWEI MOUNTAIN, GANSU PROVINCE, WESTERN CHINA	YUE SU	C104	2024-08-28 11:00	2024-08-28 11:15	2289
Comprehensive Spectral and Chemical Characterization of Amber from Xixia, Henan Province	Yan LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2304
BLUE SAPPHIRE GENESIS AND CHARACTERIZATION OF BAW MAR GEM DEPOSIT, MOGOK TOWNSHIP, MYANMAR	Arkar Moe MYINT	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2306
Mahan Carnelian beads production techniques and sociopolitical significance of long-distance trade	JINA HEO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2307
Hauyne of an Unusually Rare Green Color	BUDSABAKORN SRISATAPORN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2308
Transparent and Bright Greenish-Blue Sodalite: An Extremely Rare Gemstone	Kannatee FUEANGAKSORN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2310
Influence of Electron Radiation on Colour Modification and Colour Stability of Pink Sapphires: A Preliminary Study	WARATCHANOK SUWANMANEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2311
S3+S1+S5 Geochemistry, Isotopic Characteristics, and Geochronology of Gem deposits		Session Chair: Scientific Program Committee			
Baddeleyite SK10-2 and Rutile KNW: Two natural reference materials for microbeam U-Pb geochronology	Shitou WU	C104	2024-08-29 08:00	2024-08-29 08:15	2312
Agrominerals and food security in Africa	Olugbenga Okunlola	C104	2024-08-29 08:15	2024-08-29 08:30	2313
Trace element in blue sapphire: Challenge or potential of element analyses by LA-ICP-TOF-MS for origin determination?	Wei ZHOU	C104	2024-08-29 08:30	2024-08-29 08:45	2317
Geochronology of diamond formation in the mantle and its relation to geodynamics	Felix Kaminsky	C104	2024-08-29 08:45	2024-08-29 09:00	2315
Three natural reference materials for in situ andradite U–Pb geochronology	Yueheng Yueheng YANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2319
Different origins of garnet in high-grade metamorphic rocks	Qiong-Xia XIA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2320
Paragenesis of Alteration/Zoning in Meta-Sedimentary Chromite from the Singhbhum Craton, Eastern India.	Asish Kumar DAS	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2321
Petrological and structural characterisation controlling gold mineralization in the northern part of the Kon Tum massif, Central Highlands of Vietnam	THÀNH VŨ-TIẾN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2322
Age of the South Ural mines: U-Pb ID-TIMS garnet dating	Yulia PLOTKINA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2323
Review on geochemical, metallogenesis, and geodynamic studies for the origin and mineralisation potential of rare metal pegmatites of Côte d'Ivoire (West Africa).	Felix Oufouet KONAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2325
MINERALOGICAL FEATURES OF GOLD ORES OF THE SARYJAY AREA (BUKANTOU MOUNTAINS, CENTRAL KYZYLKUM)	SHOKHIDA SAMANDAROVA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2327

Title	Presenter	Venue	Start	End	Page
The origin of olivine in kimberlite inferred from variably compositional zoning in kimberlite from Karowe mine, Botswana	Wentao Cao	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2328
Enhancing Ceramic Quality through Mineralogical Adjustments in Highly Silicic Clays: A Case Study from Brunei Darussalam	Elena IFANDI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2329
S4 Environmental Mineralogy: From Understanding To Application		Session Chair: Scientific Program Committee			
Molecular-scale understanding of the sorption structure and reactivity of heavy metals at mineral-water interfaces		C104	2024-08-28 14:30	2024-08-28 14:45	2341
Understanding the facet-mediated molecular-level interactions between antimony (III and V) oxyanions and boehmite (γ-AlOOH) based on the physicochemical properties of mineral		C104	2024-08-28 14:45	2024-08-28 15:00	2331
Atomistic structure models of nanocrystalline vernadite mineral		C104	2024-08-28 15:00	2024-08-28 15:15	2333
Effect of Ca-containing byproducts generated during interzeolite transformation on the sequestration and release of Cs		C104	2024-08-28 15:15	2024-08-28 15:30	2334
On the crystal structures and thermodynamics of Sr-bearing calcite		C104	2024-08-28 15:30	2024-08-28 15:45	2336
Sorption of thorium, cesium, and lead onto secondary iron minerals and clay minerals		C104	2024-08-28 15:45	2024-08-28 16:00	2337
Abiotic Catalytic Reaction Dominance in Manganese Removal from an Acidic Mine Water		C104	2024-08-28 16:00	2024-08-28 16:15	2339
Efficient Seawater Splitting with Ni-based Oxyhydroxide Catalysts: A Computational Perspective		C104	2024-08-28 16:15	2024-08-28 16:30	2343
Replacement of Calcium Carbonate ($CaCO_3$) Polymorphs by Cerussite ($PbCO_3$)		C104	2024-08-28 16:30	2024-08-28 16:45	2344
Solid Substrate-Induced Variations in the Heterogeneous Formation of Mn Solid Phases		C104	2024-08-28 16:45	2024-08-28 17:00	2345
Insights into the Origin of Pyrite in the Sediments of Brunei Darussalam		C104	2024-08-28 17:00	2024-08-28 17:15	2346
Characterization of Phosphate in Total Suspended Particles (TSP) at Seoul, South Korea	Seungsoo LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2347
Effects of different tunnel cations on adsorption, occurrence, and mobility of water in palygorskite	Jinhong ZHOU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2349
Investigation of characteristic heavy metal contamination of roadside dusts in Daejeon, Korea: Impacts of car tire, brake pad and traffic paint on the elevated levels of Zn, Cu, Sb and Cr	Seon Yong LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2350
Molecular simulations of CO_2 and H_2 insertion into palygorskite	Juhyeok KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2352
Mineralogical Study of Bentonite Transformation Under High Temperatures	SeEun CHANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2353
Laboratory-scale reproduction of Smectite-Illite transformation using Bentonil-WRK	Mi Rae KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2354
The Alteration of Fault Gouge with Supercritical CO_2: Changes in Fault Stability by Carbon Sequestration	Yuna LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2355
S6 Silicate melts, magmas, and non-crystalline earth materials in Earth and Planetary Surfaces and Interior		Session Chair: Razvan CARACAS, Sung Keun LEE			
[Invited] Planetary melts: constraining viscosity via the glass transition.	Donald B. Dingwell	C104	2024-08-29 14:30	2024-08-29 14:45	2364
[Invited] How do transition elements influence viscosity of glasses, melts and lavas?	Daniel R. NEUVILLE	C104	2024-08-29 14:45	2024-08-29 15:00	2358
An improved structural model of silicate melts and magmas probed with NMR spectroscopy: implications for planetary sciences	Jeongjae LEE	C104	2024-08-29 15:00	2024-08-29 15:15	2357
Probing the short- to medium range structures of simplified Ti-rich lunar glass using NMR spectroscopy: implication for lunar mantle dynamics	Elias EL GHAZAOUI	C104	2024-08-29 15:15	2024-08-29 15:30	2361
The pyrolite melts of the early Earth: structure, compressibility, viscosity, volatile content	Razvan CARACAS	C104	2024-08-29 15:30	2024-08-29 15:45	2360
[Invited] A multiscale simulation study of supercritical geofluids	Xiandong LIU	C104	2024-08-29 15:45	2024-08-29 16:00	2359
Speciation of carbon in silicate melts at high pressure up to 8 GPa	Eun Jeong KIM	C104	2024-08-29 16:00	2024-08-29 16:15	2365
Bonding transitions in amorphous oxides at multi-Mbar: Insights into the structure of oxide melts in Earth's and super-Earth's Interiors	Yong-Hyun Kim	C104	2024-08-29 16:15	2024-08-29 16:30	2362
The possible role of gold-rich colloids in the formation of high-grade supergene gold ores	Yafei WU	C104	2024-08-29 16:30	2024-08-29 16:45	2366
Variations of atomic structures and mechanical properties of natural opal-CT-based geopolymers with synthesis conditions	Hyo-Im KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2368
Structure of silica glasses under ultrahigh pressure: ab-initio calculations of nuclear magnetic resonance properties	Jae-Hyeon PARQ	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2369
MAGMATOMIX: a highly efficient post-processing tool for analyzing molecular dynamics simulations	Razvan CARACAS	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2370
Evolution of Li environment in partially molten magmas during fractional crystallization: A view from solid-state NMR spectroscopy	Seoyoung LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2371
Comparative study on phase transition of zeolite in subducting slabs by hydrous and anhydrous environments	HYUNSEUNG LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2372
Mechanochemical amorphization of clay minerals: Understanding the role of low-crystalline fault gouge in slip behaviour	Hyun Na KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2374

Title	Presenter	Venue	Start	End	Page
The distribution of H2O bubbles in hydrous albite melts at 0.5 GPa with varying temperature and water contents	Yerin Jeon	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2375
S7 Gem materials		Session Chair: Stefanos KARAMPELAS, SPC			
Gem Materials with Unusual Optical Properties	Andy H SHEN	C104	2024-08-30 08:00	2024-08-30 08:15	2391
The study of external morphology and internal zonal structure of spinel law contact twinned natural macle diamond.	Ahmadjan ABDURIYIM	C104	2024-08-30 08:15	2024-08-30 08:30	2388
An "agate"-like mixed-habit diamond from Yuan River, Hunan, south-central China	Xinwei LIU	C104	2024-08-30 08:30	2024-08-30 08:45	2390
Spectroscopic Analysis of Defects in Photochromic Yellow Sapphire	Yunqi Yang	C104	2024-08-30 08:45	2024-08-30 09:00	2381
Detecting epigenetic iron staining in ruby and sapphire by using Raman spectroscope	Wei ZHOU	C104	2024-08-30 09:00	2024-08-30 09:15	2385
Amphibole inclusions in emeralds	Stefanos Karampelas	C104	2024-08-30 09:15	2024-08-30 09:30	2376
Enhanced Provenance Determination of Turquoise through Comparative Analysis of XRF and LA ICP MS Techniques Coupled with Machine Learning	Bahareh SHIRDAM	C104	2024-08-30 09:30	2024-08-30 09:45	2389
Analysis of the chemical composition of red gem garnets in ancient jewellery by Raman and hand-held X-ray fluorescence spectrometry for origin determination	H. Albert Gilg	C104	2024-08-30 09:45	2024-08-30 10:00	2392
Study of Garnets in GrecoRoman Jewellery from the Collections of Archaeological Museum of Thessaloniki.	Stefanos Karampelas	C104	2024-08-30 10:00	2024-08-30 10:15	2383
Four thousand years of gem garnet trade in NW Africa	H. Albert Gilg	C104	2024-08-30 10:15	2024-08-30 10:30	2379
Gemological Characteristics and Heat Treatment of Trapiche-like Sapphires from Changle, Shangdong province, China	Xiaojing LAI	C104	2024-08-30 10:45	2024-08-30 11:00	2380
A Correlation of Clay Minerals Distribution Map with Jasper Impurities Using Satellite Data in Garut, West Java, Indonesia	Kemala WIJAYANTI	C104	2024-08-30 13:45	2024-08-30 14:00	2387
Geochemistry of blue fluorescence from golden amber in response to thermal maturity	Jing YU	C104	2024-08-30 14:00	2024-08-30 14:15	2377
Accessory minerals under rock-fluid interaction conditions and remobilization of rare lithophile elements in felsic magmatic and metamorphic systems	Martin ONDREJKA	C104	2024-08-29 09:30	2024-08-29 09:45	2408
Unraveling the role of impurities and thermal energy in sapphire structural relaxation: Insights from Raman spectroscopic analysis of heat-treated specimens	Seung Kwon LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2394
XRF and Photoluminescence combined as a tool in the determination of the origin of Colombian emeralds	JAVIER GARCIA TOLOZA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2397
A Study of Turquoise Origins Based on Trace Elements and LDA Method: a Case Study of Liangzhu Culture-related Sites in China	YAN JIANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2398
Synthesis of silica spheres with homogeneous size distribution by electrospray-assisted Stöber method for the fabrication of opal photonic crystals	JUNGMIN KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2400
ICE JADE FROM GUATEMALA	Tao CHEN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2402
Investigation of Traps in Electron-irradiated Sapphire: Insights from Thermoluminescence and Fluorescence Spectrum	Yuyang ZHANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2403
Effect of Fe2O3 Core/SiO2 Shell Nanoparticle Pigments Doping Ratio on the Color of Synthetic Precious Fire Opal	Bowen Li	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2404
Anisotropic photoluminescence in ruby and chrysoberyl	Linling DONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2406
Spectroscopic and DFT study of the orientational order of water molecule and its influence on the coloration of beryl	SUNGJAE KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2407
Formation, identification and color grading of Nanhong agate from the Southwestern of China	Chaowen Wang	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2395
S8 General Topics		Session Chair: Scientific Program Committee			
Hyperspectral Imaging: An effective mineral mapping tool for apatite in the Upper Zone, northern limb, Bushveld Complex	Clement NDOU	C104	2024-08-29 09:45	2024-08-29 10:00	2410
Platinum-group minerals, an experimental overview	Anna VYMAZALOVA	C104	2024-08-29 10:00	2024-08-29 10:15	2412
Natural Radioactivity of the Mesozoic Granites in the Southern Part of the Korean Peninsula	Chaewon KIM	C104	2024-08-29 10:15	2024-08-29 10:30	2413
Reaction Between Feldspar and Water Under the Mantle Transition Zone Conditions	Yeonhak JUNG	C104	2024-08-29 10:30	2024-08-29 10:45	2414
A high-precision measurement method for analyzing Sr, Nd and Sm isotope ratios in single-grain minerals	Guiqin WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2415
ASSESSMENT OF GOLD PROSPECTS AT EXPLORATION OBJECTS IN UZBEKISTAN	Vladimir TSOY	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2416
APOCARBONATE TYPE OF GOLD MINERALIZATION IN UZBEKISTAN, CONDITIONS OF FORMATION AND PREVALENCE	Bobir ISLAMOV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2418
Crystal Structure of Canfieldite	Guanghua Liu	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2420
Minerals in Thin Section (MINTS) – An open-access interactive website for transmitted-light petrographic microscopy	Juergen REINHARDT	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2421

Title	Presenter	Venue	Start	End	Page
Semi-quantitative analysis of minerals in manganese nodule from the Magellan seamount cluster in Western Pacific Ocean	Jeongmin KONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2423
Relationship between distributions of the extra-framework species and adsorption capacity for CO2 gas on synthetic mordenite.	Soojin LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2424
Infrared behavior of phlogopite from some magnesian skarns in the Banatitic Magmatic and Metallogenetic Belt from Romania	Cristina SAVA GHINET	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2425
Structure vs. FTIR and Raman behavior of spodumene from Conţu (Lotru Mountains, South Carpathians, Romania)	Stefan MARINCEA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2427
TOURMALINE AS AN INDICATOR MINERAL FOR BASE METAL AND ASSOCIATED MINERALIZATION IN SUPRACRUSTAL ROCKS OF NORTH SINGHBHUM MOBILE BELT	MANSI JAIN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2429
Structure vs. FT-IR and Raman behavior of wollastonite-2M ("parawollastonite") from Cerboaia Valley, Măgureaua Vaţei (Metaliferi Massif, Apuseni Mountains, Romania)	Delia DUMITRAS	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2431
Mineralogical variations of shallow manganese nodules in the East Siberian Sea with respect to water depth	Hyo-Jin KOO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2433
Occurrence of Perovskite-magnetite hosted REE mineralization in Jashora Ultramafic Alkaline Complex, West Karbi Hills, Assam, India.	TAPAN PATOWARY	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2435
Mineral chemistry and trace element variations in index minerals around pyrophyllite deposit in the Mailar village, Lalitpur district, Uttar Pradesh.	MADHUMITA BANERJEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2436
A Comparison Study of Quantitative analysis and Morphology of Microlites in the Obsidians Using Electron Probe Micro Analysis	JIN MI-EUN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2437
Mineralogical studies of iron ore deposits of Sonhari member of Eocene age, Laki Formation, Sindh, Pakistan	Muhammad Hassan AGHEEM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2438
The component analysis and U-Pb dating of cassiterite using LA-(MC)ICP-MS	YounJoong JEONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2440
Production of Montmorillonite Nanosheets using high-energy ball milling: A Study on Milling Methods and Solvent Effects	Bo Gyeong PARK	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2441
T14 Low Temperature Geochemistry					
S1 Challenges and Opportunities of Global-Scale Geochemical Mapping (4th Arthur Darnley Symposium)		Session Chair: Anna LADENBERGER, Maria João Batista			
[Keynote] International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network	ALECOS DEMETRIADES	M316	2024-08-27 14:30	2024-08-27 15:00	2444
The Geochemical Mapping of Ireland: Geological Survey Ireland's Tellus Programme - results, challenges, and outcomes.	Ray Scanlon	M316	2024-08-27 15:00	2024-08-27 15:15	2448
Geochemical Map of Latin America and the Caribbean. Methods for implementation	Maria João Farinha Batista	M316	2024-08-27 15:15	2024-08-27 15:30	2449
Determination of Rare Earth Element Baselines in the Brunei Darussalam Soils.	Haezan JANGARUN	M316	2024-08-27 15:30	2024-08-27 15:45	2464
Soil geochemical mapping of the Aotearoa New Zealand convergent margin	Mark Rattenbury	M316	2024-08-27 15:45	2024-08-27 16:00	2450
Geochemical Mapping in Sweden – establishing baselines at national to local scales	Anna LADENBERGER	M316	2024-08-27 16:00	2024-08-27 16:15	2456
Why stop at the regolith? Plants as an active geochemical mapping sampling media	David Cohen	M316	2024-08-27 16:15	2024-08-27 16:30	2446
Challenges and Opportunities in Compiling a Complete Africa Geochemical Database for Medical Geology Applications	Theophilus Clavell DAVIES	M316	2024-08-27 16:30	2024-08-27 16:45	2465
A COMPREHENSIVE REVIEW OF ABANDONED MINING WASTE FACILITIES TO ASSESS THE REPRESENTATIVENESS OF THEIR SAMPLING	Paula ADANEZ-SANJUAN	M316	2024-08-27 16:45	2024-08-27 17:00	2460
Spatial Distribution of Copper, Iron and Arsenic in soil from the Okahandja 2116 map area in Otjozondjupa Region, Namibia	Badumisa Vicious SIBOLILE	M316	2024-08-27 17:00	2024-08-27 17:15	2454
PLANAGEO-Methodology to conduct a geochemical survey for mineral exploration in SW Angola	Maria João Farinha Batista	M316	2024-08-27 17:15	2024-08-27 17:30	2458
Addressing the problem of microplastic contamination in soil: Challenges during separation and recovery of natural and anthropogenic organic polymers.	Ariadne ARGYRAKI	M316	2024-08-27 17:30	2024-08-27 17:45	2452
Cadmium content in soils of the Upper Silesia Region – an analysis based on geochemical mapping in Poland	Irena Agnieszka WYSOCKA	M316	2024-08-27 17:45	2024-08-27 18:00	2462
State of the art of global geochemical mapping in Mozambique	Vicente Albino MANJATE	M316	2024-08-27 18:00	2024-08-27 18:15	2443
Overview of geochemical mapping in the Geological Surveys of Ibero-America.	Iván MARTÍN-MÉNDEZ	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2467
Nonlinear nature-based localization criteria for the resource potential assessment and interpretation of the anomalous structural-geochemical fields	Igor SPIRIDONOV	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2470
THE RESOURCE POTENTIAL ASSESSMENT OF SOLID MINERALS BASED ON THE RESULTS OF MULTI-PURPOSE GEOCHEMICAL MAPPING OF THE TERRITORY OF RUSSIA	Viktor KILIPKO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2471

Title	Presenter	Venue	Start	End	Page
Continental-scale distribution of niobium and tantalum in catchment sediments throughout China: Prospecting implications from the China geochemical Baselines project	Hanliang Liu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2472
USE OF NATIONAL SCALE GEOCHEMICAL DATA FOR THE DEVELOPMENT OF A GEOSTATISTICAL METHODOLOGY FOR INTERACTION ANALYSIS OF VARIABLES AT DIFFERENT SCALES	Paula ADANEZ-SANJUAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2468
S2 Application of metal isotope fractionation in low temperature geochemistry		Session Chair: Kideok KWON, Wei Li			
K isotope separation based on liquid solution centrifugation and its application to cation exchange experiments between birnessite and aqueous solution	Jiayang CHEN	M316	2024-08-26 16:00	2024-08-26 16:15	2474
Comprehensive assessment of Cu, Mo, Pb, and Zn isotopes in contaminated groundwater, surface water, and soil in Erdenet city, Mongolia	Dukmin KIM	M316	2024-08-26 16:15	2024-08-26 16:30	2475
The Cenozoic Seawater Conundrum: New constraints from Mg isotopes	Zhongya HU	M316	2024-08-26 16:30	2024-08-26 16:45	2477
Experimental determination of kinetic isotope fractionation during chemical diffusion of alkaline and alkaline-earth elements in aqueous solution	Weiqiang LI	M316	2024-08-26 16:45	2024-08-26 17:00	2479
Stable chromium isotope fractionation during the alteration of abyssal peridotite: Implications for marine chromium isotope mass balance	LiJuan Li Xu	M316	2024-08-26 17:00	2024-08-26 17:15	2480
Applying standard addition to measure antimony isotopes in low-Sb samples using HG-MC-ICP-MS	Jian-Ming ZHU	M316	2024-08-26 17:15	2024-08-26 17:30	2481
Lithium rich salt lakes in small-scale basin on the Qinghai Tibet Plateau——Tracing by lithium isotope	Maoyong HE	M316	2024-08-26 17:30	2024-08-26 17:45	2482
Links between the Archean anoxic continental weathering and the Great Oxidation Event	KE SHAN	M316	2024-08-26 17:45	2024-08-26 18:00	2483
Tracing meltwater discharge with Ba isotopes from West Greenland fjords	Ruifang C. XIE	M316	2024-08-26 18:00	2024-08-26 18:15	2484
Cadmium Isotope Fractionation during Adsorption onto Edge Sites and Vacancies in Layered Manganese Dioxides	Hui YIN	M316	2024-08-26 18:15	2024-08-26 18:30	2485
Coupling of Molybdenum, Barium, and Sulfur (Mo-Ba-S) biogeochemistry in demarcating past methane seepage episodes	aninda mazumdar	M316	2024-08-26 18:30	2024-08-26 18:45	2486
Equilibrium metal isotopic fractionations at the calcite-water interface	SANGBO SON	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2487
Zinc isotope fractionation during wastewater treatments	Jeonghun KIM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2488
Influence of estuaries on chromium isotope ratio and geochemical behavior: A study in two rivers, Kochi, Japan	Akane ITO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2489
S3 Geochemical Signatures of Earth Surface Processes		Session Chair: Scientific Program Committee			
Anthropogenic Activities Have Accelerated the Global Sulphur Cycle	Haoyang NIE	M316	2024-08-27 09:30	2024-08-27 09:45	2493
Heavy metal migration and Lithium isotope fractionation under extreme weathering of basalt on tropical Hainan Island, China	Weihua WU	M316	2024-08-27 09:45	2024-08-27 10:00	2494
Regional Geochemical Survey of the Rooikraaldam Area, Eastern Bushveld Complex, South Africa.	Mehdi BENSID	M316	2024-08-27 10:00	2024-08-27 10:15	2495
Isotopic Behavior and Distribution of Bromine and Chlorine in Evaporites: Insights from the Salina Formation in the Michigan Basin	Yon-Gyung RYUH	M316	2024-08-27 10:15	2024-08-27 10:30	2497
Geochemistry of shale, quartzite and carbonaceous shale of the Cumbum Formation of Kadapa Basin: Implications for provenance, weathering and tectonic setting	Raghunath MISHRA	M316	2024-08-27 10:30	2024-08-27 10:45	2491
Geochemistry, mineralogy, and origin of Late Cretaceous ironstone deposits, Northern Oman Mountains	Salah Al-Khirbash	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2498
Geochemical preservation of Mid-Ordovician carbonates in the Taebaeksan Basin: Insights from strontium isotope analysis	Joonseok LIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2500
Simultaneous measurement of 147Sm/144Nd and 143Nd/144Nd ratios in natural geological samples by MC-ICP-MS after one stage chemical purification using TODGA resin	Yueheng YANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2501
Submarine groundwater discharge in coastal zones of a mountainous island: the evidence of trace elements and uranium isotopes	Ruo-Mei WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2502
S4+S5 New geochemical application of Rare Earth Elements and their Isotopes in low temperature geochemical environment		Session Chair: Scientific Program Committee			
Data recovery of incomplete rare earth element data sets	David ERNST	M316	2024-08-27 08:00	2024-08-27 08:15	2503
Formation of H2 by serpentinization of (ultra)mafic rocks	Sookyung KIM	M316	2024-08-27 08:15	2024-08-27 08:30	2505
The Biogeochemical Cycle of Rhenium in the Yangtze River Basin and Perturbations by Human Activities	Yang CHEN	M316	2024-08-27 08:30	2024-08-27 08:45	2506
Geochemical significance of Eu Isotope Ratio in Carbonate rocks	Seung-gu LEE	M316	2024-08-27 08:45	2024-08-27 09:00	2507
CONTRIBUTION TO THE GEOCHEMICAL ATLAS OF THE KINGDOM OF SAUDI ARABIA: GEOCHEMICAL SURVEY OF THE MAHD ADH DHAHAB QUADRANGLE, 23E	Fawwaz AL-FIDANI	M316	2024-08-27 09:00	2024-08-27 09:15	2509
Geochemical features of intrusion related gold deposits (IRGD) in the Yana-Kolyma Gold Belt (Northeast Asia)	Anna Igorevna NESMEYANOVA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2511
Assessing fluoride occurrence in groundwater and related factors in the Eumseong Basin area	Jong Hyun OH	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2512

Title	Presenter	Venue	Start	End	Page
T15 Paleoclimate and Paleoceanography					
S1+S2 Paleoclimate and paleoceanography in the Ross Sea, Antarctica		Session Chair: Kyu-Cheul YOO, Sunghan KIM			
Glaciovolcanic processes between the Campbell Glacier and Mt. Melbourne Volcano, Antarctica: Ice and Fire	Hyun Hee RHEE	M315	2024-08-29 08:00	2024-08-29 08:15	2514
Diatom- to coccolithophore-dominant surface production shift during the MPT in the Ross Sea and its implication	Sunghan KIM	M315	2024-08-29 08:45	2024-08-29 09:00	2517
Extent of the marine-based ice sheet in the western Ross Sea during the Last Glacial Maximum	Jae Il LEE	M315	2024-08-29 08:15	2024-08-29 08:30	2515
Sensitivity of the West Antarctic Ice Sheet to +2°C (SWAIS 2C)	Jae Il LEE	M315	2024-08-29 08:30	2024-08-29 08:45	2516
Dinoflagellate cyst assemblages in surface sediments from the Ross Sea, Antarctica	So-Young KIM	M315	2024-08-29 09:00	2024-08-29 09:15	2518
Ice loss from the East Antarctic Ice Sheet in the Ross Sea during late Pleistocene interglacials	Min Kyung LEE	M315	2024-08-29 09:15	2024-08-29 09:30	2519
Enhanced terrestrial methane cycle during the early Eocene hyperthermals	Zuoling CHEN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2520
Lithium isotope evidence for enhanced weathering during the Middle Ordovician	Jena JEONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2521
Depositional records by the active glacier in the northern Drygalski Basin in the Ross Sea since the Last Glacial Maximum	Sangbeom HA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2522
S3 Recent developments in paleoclimatology		Session Chair: Jae-Il LEE			
Minor and trace elemental ratios in coral Porites lobata from Koshiki Island (Japan): evaluation of the temperature proxies	Claire Rollion-Bard	M315	2024-08-29 14:30	2024-08-29 14:45	2523
Biologically mediated trace element mobilization and isotope fractionation: Are certain redox-sensitive trace elements bio-proxies rather than redox-proxies?	Dennis Kraemer	M315	2024-08-29 14:45	2024-08-29 15:00	2525
Giant discoveries for magnetofossils from Cretaceous and Quaternary marine sediments	Courtney WAGNER	M315	2024-08-29 15:00	2024-08-29 15:15	2527
Geochemical evidence for an increased primary productivity during the Bö lling-Alleröd interstadial period compared to Holocene along the south-western continental margin of India	Busnur Rachotappa Manjunaha	M315	2024-08-29 15:15	2024-08-29 15:30	2528
A new method for quantifying astronomical forcing in paleoclimate proxies by evaluating spectral power distribution	Cheng PENG	M315	2024-08-29 15:30	2024-08-29 15:45	2529
Evolution of sea surface temperature in the North Pacific over the past 10 million years	Kyung Eun Lee	M315	2024-08-29 15:45	2024-08-29 16:00	2531
MULTIPLE MIOCENE TROPICAL STORMS RECORDS IN THE EQUATORIAL CARBONATE PLATFORM OF BRAZIL	Orangel AGUILERA SOCORRO	M315	2024-08-29 16:00	2024-08-29 16:15	2534
Land Snail Shell Morphology Records Multiple Orbital Cycles of the Asian Monsoon	RUI Bao	M315	2024-08-29 16:15	2024-08-29 16:30	2530
The effect of barrier layer's evolution in the western Pacific warm pool on the deglaciation	Shuai ZHANG	M315	2024-08-29 16:30	2024-08-29 16:45	2532
Characteristics of late Pleistocene TEX86-based temperatures in the northern Okinawa Trough	Tae Wook KO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2535
Short-term anomalous sea surface temperature events controls growth rates in giant clamshells (Tridacna maxima) of the Lakshadweep Archipelago, India	Fousiya AOUGE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2536
Cretaceous alkenones from Southern high latitudes: potential for paleoceanographic proixies	Takashi HASEGAWA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2537
Seawater temperatures, pH and water mass provenance reconstructions over the last century from cold-water coral geochemistry in the North Atlantic Ocean	Manuel RIGO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2538
Quantitative constraints on the environmental conditions of bauxite formation since Mesozoic	Xiujuan BAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2540
S4 General Topics		Session Chair: Scientific Program Committee			
Pliocene palaeoceanographic changes reconstructed by biomarker analysis of sediments from the Gulf of Alaska of the northeastern North Pacific	Kotaro HOSHI	M315	2024-08-29 09:30	2024-08-29 09:45	2541
Sediments of the Baker-Martinez fjord system (48°S) in Patagonia, Chile, reveal land-ocean interactions over the past 500 years	Javier Eduardo MALDONADO	M315	2024-08-29 09:45	2024-08-29 10:00	2543
Millennial scale variability of Indian Winter Monsoon during mid-late Holocene and its links to Solar Changes: New Evidence from Coastal sediments from Sri Lanka	Hewa Marambage Kusala Madhushani Madhushani PREMARATNE	M315	2024-08-29 10:00	2024-08-29 10:15	2547
Reconstructing Temperature Changes in the Upper Ocean of the Central South China Sea Since the Industrial Revolution Using Cold-water Corals	Xinru HUI	M315	2024-08-29 10:15	2024-08-29 10:30	2548
Late Cretaceous high-resolution sea and lake-level reconstructions based on sedimentary noise modeling: water circulation and orbital forcing	Kaixuan JI	M315	2024-08-29 10:30	2024-08-29 10:45	2550

Title	Presenter	Venue	Start	End	Page
Morphological Variations On The Growth Of Quaternary Saturnalids Radiolaria In The Antarctic Ocean	Girish Kumar SHARMA	M315	2024-08-29 11:00	2024-08-29 11:15	2546
Radiolarian Events and Palaeoceanography of Core ABP-06, Station-I (Section 6), Central Indian Ocean.	ABHISHEK KOHLI	M315	2024-08-29 10:45	2024-08-29 11:00	2545
Catastrophic Flooding during Late Holocene in Northern Bihar Plains, India: A Geo-archaeological Perspective	SHANKER SHARMA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2551
Spatial and Temporal Distribution of Typhoons during the Joseon Dynasty (1392 – 1910)	Jin Gu KANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2552
Terrestrial n-alkane and alkenones flux and its relationship with climate and paleoceanogrphy of the low-latitude Indian Ocean during the Quaternary	Sangmin HYUN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2553
The Strontium and Neodymium isotopic signatures of the Zambezi River Basin in Southern Africa: From source to sink.	Sonwabile Kidwel RASMENI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2554
Calcareous Nannofossil and Paleoclimatic Evolution Across the Eocene Oligocene Transition at IODP Site U1509, Tasman Sea, Southwest Pacific Ocean	Claudia AGNINI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2555
Paleoceanographic changes in the Western Equatorial Pacific Ocean since the latest Miocene: Insights from Planktic Foraminiferal Census Data	Ayushi RAM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2557
The evolution of Southern Benguela Upwelling System and its impact on southwest African climate during the Late Miocene	RUDRA NARAYAN MOHANTY	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2558
Grain size distribution in the Northwest Pacific deep-sea sediments: implication for rare earth elements and Yttrium enrichment	EUIJONG LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2559
T16 Coastal, Marine and Lacustrine Geosciences					
S1 Geohazard assessment from submarine landslides: a multi-stage approach		Session Chair: Seong-Pil KIM, Qiliang Sun			
[Keynote] Geohazard assessment from submarine landslides: a multi-stage approach for the Ulleung Basin	Roger Urgeles	M313	2024-08-26 16:00	2024-08-26 16:30	2561
Generation and propagation characteristics of submarine-landslide tsunami	Ao Sen	M313	2024-08-26 16:30	2024-08-26 16:45	2563
Factors controlling carbonate slope failures: Insight from stratigraphic forward modelling	Jianliang LIU	M313	2024-08-26 16:45	2024-08-26 17:00	2564
Analysing submarine landslide distribution along the Calabrian continental margins, insights from high-resolution morpho-bathymetric data.	Marco BIANCHIN	M313	2024-08-26 17:15	2024-08-26 17:30	2565
Numerical Assessment of tsunamigenesis from submarine mass movements along the slopes of Ionian Calabrian Margin (South Italy)	Xiujuan Wang	M313	2024-08-26 17:30	2024-08-26 17:45	2568
Multistage submarine landslides and their effects on widespread seeps, shallow gas and gas hydrate occurrences	Xiujuan WANG	M313	2024-08-26 17:45	2024-08-26 18:00	2567
Causes of Mass Transport Complexes (MTCs): Implications for the Guyana Basin	Deron Saul	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2570
S3+S2 Coastal Environment Risk and its Influence on the Economic Development of a Country		Session Chair: Ashvin WICKRAMASOORIYA			
Ground subsidence studies of Mumbai city, India using InSAR	Santhosh Kumar SAKTHIVEL	M313	2024-08-27 14:30	2024-08-27 14:45	2571
Tapping into Potential: Unveiling Geological Dynamics and Geohazard Risks in the Potiguar Basin, Brazil	Yasmym Consthance SILVA	M313	2024-08-27 14:45	2024-08-27 15:00	2572
Investigating the influences of an ecological restoration project to the coastal groundwater system along the South Flank of the Yangtze Delta	Bradley Allen A. WEYMER	M313	2024-08-27 15:00	2024-08-27 15:15	2574
Analysis of major Shoreline changes along southern Karnataka coast,India for Five Decades.	Gayathri Nivedha Nivedha R	M313	2024-08-27 15:15	2024-08-27 15:30	2575
Monitoring time-series surface deformation of coastal port area in Busan with space-based radar interferometry	Seongcheon PARK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2577
Earth observation on Asian Mega-deltas environment risk under climate changes and mitigation strategy for sustainable development	Ping YIN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2579
Construction of hydrogeological database of coastal reclaimed land considering underground development in industrial area	Juhee KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2580
S4 Beach sedimentary processes and mechanism		Session Chair: Jun-Yong Park, Joo Bong JEONG			
Lithofacies, Petrographic, SEM-EDX, and Isotope Analyses of Emergent Late Holocene Beachrocks as Sea-Level Indicators along the Negros Trench Forearc, Philippines	Lyndon Jr Nawanao	M313	2024-08-27 10:15	2024-08-27 10:30	2583
Geochemical and mineralogical characteristics of beach sediments along the Bay of Bengal coast, Bangladesh	H. M. HOSSAIN	M313	2024-08-27 10:30	2024-08-27 10:45	2581
Investigation of coastal dynamics in the Nakdong Estuary using sediment core biogeochemistry	YUNJI KIM	M313	2024-08-27 10:45	2024-08-27 11:00	2582
Characteristics of surface topography and sedimentation before and after typhoons Kompasu and Soulik in the Gochang Donghori intertidal flat, Korea	Woo Hun RYANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2585
Analysis of seabed stability spatial distribution for underwater platforms	Joo Bong JEONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2586
Spatio-temporal distribution and migration patterns of microplastics on tourist beaches: A case study in the Beidaihe District, North China	Yutao ZUO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2588

Title	Presenter	Venue	Start	End	Page
The Neogene delta-front wave-built sand bodies and their petrophysical characteristics in the Enping Sag of the Pearl River Mouth Basin.	YA XUE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2589
S5 Records of climate and environmental change from lacustrine sediment		Session Chair: Ara CHO, Min HAN			
Variations in paleovegetation and paleoclimate recorded by plant terpenoids in the sediments from Lake Suwa (central Japan) from the last glacial period to Holocene	Ryosuke FUKUCHI	M313	2024-08-27 08:00	2024-08-27 08:15	2592
Hydroclimatic Variability during the 4.2 ka Event: Insights from a High-Resolution Diatom Record in Korea	Ara CHO	M313	2024-08-27 08:15	2024-08-27 08:30	2596
Historical hydroclimate events recorded in paleo-Gaho lake sediments over the past 7ka	Sujeong PARK	M313	2024-08-27 08:30	2024-08-27 08:45	2600
High-resolution paleolake records of late Holocene hydroclimate change in central South Korea and its controlling factors	Arum JUNG	M313	2024-08-27 08:45	2024-08-27 09:00	2599
Paleolimnological analysis of three shallow freshwater lakes in urban development areas around the city of Glasgow, Scotland, UK	Xinchang WANG	M313	2024-08-27 09:00	2024-08-27 09:15	2590
Paleo-oceanographic reconstruction using geochemical and mineralogical proxies from sediment core off Lakshadweep Islands, Arabian Sea	SAINABA N N.K	M313	2024-08-27 09:15	2024-08-27 09:30	2594
Lake-floor signatures revealed by a post-earthquake follow-up geophysical survey	Seong-Pil . Kim	M313	2024-08-27 09:30	2024-08-27 09:45	2597
Late Holocene hydroclimate changes in Tsushima Island, Japan	Jaesoo LIM	M313	2024-08-27 09:45	2024-08-27 10:00	2598
Sedimentary diatom records and climate and environment changes of Yazihai Lake, Ningwu County, Shanxi Province before and after the 4.2 ka event	Huiyuan JIA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2601
Geological and climatic conditions during the Miocene evolution of the North Patagonian Andes, South America: Insights from ancient lake deposits of the Ñirihuau Basin, Argentina	Camila SANTONJA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2602
Mechanism of Salinization in Lacustrine Basins and Organic Matter Enrichment Patterns in Paleolake Water with Different Salinities—A Case Study of the Bohai Bay Basin	Zhenguo QI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2604
Isotopic composition (δ13C, δ15N) and Elemental (C/N ratios) of sedimentary organic matter from a high-altitude mountain lake, western Himalaya: Implications to lacustrine productivity	Aasif Mohmad LONE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2606
Study on atmospheric CO2 concentration and climate change since the Holocene recorded in lake sediments on the Tibetan Plateau	Xueyun MA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2607
Reconstructing Holocene Indian Summer Monsoon Variability Using Multi-proxy Records from Eastern Indian Lake Sediments	ARPITA PARHI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2609
Paleoclimate and Paleoenvironments of Chegarman Lake according to sedimentological and geochemical studies during Late Holocene in SW Iran	Javad DARVISHI KHATOONI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2610
S6+S8 Sedimentation, sediment transport, and morphodynamics on the coastal system		Session Chair: Kyungsik CHOI, Ho Kyung Ha			
Monitoring of the land-sea interface: Analysis of high-resolution time series from 1950 to the present-day illustrating erosion, transport, and coastal sedimentation processes on the west Atlantic coast of France.	David MENIER	M313	2024-08-27 16:00	2024-08-27 16:15	2612
Human-controlled discharge effect on hydrodynamic and benthic sedimentary processes in the tide-dominant estuary	Seong Woon JEONG	M313	2024-08-27 16:15	2024-08-27 16:30	2614
Seasonal controls on the channel morphodynamics in an open coast macrotidal flat, west coast of Korea	Seolhui BANG	M313	2024-08-27 16:30	2024-08-27 16:45	2615
Variations in flocs related to wind-induced turbulent shear in macrotidal flat, Asan Bay	Sun Min CHOI	M313	2024-08-27 16:45	2024-08-27 17:00	2616
Tidal and seasonal influences on the morphodynamic evolution of the tidal channels in a macrotidal embayment: Garolim Bay, west coast of Korea	Seungyeon SOHN	M313	2024-08-27 17:00	2024-08-27 17:15	2617
Chronology of raised marine terraces at the coasts of Tamil Nadu, South India- Implications on palaeotsunmi and higher sea-level	LINTO ALAPPAT	M313	2024-08-27 17:15	2024-08-27 17:30	2618
Distribution Characteristics and Accumulation Mechanism of High Saturation Gas Hydrates in the Makran Accretionary Prism offshore Pakistan	JING LIAO	M313	2024-08-27 17:30	2024-08-27 17:45	2619
Analysis of characteristics of seaweed forest distribution area using acoustic exploration method (multi-beam echo sounder)	SoonYoung CHOI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2620
Sediment Dynamics in the Nakdong River Estuary, South Korea: Insights from the Nakdong Estuary Information Service System (NEISS)	Jun-Ho Lee	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2621
Deciphering Dokdo Seamount's Submarine Topography: Generation and preservation of submarine terrace structure	Duhwan KEUM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2622
Multiscale Sea-Level Variability and Predictive Modeling in the Northern South China Sea Under Climate Change	Yilin YANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2623
Characteristics of surface sedimentary facies in the Watan Estuary intertidal flat, western Korea	Woo Hun RYANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2624
Coastal Topography Monitoring utilizing CubeSat Constellation, in Hujeong Beach, South Korea	byunggil LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2625
Exploring spatiotemporal variations in sediment retention in delta evolution: A numerical experiment with Delft3D	Minsik KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2626

Title	Presenter	Venue	Start	End	Page
Investigating and quantifying tidal effects on the formation of bifurcated channel networks in modern river deltas	Jiyoung LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2627
Effect of coastal seiches on sediment transport in a Masan Bay	JUN YOUNG SEO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2628
Impact of dike construction on sedimentary facies and morphological evolution of semienclosed macrotidal flats in the western coast of Korea	Joohee JO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2629
Volatile geochemistry of inorganic gases emitted from the Central Indian Ridge 9°44' - 15°33'S using H_2, He, CO_2, and CH_4	Heejun KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2631
Evolution of the Eastern Gulf of Finland area through Holocene	Olga KOVALEVA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2632
Pockmark Seafloor in Hupo Basin, East Sea	Chang Hwan KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2633
Progress on Geoscientific Map Series of China-ASEAN Seas and Adjacent Areas	Baojun WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2634
Influence of meteorological events on the sediment and microphytobenthos resuspension in intertidal flats	Hun Jun HA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2635
Exploring Novel Bioactive Compounds from Deep-Sea Microorganisms Originating in Marine Sediments	Ji Young LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2636
Analysis of benthic environment characteristics and microbial community structure in Suyeong River, South Korea	Hee Eun WOO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2637
Harmonizing marine geological data to support the sustainable use of the maritime areas and their resources - EMODnet Geology as an example	Anu Marii KASKELA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2655
S7 EMODNET-Geology's new standards revealing Earth's seabed geology		Session Chair: Anu Kaskela, Xavier Monteys			
EMODnet-Geology's new standards revealing Earth's seabed geology	Henry T. V. VALLIUS	M317	2024-08-28 08:00	2024-08-28 08:15	2650
Mapping the sedimentation rates in the continental shelf – an European view to the seabed change	Aarno Tapio Kotilainen	M317	2024-08-28 08:15	2024-08-28 08:30	2638
Cross-EEZ Cooperation, Standards and Harmonization: Compiling Spatial Data of the European Seafloor Geology and Geomorphology within the EMODnet Geology Project	Kristine E.C. ASCH	M317	2024-08-28 08:30	2024-08-28 08:45	2640
Advancing the Understanding of Seabed Substrate Characteristics: Insights from EMODnet Geology	Susanna KIHLMAN	M317	2024-08-28 08:45	2024-08-28 09:00	2642
Brazilian research in the Atlantic Ocean	Luciana Felicio PEREIRA	M317	2024-08-28 09:00	2024-08-28 09:15	2644
Hadal Trenches: highly variable geological environments on the Earth	Hiroshi KITAZATO	M317	2024-08-28 09:15	2024-08-28 09:30	2652
Collating and harmonizing data on geological events in European seas	Andrea FIORENTINO	M317	2024-08-28 09:30	2024-08-28 09:45	2645
Paleobotanical zoning of exposed continental shelves as a tool to overcame geographical discontinuity of scattered paleolandscape data	Francesco Latino CHIOCCI	M317	2024-08-28 09:45	2024-08-28 10:00	2647
Europe's marine minerals: EMODnet geology	Xavier MONTEYS	M317	2024-08-28 10:00	2024-08-28 10:15	2649
Need for the uniform information in multinational marine areas - Experiences from the harmonization within seabed substrate data	Susanna KIHLMAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2653
MAPPING THE MARINE GEOLOGICAL RESOURCES OF THE CARIBBEAN SEA IN THE EMODnet-GEOLOGY PROJECT	Teresa MEDIALDEA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2657
First comprehensive assessment of pockmarks and debut of susceptibility mapping along the Italian Continental Margins	Francesco CHIOCCI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2659
T17 Geoscience in Alpine and Polar Regions					
S1+S4 Status of Himalayan Glaciers under the current climate change scenario		Session Chair: Rasik RAVINDRA, N C Pant			
Ground ice formation mechanisms constrained by stable water isotope ratios and occluded gas compositions	Nikolai FEDOROV	M317	2024-08-26 16:00	2024-08-26 16:15	2661
A comparison of the geochemistry between the Chokurdakh ice wedge and the central Yakutian ice wedges formed during the Last Glacial Maximum (LGM)	Nayeon KO	M317	2024-08-26 16:15	2024-08-26 16:30	2662
Characterization of the electrical response of subglacial bedrock in Antarctica considering free pore water and film water	Yuanyuan ZHANG	M317	2024-08-26 16:30	2024-08-26 16:45	2663
Time-series deformation monitoring of post-glacial rebound using space-based synthetic aperture radar observations	Seong-Woo JUNG	M317	2024-08-26 16:45	2024-08-26 17:00	2665
Understanding Intra/inter-regional Heterogeneous Glacier Retreat and Glacier-Climate Synthesis over the Himalayas	Parvendra KUMAR	M317	2024-08-26 17:00	2024-08-26 17:15	2666
Effect of varying the fluidity parameter in Glen's Law on ice sheet dynamics using 2D finite element software, Elmer/ice.	Su-Jeong LIM	M317	2024-08-26 17:15	2024-08-26 17:30	2667
Exploring the Soft-Sediment Deformation Structures (SSDS) in Glacial Environments: Insights from Physical Dropstone Deposition's Simulations	Ana Beatriz Dias JARDIM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2668
Elevation changes of the ice sheet above subglacial lakes around David Glacier in East Antarctica measured using Sentinel-1 DDInSAR	Taewook Kim	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2670
An Innovative Experiment of Geophysical Measurements with Low-Altitude UAV in the Ingrid Christensen Coastal Ice Sheet	Changchun ZOU	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2672
Diel variations in isotopic and chemical compositions of stream water in Antarctica	Hyejung JUNG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2673

Title	Presenter	Venue	Start	End	Page
Development and benchmarking of ice sheet dynamics model using COMSOL Multiphysics® compared to Ice Sheet System Model (ISSM)	Yi-Jeong BAEK	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2674
Meltwater influence on sulfur isotope composition of sulfate in ice wedge	Hyeonjeong JEONG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2675
S2 Arctic evolution and climate changes during the Cenozoic		Session Chair: Jung-Hyun KIM, Jochen Knies			
[Keynote] Arctic Ocean pH and CO2 history of the last glacial cycle	Jannik Martens	M317	2024-08-27 08:00	2024-08-27 08:15	2677
A digital geoscience data repository for Arctic reconstructions	Carmen GAINA	M317	2024-08-27 08:15	2024-08-27 08:30	2679
Impact of current flow on the depositional environment in Kongsfjorden trough of Arctic Svalbard	Youngkyu AHN	M317	2024-08-27 08:30	2024-08-27 08:45	2682
Glacier-induced provenance changes in Bellsund, Svalbard, during the Holocene	Young Jin Joe	M317	2024-08-27 08:45	2024-08-27 09:00	2676
Brackish and anoxic environments in the western Arctic Ocean during the last glacial period: insights from authigenic calcites	kwangchul JANG	M317	2024-08-27 09:00	2024-08-27 09:15	2681
Variations in aged-soil derived organic carbon input into the Kongsfjord over recent centuries: application of CuO oxidation products	Dahae KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2683
Biogeochemical evidence for methane emission within gas hydrate bearing mound structures of the Chukchi borderland in the western Arctic Ocean	Dong-Hun LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2684
Persistent marginal sea ice conditions in the Eurasian Arctic during the past 750 000 years	Jochen Knies	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2685
S3 Ice core science for alpine and polar ice cores		Session Chair: Jin-Ho AHN, Jinhwa SHIN			
Novel insights and paleoclimate impact of the Millennium Eruption from Mt. Baekdu	Giyoon LEE	M317	2024-08-27 09:30	2024-08-27 09:45	2686
Greenhouse gas (CO_2, CH_4) alteration in shallow ice of Larsen blue-ice area, northern Victoria Land, East Antarctica	Giyoon LEE	M317	2024-08-27 09:45	2024-08-27 10:00	2687
Identification of the source of the 1458/58 CE bipolar volcanic event in the Vostok firn core using a novel quantitative approach for analyzing unpolished small (< 10 µm) glass shards	Seokhyun RO	M317	2024-08-27 10:00	2024-08-27 10:15	2688
Assessing Artificial Intelligence Techniques to Simulate Atmospheric CO_2 Concentration from Antarctica Ice Core Records During MIS 1 to 5	Nasrin SALEHNIA	M317	2024-08-27 10:15	2024-08-27 10:30	2690
Dating of a coastal East Antarctic ice core by using high-resolution impurity records and reconstruction of historical snow accumulation variability	Seokhyun RO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2691
Geochemical characterization of East Siberian ice wedges : Implications of their origin and paleoenvironment	Subon KO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2693
T18 Groundwater and Hydrogeology					
S1 Microplastics and nanoplastics in soil and groundwater		Session Chair: Jin-Yong LEE, Wainka Chia Rogers			
[Keynote] Microplastics and nanoplastics in groundwater: the essential role of the hydrogeologists	STEFANO VIAROLI	M311	2024-08-27 08:00	2024-08-27 08:15	2694
A Comprehensive Analysis of How Drought Affects Groundwater Microplastics	WAINKWA CHIA Chia ROGER	M311	2024-08-27 08:15	2024-08-27 08:30	2695
Microplastic pathways into bedrock aquifers: focusing on groundwater well management in Korea	Eunju JEONG	M311	2024-08-27 08:30	2024-08-27 08:45	2696
Global Occurrence, Concentrations, and Characteristics of PFAS in Groundwater: A literature Review	Jihye Cha	M311	2024-08-27 08:45	2024-08-27 09:00	2697
Risk of microplastic contamination in groundwater wells from plastic casings and pipes	Michele LANCIA	M311	2024-08-27 09:00	2024-08-27 09:15	2698
Comparative adsorption characteristics of Pb and Cd by microplastics based on particle size	Taejung Ha	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2699
Soil and groundwater microplastic pathways and related impact on human health	Ntegang Venant Atem	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2700
S2 Groundwater Development for achieving food security and improving rural health in low- income countries		Session Chair: S. D. Limaye, Shreerup Goswami			
Appraisal of groundwater quality for drinking and irrigational purposes from parts of Warora tehsil, Chandrapur district, Maharashtra state, India.	Alka Kumari MISHRA	M311	2024-08-27 09:30	2024-08-27 09:45	2702
Kinetic, Thermodynamics and Equilibrium studies on adsorption of perchlorate ion on SIR-110-HP resin in groundwater.	BHAGIRATHI BEHERA	M311	2024-08-27 09:45	2024-08-27 10:00	2704
Groundwater salinization in the dry zone of Sri Lanka and its impact on food security and livelihood: A case study from the Medderambawa cascade irrigation system	Chirath CHANDRARATHNA	M311	2024-08-27 10:00	2024-08-27 10:15	2707
Seasonal dynamics of groundwater Arsenic pollution: A multivariate statistical approach of One-way ANOVA and Shannon entropy weight	Imran Khan	M311	2024-08-27 10:30	2024-08-27 10:45	2701
Groundwater based drinking water scarcity: a geomorphological approach	Bhagyashri Chandrakant MAGGIRWAR	M311	2024-08-27 10:45	2024-08-27 11:00	2706
Hydrogeochemical Assessment of Groundwater Quality in N'kapa, Littoral Region Cameroon: Implications for Sustainable Domestic, Agro-Industrial, and Irrigation Use	Virgine EBIA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2709

Title	Presenter	Venue	Start	End	Page
Groundwater exploration for the development of agricultural irrigation in Wang Nam Yen District, Sa Kaeo Province	Chunintorn CHAMATHONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2711
Irrigation Groundwater Quality for Agricultural Usuability and food security: A case study of Mahakalpara block of Kendrapada District, Odisha.	SUSHANT SAMAL	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2713
Geospatial Distribution and Health risk assessment of Fluoride in groundwater of Balasore district, odisha, India.	Utsav DAS	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2714
ASSESSMENT OF GROUNDWATER STORAGE ZONES FOR SUSTAINABLE AGRICULTURAL PRACTICES IN MAHARASHTRA STATE, INDIA USING GRACE SATELLITE DATA AND RS-GIS TECHNIQUES	BHAVANA UMRIKAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2715
Remediation Strategies for Elevated Iron Levels in the Lower Reaches of the Mahanadi Delta: A Comprehensive Review	SUHANI SRUJANIKA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2716
Geochemical Processes Affecting Fluoride Mobilization in the hard-rock Aquifers of Central India: Implication for Ensuring fluoride-safe drinking water supply	Naved ALAM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2717
Application of Bio-waste derived adsorbent obtained from Acacia nilotica and Neolamarckia cadamba fruits for Removal of fluoride from drinking water	NARENDRA KUMAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2719
Geological Influences on Water Quality: Implications for Agriculture and Food Security in the Athgarh Basin, Odisha	Shreerup GOSWAMI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2721
S3 Integrated use of groundwater and surface water resources keeping up with extreme droughts periods		Session Chair: Byung-Sun LEE			
Effect of Climatic Conditions on Groundwater Potability in the Hambantota District in Sri Lanka	Ashvin Kamal Wickramasooriya	M311	2024-08-27 14:30	2024-08-27 14:45	2723
Monitoring studies within the Orto-Alish artesian basin (Kyrgyzstan) under climate change conditions.	Dmitrii PLAKSIN	M311	2024-08-27 14:45	2024-08-27 15:00	2724
Groundwater change and sustainable management using monitoring wells in the Kanto Groundwater Basin, Japan	Kunio FURUNO	M311	2024-08-27 15:00	2024-08-27 15:15	2726
Cases of Groundwater Dam Construction in Areas of Poor Water Supply	Hyun PARK	M311	2024-08-27 15:15	2024-08-27 15:30	2728
[Plenary] Impact of Climate Change on Groundwater Resources and Way Forward	Elango LAKSHMANAN	M311	2024-08-27 15:30	2024-08-27 15:45	12
Geospatial Assessment of Drought Vulnerability in Nira River Basin, Western India	PAYAL WAINDESHKAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2729
Long term base flow assessment according to land use and climate change on Yeongsan and Seomjin river basins, South Korea	Kyoochul HA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2730
S4 Eco-hydrological Process and its Effects in Karst Environment		Session Chair: Guanghui JIANG, Xuan Yu			
[Keynote] Hydrological processes in karst critical zones in southwest China	Jun Zhang	M311	2024-08-27 16:00	2024-08-27 16:15	2732
Observation and Characterization of Rapid Infiltration and Runoff Processes in Karst Hillslopes	Jun Zhang	M311	2024-08-27 16:15	2024-08-27 16:30	2731
Geospatial patterns in the hydroecological characteristics of surface waters in the karst area of Samcheok, South Korea	Regina Martha Gabest LUMONGSOD	M311	2024-08-27 16:30	2024-08-27 16:45	2735
Hydro-ecological processes of hyporheic zone and the function degradation in karst spring-fed pools	Fang GUO	M311	2024-08-27 16:45	2024-08-27 17:00	2736
Water age dynamics in transpiration for typical plants under different earth critical zones	Zidong Luo	M311	2024-08-27 17:00	2024-08-27 17:15	2737
Development construction of water resources in karst peak cluster depression based on subsurface and vadose zone hydrological processes	Fan LIU	M311	2024-08-27 17:15	2024-08-27 17:30	2738
Examining the Changes in Karst Spring Flow Over an Extended Gauging Period: Impact of Climate and Vegetation Recovery	Guanghui JIANG	M311	2024-08-27 17:30	2024-08-27 17:45	2740
Coupled physically based hydrologic model and transit time theory (SWAT-SAS) for simulating the eco-hydrological process in karst basins	Wuhua LI	M311	2024-08-27 17:45	2024-08-27 18:00	2734
DETERMINATION OF PETROLEUM PRODUCTS IN WASTEWATER BY GRAVIMETRIC METHOD	MUNISXON MEYLIYEVA	M311	2024-08-27 18:00	2024-08-27 18:15	2741
S5 KRC Special session: Drought vulnerability of groundwater aquifer under climate crisis environment in S. Korea		Session Chair: Gyusang LEE, Hwan-Ho YONG			
Suggestions for Korea's groundwater use and management in the era of climate crisis	Kang Kun LEE	M317	2024-08-28 14:30	2024-08-28 15:00	2745
Case Study on the Operation of Hybrid Artificial Recharge Circulation System in Drought-Prone Areas	Gyoo-Bum KIM	M317	2024-08-28 15:00	2024-08-28 15:30	2746
Enhancement of denitrification using agricultural biproducts and limestone for use in the artificial recharge system	Boyeon JEON	M317	2024-08-28 15:30	2024-08-28 16:00	2748
Assessment of Groundwater Drought Evolution Over Two Decades in Korea Using Storage-Based Approach	Anuradha Karunakalage	M317	2024-08-28 16:00	2024-08-28 16:30	2743
A technical approach on agricultural groundwater irrigation by applying the well-network system (WNS) to a drought-prone zone, South Korea	Byung Sun LEE	M317	2024-08-28 16:30	2024-08-28 17:00	2747
S6 Groundwater and surface water interactions		Session Chair: Steven Berg, Hyoun-Tae Hwang			
[Keynote] Integrated surface and subsurface hydrological modeling to support water management	Rene THERRIEN	M311	2024-08-28 09:30	2024-08-28 09:45	2760

Title	Presenter	Venue	Start	End	Page
Saltwater circulation driven by shoreline curvature in coastal aquifers	Xuan YU	M311	2024-08-28 09:45	2024-08-28 10:00	2749
Exploring heterogeneity in the Varaždin aquifer: Integrating geostatistics and Markov chain analysis with borehole log and electrical resistivity tomography data	Igor Karlovic	M311	2024-08-28 10:00	2024-08-28 10:15	2754
Optimizing DNAPL Source Identification in Varied Real Field Scenarios with Scarce Data Using Linked Simulation-Optimization	Jun-Young SHIN	M311	2024-08-28 10:15	2024-08-28 10:30	2755
Application of feature-based clustering and machine learning to investigate spatiotemporal patterns and controlling factors of the groundwater level of Jeju Island, South Korea	Jimin HWANG	M311	2024-08-28 10:30	2024-08-28 10:45	2756
The susceptibility of urban hard rock aquifer in equatorial climate to hydraulic and contaminant stresses: The case of Shah Alam, Malaysia.	norsyafina roslan	M311	2024-08-28 10:45	2024-08-28 11:00	2759
Hydrochemical Analysis of groundwater in Chamoli district, Garhwal Himalaya India	Abhishek Mehra	M311	2024-08-28 11:00	2024-08-28 11:15	2757
Hydrogeological modelling of alluvial aquifer in north-eastern Uzbekistan	AZIZ HAKIMOV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2750
Groundwater of the foothill plain on the northern slopes of the ridge Nuratau and features of their interaction with surface water	Nosirali KURBANOV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2752
Assessing changes in hydrogeological conditions during solid minerals development: an in-depth analysis	Gleb ZARNITSYN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2761
A Study into the assessment of groundwater flow utilizing thermal and hydrochemical datasets from both groundwater and surface water in the karst area of Samcheok, South Korea	Han-Sun Ryu	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2763
Using 3D geology models to support and improve decision-making in water resources regulation in England.	Michael Kehinde MBE CGEOL	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2764
Numerical calculation and case analysis of seepage field in anisotropic aquifer	Lei LYU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2766
Study on the quality of water wells in the city of Hashtgerd using hydro-geochemical charts	Zahra SHARIFI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2767
Evaluation of the impact of artificial replacement on groundwater in the Yongding River	Tian NAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2769
Pollutant Migration in mineral area through Copper Isotope Values in Soils and Waters	JINGWEN SU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2770
S7 General Topics		Session Chair: Scientific Program Committee			
Analysis of Oxygen and Hydrogen Isotopes in Groundwater Basin: Mapping of Origins, Dynamics, and Use of Groundwater Resources in Bandung Basin Area	Dewandra Bagus Eka Putra	M311	2024-08-28 14:30	2024-08-28 14:45	2771
Estimation of the CO2 emission flux to the air by groundwater extraction in Korea	Jiwook JANG	M311	2024-08-28 14:45	2024-08-28 15:00	2776
Geological Characterization and Modeling in Southeastern Florida (USA) to Inform the Design of a Coastal Subsurface Monitoring Network	Miguel E. VALENCIA	M311	2024-08-28 15:00	2024-08-28 15:15	2777
A new approach to vulnerability analysis of Asian aquifers: machine learning and geochemical evidence	Wengeng CAO	M311	2024-08-28 15:15	2024-08-28 15:30	2781
Assessing the impact of climate change on hydrological components using CMIP6 GCM models of the Hasdeo river basin, Chhattisgarh, India: Implications for sustainable water resources in the future	satish B	M311	2024-08-28 15:30	2024-08-28 15:45	2772
Deciphering probable groundwater recharge patterns in Khapri watershed of Deccan Volcanic Province (DVP), western India: Insights from stable isotopes	Chinmay Uday DONGARE	M311	2024-08-28 15:45	2024-08-28 16:00	2774
Fluoride in groundwater of a hard rock sub-basin of northern Karnataka, India – sources and controlling geochemical processes	TEJASWAI LAKKUNDI	M311	2024-08-28 16:00	2024-08-28 16:15	2775
An introduction to the National Groundwater Monitoring Network for Systematic Management of Korea's Groundwater Resources	Laesoo KANG	M311	2024-08-28 16:15	2024-08-28 16:30	2778
Prediction of Fluoride Concentrations in Groundwater Using Machine Learning and Human Health Risk Assessment in Eastern India	SUBHASISH TRIPATHY	M311	2024-08-28 16:30	2024-08-28 16:45	2780
Geological Characteristics of Coastal Aquifer in the southwest of Korea	SUNG KEUN LIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2782
Groundwater basin management in Japan with quantitative and qualitative modeling	Katsuhiro FUJISAKI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2783
Contaminant Transport Simulation in Industrial Complex Area	YU-CHUL PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2784
Hydrogeochemistry and mechanism controlling the groundwater chemistry along the Kankai River Basin, East Nepal Himalaya	Champak SILWAL	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2785
Geology-related groundwater productivity analyses based on the specific capacity data in South Korea: Case for the Geumgang and Nakdonggang river basin	Sang-Ho MOON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2787
Relationship between Spatiotemporal Groundwater Quality and Changing Land Use and Land Cover in Korea: A Comprehensive Approach Utilizing Monitoring Data and GIS	Chanhyeok Jeon	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2789
Enhancing Measurement of Groundwater Flux: Synergistic Effects of Polysulfone-Activated Carbon Composite Carriers	Hyemin PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2790

Title	Presenter	Venue	Start	End	Page
Anomalous uranium occurrence in southern Telangana, India and its societal implications: Evidence from geological, geophysical, and hydrogeological studies	RAMESH GUGULOTH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2791
A Study on Groundwater Treatment and Useful Resources Recovery Methods in Uzbekistan	Kyungwon Na	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2793
Changes in soil characteristics due to long-term groundwater artificial recharge	Myoung-Rak CHOI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2795
Development of a predictive model for chloride ion and nitrate nitrogen concentrations in groundwater using ensemble models	Chan-Ik HWANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2796
Modeling seawater intrusion and brine water injection impact in a complex volcanic aquifer of East Jeju, Jeju island, South Korea	Dewandra PUTRA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2797
Recharge processes and chemical evolution of groundwater affected by geogenic and agricultural contamination in the mountainous areas with granitic and sedimentary bedrocks	Hyo-Sik Seo	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2798
Stable water isotopes (δ18O, δD) and groundwater dating tools (3H, CFCs) coupled with hydrochemistry to evaluate groundwater flow dynamics of complex basaltic aquifer	Hyun-Ji Kang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2800
Exploration of Groundwater in the Eastern Region of Thailand for Sustainable Groundwater Management	Benya SUNANTA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2802
Groundwater recharge estimation along a climate gradient - a Northern Namibian case study	Josefina Hamutoko	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2803
Hydrogeochemical Appraisal and macrophyte diversity in Inland water bodies of a subtropical country	DEEPTI PANDEY	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2804
Occurrence and behavior of nitrate and per- and polyfluoroalkyl substances (PFAS) in groundwater of Haean basin, Korea	seunghoon CHOO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2805
Criteria of groundwater level change in relation to the operation of a river barrage	Se-Yeong HAMM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2806
Analysis of freshwater-saltwater interface in the aquifer around Hwajinpo lagoon on the Eastern Coast of Korea: Potential implications for coastal ecosystem	Minji KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2807
Delineation of Seawater intrusion in the coastal aquifer using the 3-Dimensional Groundwater modelling in the Harbour city of Thoothukudi, Tamil Nadu, India.	THIRUMURUGAN MARIMUTHU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2808
Geochemistry of Accessory Minerals as Sources of Radionuclides in Mesozoic Granite Aquifers of Korea	Jin-Yong LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2809
Comparison of occurrence characteristics of PFAS in Korean groundwater and surface water using online SPE-LC-MS/MS	Sang Hun AN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2810
Identification of arsenic spatial distribution by hydrogeochemical processes represented by different ion ratios in the Hohhot Basin, China	Yu REN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2812
Groundwater and Environmental Challenges in Asia	Yanpei CHENG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	2813
T19 Geobiology					
S1 Microbial carbonates through space and time		Session Chair: Joydip Mukhopadhyay, Jeong-Hyun LEE			
[Keynote] Oxygenation and marine microbial carbonates: The long history	Robert RIDING	M214	2024-08-29 08:00	2024-08-29 08:15	2827
Nubecularia-coralline algal-serpulid-microbial bioherms of the Paratethys Sea – distribution and paleoecological significance (upper Serravallian, upper Sarmatian, Middle Miocene)	Werner E. E. Piller	M214	2024-08-29 08:15	2024-08-29 08:30	2814
The basal Triassic microbialites, between reef building and red ammonoid limestone	Aymon BAUD	M214	2024-08-29 08:30	2024-08-29 08:45	2816
Carbonate platform configuration and microbial sedimentation in the Mesoproterozoic Penganga Platform, Peninsular India	Joydip MUKHOPADHYAY	M214	2024-08-29 08:45	2024-08-29 09:00	2818
Trophic level variability of an intertrappean lake during Deccan volcanism: New insights using stable isotopes	Yogaraj BANERJEE	M214	2024-08-29 09:00	2024-08-29 09:15	2820
Biochemical Ba cycling in microbial mats through deep time: Insights from Ba concentrations and isotopes in stromatolitic carbonates	Simon V. Hohl	M214	2024-08-29 09:15	2024-08-29 09:30	2822
Carbonate mineral precipitation induced by microorganisms enriched from the cave water and biofilm in Yongcheon Cave, Jeju Island	Yul ROH	M214	2024-08-29 09:30	2024-08-29 09:45	2824
Abiotic and biotic constraints on Earth's ancient colonisers	Indrani MUKHERJEE	M214	2024-08-29 09:45	2024-08-29 10:00	2826
Microstructural Analysis of Recent and Pleistocene Stromatolites at Ruidera Pools, Spain.	Mar SIMONET RODA	M214	2024-08-29 10:00	2024-08-29 10:15	2829
Dissolved silicon as a beneficial factor for biomineralization of protodolomite by a halophilic cyanobacterium	Ting CHEN	M214	2024-08-29 10:15	2024-08-29 10:30	2830
Diverse origins and depositional environments of phytoclast tufas from the Cretaceous Jinju Formation, Korea	Seunghoon LEE	M214	2024-08-29 10:30	2024-08-29 10:45	2831
S2 Assessing the interplay of environmental and evolutionary controls in animal-substrate interactions through time		Session Chair: Anthony Shillito, Romain Gougeon			

Title	Presenter	Venue	Start	End	Page
[Keynote]Infaunal feedback during the end-Permian Mass Extinction: Evidence from ichnology	Mao LUO	M214	2024-08-29 15:30	2024-08-29 15:45	2837
Ichnological record of palaeonvironmental changes and its cyclostratigraphic aspects in the Sinemurian-Toarcian basinal deposits from the Mochras drill core, Cardigan Bay Basin, UK	Alfred Uchman	M214	2024-08-29 15:45	2024-08-29 16:00	2832
Early colonization of the deep-sea bottom–the protracted build-up of an ecosystem	Luis A. BUATOIS	M214	2024-08-29 15:00	2024-08-29 15:15	2834
Temporal constraints on the ichnofacies paradigm	Anthony Shillito	M214	2024-08-29 15:15	2024-08-29 15:30	2838
The interplay of evolutionary, taphonomic, and environmental controls on trace fossils from Burgess Shale-type deposits	Gabriela Gabriela MANGANO	M214	2024-08-29 14:30	2024-08-29 15:00	2839
Evolution and palaeoenvironmental migration of a Cambrian undermat-miner	Li-Jun ZHANG	M214	2024-08-29 14:45	2024-08-29 15:00	2841
The use of time-environment matrices to decipher behavioural events in early Paleozoic animal evolution	Romain GOUGEON	M214	2024-08-29 16:00	2024-08-29 16:15	2835
Integrated sedimentological and ichnological analysis of Holocene deposits in the Nakdong River delta, South Korea	BOHYUN JEON	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2842
Lipid Biomarker Patterns Reflect Nutritional Strategies of Seep-Dwelling Bivalves From the South China Sea	Hongxiang GUAN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	2843
S3 Mid-Phanerozoic mass extinctions, recovery, extreme environmental events and integrated stratigraphic correlations		Session Chair: Yu Pei			
[Keynote] Mid-Phanerozoic major environmental perturbations and ecosystem responses	Zhong-Qiang CHEN	M214	2024-08-30 08:00	2024-08-30 08:15	2859
The Guadalupian Extinction: Severity, Selectivity, and Timing	Matthew CLAPHAM	M214	2024-08-30 08:15	2024-08-30 08:30	2863
Early Permian carbonate buildups from eastern Inner Mongolia, North China: Insights regarding the late Early Permian Turnover	Zhen YAN	M214	2024-08-30 08:30	2024-08-30 08:45	2856
Organic matter influence on ooid formation: New insights into classic examples (Great Salt Lake, USA; Triassic Germanic Basin, Germany)	Yu PEI	M214	2024-08-30 08:45	2024-08-30 09:00	2850
Dynamic variations of carbon-sulfur cycles through the Late Permian to Early Triassic	Lei ZHANG	M214	2024-08-30 09:00	2024-08-30 09:15	2866
Millennial-scale variations of Carbon-Sulfur isotopes were regulated by microbe activities following the end-Permian extinction	zijie zheng	M214	2024-08-30 09:15	2024-08-30 09:30	2854
A new charophyte flora from early Middle Triassic (Guizhou, South China) indicates ecologic adaptation to shallow marine	Meijia Zhang	M214	2024-08-30 09:30	2024-08-30 09:45	2858
Upper Triassic (middle Norian) conodont biostratigraphy succession from eastern Tibet, southwest China	Zhengyi LYU	M214	2024-08-30 10:00	2024-08-30 10:15	2861
Secular variations of ichnofossils before and during the Carnian Pluvial Episode from the continental Upper Triassic successions, South China	Liao YANG	M214	2024-08-30 10:15	2024-08-30 10:30	2864
New Hybodont sharks (Chondrichthyes, Elasmobranchii) from the Early Triassic continental Dongchuan Formation (Yunnan Province, China), revealing the recovery of lacustrine ecosystems after the end-Permian mass extinction	Wen WEN	M214	2024-08-30 10:30	2024-08-30 10:45	2845
Marine carbonate factory changes across the end-Permian mass extinction in South China	Danna LIU	M214	2024-08-30 10:45	2024-08-30 11:00	2848
The earliest record of freshwater siliceous algae from the Middle Triassic: Chrysophyte stomatocyst from the Ordos Basin, North China	Bohang CHENG	M214	2024-08-30 13:45	2024-08-30 14:00	2851
Silicified gastropod fossils from the uppermost Permian of Guangxi Province, South China	Jie Liu	M214	2024-08-30 14:00	2024-08-30 14:15	2853
Microbial bloom, microbe-metazoan interaction and palaeoecologic crisis linked with volatile volcanisms during the Guadalupian-Lopingian (Permian) transition	Zhensheng Wei	M214	2024-08-30 14:15	2024-08-30 14:30	2846
Middle Jurassic restructuring of palaeo-food webs stabilized dinosaur-dominated communities in Southwest China	Yuangeng HUANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2867
S4 General Topics		Session Chair: Scientific Program Committee			
Organic geochemical evidence for episodic elevated precipitation in the Carnian Pluvial Episode	HUIWEN LI	M214	2024-08-30 14:30	2024-08-30 14:45	2868
Tracing Dissolved Oxygen Variability in Riverine Environments: A High-Resolution Study Using *Lamprotula leai* Shell Trace Elements	Xinran Su	M214	2024-08-30 14:45	2024-08-30 15:00	2869
Rise of calcareous deposition during the Carnian Pluvial Episode (Late Triassic)	QILE qile GENG	M214	2024-08-30 15:00	2024-08-30 15:15	2871
The habitat of the Ediacaran Period fossil Dickinsonia: Redox conditions of the fossiliferous Cherny Kamen Formation in the Ural Mountains	Natasha BYKOVA	M214	2024-08-30 15:15	2024-08-30 15:30	2872
Vanadate reduction by gram-positive fermentative bacteria isolated from deep-sea sediments on the northern Central Indian Ridge	Bokyung KIM	M214	2024-08-30 15:30	2024-08-30 15:45	2874
Arsenic immobilization using combined treatment of arsenite-oxidizing bacterium and biochar	So-Jeong KIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	2875
T20 Biogeochemical cycles					

Title	Presenter	Venue	Start	End	Page
S3+S2 Local scale fluxes of carbon dioxide in urban environment: Sectorial emission and sequestration challenges		Session Chair: Scientific Program Committee			
Greenhouse gas molar ratios and stable isotopic compositions in Seoul Mega City	JeongEun KIM	M317	2024-08-27 16:00	2024-08-27 16:15	2876
Optimizing Carbon Sequestration in Winter Wheat in Wooster, OH	Grace BRAVER	M317	2024-08-27 16:15	2024-08-27 16:30	2881
Rock Weathering Dynamics in Himalaya: Insights from Metagenomics and U-series Isotopes	Pradeep Srivastava	M317	2024-08-27 16:30	2024-08-27 16:45	2882
Inventorization of Green House Gases – Sources and Sinks in Urban Delhi, India	CHIRASHREE GHOSH	M317	2024-08-27 16:45	2024-08-27 17:00	2879
Unravelling Carbon Fluxes in Delhi's Urban Fabric: Emission and Sequestration Dynamics	SHAILENDER KUMAR	M317	2024-08-27 17:00	2024-08-27 17:15	2877
Analysis of the impact of crushed basalt dust addition to corn fields on the diversity and functionality of soil microbiota	Hao-Cheng Chang	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2883
S4+S1 General Topics		Session Chair: Scientific Program Committee			
Secondary mineralization of Sb(V)-bearing Fe(III) phases stimulated by Fe(II) under advective flow and the impact on Sb mobility	Yidan ZHANG	M317	2024-08-27 14:30	2024-08-27 14:45	2884
Microbial communities development and secondary minerals formation during microbial Fe(III) reduction across a pH gradient	Yunseo Jang	M317	2024-08-27 14:45	2024-08-27 15:00	2885
Internal P-recycling in Late Ordovician marine reefs: the first evidence from the mutualistic commensalism of cyanobacteria and green algae in the fossil record	Jinwen SHEN	M317	2024-08-27 15:15	2024-08-27 15:30	2887
The relationships between vertical variations of shallow gas and pore water geochemical characteristics in boreholes from the inner shelf of the East China Sea	xue LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2889
Investigate the impact of different fertilizers in combination with dicyandiamide on bacterial communities participating in nitrogen and methane cycles	Hao-Yu CHU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2890
Isotopic distribution of bioavailable Sr, Nd, and Pb in Chungcheongbuk-do Province, Korea	Min-Ji JUNG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2891
T21 Environmental Geosciences					
S1 Geoscience knowledge in Environment and Environmental Ecosystem		Session Chair: Shahina TARIQ			
Potential of Geoscience knowledge towards Environmental Ecosystem	Shahina TARIQ	M215	2024-08-26 16:00	2024-08-26 16:15	2894
Ground Substrate: Conceptual Proposal, Scientific Connotation and Great Significance	Zhiqiang YIN	M215	2024-08-26 16:15	2024-08-26 16:30	2895
Earth System Modeling for Explaining and Predicting changes in the Climate, Water, and Ecosystem	June-Yi LEE	M215	2024-08-26 16:30	2024-08-26 16:45	2897
DISTRIBUTION OF HEAVY METALS IN SOILS AND PLANTS IN MINING WASTE STORAGE AREAS UZBEKISTAN	Nosir SHUKUROV	M215	2024-08-26 16:45	2024-08-26 17:00	2900
Providing the most appropriate management solution based on the new conditions of Urmia Lake, Northwest of Iran	Razyeh Lak	M215	2024-08-26 17:00	2024-08-26 17:15	2893
Studying on the structural features of municipal solid waste landfills before recultivation	Elena SOLOMATINA	M215	2024-08-26 17:15	2024-08-26 17:30	2898
Redox activity of soil dissolved organic matter as affected by soil warming	Shuhan WANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2901
Assessment of Seawater Intrusion Signatures: A Geochemical and Geospatial Study in the Coastal Region of Paradeep Municipality, Jagatsinghpur, Odisha.	SUSANTA KUMAR DAS	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2902
Understanding Loggerhead Sea Turtle Nesting Preferences in Broward County, Florida	Brooke Marlo WALKER	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2903
Geochemical Characteristics of Coal Mine Drainage and Waste Rocks from Livingstonia Coalfield in Malawi	Amidu Amali MAKWINJA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2904
S3+S2 Anthropogenic contaminants in the environment		Session Chair: Scientific Program Committee			
Estimation of heavy metal(loid) accumulation rate in urban soil using in situ pXRF: the example of Shijiazhuang City, China	ZHAOXIAN YUAN	M215	2024-08-27 08:00	2024-08-27 08:15	2906
Seasonal variations of microplastics in a coastal wetland from southwest India and their risks to *Gerres filamentosus* and *Sillago sihama*	Anish Kumar WARRIER	M215	2024-08-27 08:15	2024-08-27 08:30	2907
Impact of subsurface material on the quality of groundwater in the vicinity of the Gohagoda waste disposal site in Kandy, Sri Lanka	Ashvin Kamal Wickramasooriya	M215	2024-08-27 08:30	2024-08-27 08:45	2908
Meltwater - contamination indicator of industrial areas (Baikal region, Russia)	Evgeniia TSVETKOVA	M215	2024-08-27 08:45	2024-08-27 09:00	2909
A SPATIO-TEMPORAL RECORD OF MICROPLASTICS DURING THE PAST FOUR DECADES IN A LACUSTRINE SEDIMENTARY SEQUENCE FROM SOUTHERN INDIA	Sandeep KIZHUR	M215	2024-08-27 09:00	2024-08-27 09:15	2911
DEVELOPMENT OF METHODS FOR PHYTOREMEDIATION OF CONTAMINATED SOILS USING TOLERANT PLANTS OF LOCAL NATURAL LANDSCAPES (UZBEKISTAN)	Nosir SHUKUROV	M215	2024-08-27 09:15	2024-08-27 09:30	2912
Lead (Pb) Contamination and Associated Health Risks in the Mining Town of Rosh Pinah, Namibia.	Michelle Uetupa Hailonga	M215	2024-08-27 09:30	2024-08-27 09:45	2914

Title	Presenter	Venue	Start	End	Page
Microtechnofossils as a multiproxy record for the human-impacted sediments	Zdzisław M. Migaszewski	M215	2024-08-27 09:45	2024-08-27 10:00	2917
On the proper use of geochemical indices in pollution assessment of the road dust	Agnieszka GALUSZKA	M215	2024-08-27 10:00	2024-08-27 10:15	2919
Associated Professor	Jia Duo	M215	2024-08-27 10:15	2024-08-27 10:30	2922
Overcoming Construction Management Challenges During the Remediation of a Former Gold/Arsenic Mine in Ontario, Canada	MARK William PRIDDLE	M215	2024-08-27 10:30	2024-08-27 10:45	2916
METAL ACCUMULATION COMBRETUM IMBERBE, CYNODON DACTYLON AND SPOROBOLUS AFRICANUS AT KLEIN LETABA TAILINGS STORAGE FACILITY, LIMPOPO PROVINCE, SOUTH AFRICA	Phumudzo Gift MUNYAI	M215	2024-08-27 10:45	2024-08-27 11:00	2920
Why is the air humid during wintertime heavy haze days in Beijing?	Jiarui WU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2923
Impacts of changes in land use and land cover between 2001 and 2018 on summertime O3 formation in North China Plain and surrounding areas-A case study	jiaoyang YU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2924
Hydrochemical characterization and indicators of anthropic influence on groundwater surrounding Guanabara Bay, Rio de Janeiro, Brazil	Alexis Rosa NUMMER	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2925
Study of soil contamination in vicinity of the municipal solid waste landfills after recultivation	Irina VASILEVNA Galitskaya	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2926
Characterization and adsorption properties of rectorite/sludge derived biochar composites for Pb(II) removal	huanhuan WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2928
Seasonal Changes in the Eutrophication Index and Alleviation of Eutrophication with Calcium-Citrate Complex in the Surface Water of Osongji (Osong Pond), Jeonju-si, Korea	Suyeong Noh	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2929
Pore-scale simulation of CO2-water-rock Interaction on Rock Permeability and Mechanical Properties	Yang BO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2931
Tree stumps as passive sampler for trace metal dust deposition	Shubin ZHOU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2933
Assessment of Ground Water Quality by Statistical Methods in Greater Bangalore, South India	Hemamalini Rajanna R	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2934
Mercury in soils near a base metal smelting plant, Plovdiv, Bulgaria	Lora BIDZHOVA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2936
SOIL POLLUTION ASSESSMENT IN ALMALYK MINING AREA USING PRINCIPAL COMPONENT AND CLUSTERING ANALYSIS	Nosir SHUKUROV	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2938
A review of heavy metal contamination around Rosh Pinah area in Southern Namibia	Michael Action EINO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2940
Effect of salinity on arsenic mobilization from desulfurized and filtered mine tailings	Rocky KUBUYA KIRO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2942
Tracing Sources of Zinc Contamination in Groundwater of Industrial Complexes Using Zinc and Sulfur-Oxygen (S-O) Isotopes	Dae-Gyu IM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2943
Eco-friendly natural mineral biotite as a cesium adsorbent: Utilizing low-concentration acid and hydrogen peroxide	Sunki KWON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2945
FEATURES OF ANOMALIES OF POLARIZABILITY AND RESISTANCE OF THE INDUCED POLARIZATION METHOD IN THE LIGHT OF PREDICTING GROUNDWATER POLLUTION BY PETROLEUM PRODUCTS	Qodirjon MINGBOYEV	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2946
Tracing iron mining dam collapse pollutants from the Fundão-Mariana accident (2015), using Nd-Sr isotopes in sediments from the Doce River and adjacent marine environment	Claudio de Morisson VALERIANO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2948
S4+S5 Emerging environmental pollutants, hazards, and energy resources and their associated human-natural system risks: Oral and postal presentation		Session Chair: Stefano Viaroli, Wainkwa Chia Rogers			
Examples of the advection mechanism of contaminated groundwater due to VOCs to deep aquifers and the advection of contaminated groundwater in aquifers with different flow directions: wells that diffuse contaminated groundwater deep and wells that do not	Osamu KAZAOKA	M215	2024-08-27 14:30	2024-08-27 14:45	2949
Identification of *As-III* and *As-V* species in As-contaminated water using cupric acetate monohydrate	Swati GANVEER	M215	2024-08-27 14:45	2024-08-27 15:00	2931
Characterization of urban aquifers of an Asian megacity (Shenzhen, China) using chemical, antibiotics, and isotope analyses	STEFANO VIAROLI	M215	2024-08-27 15:00	2024-08-27 15:15	2955
Urban local body - Farmer partnership for sustainable waste management and organic farming	Kiran D A	M215	2024-08-27 15:15	2024-08-27 15:30	2953
Pb isotopic source tracing and mass balance on heavy metals from East Kolkata Wetland, a Ramsar site of West Bengal, India	KAMALAKANNAN D	M215	2024-08-27 15:30	2024-08-27 15:45	2932
Exploring Management Practices of Tailings and their Impact on the Downstream Economies and Environment; insights from Uis, Namibia.	Hilya Ndeyapo AMUKWA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2957
The Lower Paleozoic strata in the Baltic Syneclise (NE Poland) – reconstruction of paleoenvironmental conditions based on the distribution of biomarkers	Pawel KOSAKOWSKI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2958
Dr	Qian Jiang	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2960
Estimative engineering geological zoning for the disposal of municipal solid waste	Olga Nikolaevna EREMINA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2961

Title	Presenter	Venue	Start	End	Page
Spatial Analysis and Probabilistic Risk Assessment of Heavy Metal Contamination in Urban Soils: A Case Study from Seoul, South Korea	Hyunsoo Seo	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2963
Assessment of Current Water Quality Status of Rivers near Two Major Cities in Myanmar	Arkar SAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2965
CO2 measurement with high spatiotemporal resolution using low-cost sensors in urban Seoul, South Korea	JaeYoung PARK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2966
Regional features of ecological-geological systems of rock massifs in Kamchatka	Violetta SHANINA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2967
Spatiotemporal characterization of iron and manganese distribution in a stratified aquifer during in-situ chemical oxidation operation	Seoyoung SON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2969
Assessment of heavy metal pollution in marine sediments around southern waters of Gyeonggi Bay	Hyerim LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2970
Tracking tobacco-specific nitrosamines (TSNAs) source in fertilizer: an environmental forensic approach	Min-Hui Son	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2971
The relationship between the intensified heat waves and deteriorated summertime ozone pollution in the Beijing–Tianjin–Hebei region, China, during 2013–2017	Ruonan WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2972
Environmental pollution problems in the mining regions	Elena Nikolaevna LEVCHENKO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2973
Arsenic contamination in ground water, mechanism and role of subsurface sediments for high arsenic concentration, in the Flood Plain of Ghaghara River, Uttar Pradesh. India	Abhinandan SRIVASTAV	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2974
Composition and size distribution of wintertime inorganic aerosols at ground and alpine regions of northwest China	Haijiao Liu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2976
Occurrence and behavior of per- and polyfluoroalkyl substances (PFAS) and antibiotics in the hyporheic zone	Hyobin LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2977
EFFECTS OF ACID MINE DRAINAGE FROM COAL MINING ON WATER QUALITY IN THE ARARANGUÁ RIVER BASIN	Marlon Colombo HOELZEL	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2978
Dust generated by e-waste processing: Impact of sample treatment and decomposition method on chemical and isotopic compositions	Eva Martinková	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2979
State-of-the-art integration of digester, heating system and automation	Atta ur RAHMAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2981
Contribution of Geogenic Radon for Indoor Air Quality using Grey-Box Modeling	Yijune CHOI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2982
Development of Vapor Intrusion Risk Assessment Program for Urban Subsurface Environments	Min Seo BAE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2983
New insights from landfill microbiome by genome-resolved metagenomics	So-Jeong KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	2984
T22 GIS and Remote Sensing					
S1+S11 Remote Sensing of Global Resources with the New and Forthcoming Generation of Satellite Sensors		Session Chair: Carlos Roberto de Souza FILLHO			
[Keynote] CURRENT AND FUTURE HIGH-RESOLUTION THERMAL INFRARED-SATELLITE AND AIRBORNE- SENSOR SYSTEMS	Simon John HOOK	C109	2024-08-26 16:00	2024-08-26 16:15	2987
50 years of Lithologic Mapping and Mineral Exploration from Space	Michael ABRAMS	C109	2024-08-26 16:15	2024-08-26 16:30	2985
Characterization of "Sale 'e Porcu" salty pond (SPp Sardinia, Italy) suitable for CAL/VAL activities using multi sensor approach in the VNIR-TIR range: new optical satellite mission perspective	Maria Fabrizia BUONGIORNO	C109	2024-08-26 16:30	2024-08-26 16:45	2991
The EnMAP hyperspectral satellite: an overview of the mission and its applications in geology and resource exploration	Saeid Asadzadeh	C109	2024-08-26 16:45	2024-08-26 17:00	2990
A Multiscale Hyperspectral Remote Sensing Approach for Detection of Petroleum Offshore	Carlos Roberto Souza Filho	C109	2024-08-26 17:00	2024-08-26 17:15	2989
Remote Measurement of the Earth system with EMIT Imaging Spectroscopy from the International Space Station	Robert Otis Green	C109	2024-08-26 17:15	2024-08-26 17:30	2995
Assessing Spatio-temporal Changes of climate variables on Diverse Crops in region of Punjab, Pakistan	Waqar YASIN	C109	2024-08-26 17:30	2024-08-26 17:45	2996
Active deformation across Indo-Myanmar suture zone, NE India: Insights from integrated RS-GIS-based Geomorphic Investigations	ALEXANDER S KSHETRIMAYUM	C109	2024-08-26 17:45	2024-08-26 18:00	2993
Detection of high-geothermal-potential zones in densely vegetated areas through a combination of vegetation and mineral indices derived from hyperspectral satellite imagery	Taiki KUBO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2997
DELINEATION OF MINERAL POTENTIAL HYDROTHERMAL ALTERATION ZONES AND FAULT ZONES USING MULTISPECTRAL ASTER AND LANDSAT 8 DATA OVER SANDUR SCHIST BELT, BELLARY DISTRICT, KARNATAKA, INDIA.	VIJAYAKUMAR MOOLA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	2999
Research on Vegetation Geochemical Anomalies in Uranium Mining Areas Based on Hyperspectral Remote Sensing and Vegetation Spectral Analysis	Yongfei CHE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3001
S2 Geoscience information, geological mapping and modelling		Session Chair: Kristine ASCH			
[Keynote] Bathy-morphological mapping for geohazard assessment	Francesco Latino CHIOCCI	C109	2024-08-27 08:00	2024-08-27 08:30	3010
Thematic mapping, potential and interactions	Roland Erich OBERHAENSLI	C109	2024-08-27 08:30	2024-08-27 08:45	3014

Title	Presenter	Venue	Start	End	Page
Boosting Europe's Energy Transition: The Pivotal Contribution of a Geological Service for Europe in Delivering FAIR Subsurface Data and Knowledge for Informed Policy and Industrial Decision-Making	Patrick Wall	C109	2024-08-27 08:45	2024-08-27 09:00	3006
Towards an integrated and harmonized geological data model for Europe	Esther HINTERSBERGER	C109	2024-08-27 09:00	2024-08-27 09:15	3015
Polish Geological Cartography Platform: fostering geological map data accessibility, enhancing integration and harmonisation for informed decision making	Katarzyna JÓŹWIK	C109	2024-08-27 09:15	2024-08-27 09:30	3003
Geological Map of South America in the twenty–first century	Jorge GÓMEZ TAPIAS	C109	2024-08-27 09:45	2024-08-27 10:00	3017
A structural map of Italian seas, thematic map derived from collation and harmonization of geological data	Andrea FIORENTINO	C109	2024-08-27 10:00	2024-08-27 10:15	3012
Computing Sediment Grain Volumes with GIS	Tim Whiteaker	C109	2024-08-27 10:15	2024-08-27 10:30	3002
Spatial relationships between gold deposits, crustal structures, and geophysical fields using GIS and statistical analysis in Central Kyzylkumes, Uzbekistan	Bakhtier NURTAEV	C109	2024-08-27 10:30	2024-08-27 10:45	3019
Lime phosphates in Senegal: characterization, modelling and predictive mapping for the development of a prospecting guide.	Abdoul Aziz NDIAYE	C109	2024-08-27 10:45	2024-08-27 11:00	3004
On the issue of developing a methodology for compiling a map for assessing the anisotropy of the natural stress state of dispersed soil massifs	Violetta SHANINA	C109	2024-08-27 11:00	2024-08-27 11:15	3008
Exploratory modeling of Giran Rig- Chah Sangi area (Sistan and Baluchestan Province, Iran)	Elnaz Aghaali	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3021
The geochronological database of Colombia: Review and new geological perspectives for this sector of the Americas	Daniela MATEUS ZABALA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3022
New edition of the Geological Map of Colombia at a scale of 1:1,5M	Vanessa Rey León	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3024
Surface and subsurface geological data in Italy: state of the art of the harmonization process.	Marco PANTALONI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3026
Exploration and Application of High-Precision Inclined Photography and 3D Modeling Technology in Digital Geological Outcrops	Zongqi Lin	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3028
Geological and Prospectivity mapping of phosphates deposits in the Senegalese sedimentary basin	Mamadou Fall	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3030
Innovative Approaches to 3D Geo-Modeling of Geological Structures: Integration of Laser Scanning and Digital Photogrammetry, case studies from Ukraine	Mariia OLIINYK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3032
Detecting Brittle Structures in Vegetated Landscapes with Sentinel-2 Data: A Case Study of Deep Geological Repository Site Assessment	Jan JELENEK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3034
(Open)GeoSGB: State of the art of Transition to an Open Source, semi-automated, FAIR-ready Geological Spatial Data Infrastructure of the Geological Survey of Brazil	CARLOS EDUARDO MOTA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3035
Rapid Geological Modelling for Surat Basin Based on Well Logs	GUOXU CHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3037
GEODEATLAS.nl; A web-based GIS resource atlas showing multiple geo-energy uses to support subsurface planning	Susanne NELSKAMP	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3038
S5+S3+S6 Advances in GIS and remote sensing approach for geological hazards management		Session Chair: Scientific Program Committee			
The Landslide Whisperer: An Intelligent and Efficient Framework for wrapped Interferogram Detection of Potential Hazards	Ruixuan Zhang	C109	2024-08-28 08:00	2024-08-28 08:15	3040
Multi-frequency SAR time-series analysis of ground subsidence at coastal reclaimed land in Busan	Jeong-Heon JU	C109	2024-08-28 08:15	2024-08-28 08:30	3044
Coastal Change from Space: Geohazard Assessment using S1-SAR and S2 datasets	Xavier MONTEYS	C109	2024-08-28 08:30	2024-08-28 08:45	3045
Multitemporal Monitoring of Landslides using Remotely Piloted Aircraft (RPA) and Structure from Motion–Multi View Stereo (SfM-MVS): Case Studies in Brazil	Camila Duelis VIANA	C109	2024-08-28 08:45	2024-08-28 09:00	3047
Utilizing PSInSAR and Open-Source Software for Monitoring Slow-Moving Landslides: A Case Study from Southern Taiwan	Abhishek Ravindra LAKHOTE	C109	2024-08-28 09:00	2024-08-28 09:15	3049
Fostering New Talent: Exploring Innovative Approaches in Geoscience to Meet 21st Century Societal Needs	Courtney Elaine Jermyn	C109	2024-08-28 09:15	2024-08-28 09:30	3050
The f(utility) of GIS-based landslide susceptibility: a review approach	Mihai Niculiță	C109	2024-08-28 09:45	2024-08-28 10:00	3041
Geospatial Analysis of Coastal Dynamics and Development Strategies: A Case Study of Nagapattinam District, Tamil Nadu, India	Isai RAMACHANDRAN	C109	2024-08-28 10:00	2024-08-28 10:15	3046
InSAR analysis for monitoring Cultural Heritage threatened by multiple risk and anthropogenic hazards: the seaport quarter in Valparaiso (Chile) case study.	Daniele SPIZZICHINO	C109	2024-08-28 10:15	2024-08-28 10:30	3042
Landslide susceptibility assessment using Mahalanobis Distance-based class imbalance strategies: A comparison of under-sampling, over-sampling, and hybrid sampling techniques	Kounghoon NAM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3051
Opportunities of Advanced Remote Sensing for Rock Mass Classification on Inaccessible High Alpine Rock Slopes	Nicole OYSMUELLER	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3052

Title	Presenter	Venue	Start	End	Page
A Study on the Utilization of GNSS Data for Monitoring the Stability of the Yangsan Fault	Heeun KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3053
Geological Risk Mapping in the Largest City in Brazil: From Paper Reports to Artificial Intelligence	Thais Feitosa TREVISANI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3054
2023 Multi-temporal Surface Deformation and Activity Evaluation of Deep-Seated Landslide Sites	Suet-Yee AU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3056
Remote Sensing Technology Applied to the Potential Analysis of Engineering Geological Disasters	Tsung ting CHEN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3057
Assessing Landslide Vulnerability in Sindhudurg District, Western India: Integrating Stakeholder Perspectives and Geospatial Analysis	AMIT VIJAYKUMAR SHIRKE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3059
Research on Precipitation Prediction and Geological Disaster Warning Based on Infrared Remote Sensing and Deep Learning	jingyi zhang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3060
Geological Hazard Mitigation Portal of Indonesia	Ahmad BARNES	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3061
Integration of ISAR and GNSS for Monitoring the Stability of Artificial Slope: a Case Study of Lijiang, China	Yinjie CAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3062
Multi-Sensor Remote Sensing Data and Deep Learning for Time-Series Analysis of Caldera Lake Dynamics at Mt. Changbai: Monitoring Volcanic Activity	EURU LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3064
Assessing the Potential of Novel Remote Sensing Techniques in Landslide Monitoring and Susceptibility Mapping	Dylan GORDON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3066
Mitigating decorrelation noises and atmospheric delays in InSAR	Jun HU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3067
High-Density and High-Temporal-Frequency Monitoring of Reservoir Landslides with InSAR based on Environmental Prior Information	Qian SUN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3069
S7 Mapping the Way Forward: Advances in Applied Geoinformatics for Mineral Exploration		Session Chair: Mana RAHIMI			
[Keynote] Assessment of Machine Learning Techniques for Prospectivity Modeling and Vectoring of IOCG Mineralizations	Carlos Roberto Souza Filho	C109	2024-08-27 16:00	2024-08-27 16:30	3079
Identification of lithium deposits information based on two Chinese satellites	Nannan ZHANG	C109	2024-08-27 16:30	2024-08-27 16:45	3071
Exploration Information System (EIS): Open-Source Toolkit & QGIS Plugin for Mineral System Modelling and Mineral Predictive Mapping	Vesa Nykänen	C109	2024-08-27 16:45	2024-08-27 17:00	3072
Characterization of mineral systems in northern Finland using autoencoders- and self-organizing maps-based deep learning architecture.	Bijal Chudasama	C109	2024-08-27 17:00	2024-08-27 17:15	3074
Sparse spectral unmixing applied to hyperspectral satellite imagery for accurate identification and mapping of hydrothermal alteration minerals	Masahide KISHIMOTO	C109	2024-08-27 17:15	2024-08-27 17:30	3075
Spectral Geological mapping in Kuhi area, Maharashtra, with AVIRIS-NG Airborne Hyperspectral Data	Trina Vishal VYAS	C109	2024-08-27 17:30	2024-08-27 17:45	3076
Approaches and Technologies of the Digital Twin of Russia's Mineral Resources: possibility of using the experience of the Karpinsky Institute for the development of information systems in geological surveys and institutes	Olga KOVALEVA	C109	2024-08-27 17:45	2024-08-27 18:00	3077
Enhancing Mineral Prospectivity Mapping for Cu-Pb-Zn in Faraj Abad, Qom, Iran: A Comprehensive Integration of Geology, Geochemistry, and Remote Sensing Data Using Fuzzy Analytical Hierarchy Process Models.	Kamyar KESHAVARZ	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3081
Identification of High-grade Ni Laterite Ores Using Hyperspectral Imaging and Deep Learning	Koichi FURUKAWA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3082
Advancing Mineral Resource Prediction through Distributed Cloud Computing and Remote Sensing: A Case Study in Namibia	Tianyi LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3084
Hydrothermal Alteration Mapping using Remote Sensing and GIS in parts of North Purulia Shear Zone (NPSZ), Purulia District, West Bengal, India	Anirudh CHAKRABORTY	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3085
S8 Advances in AI and remote sensing approach for tidal flat monitoring		Session Chair: Scientific Program Committee			
Evolution of a Sand Spit in Ujeon Tidal Flat at Sinangun, Jeollanamdo, Korea's West Coast	Jun-Ho Lee	C109	2024-08-29 08:00	2024-08-29 08:15	3086
Guided sampling method of diffusion model for cloud area restoration from tidal flat satellite images	Donguk Lee	C109	2024-08-29 08:15	2024-08-29 08:30	3087
Performance comparison of waterline based topographical mapping of tidal flats with different spatial interpolation methods	Jingyo Lee	C109	2024-08-29 08:30	2024-08-29 08:45	3089
Airborne Sensor system for monitoring Tidal Flat	Hyunsoo Hur	C109	2024-08-29 08:45	2024-08-29 09:00	3090
Exposure Duration and Geochemical Influences on Surface Sediment Properties for Monitoring Approach at Hwangdo Tidal Flat, Taean, Cheonsu Bay, Korea's West Coast	Jun-Ho Lee	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3091
S9 Artificial Intelligence Methods Applied to Geological hazard using Remote Sensing and GIS		Session Chair: Scientific Program Committee			
Land Subsidence Observation using InSAR Time-Series Analysis of Bangkok and Samut Prakan, Thailand	Raisa Najma Sakina	C109	2024-08-29 09:30	2024-08-29 09:45	3093
Identification of slope failure by random forest using topographic characteristics changes	Mitsunori UEDA	C109	2024-08-29 09:45	2024-08-29 10:00	3094

Title	Presenter	Venue	Start	End	Page
Integrating InSAR Time-Series Machine Learning Optimized and Susceptibility Assessment for Monitoring Land Subsidence in the Iron Mining Site Musan	Muhammad Fulki Fadhillah	C109	2024-08-29 10:00	2024-08-29 10:15	3096
S10 Geoscience Information in the 2020s		Session Chair: Harvey THORLEIFSON			
New opportunities with Earth Science data platforms in Europe: fostering next-generation cross-domain research and decision-making	Marc URVOIS	C109	2024-08-27 14:30	2024-08-27 14:45	3099
International geoscience terminology management and governance	Mark Rattenbury	C109	2024-08-27 14:45	2024-08-27 15:00	3101
A Framework for Smart Geological Mapping Using Data and Knowledge Hybrid-drivenFAIR	Yongzhi WANG	C109	2024-08-27 15:00	2024-08-27 15:15	3102
Geoscience Information in the 2020s	Harvey Thorleifson	C109	2024-08-27 15:15	2024-08-27 15:30	3104
NSDI Implementation at the Ministry of Mines and Energy in Namibia	FREDDY MUYAMBA	C109	2024-08-27 15:30	2024-08-27 15:45	3097
EarthResourceML 3.0	Michael Graham SEXTON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3105
Building a Digital Framework for Europe's Geology: GSEU and the Significance of Data Modelling and Vocabularies	Kristine ASCH	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3106
REASSESSMENT OF DETAILED LITHOLOGICAL MAPPING USING A MACHINE LEARNING ALGORITHM: A CASE STUDY ON THE BOA VISTA SHOSHONITIC STOCK IN NORTHEASTERN BRAZIL	Mariana Izabel Tomaz de LIMA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3108
Serverless Computing Powered Efficient Remote Sensing Image Processing: A Case Study on Potential Sand Source Identification in the Yarlung Zangbo River Middle Reaches	Qing LAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3110
Enhancing Environmental Understanding with Spatio-Temporal Knowledge Activation in Large Language Models	Xinhua FAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3111
T23 Seismology					
S2+S1 Statistical Seismology and Episodic Events		Session Chair: Scientific Program Committee			
Estimation of earthquake hazard parameters of delineated sources of the Shillong Plateau, Northeast India and adjoining regions	MOHD SHAHABUDDIN	M213	2024-08-28 08:00	2024-08-28 08:15	3114
Unraveling Seismic Patterns: A Deep Dive into Earthquake Sequences and Swarms in Northeastern Algeria through a Dual Method Approach	Sofiane Taki-Eddine Rahmani	M213	2024-08-28 08:15	2024-08-28 08:30	3112
Using eathquake time series to characterize seismicity in the Mount Cameroon	Delair ROUAI	M213	2024-08-28 08:30	2024-08-28 08:45	3115
A regional insight on the tectonic and geometric configuration of the Bengal Basin for hosting predicted mega earthquakes	MIR FAZLUL KARIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3116
S3 East Asia Earthquakes, Seismic Structure and Tectonics		Session Chair: Won-Young KIM, YoungHee KIM			
[Keynote] Lithosphere structure from comparative tomographic study: Implications for deformation mechanisms of the Tibetan Plateau	Xiaodong SONG	M213	2024-08-27 08:00	2024-08-27 08:30	3132
HIGH RESOLUTION P AND S WAVE VELOCITY STRUCTURES OF THE EASTERN SINO-KOREAN CRATON	Yanbing LIU	M213	2024-08-27 08:30	2024-08-27 08:45	3118
Do Subducted Seamounts Act as Weak Asperities?	Sungho Lee	M213	2024-08-27 09:00	2024-08-27 09:15	3127
Crustal Structure in the Southeastern Korean Peninsula Using a Receiver Function Analysis	Jeongin Lee	M213	2024-08-27 09:15	2024-08-27 09:30	3128
Constraints on crustal seismic properties of the southern Korean Peninsula using Virtual Deep Seismic Sounding	Young Oh SON	M213	2024-08-27 09:30	2024-08-27 09:45	3123
Recent Earthquakes along the Ogcheon Fold Belt in the Korean Peninsula	Won-Young Kim	M213	2024-08-27 09:45	2024-08-27 10:00	3117
The 2022 Goesan earthquake of the moment magnitude 3.8 along the buried fault in the central Korean Peninsula	Hobin LIM	M213	2024-08-27 10:00	2024-08-27 10:15	3120
Focal Mechanism Solutions and Crustal Stress Field around the Korean Peninsula	Dong geon KIM	M213	2024-08-27 10:15	2024-08-27 10:30	3125
Utilization of Regional Lg Wave in Precise Epicentral Relocation and Source Characterization of Two 2021 Earthquake Sequences in Gunsan Basin, Yellow Sea	JUN YONG PARK	M213	2024-08-27 10:30	2024-08-27 10:45	3130
Fault complexity revealed by focal mechanisms of small earthquakes in Gyeongju, South Korea: effective use of S-wave polarizations retrieved from the high-density seismic array	Sangwoo HAN	M213	2024-08-27 10:45	2024-08-27 11:00	3126
Resolving rupture properties of small earthquakes in the southern Korean Peninsula using direct and reflected phases	Min-Seong SEO	M213	2024-08-27 11:00	2024-08-27 11:15	3121
Comprehensive Earthquake Parameter Determination using the AI and Bayesian Inference Techniques: Case Study on the Southeastern Korean Peninsula	Jongwon HAN	M213	2024-08-27 11:15	2024-08-27 11:30	3129
Teleseismic constraints on the crustal structure beneath Gyeongju, S. Korea from high-density seismic array data	Minkyung KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3133
The intricate fault interactions: source parameter estimation of the 2017 Pohang, Korea, earthquake and its aftershocks	Minkyung SON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3135
Seismic Properties of Upper-mantle 410- and 660-km Discontinuities Beneath the Korean Peninsula Using P-wave Receiver Functions	Juhyung LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3136

Title	Presenter	Venue	Start	End	Page
Constraining crustal composition of the continental China by three-dimensional Vp/Vs model	Guifang ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3137
Intraplate lithospheric structures near plate margins: comparison between northeast India (Eastern Himalayan Syntaxis) and southern Korean Peninsula	ABHISHEK KUNDU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3138
Deploying a Temporary Seismic Network for the 2022 Goesan Earthquake Sequence and its Integration with the Deep Learning Model EQTransformer	EunJin LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3139
Upper crustal azimuthal anisotropy and seismogenic tectonics of the Hefei segment of the Tan-Lu fault zone from ambient noise tomography	LI CHENG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3140
Determination of moment magnitude of earthquakes in the Korean Peninsula from 2017 to 2022.	Yoontaek HONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3141
Recent seismicity in the Haenam and Suncheon regions using template matching method	Bohyun KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3142
Determination Focal Depth of the 2014 ML 5.1 Offshore Gyeongyeolbi Island Earthquake Using Depth Phase	Hyeonjun LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3143
Introduction to Research using the Unified Model for Subsurface Fault and Velocity Structure in the Korean Peninsula	Kyungmin MIN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3144
Analysis of the three earthquakes with moment magnitudes greater than 4 in the Gunsan Basin, Yellow Sea, Korea, 2021	Miji KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3145
S5 The 2023 M7.8 and M7.5 Kahramanmaraş, Turkey, Earthquake Sequence		Session Chair: Tamer Y. DUMAN, YoungHee KIM			
[Keynote] The East Anatolian Fault System: An Overview on Active Tectonic Setting of the February 6, 2023, Kahramanmaraş Earthquake Sequence, Türkiye	OMER EMRE	M213	2024-08-27 14:30	2024-08-27 14:50	3147
[Keynote] Rupture Geometry and Segmentation associated with the 6 February 2023 Pazarcık (Mw 7.8) and Elbistan (Mw 7.6) Earthquakes: East Anatolian Fault, Southeastern Türkiye	Tamer Y. DUMAN	M213	2024-08-27 14:50	2024-08-27 15:10	3161
The Role of Stress Transfer in Earthquake Nucleation and Inhibition in the 2023 Kahramanmaraş, Türkiye, Earthquake Sequence	Shinji TODA	2024-08-27 10:00	2024-08-27 18:00	2024-08-27 15:25	3155
[Keynote] What determined the Rupture Extent of the 2023 Mw7.8 Kahramanmaraş Earthquake	Ali Ozgun KONCA	M213	2024-08-27 15:25	2024-08-27 15:45	3146
The 2023 Kahramanmaraş, Türkiye, earthquake doublet as the most powerful continental earthquake doublet: magnitudes, rupture process, triggering mechanism, and aftershocks	Xiaodong SONG	M213	2024-08-27 15:45	2024-08-27 16:00	3159
[Keynote] The earthquake deformation cycle along the East Anatolian Fault deduced from space geodesy; implications for rupture propagation and arrest	Ziyadin CAKIR	M213	2024-08-27 16:00	2024-08-27 16:20	3149
Stress perturbation induced by precedent earthquakes and its implications for the 2023 Kahramanmaras earthquake sequence	Junhyung Lee	M213	2024-08-27 16:45	2024-08-27 17:00	3156
Understanding the 2023 Mw 7.8 Pazarcık (Kahramanmaraş) Earthquake by integrating multi-parameter paleoseismological data from the Pazarcık segment of the East Anatolian Fault	Gülsen Ucarkus	M213	2024-08-27 17:00	2024-08-27 17:15	3157
Establishing and Operating the AFAD Earthquake Clearinghouse for Reconnaissance Efforts After the 6 February 2023 M7.7 and M7.6 Eastern Türkiye Earthquakes	RECEP CAKIR	M213	2024-08-27 17:15	2024-08-27 17:30	3150
Near-Fault and Off-Fault Field Observations of The 6 February 2023 Mw7.8 and Mw7.6 Kahramanmaraş and 20 February 2023 Mw6.4 Antakya earthquakes	Hasan SOZBILIR	M213	2024-08-27 17:30	2024-08-27 17:45	3153
A Comprehensive Analysis of Türkiye's Earthquake Disaster Response and Recovery Efforts Following the Devastating 6 February 2023 M7.7 and Mw7.6 Kahramanmaraş-Elbistan Earthquakes	Orhan TATAR	M213	2024-08-27 17:45	2024-08-27 18:00	3152
In the light of fault geometry, segmentation and slip distribution data an assessment of the February 06 2023 Pazarcık (Kahramanmaraş) earthquake (Mw 7.8), East Anatolian Fault Zone, Turkey.	Akın KÜRÇER	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3163
Rupture geometry and slip characteristics of the Doğanşehir Fault Zone rupture associated with the February 06, 2023 Ekinözü Earthquake (Mw 7.6), Eastern Anatolia, Türkiye	Hasan ELMACI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3165
Rupture Propagation Paths and Probabilities Considering Fault Continuity and Geometry in the 2023 Kahramanmaraş, Türkiye Earthquake	Yuki HARA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3167
Preliminary Study on Surface Rupture Displacement Analysis of the 2023 Kahramanmaraş(Turkey) Earthquake Using High-Resolution Optical KOMPSAT-3(A) Satellite	Chaehyeon CHOI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3169
S6 Investigating subsurface structures with dense seismic array: Theories and applications		Session Chair: Hongyi LI			
Advanced seismic imaging of subsurface structures using wavelet-based decoupled wavefields on small aperture dense arrays	Hongfeng YANG	M213	2024-08-26 16:00	2024-08-26 16:15	3170
Subsurface structure imaging robustness enhancement with multiple processing methods on a dense seismic array	Lanbo Liu	M213	2024-08-26 16:15	2024-08-26 16:30	3171

Title	Presenter	Venue	Start	End	Page
Seismic velocity changes observed on a dense array of nodal seismometers reveal soil moisture changes in the Critical Zone	James HAMMOND	M213	2024-08-26 16:30	2024-08-26 16:45	3172
Unravelling crust-to-upper-mantle structures around the central Korean Peninsula using combined tomographic analyses	SEONGJUN PARK	M213	2024-08-26 16:45	2024-08-26 17:00	3174
Extraction of body waves from seismic ambient noise recorded by a dense seismic array at the Zhangbaling segment of Tanlu Fault Zone, China	Mingze DU	M213	2024-08-26 17:00	2024-08-26 17:15	3186
Lateral variation of the Mantle Transition Zone Beneath Southern Tibet inferred from receiver function analysis	YiBin WU	M213	2024-08-26 17:15	2024-08-26 17:30	3176
Pn-wave receiver function method	LiangYu ZHANG	M213	2024-08-26 17:30	2024-08-26 17:45	3177
Lithospheric Structure Beneath the Upper Indus Basin and its Adjacent Regions from Inversion of Surface Wave Dispersion	G.Suresh	M213	2024-08-26 17:45	2024-08-26 18:00	3175
Detailed crustal structure beneath the epicentral region of 2016 Mw 5.5 Gyeongju earthquake: preliminary results of teleseismic receiver functions from the Naenam Fault Array	Hobin LIM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3178
The Seismogenic Processes of Main Faults in Sichuan-Yunnan Based on Time-varying Repeating Event Waveforms	Boyang WANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3179
The Characteristics of Regional Seismicity before the 2008 Mw 7.9 Wenchuan Earthquake	Xinzhong YIN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3181
Characterizing the shallow subsurface of the Bukpyeong Basin, Korea, by the HVSR method	SU YOUNG KANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3182
Fragmented Plates in Sumatra-Andaman Subduction Zone Revealed by Distinct Mantle Anisotropic Directions	BHASKARARAO ILLA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3183
Ambient Noise Tomography with a Short-Period Dense Array: Case of Sedimentary Basin	Hyejeong CHO	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3184
Deep Learning-driven ambient noise surface wave dispersion data selection along linear array	Yan WANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3185
Azimuthal anisotropy of the upper crust beneath the Gyeongju Hi-density Broadband Seismic Network rebuilt by the local shear wave splitting	June Baek	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3188
Investigation on the Influence of Non-uniform Noise Source Distribution on Ambient Noise Imaging Effectiveness	Fei HUANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3190
S7 Site survey and seismic safety for nuclear installations (Sponsor Special Session)		Session Chair: Korea Hydro & Nuclear Power Co., Ltd. (KHNP)			
[Keynote] Physics-based Ground Motion Prediction for Advanced Seismic Hazard Assessment: Potentials and Challenges	Seok Goo SONG	M213	2024-08-28 09:30	2024-08-28 09:45	3197
Procedure for the determination of Safe Shutdown Earthquake ground motion for nuclear power plants	Sinae HAN	M213	2024-08-28 09:45	2024-08-28 10:00	3195
Hybrid Empirical Ground Motion Predictions for the southern Korean Peninsula	Sae-Woon CHOI	M213	2024-08-28 10:00	2024-08-28 10:15	3194
Ground Motion Models for South Korea using the Hybrid Empirical Method and NGA-West2 Empirical Ground Motion Models	Seonjeong PARK	M213	2024-08-28 10:30	2024-08-28 10:45	3192
Investigation of Directional Variability of Earthquake Ground Motion of South Korea for Nuclear Seismic Safety Assessment	JEONGGON HA	M213	2024-08-28 10:45	2024-08-28 11:00	3193
Short and long-term behavioral characteristics of the Eupcheon Fault in the southeastern part of the Korean Peninsula	Sung-il CHO	M213	2024-08-28 11:00	2024-08-28 11:15	3191
Preliminary evaluation of fault activity around the southeastern part of the Korean Peninsula using probabilistic approach on seismogenic potential of a fault	Sung-il CHO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3198
Using logic-tree approach, reduction of uncertainty in fault source characterization for probabilistic seismic hazard analysis in South Korea	Sehyeon GWON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3199
The Study on the Seismic Source Parameters of Major Earthquakes in 2023	Hyun-Me RHEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3200
Shallow earthquakes in stable continental regions and implications for probabilistic seismic hazard analysis in SE Korea	Sehyeon GWON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3201
Development of Earthquake Ground Motion Database in Korea	Sang-hyun Lee	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3202
The high frequency spectral decay in seismic station near nuclear power plant using S wave autopicking.	Arim HAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3203
Application of High-Dimensional Visualization Techniques for the development of Ground Motion Characterization Model for the Korean Peninsula	Sae-Woon CHOI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3204
Fault investigation through geomorphic analysis	Su-Ho JEONG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3205
Geological and Geotechnical Characterizations in the Arabian Gulf Coast	Yongwoo NOH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3206
S8+S4 General Topics		Session Chair: Scientific Program Committee			
On a numeric and interactive database for Algerian historical earthquakes	Radia KHERCHOUCHE	M213	2024-08-28 16:00	2024-08-28 16:15	3207
Ambient noise levels and their effects on the Pohang Community Seismograph Network (PCSN), South Korea	Yu Jin Sohn	M213	2024-08-28 16:15	2024-08-28 16:30	3212
Automatic earthquake detection using open source software	Nomin-Erdene ERDENETSOGT	M213	2024-08-28 16:30	2024-08-28 16:45	3211
Imaging the Aegean crustal structure using P and S phase travel times	Pratul RANJAN	M213	2024-08-28 16:45	2024-08-28 17:00	3210

Title	Presenter	Venue	Start	End	Page
Role of the Main Himalayan Thrust in generating earthquakes in the Himalaya	Devajit Hazarika	M213	2024-08-28 17:00	2024-08-28 17:15	3209
IMPLICATIONS ON THE PALEOSEISMICITY IN THE PRECAMBRIAN INTRACRATONIC BASINS: CASE STUDY OF THE BALTIC SEDIMENTARY BASIN	Jurga LAZAUSKIENĖ	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3214
Vector Autocorrelation and Cross Correlation for Resolution Improvement of Apparent Source Time Function	Wu-Cheng Chi	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3216
Estimation of seismic source parameters and high-frequency attenuation characteristic (Kappa) using microearthquake data in the southeastern Korean Peninsula	BYEONG SEOK AHN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3217
Seismic Noise in the Deep Underground Seismic Laboratory (JSTB): Influences from Mining Activity, Typhoons, and Precipitation	Do Woon KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3218
Determining Hypocenter of recent earthquakes in South Korea using the 3D velocity structure model and Antelope DB	Yeongjae CHOI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3219
A Study on Earthquake Detection and Intensity Analysis Using High-Density MEMS Observation Network	EUNA PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3220
Case study on maximum seismic amplitude estimation for high-rise structures	Keun-Joo SEO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3221
Surface-to-borehole Site Correction: Assessing the suitability of transfer function	Jeongseon OH	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3222
Research on the identification of micro-seismic events in the Kangping area of Liaoning province based on random forest.	Zihao LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3224
Impact of data fidelity for double-difference relocation: A case study of the Kiskatinaw microseismic monitoring, British Columbia, Canada	Suhee PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3225
Tracking Typhoon Hinnamnor (2022) using microseism recorded at CTBTO seismic array	Yunah KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3227
Estimating Moment Magnitudes of Certain South Korean Macroseismic Events	SUNGSU KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3228
Seismicity in the South Korean Region Across Two Millennia	SEUNGHEE YUN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3229
Comparing Acceleration and Velocity Horizontal-To-Vertical Spectral Ratios at South Korean Sites	Youngtaek HONG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3230
Comparing South Korean Earthquakes to Next Generation Attenuation West Ground Motion Models	Jungho KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3231
Comparing Peak Frequency to Shear Wave Velocity Models in South Korea	Joohwan CHA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3232
New insights of seismicity and stress pattern from the dense temporary deployment network in Anker, Kunene Region, Namibia	Bufelo Lushetile	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3233
Stratigraphic Analysis of Regressive Erosion in the Upper Coca River Basin: Insights from Seismic Imaging and Field Data	Christian WLADIMIR ROMERO CÓNDOR	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3234
Focal mechanisms of earthquakes in the Korean Peninsula based on P-wave first-motion polarity determination using deep learning	Ah-Hyun BYUN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3235
T24 Geophysics					
S1 Fault detection and paleoseismology with near-surface geophysics		Session Chair: Takao Kobayhasi, Jin-Hyuck CHOI			
Detection of the buried rupture of the North Anatolian Fault in Kocaeli, Türkiye using ERT and VLF-R methods	Ümit AVŞAR	M212	2024-08-26 16:00	2024-08-26 16:15	3236
Geophysical investigation using ERT and MASW surveys at the Quaternary faults along the Yangsan fault system, SE Korea	Hwanwoo SEO	M212	2024-08-26 16:15	2024-08-26 16:30	3241
Structural characterization of intracratonic strike-slip faults in the southern Oridos Basin	Yunwen GUAN	M212	2024-08-26 16:30	2024-08-26 16:45	3238
GPR detection of buried paleo-channel through unconsolidated layer and characterization of the channel fill	Takao KOBAYASHI	M212	2024-08-26 16:45	2024-08-26 17:00	3239
Buried Geomorphic Signatures of Paleo-Earthquakes Detected by 3D GPR survey and Trench Analysis: A Case Study of the Yangsan Fault, South Korea	Changwan SUN	M212	2024-08-26 17:00	2024-08-26 17:15	3240
Detection of buried faults: a case study at the north end of the Miryang Fault, southeastern Korean Peninsula	Lanbo Liu	M212	2024-08-26 17:15	2024-08-26 17:30	3237
3D Imaging of Fault Fracture Zones using Electrical Resistivity Survey	Samgyu PARK	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3242
Utilizing Electrical Resistivity Method to Characterize Buried Faults in Suhari, Hong-Cheon, South	Jeong-Ryul CHOI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3243
Peering Through Sediments: Ground-Penetrating Radar Mapping of the Yangsan Fault	Hak Min LEE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3244
Understanding the subsurface structure of Bukpyeong Basin through 2-D electrical resistivity survey	WooHyun Kim	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3245
S2 Coupling of deep Earth and surface processes		Session Chair: Sang-Mook LEE, Haemyeong JUNG			
[Keynote] Pacific Array: an observational effort to find a link between the deep mantle process and surface features of the Pacific Basin	Hisashi UTADA	M212	2024-08-27 08:00	2024-08-27 08:30	3248
New Parameterization of Lithosphere-Asthenosphere System Beneath the Oldest Pacific Based on In-situ Seafloor Geophysical Observations	Hogyum KIM	M212	2024-08-27 08:30	2024-08-27 08:45	3255

Title	Presenter	Venue	Start	End	Page
A top-down control on upper crustal inheritance on the south-eastern Tibetan Plateau	Kun ZHANG	M212	2024-08-27 08:45	2024-08-27 09:00	3246
Lithosphere thermal structure of Greenland and Antarctica: Implications for the ice sheets dynamics –	Irina M. ARTEMIEVA	M212	2024-08-27 09:00	2024-08-27 09:15	3249
Geodynamic implications of small plume-driven weakening of the continental lithosphere	Ritabrata Dasgupta	M212	2024-08-27 09:15	2024-08-27 09:30	3251
Formation of the Continent and Surrounding Region from the Perspective of Changes in Subduction Configuration	SANG-MOOK LEE	M212	2024-08-27 09:30	2024-08-27 09:45	3253
Unraveling the diversity in arc volcanism and seismicity in Southwest Japan subduction zone: insights from numerical models	Goeun HA	M212	2024-08-27 09:45	2024-08-27 10:00	3254
Deformation microstructures of experimentally deformed epidote blueschist and implications for seismic low velocity layer and S-wave anisotropy in warm subduction zones	Yong PARK	M212	2024-08-27 10:00	2024-08-27 10:15	3252
Kinematics of Capricorn plate inferred from the GPS data relative to its surroundings region and possible Geodynamical implications	AKILAN A	M212	2024-08-27 10:15	2024-08-27 10:30	3250
GEOELECTRIC STUDY OF BARAK BASIN USING MAGNETOTELLURIC TECHNIQUE, NORTH-EASTERN INDIAN REGION	Devesh WALIA	M212	2024-08-27 10:30	2024-08-27 10:45	3256
Deformation fabrics of talc and chloritoid and implications for seismic anisotropy in subduction zones	Jungjin LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3257
Constraining Upper Mantle Seismic Anisotropy beneath the Oldest Pacific Seafloor from Shear-wave Splitting	Seung-Heon CHOI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3258
Geodynamic Investigation of Subduction Angle and Possible Flat Subduction Beneath East Asia During Mesozoic	Kien PHAM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3260
Anomalous Inclination of Rock Samples from the South Atlantic Transect (SAT) and Their Implications for Variability in Magmatism of Slow-Spreading Ridges	Gilbert HONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3261
S3 New Insights into the evolution of Deccan Volcanic Province and its seismic scenario		Session Chair: Scientific Program Committee			
[Keynote] The Deccan Volcanic Province (DVP) of India hosts three different types of earthquake sequences	Harsh K GUPTA	M212	2024-08-27 14:30	2024-08-27 14:45	3266
Remnant mantle pathways of the Deccan volcanic eruption in the Indian subcontinent revealed by 3D magnetotelluric imaging	ABDUL AZEEZ KIZHAKKEKARA KUNJAVARAN	M212	2024-08-27 14:45	2024-08-27 15:00	3264
Tomographic imaging of sub-trappean Mesozoic sediments and basement configuration using long-offset seismic data in the Deccan Volcanic Province (DVP) of India	LAXMIDHAR BEHERA	M212	2024-08-27 15:00	2024-08-27 15:15	3267
Crustal geoelectrical structure of Koyna region, India: Role of fluids as inferred from magnetotelluric study	Bantu Prasanta Kumar PATRO	M212	2024-08-27 15:15	2024-08-27 15:30	3268
A RELOOK AT THE THICKNESS OF DECCAN TRAPS: IMPLICATIONS ON PALEOTOPOGRAPHY	VIVEK S. KALE	M212	2024-08-27 15:30	2024-08-27 15:45	3272
Crustal Architecture beneath southern Deccan Volcanic Province: Implications from Integrated Studies	Vasanthi ANTHWAR	M212	2024-08-27 15:45	2024-08-27 16:00	3274
Development of rift systems in the Kutch-Saurashtra region-A tale of multiple breakup events: Constraints from geophysical and geochronological data	Munukutla RADHAKRISHNA	M212	2024-08-27 16:15	2024-08-27 16:30	3276
Seismic imaging of southern part of Kachchh region (western India)	CHANDRAKALA KOTESWARA	M212	2024-08-27 16:30	2024-08-27 16:45	3275
Possible sub-surface extension of Deccan Magma in the north Arabian Sea	Vasanthi ANTHWAR	M212	2024-08-27 16:45	2024-08-27 17:00	3277
Constraining focal mechanisms of reservoir triggered seismicity in the Deccan Volcanic Province	D SHASHIDHAR	M212	2024-08-27 17:00	2024-08-27 17:15	3269
Bole beds and earthquake swarms in Deccan Volcanic Province, India	Rajender Kumar CHADHA	M212	2024-08-27 17:15	2024-08-27 17:30	3262
Characterization of 3D shallow subsurface structure of Deccan Volcanic Province, India using high frequency noise tomography	Sion Kumari Pasagadgu	M212	2024-08-27 17:30	2024-08-27 17:45	3265
Mid-crustal basement below Deccan Volcanic Province: Evidence from multiparametric borehole study	Om Prakash PANDEY	M212	2024-08-27 17:45	2024-08-27 18:00	3270
Tectonomagmatic evolution of the crust and lithosphere beneath the Western Deccan Volcanic Province, India – A magnetotelluric study	Pavankumar GAYATRI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3278
Delineation of lithospheric structure across the Deccan Volcanic Province and Eastern Dharwar Craton, south Indian shield using joint inversion of receiver function and surface wave dispersion data	Sudesh KUMAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3279
Configuration of Deccan Traps and its effect on triggered seismicity in Koyna-Warna Seismic Zone, India	Ujjal BORAH	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3280
Deep Seismic Reflection Profiling across the Seismically active Mesozoic Kachchh rift basin, NW India: implications for crustal evolution	BISWAJIT MANDAL	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3281
Paleomagnetism of KBH-7 core from Koyna, Western Ghats, India	Venkateshwarlu MAMILLA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3282

Title	Presenter	Venue	Start	End	Page
Secondary mineralization and fluid channelization through fractures within the basement rocks of seismically active Koyna-Warna area, Maharashtra, India	Manas GOSWAMI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3283
S6+S4+S5 Trending Machine Learning Applications in Oil and Gas Industry		Session Chair: Scientific Program Committee			
Application of supervised neural network algorithm in logging predicting shale lithofacies - A case study from the first member of Qingshankou Formation in Gulong Sag, Songliao Basin	danting LUO	M212	2024-08-28 08:00	2024-08-28 08:15	3285
A review of the utilization of novel artificial intelligence tools for advanced reservoir characterization	SHIB SANKAR GANGULI	M212	2024-08-28 08:15	2024-08-28 08:30	3286
Blank strip filling method for electrical logging images based on the combination of convolution neural network and Transformer	XU PANG	M212	2024-08-28 08:30	2024-08-28 08:45	3284
Appraisal of gas hydrate saturation in KG basin using synergistic implementation of geophysical log analysis and machine learning approaches	SUMAN KONAR	M212	2024-08-28 08:45	2024-08-28 09:00	3287
Fine Structure Description and Hydrocarbon Prediction of Fault-karst Reservoir	Hong ZHANG	M212	2024-08-28 09:00	2024-08-28 09:15	3288
Quantification of uncertainty in the reconstruction of resistivity tomography image with machine learning	Xixi LAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3290
Identification Method Of Micro Residual Oil Types And Quantitative Characterization Based On Deep Learning	Xianda SUN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3291
S7 General Topics		Session Chair: Scientific Program Committee			
Characterizing electrical properties of hydrate-bearing sediments during dissociation via 3D multifield-coupled numerical simulation	Xixi LAN	M212	2024-08-28 09:30	2024-08-28 09:45	3295
Structure of the Denizli Graben-Horst System & Acıgöl Graben in the Western Anatolian Extensional Province from magnetotelluric resistivity models.	Ümit AVŞAR	M212	2024-08-28 09:45	2024-08-28 10:00	3296
2-D Integrated Geophysical Modelling Over an Anomalous Magnetic Body in North-Western Bangladesh	XixiLAN	M212	2024-08-28 10:00	2024-08-28 10:15	3297
A novel method of seismic data reconstruction in reverse time migration	YueZHENG	M212	2024-08-28 10:15	2024-08-28 10:30	3293
Particle Swarm Optimization - Gravitational Search Algorithm Tuned Deep Neural Network to estimate the subsurface interlayer boundary	Sunam KumarSHARMA	M212	2024-08-28 10:30	2024-08-28 10:45	3292
Oscillatory constituents of the secular variation of the geomagnetic field	CrișanDEMETRESCU	M212	2024-08-28 10:45	2024-08-28 11:00	3298
Investigation of fluid gas migration with an insight of mineralization using Amplitude vs Offset analysis for offshore Multichannel Seismic reflection Data	DEBAJYOTI SAHA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3299
The density structure of the around Gyeongju based on gravity analysis	Young-Cheol Lee	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3300
Neotectonic deformation in the southwestern part of the Anatolian Block in consideration of palaeomagnetic results in Bodrum peninsula.	Ümit AVŞAR	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3302
Seismic Fine Description of Facies Change Reservoir in Subei Basin	Zhipeng Gui	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3303
Improved C3 coherence algorithm considering structure dip without interpolation	ZiCheng Wang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3305
MODERN GEOELECTRIC MODEL OF GROUNDWATER FILTRATION FLOWS AND ITS SEARCH VALUE	Rakhimjan TURSUNMETOV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3307
Generalized linear inversion of prestack data based on exact Zoeppritz equation	Guobin HU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3309
Optimized spectral decomposition method based on Restart and Adaptive Rapid Iterative Shrinkage Threshold	Jifei Qi	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3310
Analytical study of geomagnetic observations using automated absolute measurements collected in 2023 at the Cheongyang Geomagnetic Observatory in South Korea.	Sohyeon Park	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3311
T25 Geotechnology and Geophysical Exploration					
S1 Advances in Geophysical Exploration Techniques for Resource Characterization		Session Chair: Scientific Program Committee			
[Keynote] Identification of prospective regions for selected critical minerals through integrated geophysical, geochemical and geologic data	Carol A FINN	M212	2024-08-29 14:00	2024-08-29 14:15	3320
A seismic geomorphology study of the fluvial and shallow-delta facies of the Oligocene Huagang Formations in the East China Sea Shelf Basin, China	Huafeng LIU	M212	2024-08-29 14:15	2024-08-29 14:30	3315
Research On The Frontier Technology Of Continuous Coring For Directional Drilling	Yinlong MA	M212	2024-08-29 14:30	2024-08-29 14:45	3317
Research on Anti-Adhesion and Drag Reduction Performance of Bionic Sampling Tube for Shallow Submarine Sediments	Pengyu ZHANG	M212	2024-08-29 14:45	2024-08-29 15:00	3318
Microscopic structure and wear properties of micro-nano sized (TiCp-SiCp)/ 7075Al composites	Yueqi LI	M212	2024-08-29 15:00	2024-08-29 15:15	3319

Title	Presenter	Venue	Start	End	Page
Identification of River Sand Body Based on Deep Residual Shrinkage Network	yufei SU	M212	2024-08-29 15:15	2024-08-29 15:30	3322
New progress in research of lightweight wear-resistant drilling pipe materials	Shaoming MA	M212	2024-08-29 15:30	2024-08-29 15:45	3323
Deterministic Approaches and Machine Learning Approaches for fluid detection: a comparison and integration	Mohammed FARFOUR	M212	2024-08-29 15:45	2024-08-29 16:00	3313
Use of geochemical and ground magnetic data in the definition of copper-cobalt targets in the blind area. A case study: Kanseba prospect.	Naveen BHADU	M212	2024-08-29 16:00	2024-08-29 16:15	3314
Enhancing Reservoir Performance Prediction Through Advanced Data Analytics and Machine Learning: A Study on Reservoir Evaluation Management for Improved Oil and Gas Recovery in the Orange Basin, Namibia.	Freddie KAFULA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3324
The application of comprehensive electromagnetic methods in the search for copper-nickel polymetallic ores in shallow-covered areas-A case study of the Jing'erquan area in the East Tianshan Mountains of Xinjiang	ShiHao JIA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3325
An efficient 3D inversion algorithm for the inversion of large-scale magnetic dataset when remanence exists	Jun WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3327
Accurate first arrivals picking method combining dynamic threshold control and bisection in complex geological environment.	Hongyan Yan	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3328
S-wave propagation and analysis under the modified couple stress theory	Wenlei BAI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3329
Improving Seismic Profile Resolution through Inversion of Reflection Coefficients based on Short-Time Fourier Transform and Restarted Fast ADMM	Wei SONG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3330
Wave propagation and analysis under the single-parameter second-order strain gradient theory	Chaopu CHEN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3331
S2+S3 Geotechnology and its Applications in Geological Hazard Assessment and Monitoring		Session Chair: Scientific Program Committee			
Nuclear magnetic resonance constrained triple-water resistivity model to estimate the fluid saturation in Zao 34 block, Bohai bay basin	XueJuan ZHU	M212	2024-08-29 16:45	2024-08-29 17:00	3340
A holistic approach towards geophysical characterization of the Quick Clays in Norway; A case study from Gjerdrum	Saman Tavakoli	M212	2024-08-29 17:15	2024-08-29 17:30	3333
Multi-thematic geoscience study in Hamirgarh Bhiyana segment, eastern Aravalli Craton Rajasthan, Western India: Evidences of existence of dual mineral systems	Rana BANDYOPADHYAY	M212	2024-08-29 17:30	2024-08-29 17:45	3338
Slope Failure Back Analysis from Ground-Based Radar Data to Estimate the Safe Re-entry Time After Failure	Dio Yudha PRATAMA	M212	2024-08-29 17:45	2024-08-29 18:00	3336
Interpretation of aero-magnetic ring features in Sausar fold belt, Bastar Craton, Central India	SHEIKH MOHAMMAD SHAKIL HASHMI	M212	2024-08-29 18:00	2024-08-29 18:15	3334
Proximity Excavation in Down Town area Using High Tension Net	BYUNG DON RO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3342
Correlation between consolidation of soft ground and time-lapse gravity	YeongJae LEE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3343
Gravity and Gravity Gradient Joint Fast Inversion Method	Zhengyuan JIA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3344
Distribution of plume-shaped low-gravity zone in the southeastern part of the Korean Peninsula estimated through 3D gravity modeling	sung-wook KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3345
Investigation on the magnetotelluric (MT) survey from the Yeonil Tectonic Line and Ulsan fault zones in the Gyeongsang Basin of Korea	Kyeongho Ryu	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3346
T26 Geoscience Education					
S1 Geology Degrees Across the World – How are the Next Generation of Geologists Being Educated for the Geosciences of Tomorrow		Session Chair: Scientific Program Committee			
PROFESSIONAL INITIATION RESIDENCE PROGRAM LATO-SENSU IN EARTH SCIENCES AT THE GEOLOGICAL SURVEY OF BRAZIL – CPRM	Patricia DURINGER Jacques	M215	2024-08-28 08:00	2024-08-28 08:15	3348
ERASMUS+: a strategic tool to build partnerships among continents to enhance Geoscience through Higher Education.	Lola PEREIRA	M215	2024-08-28 08:15	2024-08-28 08:30	3350
Towards a common understanding of raw materials education worldwide – An international Qualification Framework for Raw Materials	Vitor Correia	M215	2024-08-28 08:30	2024-08-28 08:45	3352
Vision and Change – Transforming Geoscience Education in the United States	Christopher KEANE	M215	2024-08-28 08:45	2024-08-28 09:00	3353
Geoscientists for Ireland's future – What are we doing to encourage their creation?	Siobhán Eilís Power	M215	2024-08-28 09:00	2024-08-28 09:15	3354
The role of the NATIONAL FORUM OF GEOLOGY COURSES IN BRAZIL in the training of geologists and geological engineers	Alexis Rosa NUMMER	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3355
Enhancing Geoscience Education Through Critical Thinking: Insights on Teacher Development and Student Engagement	Liang Qiu	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3356
S2 Exploring Geoscience Across the Globe: Special Session in Memory of Chris King		Session Chair: Scientific Program Committee			
Promoting Geoscience Education in a South African Science Centre	Tanja REINHARDT	M215	2024-08-28 10:00	2024-08-28 10:15	3357

Title	Presenter	Venue	Start	End	Page
Teaching with toilet roll and learning with LegoTM to address the geosciences knowledge and skills gaps in the UK and beyond. -Teaching in the shadow of a king	Phillip MURPHY	M215	2024-08-28 10:15	2024-08-28 10:30	3358
Geoscience outreach for visually impaired learners: A journey to “see” Earth and space differently	Tanja REINHARDT	M215	2024-08-28 10:30	2024-08-28 10:45	3359
The Transformative Power of International Geoscience Experiences for Students	Tara Schielein	M215	2024-08-28 10:45	2024-08-28 11:00	3360
Sharing outreach and educational materials through YouTube: a case study from the Shear Zone Channel.	Rob BUTLER	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3361
Participatory Photography Methods in Geoscience Education	Sharon LOCKE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3363
S4 International perspectives for natural disaster education		Session Chair: Scientific Program Committee			
[Keynote] Systematization of Education for Disaster Risk Reduction from the Viewpoint of SDGs	Tatsuya FUJIOKA	M215	2024-08-28 16:00	2024-08-28 16:15	3368
UK Perspectives on Educating for "No Natural Disasters"	ILAN KELMAN	M215	2024-08-28 16:15	2024-08-28 16:30	3364
Incorporating Natural Blessings and Disasters to Develop an Integrated School Curriculum	Hisashi OTSUJI	M215	2024-08-28 16:30	2024-08-28 16:45	3365
Natural Disaster and Education in South Korea	Young Shin Park	M215	2024-08-28 16:45	2024-08-28 17:00	3366
Current Status and Issues of Earthquake Disaster Prevention Education in a Major City that Experienced The 1995 Southern Hyogo Prefecture Earthquake: A Case Study of Kobe City	Toshio ARIMICHI	M215	2024-08-28 17:00	2024-08-28 17:15	3370
Educating Local Communities in the Southeastern USA through a Natural Hazards Course	Athena Owen NAGEL	M215	2024-08-28 17:15	2024-08-28 17:30	3371
Development of Volcano Disaster Prevention Education Program from the Perspective of STEAM Education	Shintaro SATO	M215	2024-08-28 17:30	2024-08-28 17:45	3372
Examples of SDGs that raise awareness of disaster prevention and mitigation in schools and local communities.	Ichiro MATSUMOTO	M215	2024-08-28 17:45	2024-08-28 18:00	3374
S5 Geoscience Education and Outreach for All: Techniques and Trends for Engaging Non-Specialist Learners		Session Chair: Scientific Program Committee			
Exploring Learning in Virtual Geological Field Trip: A Theoretical Approach Based on the Revised Novelty Space Concept	YOONSUNG CHOI	M215	2024-08-29 08:00	2024-08-29 08:15	3375
Anthropomorphic characters: “Lucky charms - Geo-Mascots – Geo-Cartoons – Geo-Emoji Mascots” in Geoscience communication and popularisation	Maria-Luise Luise FREY	M215	2024-08-29 08:15	2024-08-29 08:30	3376
Understanding time scales: which teaching materials do students find easier to understand? - Cosmic (Geologic) Ticker Tape, Cosmic (Geologic) Calendar, and Cosmic (Geologic) historical film in case of undergraduate students –	Hiroo NEMOTO	M215	2024-08-29 08:30	2024-08-29 08:45	3378
Elementary Students' Understanding of Fossil Formation and Geological Change	Younkyeong Nam	M215	2024-08-29 08:45	2024-08-29 09:00	3382
Promoting Use of the UN Sustainable Development Goals in Pre-college Geoscience Education	Ed C. Robeck	M215	2024-08-29 09:00	2024-08-29 09:15	3383
Earth of all, Geology for all	Michele LUSTRINO	M215	2024-08-29 09:15	2024-08-29 09:30	3384
Geology and Disaster Risk Reduction Training for Non-Specialist Science Teachers: Implications for Professional Development of Teachers	Magnolia Vida Ante CANO	M215	2024-08-29 09:30	2024-08-29 09:45	3387
Communicating like Hutton and Muir: Connecting geology and ecology (Geocology) to improve public support for critical raw material extraction	Maureen Gallagher	M215	2024-08-29 09:45	2024-08-29 10:00	3386
Geodyssey: Forging a new path for app-based geoscientific teaching and learning	Cameron Roy PENN-CLARKE	M215	2024-08-29 10:00	2024-08-29 10:15	3380
The Geological History of Colombia Told by Its Rocks	Vanessa Rey León	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3389
Advancing geography education through 3D geospatial information	yuichi S. hayakawa	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3391
Sandsnap: Engaging the Public in Coastal Geoscience Through Social Media and Education Outreach	Brooke Marlo WALKER	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3392
Role-Playing: A New Method for Museum Exhibitions , (A Case Study from the Liu Guanghua Museum of Natural Heritage)	ZHUQING DENIS DING	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3393
Geolchat Fossil Edition: Using Paleontology as an science outreach strategy in social media	María Daniela MUÑOZ-GRANADOS	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3394
School Rock Maps: Geological information translated for society by the Geological Survey of Brazil	Andrea SANDER	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3396
Popularizing Brazilian paleontology through fossil replica workshops at the Geological Survey of Brazil	Andrea SANDER	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3398
Dissemination of Geosciences: SGBeduca's teaching collection of minerals and rocks donated to teachers	Andrea SANDER	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3400
S6 Geoscience Education and Awareness		Session Chair: Scientific Program Committee			
GEOLOGISTS.COM—the global digital platform fostering communication and collaboration among geologists and other professionals across Earth science disciplines	Olena IVANOVA	M215	2024-08-30 08:00	2024-08-30 08:15	3402

Title	Presenter	Venue	Start	End	Page
The importance of informal educators in improving geoscience education in Namibia	Josephine UUSHONA	M215	2024-08-30 08:15	2024-08-30 08:30	3406
REGIONAL DRILL CORE REPOSITORY, GSI, NAGPUR: A CENTRE FOR GEOSCIENCE INFORMATION DISSEMINATION	praveer PANKAJ	M215	2024-08-30 08:30	2024-08-30 08:45	3404
The Importance of Science Communication About Hydrogeology in Culturally Sensitive Arid Areas	Barbara REYES	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3408
Interpreting Dragons and Dinosaurs: Gaining Insights Through Museum Initiatives (Exhibition Practices at the Liu Guanghua Museum of Natural Heritage)	ZHUQING DING	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3409
ALTERNATIVE E-ASSESSMENT WITH INTEGRATED ACADEMIC STUDENT SUPPORT: CASE STUDY- ENVIRONMENTAL SCIENCES	Helena VAN NIEKERK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3411
S7 Mitigating multi-hazard risks: perception, awareness and educational perspectives to cultivate a risk culture and strengthen disaster resilience in vulnerable communities		Session Chair: Scientific Program Committee			
Conceptions of risk in the face of crises and the memory of events in tropical island territories. Ways of establishing a risk culture in the French West Indies.	Yves MAZABRAUD	M215	2024-08-30 09:30	2024-08-30 09:45	3412
Strategies and challenges for risk education in the city of São Paulo, Brazil	Natalia Leite de MORAIS	M215	2024-08-30 09:45	2024-08-30 10:00	3415
Languages and natural risk prevention in diglossic territories: a study in Guadeloupe	Béatrice JEANNOT-FOURCAUD	M215	2024-08-30 10:00	2024-08-30 10:15	3414
Deciphering the Scientific Conceptions of Students and Teachers: from Interaction-Based Modelling to Machine Learning Perspectives.	Alexandra RENOUARD	M215	2024-08-30 10:15	2024-08-30 10:30	3413
CREDO-L: An Innovative Landslide Mitigation Strategy for Highschool Students (Study Case: Depok, Indonesia)	TWIN HOSEA WIDODO KRISTYANTO	M215	2024-08-30 10:30	2024-08-30 10:45	3417
S8 International Perspectives on Earth Science Education		Session Chair: Scientific Program Committee			
Over 20 years of serving secondary and tertiary education worldwide – The activities of the Education Committee of EGU	Friedrich BARNIKEL	M215	2024-08-29 14:30	2024-08-29 14:45	3418
Measuring and Communicating the Impact of Earth Science Research on Society and the United Nations Sustainable Development Goals	Phoebe MCMELLON	M215	2024-08-29 14:45	2024-08-29 15:00	3420
Between Fieldwork and Classroom Training: the School of Geology and the Early Geological Survey in China (1913-1916)	Lijuan YANG	M215	2024-08-29 15:00	2024-08-29 15:15	3422
Fostering geoheritage education through Virtual Reality technologies	Vittoria VANDELLI	M215	2024-08-29 15:15	2024-08-29 15:30	3423
Practice of Geoscience Education for Guilin Karst World Natural Heritage Site -- Taking "A Drip of Water Travel" as an Example	Lina SHEN	M215	2024-08-29 15:30	2024-08-29 15:45	3428
Philippine Participation in the International Earth Science Olympiad (IESO): A Longitudinal Study	Miguel CANO	M215	2024-08-29 15:45	2024-08-29 16:00	3427
Evolution and Achievements of the IUGS Commission on Geoscience Education (COGE)	Ian Francis CLARK	M215	2024-08-29 16:00	2024-08-29 16:15	3425
[Keynote] Engaged Geosciences: Connecting Students, Teachers, and Community to Solve Local and Global Problems	Sharon LOCKE	M215	2024-08-29 16:30	2024-08-29 16:45	3429
Arts and Geoscience: An Interdisciplinary Approach to Enhancing Geoscience Education	Sandra Paula VIILLACORTA CHAMBI	Exhibition Hall			3430
Mobilizing Geoscience Education: The Mobile Laboratory (Laboratorio Móvil - LAM) Experience in Rural Uruguay	Elena Peel	Exhibition Hall			3432
S9 General Topics		Session Chair: Scientific Program Committee			
CLIMATIC DYNAMICS AND POPULATION TRENDS OF MICROTUS (IBEROMYS) CABRERAE (THOMAS, 1906) IN THE MEDITERRANEAN: A BIOCLIMATIC NICHE MODELING APPROACH	JULIA JIMENO-ALDA	M215	2024-08-30 13:50	2024-08-30 14:05	3433
Evaluation of Interpolation Methods for Mapping Potential Hydrogen for Windhoek Municipal Boreholes	Taleni Silas Taleni David	M215	2024-08-30 14:05	2024-08-30 14:20	3435
Promoting the equality of research and education in geosciences using 3D digital outcrops: implications of the DDE-Outcrop3D platform	Xia WANG	M215	2024-08-30 14:20	2024-08-30 14:35	3436
The why and how of seismic and geomechanical approaches for effective reservoir characterization	SHIB SANKAR GANGULI	M215	2024-08-30 14:35	2024-08-30 14:50	3437
Science Diplomacy in Action: Unveiling Opportunities and Challenges – A Case Study of Namibia's Endeavor to Integrate Science and Politics	Martha Ndapandula Haludilu	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3438
Erosion, Transport, and Deposition of Microplastics	Ino-Ethandje Thomas	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3439
The subsurface of Valencia: Conceptualization and 3D high-resolution model	ARIADNA CALLEA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3440
PETROGRAPHIC CHARACTERIZATION AND DIAGENESIS OF CARBONATE ROCKS IN THE NAMA BASIN OF SOUTHERN NAMIBIA: IMPLICATION AS VALUABLE RESOURCES.	Sam Shihafeleni SHANGHETA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3441

Title	Presenter	Venue	Start	End	Page
Re-assessing late Holocene Lake level fluctuations in Lago Cardiel, Southern Patagonia (Argentina) – Geomorphological and archeological implications.	Luis Rubén Horta	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3442
Neoichnology in Salar de Antofalla, Catamarca province, Argentina: a study case of Diptera living in an extreme environment	Gabriel Ricardo LÓ PEZ ISLA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3443
DECIPHERING THE LIMITS OF HABITABILITY: GEOSPATIAL ANALYSIS OF ANDEAN MICROBIALITIC SYSTEMS AS ANALOGUES FOR THE SEARCH FOR LIFE ON MARS.	Micaela DELLA VEDOVA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3445
Geochemical, isotopic, and mineralogical study of Vega Verde travertine system, central Andes -Argentina.	Guido Ezequiel Alonso	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3446
T27 Geoheritage, Geopark, and Geotourism					
S1+S2 Heritage Stone: safeguarding the cultural and social legacy of rocks		Session Chair: Víctor Cárdenes Van den EYNDE, Angela Ehling			
Trail of Heritage Stones along the trade routes through the ages	Angela EHLING	M211	2024-08-29 08:00	2024-08-29 08:15	3450
Portuguese limestones from the Middle Jurassic of the MCE candidate for heritage stone	Luis LOPES	M211	2024-08-29 08:15	2024-08-29 08:30	3452
A New Approach to Key Mineral Analysis for Tracking the Provenance of Stone Heritage	Myoungju CHOIE	M211	2024-08-29 08:30	2024-08-29 08:45	3458
A new look at the geology collections of the National museum of natural history - Paris, heritage stones from buildings or sites	Grégoire EGOROFF	M211	2024-08-29 08:45	2024-08-29 09:00	3453
Heritage Stone Subcommission: Showcasing the first 50 IUGS Heritage Stones	VINOD KUMAR SHARMA	M211	2024-08-29 09:00	2024-08-29 09:15	3462
Heritage Stones, and their cultural and historical legacy in the Indian subcontinent	VINOD KUMAR SHARMA	M211	2024-08-29 09:15	2024-08-29 09:30	3448
GOREE ISLAND (Dakar, Senegal, West Africa), UNESCO World Heritage Site without GEODIVERSITY ? Inventory AND Assessment of a GEOMORPHOSITE Sensitive to Coastal Erosion	Cheikh Ibrahima YOUM	M211	2024-08-29 09:30	2024-08-29 09:45	3463
The natural stones of the cemeteries in the PNDO (Ardennes, Wallonia, Belgium): a geoheritage approach linking geodiversity and biodiversity	Xavier DEVLEESCHOUWER	M211	2024-08-29 09:45	2024-08-29 10:00	3460
Geoheritage value of the Fonte Fenix and the Boca de Vaca springs from Panjim: hidden jewels from Goa, India	Raymond Ashirwad DURAISWAMI	M211	2024-08-29 10:00	2024-08-29 10:15	3456
Cultural and Social Legacy of Alpedrete Granite Heritage Stone	David Martín FREIRE-LISTA	M211	2024-08-29 10:15	2024-08-29 10:30	3454
SOCIAL LICENSE TO OPERATE FOR HERITAGE STONES QUARRIES: IS THIS APPROACH POSSIBLE?	Paola MARINI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3464
Itria Valley Heritage stones: the new studies on Natural Stone and World Heritage for the Apulian limestones	Paola MARINI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3465
S3 Geosites and Georoutes in the History of Geological Sciences		Session Chair: Ezio VACCARI, Martina KÖLBL-EBERT			
[Keynote] IUGS Geological Heritage Sites. A recognition to the history of our science	Asier Hilario	M211	2024-08-30 08:00	2024-08-30 08:15	3473
Crossing Heritages. Geosites, Geoheritage and their History through Images	Maddalena NAPOLITANI	M211	2024-08-30 08:15	2024-08-30 08:30	3466
VESUVIUS GEOROUTES	Claudia Principe	M211	2024-08-30 08:30	2024-08-30 08:45	3472
Maruia Falls (New Zealand) – a Historical Geosite for the Discovery of the Inner Earth Core	Martina KÖLBL-EBERT	M211	2024-08-30 08:45	2024-08-30 09:00	3467
Archibald Geikie and Edward Hull Tour 1887: in search of historical georoutes and geosites in County Donegal (Ireland)	Catherine (Kathleen) HISTON	M211	2024-08-30 09:00	2024-08-30 09:15	3469
The Agno Valley and Giovanni Arduino's 1758 cross section: an iconic site and a classic image for the birth of lithostratigraphy	Ezio VACCARI	M211	2024-08-30 09:15	2024-08-30 09:30	3468
MONTE AMIATA (TUSCANY, ITALY) IN THE HISTORY OF VOLCANOLOGY	Claudia Principe	M211	2024-08-30 09:30	2024-08-30 09:45	3470
The Argonauts Campaign to the Ancient Colchis Kingdom: One of the first documented geological exploration in the Human history	Avtandil OKROSTSVARIDZE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3475
Digital Preservation and Sharing of Classic Geosites and Georoutes via DDE-Outcrop3D Platform	HANTING ZHONG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3477
S4 Geoconservation and Geoheritage: geodiversity underpinning natural systems		Session Chair: Kevin Page, John Gordon			
[Keynote] Conservation of geodiversity and geoheritage in protected and conserved areas underpins natural systems and contributes to a sustainable future	John E. Gordon	M211	2024-08-27 09:30	2024-08-27 09:45	3502
The current status of geoheritage management in Korea: a decade of progress and future directions	Wansang RYU	M211	2024-08-27 09:45	2024-08-27 10:00	3492
How can we arrange a geoconservation strategy in our area? some tips based in the Basque Country (Spain).	Manu R. MONGE-GANUZAS	M211	2024-08-27 10:00	2024-08-27 10:15	3487
Integrating geoconservation and sustainability: a focus on natural resource management in the Brazilian Amazon	MARIA DA GLORIA GARCIA	M211	2024-08-27 10:15	2024-08-27 10:30	3488

Title	Presenter	Venue	Start	End	Page
Geoheritage and Geoconservation as a resource and a tool for promoting the United Nations 17 Sustainable Develop Goals (SDGs)	Kevin Neil Page	M211	2024-08-27 10:30	2024-08-27 10:45	3493
Managing natural heritage: geoconservation efforts across Latin America and the Caribbean's landscapes	MARIA DA GLORIA GARCIA	M211	2024-08-27 10:45	2024-08-27 11:00	3485
New geoheritage research initiative of the Saudi Geological Survey aiming to act as national guardian of the abiotic natural values of the Kingdom of Saudi Arabia	Karoly NEMETH	M211	2024-08-27 14:30	2024-08-27 14:45	3503
Key Geoheritage Areas: a promising IUCN initiative for global geoconservation	José B. R. BRILHA	M211	2024-08-27 14:45	2024-08-27 15:00	3500
Geoparks' way of survival in National Parks management system-perspectives from Australia and China	Qian Li	M211	2024-08-27 15:00	2024-08-27 15:15	3497
The open air Museum - A significant geoconservation in the Lesvos Petrified Forest - Lesvos island UNESCO Global Geopark, Greece.	Nikolaos ZOUROS	M211	2024-08-27 15:15	2024-08-27 15:30	3482
From Cultural Landscape to Aspiring Geopark: 18 Years of Community-Based Landscape Tourism Development in Fengnan Village, Hualien County, Taiwan (2006–2024)	Kuang Chung LEE	M211	2024-08-27 15:30	2024-08-27 15:45	3480
Geosensitivity based Geoheritage threat mapping using RS and GIS in the Darjeeling hill region, India	Lakpa TAMANG	M211	2024-08-27 15:45	2024-08-27 16:00	3484
Integrating geo- and biodiversity: Towards a more holistic approach to nature conservation	Kevin Neil Page	M211	2024-08-27 16:00	2024-08-27 16:15	3495
Addressing geohazards in populated geoheritage sites: the case of Dovžan Gorge Natural Monument in Slovenia	Matevž Novak	M211	2024-08-27 16:30	2024-08-27 16:45	3490
When citizens contribute to the discovery of geosites and to geoconservation	Isabelle ROUGET	M211	2024-08-27 16:45	2024-08-27 17:00	3498
From Cultural Landscape to Aspiring Geopark: 18 Years of Community-Based Landscape Tourism Development in Fengnan Village, Hualien County, Taiwan (2006–2024)	Kuang Chung LEE	M211	2024-08-27 17:00	2024-08-27 17:15	3480
Remote sensing assessment of biological activities on built historical structures in a tropical region: Case of the Osun-Osogbo Sacred Grove UNESCO World Heritage Site, South-Western Nigeria.	Jokotola Toyyebat OMIDIJI	M211	2024-08-27 17:15	2024-08-27 17:30	3478
How to save a discovery in an active mine? Cooperation with the mine and its workers to protect the dinosaur heritage	Piotr SZREK	M211	2024-08-27 17:30	2024-08-27 17:45	3505
Toward global modelling of geoheritage and geodiversity loss	Mihai Niculiță	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3506
Interpretation of Underground Structure and Provenance for Rock Properties in Three-story Stone Pagoda and Flagpole Support Stones from Jungchosaji Temple Site of Anyang, Korea	HyeJi Choi	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3507
U.S. Geological Survey Geoheritage Sites of the Nation Inventory	Christina DEVERA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3509
Lithological Characteristics and Provenance Interpretation of Stone Properties for Jotap-ri Five-story Brick Pagoda in Andong, Korea	Dong Hee JEONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3511
Stability Interpretation for Rock-carved Standing Buddha Triad of Dongmun-ri in Taean, Korea, based on Geophysical Exploration and Slope Analysis	ILKYU CHOI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3513
Provenance Interpretation and Petrological Characteristics from Hongjueupseong Fortress Wall and Stone Block Foundation of Joyangmun Gate in Hongseong, Korea	JUN HO SONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3515
Cultural ecosystem services as a good presentation of geodiversity in the geopark– A case study in Taitung Geopark, southeast Taiwan	Chuanyao CHI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3517
Integrated geological and geophysical monitoring of the Udo beach sediments (Natural Monument) for geoheritage conservation	WOOSEOK YOON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3518
Can computational geoscientists and digital innovation contribute to geoconservation strategies?	Antoine BOUZIAT	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3519
S6 Geoscience in Geoheritage, Geoparks and Geotourism		Session Chair: Afia Akhtar			
Exploring Hydrogeochemical Characteristics and Impact on Geoheritage Monuments in Odisha: A GIS and Statistical Approach	ROSALIN DAS	M211	2024-08-29 14:30	2024-08-29 14:45	3533
Preserving Belitong Island UNESCO Global Geopark Unique Heritage: Geomorphosites and Anthropogenic Landforms	Santi Dwi PRATIWI	M211	2024-08-29 14:45	2024-08-29 15:00	3522
Sustainable use of materials from an abandoned quarry in a Unesco Global Geopark in Spain. A proposal.	Lola PEREIRA	M211	2024-08-29 15:00	2024-08-29 15:15	3524
Paleontological Zoning: a new paradigm for geoconservation in the Uberaba Geopark, Brazil	Thiago da Silva MARINHO	M211	2024-08-29 15:15	2024-08-29 15:30	3526
Investigation and Promotion of Geological Heritage of the Karaburun Peninsula in Türkiye	Oyküm Berfin GULERGUL	M211	2024-08-29 15:30	2024-08-29 15:45	3531
The Geological Setting of Tanzania with Possibilities of Hosting Potential Geoparks Worldwide	John Desderius Kalimenze	M211	2024-08-29 15:45	2024-08-29 16:00	3528
Geoheritage and Geotourism prospect of Ramu Upazila Cox's Bazar District, Bangladesh	Md. Faruk HASAN	M211	2024-08-29 16:00	2024-08-29 16:15	3521
Importance of Rock hive/Tafoni structure as geotourism point of view at Harihareshwar beach in Raigad district of Maharashtra, India	SHARAD GAJANANRAO PORATE	M211	2024-08-29 16:15	2024-08-29 16:30	3529

Title	Presenter	Venue	Start	End	Page
Wugongshan Geopark: A natural museum to study the granite dome and associated geological landforms	QINGCHENG HE	M211	2024-08-29 16:30	2024-08-29 16:45	3535
Study on Features and the Formation Mechanism of the Geomorphic Landscape of Slit-typed Danxia Gorge in the Loess Plateau in China	Hua DING	M211	2024-08-29 16:45	2024-08-29 17:00	3537
Karstological planning and construction control of new motorways and railway line crossing Classical Karst (Slovenia)	Martin Knez	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3539
STATE AND DEVELOPMENT OF GEOPARKS IN THE REPUBLIC OF UZBEKISTAN	Jurabek AZIMOV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3540
Geoheritages of Georgia (The Caucasus) and potential for aspiring UNESCO Geoparks	Avtandil OKROSTSVARIDZE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3541
Establishing a Geoheritage Museum in Nanchang, China: A Nexus for Scientific Research, Educational Outreach, Artistic Display, and Touristic Interaction – A Case Study	Guanghua Liu	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3543
Middle Jurassic Chaukhi Gabbro-Diabase-Pillow lava massif: An Impressive Geoheritage of the Greater Caucasus, Georgia	Salome GOGOLADZE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3545
Geotourism Sites of the Outer Ukrainian Carpathians	Ihor BUBNIAK (BUBNYAK)	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3547
The Spatial-temporal evolution and determinants of homestays in the Dabie old-revolutionary-base-region, China.	Qiankun LIU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3549
Tourism Intelligence in Cabo Ortegal Geopark. Case of San Andrés de Teixido (Spain)	Sergio MUINO FREIRE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3550
Geological Characterization of the Geoparks within the Central Zone of the Limpopo Mobile Belt: Implication to the development of E - virtual geo-tourism, South Africa	Humbulani MUNDALAMO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	3551
S8 The Second 100 IUGS Geological Heritage Sites		Session Chair: Scientific Program Committee			
IUGS GEOLOGICAL HERITAGE SITES		C205	2024-08-27 14:00	2024-08-27 14:15	3567
Italian sites for the history of geosciences: Vesuvius and Agno Valley	Catherine (Kathleen) HISTON	C205	2024-08-27 14:30	2024-08-27 14:40	3564
Jurassic Coast: Lyme Regis	David A.T. HARPER	C205	2024-08-27 14:40	2024-08-27 15:00	3560
The Durbuy Anticline: a top geoheritage site in the UNESCO Global Geopark Famenne-Ardenne, Belgium		C205	2024-08-27 14:50	2024-08-27 15:15	3578
The combined Esmark Moraine and Otto Tank's Moraine (Norway)	Ezio VACCARI	C205	2024-08-27 15:00	2024-08-27 15:30	3561
Mesoproterozoic Belt-Purcell Supergroup	Kylie CAESAR	C205	2024-08-27 15:10	2024-08-27 15:45	3562
Iconic Colorful Navajo Sandstone of The Wave at Coyote Buttes, Vermilion Cliffs National Monument, Arizona, United States	Marjorie A CHAN	C205	2024-08-27 15:20	2024-08-27 16:00	3570
Molassic sediments and pinacles of Meteora, Greece	Nikolaos ZOUROS	C205	2024-08-27 15:30	2024-08-27 16:15	3569
Kikaijima Island – the history of coral reefs over 100,000 years	Atsuko YAMAZAKI	C205	2024-08-27 15:40	2024-08-27 16:30	3571
Wuda Plant Fossil Site: Permian Vegetational Lagerstätte unveiling ancient coal forming plants and forest		C205	2024-08-27 15:50	2024-08-27 16:00	3579
Middle Jurassic dinosaur footprints from the Serras de Aire and Candeeiros	Luis LOPES	C205	2024-08-27 16:00	2024-08-27 16:10	3572
A Dinosaur Quarry, the World's Wonder: The Dashanpu Middle Jurassic Dinosaur Fossils Site	Yi LI	C205	2024-08-27 16:10	2024-08-27 16:20	3573
Las Hoyas fossil site (Cuenca, Spain): an extraordinary Early Cretaceous faunal and floral wetland	Angela D. D. BUSCALIONI	C205	2024-08-27 16:20	2024-08-27 16:30	3556
The geoheritage and geodiversity framework of the newly listed Second 100 IUGS Geological Heritage Site, the Pleistocene Al Wahba dry maar of Saudi Arabia within the Kishb monogenetic volcanic field	Karoly NEMETH	C205	2024-08-27 16:40	2024-08-27 16:50	3552
Paricutin: The Volcano born in a Mexican cornfield	Lucero	C205	2024-08-27 16:50	2024-08-27 17:00	3558
HEISEI SHINZAN LAVA DOME / THE SECOND 100 IUGS GEOLOGICAL HERITAGE SITES	Setsuya NAKADA	C205	2024-08-27 17:00	2024-08-27 17:10	3554
Mackenzie Delta - coastal landforms created by giant sediment deposition of the fluvial system under Arctic permafrost conditions	Zbigniew Zwoliński	C205	2024-08-27 17:10	2024-08-27 17:20	3575
Outstanding geoheritage values of the Korean Getbol	Kyung-Sik WOO	C205	2024-08-27 17:20	2024-08-27 17:30	3559
Wakulla Spring, Florida, USA: A preeminent example of karst hydrogeology	Jonathan ARTHUR	C205	2024-08-27 17:30	2024-08-27 17:40	3565
Tepuis and quartzite karst of Gran Sabana, Venezuela		C205	2024-08-27 17:40	2024-08-27 17:50	3580
Vatnajökull - a complex interplay of rift, fire and ice	Zbigniew Zoliński	C205	2024-08-27 17:50	2024-08-27 18:00	3576
Inverted landscape of a Plio–Pleistocene phreatomagmatic monogenetic volcanic field: Tapolca Basin, Hungary	Karoly NEMETH	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3581
S9 Global Geopark Network (GGN)/Geoparks and Society		Session Chair: Asier Hilario, Min HUH			
[Keynote] Global Geoparks Network: 20th anniversary Protecting and managing Earth heritage - Building Sustainable Communities	Nikolaos ZOUROS	M211	2024-08-28 08:00	2024-08-28 08:15	3587
Suggestion of New Paradigm for UNESCO Global Geoparks	Daekyo CHEONG	M211	2024-08-28 08:15	2024-08-28 08:30	3583
The contribution of UNESCO Global Geoparks and Global Geoparks Network to Geosciences	Maria-Luise FREY	M211	2024-08-28 08:30	2024-08-28 08:45	3584
Samcheok Geopark: Promising and aspiring geopark in Korea	Kyung-Sik WOO	M211	2024-08-28 08:45	2024-08-28 09:00	3586
UNESCO Global Geoparks in Belgium - added value and perspectives.	Xavier DEVLEESCHOUWER	M211	2024-08-28 09:00	2024-08-28 09:15	3589

Title	Presenter	Venue	Start	End	Page
UNESCO's Earth Sciences Activities in Africa: Impacts on sustainable development and capacity building	Kombada Mhopjeni	M211	2024-08-28 09:15	2024-08-28 09:30	3591
Participatory inventory of geosites as a tool for geoheritage management in the Mixteca Alta UNESCO Global Geopark (Mexico)	Jose Luis SANCHEZ-CORTEZ	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3593
The Pollino UNESCO Global Geopark (southern Italy): a route in the Ancient Tethys Ocean	Giovanni MONGELLI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3595
Geopoetics as a new tool for the enhancement of the management of Natural and Cultural Heritage in UNESCO Global Geoparks	Artur SÁ	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3597
Geoheritage conservation and promotion on a small tropical island: first steps toward a UNESCO Geopark in Guadeloupe, Lesser Antilles	Yves MAZABRAUD	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3598
University and Geopark: Fundamental Partnership for the Preservation and Promotion of Geological and Cultural Heritage.	Stela MORAIS	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3599
Strategic Management of Geoparks: Conservation, Development, and Challenges.	Stela MORAIS	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3601
Identifying the Relationship Between Geoparks and Local Government Policies	기업 김	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3603
Geoheritage and Geodiversity in Yazd Province, the Potentials to Develop Shirkouh and Bahabad Geoparks, Iran	Alireza AMRIKAZEMI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3604
S10 TRANSNATIONAL UNESCO GLOBAL GEOPARKS: The need and historical value of designating a transnational UNESCO Geopark in East Asia - focusing on Mount Baekdu and the Hantan River on the Korean Peninsula		Session Chair: Scientific Program Committee			
[Keynote] Transnational UNESCO Global Geoparks	Patrick James MCKEEVER	M216	2024-08-26 16:00	2024-08-26 16:15	3608
[Invited] The master plan of Hantangang transnational UNESCO Global Geopark between ROK and DPRK.	KIL YOUNGWOO	M216	2024-08-26 16:15	2024-08-26 16:30	3606
Historical and cultural value of Mount Baekdu as seen through old Korean maps	Sangmyeoung MOON	M216	2024-08-26 16:30	2024-08-26 16:45	3607
Expected Effects and Key Strategic Approaches for Promoting a Transnational UNESCO Global Geopark Network in Northeast Asia, Including Baekdusan aUGGp and Hantangang UGGp.	Soo Jae LEE	M216	2024-08-26 16:45	2024-08-26 17:00	3609
The Designation and Denomination of Transnational Geoparks: A Case Study in East Asia	Jisung KIM	M216	2024-08-26 17:00	2024-08-26 17:15	3611
Necessity of Transnational UNESCO Global Geopark in East Asia: Focusing on Baekdu Mountain Geopark and Gangwon Peace Geopark	Donwon CHOI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3613
S11 General Topics		Session Chair: Scientific Program Committee			
Magnetic susceptibility measurement using simulated rock samples and application to the stone used in Himeji Castle, a World heritage site	Ayaha EMURA	M211	2024-08-26 16:00	2024-08-26 16:15	3615
Inventory and Revision of Paleobiodiversity in the Uberaba Geopark: Challenges and Perspectives	Isadora	M211	2024-08-26 16:15	2024-08-26 16:30	3618
The Journey: IUGS Geological Heritage Sites of Namibia	Helke Brigitte MOCKE	M211	2024-08-26 16:30	2024-08-26 16:45	3616
Study on Environmental Characteristics of the Eundae-ri water spider(Argyroneta aquatica) habitat in Hantangang River Global Geopark	Jinah MOON	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3619
CoalHeritage project: Unlocking the potential of Europe's coal mining heritage	Nicolas CHARLES	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3620
The Italian Geosite Inventory: a useful tool for knowledge and geoconservation.	Elisa Brustia	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3622
Illuminating the cultural traces in the transition zones: Examples from the Mediterranean region	Nikos PAPADOPOULOS	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3623
T28 Forensic Geology and Medical Geology					
S2+S1+S3 Medical Geology in Honour of Professor Olle Selinus (Special Session)		Session Chair: Scientific Program Committee			
Olle Selinus (1943-2023): The Founder of Modern Medical Geology	Anna LADENBERGER	C205	2024-08-26 16:00	2024-08-26 16:15	3660
Comprehensive assessment and multivariate statistical analysis of Transfer Factors soil-to-plante stimated from bioavailable concentrations: A Case Study in the Campania Region, Southern Italy	Lucia Rita PACIFICO	C205	2024-08-26 16:15	2024-08-26 16:30	3642
Investigating the relationship between health and the environment using soil and air pollution data in a changing climate.	Jennifer M MCKINLEY	C205	2024-08-26 16:30	2024-08-26 16:45	3641
Coupling of neurodegenerative diseases to element distribution through geospatial statistics	Sarah CONRAD	C205	2024-08-26 16:45	2024-08-26 17:00	3646
Anthropogenic gadolinium in surface and groundwaters of Poland	Irena Agnieszka WYSOCKA	C205	2024-08-26 17:00	2024-08-26 17:15	3658
Role of Critical Minerals in Medical Geology: Applications and Implications	PRATIK PRAVIN GODBOLE	C205	2024-08-26 17:15	2024-08-26 17:30	3652

Title	Presenter	Venue	Start	End	Page
"RASASHASTRA": AN ANCINET INDIAN MEDICINAL SYSTEM PROMOTING MEDICAL GEOLOGY	Kirtikumar Ramkrushna RANDIVE	C205	2024-08-26 17:30	2024-08-26 17:45	3659
Forensic application of traceability technology in illegal marine sand mining crimes	Ping YIN	C205	2024-08-26 17:45	2024-08-26 18:00	3656
The Potential Traceability of Mineral Commodities using Artificial Taggant Particles	Laurance John DONNELLY	M217	2024-08-26 16:15	2024-08-26 16:30	3638
Determining the geographic origin of illegally imported Chinese dinosaur nests retrieved in Australia	Robert William FITZPATRICK	M217	2024-08-26 16:30	2024-08-26 16:45	3649
Exploration of Characteristics of Pollen Assemblages in Soil Sampes of China	ping wang	M217	2024-08-26 16:45	2024-08-26 17:00	3625
Mineralogy and morphology of earth materials in vehicle wheel-rims as significant trace evidence in a double murder and arson investigation in Australia	Robert William FITZPATRICK	M217	2024-08-26 17:00	2024-08-26 17:15	3654
Hazard and exposure assessment in contaminated land investigations and environmental management: The Lavrion case study, Hellenic Republic	ALECOS DEMETRIADES	M217	2024-08-26 17:30	2024-08-26 17:45	3639
The Development of Strontium and Oxygen Isoscapes to Determine a Geographical Origin of Human Remains in Korea	Seongshin GWAK	M217	2024-08-26 17:45	2024-08-27 16:00	3644
[Keynote] Community to Combat Crisis: Steps to engage with our environment and progress to better human and environmental health outcomes.	Kim DOWLING	M215	2024-08-27 16:00	2024-08-27 16:15	3645
Occurrence, Sources, Mechanisms of Enrichment and Possible Human Health Impacts of Fluoride-Bearing Groundwater in the Central Parts of the White Volta River Basin of Ghana	Moses Boakye OKYERE	M215	2024-08-27 16:15	2024-08-27 16:30	3626
Assessment of potentially harmful elements on human health and agriculture of surface and groundwater sourced from the granito-gneissic phreatic aquiferous formations in Bertoua and its environs, east region Cameroon.	SHARON NTUBE NGWESE	M215	2024-08-27 16:30	2024-08-27 16:45	3628
Environmental and Health Risk Assessment of Coal Mining in Moatize, Tete, Mozambique	Micaela Arlete Jose CHAPO COSSA	M215	2024-08-27 16:45	2024-08-27 17:00	3630
The occurrence of potentially harmful elements in gold mine tailings and their possible impacts on the environment and public health with reference to the Welkom goldfields in South Africa - A review	Rinae MAKHADI	M215	2024-08-27 17:00	2024-08-27 17:15	3632
Geochemical and isotropic composition assessment of groundwater consumed by a vulnerable population with chronic kidney disease of unknown origin (CKDu) in the dry zone of Sri Lanka	Navodya Dhananjalee MAHALEKAM	M215	2024-08-27 17:15	2024-08-27 17:30	3636
Potential risk of CO poisoning for casual workers exposed to emissions from clamp kiln: a South African perspective.	Lawrence DIKO MAKIA	M215	2024-08-27 17:30	2024-08-27 17:45	3648
Dimensionality reduction for visualizing gold trace element geochemistry through the chain of production in Brazil using UMAP	Angel VERBEL	M215	2024-08-27 17:45	2024-08-27 18:00	3657
Identification of mercury in stream sediment in Yanomami Indigenous Land, Roraima, Brazil	Patricia DURINGER Jacques	M215	2024-08-27 18:00	2024-08-27 18:15	3634
"We Did not Notice This Demon in Our Backyard!"—Introducing a New Source of Geogenic Health Hazard	Kirtikumar Ramkrushna RANDIVE	M215	2024-08-27 18:15	2024-08-27 18:30	3651
Mineralogical and elemental information for soil geolocation tracing	hongling guo	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3661
Forensic Geology in Chile: Foundations of a scientific basis for Justice and Environmental Sciences.	Kristian AGURTO VELASQUEZ	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3662
The impact of ashes produced during a fire event on the soil: a comparative study between anthropogenic and natural sources in the Campania region (Southern Italy).	Lucia Rita PACIFICO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3664
A Study on Discrimination Capability of Soil for Forensic Comparison based on Statistical Approach in South Korea	Yu Ran LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3666
Tracing the geographical origin of bottled water collected in South Korea via isotopic and elemental analyses	Byeong-Yeol SONG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3667
Medical and environmental aspects of multipurpose geochemical mapping	Iosif VOLFSON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3668
Occurrences of potentially toxic elements such as uranium (U) and molybdenum (Mo) in the Karoo ground-and-surface waters near Beaufort West, Western Cape, South Africa: a possible health threat to the local population?	Okuhle POTO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3670
New insights into the geological occurrence, morphology and toxicology of New Zealand erionite minerals	Martin Brook	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3671
WATER QUALITY FOR HUMAN CONSUMPTION IN THE CONTEXT OF ABANDONED ARTISANAL GOLD MINING	Marina THIMOTHEO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3672
T29 Engineering Geology and Geomechanics					
S2+1 General Topics		Session Chair: Scientific Program Committee			
Crack Propagation Analysis Through Digital Image Correlation in Volcanic and Plutonic Specimens Under Brazilian Tensile Tests	Chamran KAZEMI	C109	2024-08-30 08:00	2024-08-30 08:15	3678

Title	Presenter	Venue	Start	End	Page
Effects of heating-LN2 cooling on the Brazilian tensile strength of rock materials	BIKASH KUMAR KUMAR RAM	C109	2024-08-30 08:15	2024-08-30 08:30	3684
Influence of anthropogenic factors on landslide activity in the Moskva river valley (Moscow, Russia)	Pavel Novikov	C109	2024-08-30 08:30	2024-08-30 08:45	3682
The Engineering Geology of Havant Thicket Reservoir – The first to be built in the United Kingdom in over three decades	Hollie Elizabeth FISHER	C109	2024-08-30 08:45	2024-08-30 09:00	3677
The engineering geology of London's raised reservoirs with a summary of ground investigation risks and recommendations, citing techniques used at three sites	Hollie Elizabeth FISHER	C109	2024-08-30 09:00	2024-08-30 09:15	3676
Damage Evolution Mechanisms of Granite Rock under Cyclic Loading: X-Ray Computed Tomography and Digital Volume Correlation Technique Analysis	Shangtong YANG	C109	2024-08-30 09:15	2024-08-30 09:30	3688
INTERPLAY OF COHESIVE-ORGANIC SOILS AND DISPERSIVE BEHAVIOR: SHAH ALAM'S SUSCEPTIBILITY TO WATER PONDING	NOR SHAHIDAH MOHD NAZER	C109	2024-08-30 09:30	2024-08-30 09:45	3687
Engineering-geological characteristics of pyroclastic deposits from paroxysmal eruption of Shiveluch volcano in 2023 (Kamchatka Peninsula)	Mariya NIKULINA	C109	2024-08-30 09:45	2024-08-30 10:00	3680
Shear behavior and deformation mechanisms of reactivated ancient landslides soil in the Nepal Himalaya	Bharat Prasad BHANDARI	C109	2024-08-30 10:00	2024-08-30 10:15	3679
Frequency dependence of internal mechanical losses in rocks in the low-frequency range	Aleksandr Sergeevich VOZNESENSKII	C109	2024-08-30 10:15	2024-08-30 10:30	3674
Sensibility analysis of the parameters "Factor of Safety" and "Probability of Failure" in Slope Stability	Rubén Eduardo ROMERO MAYMA	C109	2024-08-30 10:30	2024-08-30 10:45	3686
Comprehensive studies of the engineering geological behavior of red clay soils in Bangladesh	Md Shohel RANA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3689
Successful Replacement for Slope Stability Enhancement in Group-housing Site	BYUNG DON RO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3691
Paleostress from healed microcracks and fluid inclusions in granites in the northeastern and southwestern areas of the Ogcheon folded belt, South Korea	Seong-Seung KANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3692
Comparative analysis of slope stability assessment using LightGBM and CatBoost	Seong-Seung KANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3693
A comparative study of cation exchanges in 'extreme types of clay minerals' to modify the swelling index of the foundation soil underlying the civil engineering structures	Sudipta SARKAR	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3695
Rockslides and Rock Avalanches in the Upper Part of Mzymta River Valley (Caucasus, Russia)	Oleg ZERKAL	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3697
A Basic Study on the Development of Trenchless Excavation Technology and Construction Method	YONG BAEK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3699
Investigating physico-chemical and mechanical properties of Cretaceous sandstones within Khorat Cuesta, Northeastern, Thailand	Prachya Tepnarong	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3700
Evaluation of operating cost and economic feasibility of a limestone open pit mine in Korea	Dong-Kil LEE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3701
Case of Rockmass Classification in the Submarine Ground Where Marine Investigation is Difficult Due to Rapid Current	Seong-Woo MOON	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3702
Experimental study on mechanical properties of pore-filling and fracture-filling clayey silt hydrate-bearing sediments	Yiming LI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3703
Engineering geological studies and expected support design during the construction of diversion tunnels, Renukaji Dam Project, District Sirmaur, Himachal Pradesh, India	TRIPTI BABA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3704
Review on geological and engineering aspects of gypsum solubility and dissolution in the Arabian Gulf coast	Sungbin YIM	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3706
T30 Urban Geology					
S2+S1 General Topics		Session Chair: Scientific Program Committee			
Mainstreaming urban geoheritage as a tool for environmental education and geotourism in local administrations	Juana VEGAS	M212	2024-08-30 08:00	2024-08-30 08:15	3708
The monitoring of land subsidence and groundwater level in the southeast Kanto groundwater basin, Japan	Atsushi KAGAWA	M212	2024-08-30 08:15	2024-08-30 08:30	3709
Characterizing Groundwater Drought-Induced Land Subsidence Dynamics in Economic Hub of State of Gujarat, India	Anuradha Karunakalage	M212	2024-08-30 08:30	2024-08-30 08:45	3710
Bridging the Data Gap with 3D Geoscientific City Models (GeoCIM): A case study of the Liberec municipality, Czech Republic	Jan JELENEK	M212	2024-08-30 08:45	2024-08-30 09:00	3711
Locations that are prone to liquefy and locations that are difficult to liquefy by strong earthquakes in the Tokyo bay reclaimed land: Knowledge for urban planning that is unlikely to cause earthquake damage	Osamu KAZAOKA	M212	2024-08-30 09:00	2024-08-30 09:15	3713
[Keynote] Safe Urbanization in an Alluvial Terrain (Bangladesh): In the Reality of Seismic Risk and Climate Change	A K M Khorshed ALAM	M212	2024-08-30 09:15	2024-08-30 09:30	3715
Assessment of tunnel stability in active fault zone: Integrating A multidisciplinary approach	Kiwoong PARK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3717

Title	Presenter	Venue	Start	End	Page
T31 Geohazards					
S1+S4 Surface faulting and near-fault earthquake hazard		Session Chair: Paolo BONCIO			
[Keynote] Near-fault earthquake multi-hazards	Timothy Austin STAHL	M312	2024-08-28 09:30	2024-08-28 09:45	3719
Updating empirical regressions for Probabilistic Fault Displacement Hazard Analysis of distributed ruptures for dip-slip faults	Paolo BONCIO	M312	2024-08-28 09:45	2024-08-28 10:00	3726
Paleoseismology and capable faults in the Rieti intermountain basin (Central Italy)	Alessandro Maria Michetti	M312	2024-08-28 10:00	2024-08-28 10:15	3724
The role of brittle rock mass fracturing in alpine slope instabilities	Reinhard GERSTNER	M312	2024-08-28 10:15	2024-08-28 10:30	3722
Analysing the dynamics of rockfall at Koto Panjang, Indonesia : A Multi-Temporal Approach Through Street View Images and UAV	Tiggi Choanji	M312	2024-08-28 10:30	2024-08-28 10:45	3721
Landslide susceptibility assessment based on multi-sources data in the Three Gorges Project reservoir area	Ningtao WANG	M312	2024-08-28 10:45	2024-08-28 11:00	3720
August 2022 monsoon thunderstorm impact on the sedimentation in a tectonically active small catchment; case study of Saydoon dam reservoir, Southern Iran	Arash Barjasteh	M312	2024-08-28 11:00	2024-08-28 11:15	3718
Evaluating the Relationship between Catchment Area Capacity and Constructed Slope Failure Probability in South Korea	alain bindu	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3727
Suggestions for safety distance based on surface rupture characteristics and its importance to active fault Investigations	Yeoeun SEO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3729
The advantages of using a combination of ground, air, and space technologies for mitigating large landslides in Uzbekistan.	Abdulla Baratov	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3730
Generating plausible multifault ruptures with empirical rupture simulation	Timothy STAHL	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3731
Geo-engineering characteristics and performance analysis of the landslide mitigation measures implemented in the Rohingya camps in Bangladesh	Farhad HOSSAIN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3732
Probabilistic Fault Displacement Hazard Analysis of a strategic dam in the Sansepolcro graben (Northern Apennines, Italy): methodologic implications for distributed faulting	Paolo BONCIO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3734
Landslide Prediction in Nepal Himalaya with a National-Scale Rainfall-Triggered Nowcast System	Ananta Man Singh Pradhan	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3736
Analysis of Landslide Hazard and Geoenvironmental Condition in Rangamati and adjoining areas of Chittagong-Rangamati National Highway Road, the South-Eastern Hilly Districts of Bangladesh	Lubna KHONDAKAR	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3737
InSAR techniques and multi-risk assessment approach for monitoring Cultural heritage	Daniele SPIZZICHINO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3739
Chronological constraints of a fault scarp in a glaciated high mountain environment: the Coronas fault scarp	MARÍA ORTUÑO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3741
Landslide Hazards and Forecast under Changing Climatic Patterns	Devesh WALIA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3742
S2 Outreach tools as a way to increase preparedness for geological hazards		Session Chair: María ORTUÑO, Jin-Hyuck CHOI			
[Keynote] Geological risk assessment in Mexico City: The Interactive Observatory of Land Subsidence and Fracturing, OIHFRA	Dora Celia CARREON-FREYRE	M312	2024-08-28 08:00	2024-08-28 08:15	3745
[Keynote] The UNESCO Land Subsidence International Initiative (LaSII)	Dora Celia CARREON-FREYRE	M312	2024-08-28 08:15	2024-08-28 08:30	3747
Citizen science in response to the climate crisis : focus on old building retrofit for low-income people	Jong-Won Lee	M312	2024-08-28 08:30	2024-08-28 08:45	3743
Current Research and Education Efforts for Proactive Landslide Disaster Management in the Context of Climate Change in Korea	Joon-Young PARK	M312	2024-08-28 08:45	2024-08-28 09:00	3744
Experience and challenges of popularizing sciences related to earthquake disasters in S. Korea	Jin-Hyuck CHOI	M312	2024-08-28 09:00	2024-08-28 09:15	3749
Presenting the Outcome of Earthquake Prediction Spatial Probability Mapping Utilizing Explainable Artificial Intelligence in the Nepal Himalayas	Suchita SHRESTHA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3750
SINKHOLES AND UNDERGROUND WATER FLOW AS A RESULT OF PROLONGED RAINFAL; THE CASE OF SAKATA, CHOWE, AND ZOMBA IN SOUTHERN MALAWI	Joseph CHIRWA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3751
S3 Geohazards: A global phenomenon and their Reduction Strategies		Session Chair: Madumita DAS			
The Kumalu catchment area, Bulolo District, Morobe Province, Papua New Guinea: Some findings and conclusions about the floods and landslides since 1950s	Shekinah Pilamp	M312	2024-08-27 08:00	2024-08-27 08:15	3761
Geological Survey Ireland, managing geohazards in a safe country, landslides, groundwater flooding and coastal change.	Koen M VERBRUGGEN	M312	2024-08-27 08:15	2024-08-27 08:30	3763
Development of Classification and Grading Approach for Potential Large-scale Landslides and its Application	TING-YU WU	M312	2024-08-27 08:30	2024-08-27 08:45	3765
Assessing the influence of geological structures and lineaments on the landslides in KwaZulu-Natal Province, South Africa: A case study on the Sangwana Mountain landslide	MAWANDE NCUME	M312	2024-08-27 08:45	2024-08-27 09:00	3766
Characters of Landslides Development in Arid Areas, Assessment and Trends	Gany BIMURZAEV	M312	2024-08-27 09:00	2024-08-27 09:15	3759

Title	Presenter	Venue	Start	End	Page
Man-Induced Landslides in Uzbekistan: Overview and Case Studies	Gany BIMURZAEV	M312	2024-08-27 09:15	2024-08-27 09:30	3757
Geohazards and Risk Reduction Framework in India	VINOD KUMAR SHARMA	M312	2024-08-27 09:30	2024-08-27 09:45	3755
Recent landslides of liquefaction in Uzbekistan triggered by resonant frequency oscillations during deep strong Pamir-Hindu Kush earthquakes	Mansurjon Makhmudjanovich TASHPULATOV	M312	2024-08-27 09:45	2024-08-27 10:00	3753
Geological characteristics of the area where land subsidence has continued for more than 12 years with in liquified-fluidized part on the Tokyo bay reclaimed land at the 2011 off the Pacific Coast of Tohoku Earthquake	Osamu KAZAOKA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3768
S5 Our Tasks on Global Submarine Geohazard Issues to our future earth		Session Chair: Kiichiro KAWAMURA			
Tectonic structure and deformation along the Manila Trench subduction zone: Implications on submarine geohazards in the South China Sea eastern margin	Leo ARMADA	M312	2024-08-27 14:30	2024-08-27 14:45	3779
Imaging offshore deformation features in western Luzon using integrated geophysical analyses	Carla Besa DIMALANTA	M312	2024-08-27 14:45	2024-08-27 15:00	3777
Spatial time series variation of contourite drifts on active margins: Examples from the Kuril Trench in the NW Pacific	Hisashi IKEDA	M312	2024-08-27 15:15	2024-08-27 15:30	3773
In-situ Observation and Machine Learning Prediction of Marine Shallow Gas Emission	Cong HU	M312	2024-08-27 16:45	2024-08-27 17:00	3780
Key Technologies and Equipment of Geological Environment Observation in Deep-Sea Development	Yonggang Jia	M312	2024-08-27 17:00	2024-08-27 17:15	3772
How do overpressure-driven hydrofractures grow in sedimentary basins?	Qing WANG	M312	2024-08-27 17:15	2024-08-27 17:30	3770
Submarine geohazards and renewable energy	Kiichiro KAWAMURA	M312	2024-08-27 17:30	2024-08-27 18:00	3771
Depositional process of contourite on active margins: Examples from the Kuril Trench and the Japan Trench in the NW Pacific		M312	2024-08-27 15:00	2024-08-27 15:15	3775
In-Situ Observation on the Interaction of Deep-Sea Internal Solitary Waves with the Seabed		M312	2024-08-27 15:30	2024-08-27 15:45	3781
Submarine geohazards and educational materials	Kiichiro KAWAMURA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3783
An optimal geological method to decipher active faults and related lineaments at Yamaguchi, SW Japan	Momoko TSUTSUMI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3785
Microplastics: diffusion into ocean floors by tsunamis and typhoons and application for age determination	Kiichiro KAWAMURA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3787
A harmonized database on geological events occurrence as a tool to support geohazard assessment in European seas	Andrea FIORENTINO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3788
Possible development and implication of subsurface fault structures offshore northeast Taiwan	Chien-Wei HSU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3790
Active Fault and fold structures in northern Taiwan Strait	YI-PING CHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3791
S6+S7 Advances in Modeling and Simulation of Geological Disaster Problems		Session Chair: Yu Huang			
[Keynote] Rheological behaviour of pressure-controlled steady slope flow with coexistence of multiple flow regimes	Chongqiang ZHU	M312	2024-08-26 16:00	2024-08-26 16:15	3798
Shallow Subsurface 3D Velocity Structure Identification in Turkey Antakya based on Microtremor Horizontal-to-Vertical Spectral Ratio	Jikai SUN	M312	2024-08-26 16:15	2024-08-26 16:30	3792
Framework for prioritization strategies for slope reinforcements under heavy rainfall based on probabilistic connectivity of road networks	Zhengying he	M312	2024-08-26 16:30	2024-08-26 16:45	3793
Energy evolution of subaqueous gravity flows composed of viscous liquids and particles	Chen PENG	M312	2024-08-26 16:45	2024-08-26 17:00	3794
DEM modeling of undrained cyclic triaxial behavior in submarine loose sediments under wave loading: the influence of fine contents	Yandong Bi	M312	2024-08-26 17:00	2024-08-26 17:15	3795
Simulating Cyclic Injection-Induced Fatigue in Rocks	Chang Xia	M312	2024-08-26 17:15	2024-08-26 17:30	3800
Prediction of landslide hazard using LS-RAPID model. A case study in Tia Dinh area (Dien Bien province, Vietnam)	Ha Duc NGUYEN	M312	2024-08-26 17:30	2024-08-26 17:45	3796
Numerical Insights into Microbially Induced Desaturation (MID) in Layered Silts and Sands	Patrick Kwon	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3801
Karst geohazard and climate change: case of Lithuania	Jonas SATKUNAS	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3802
From Hazard to Opportunity: Success Story of Biogenic Gas Exploration in North Sumatera Basin through Heating Rate Analysis in Offshore Area	Anggit KURNIA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3803
Improving landslide susceptibility assessment using probabilistic back analysis and Markov Chain Monte Carlo simulation	Hyuck-Jin PARK	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3804
Seismic Imaging of Fault Structures Offshore Northern Taiwan Mountain Belt	Ching-Yun HUANG	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3805
Appraisal of the present-day geodynamics in Andaman Islands through campaign mode GNSS survey	SNEHASIS BHATTACHARYA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3806
Smart Monitoring System for Flexible Barrier Using Accelerometer and Corrosion Sensors	JunHa BAEK	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3808

Title	Presenter	Venue	Start	End	Page
Stability Assessment of the Rock-Cut Slopes Based on a Multi-Method Approach	PRATEEK SHARMA	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3810
INVESTIGATION OF THE RELATIONSHIP BETWEEN GEODYNAMIC AND GAS DYNAMIC PROCESS IN MINING AREAS	Alexander KOBYLKIN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3811
GEOMORPHOLOGICAL EVOLUTION AND ASSOCIATED RISK ON THE SLOPES OF CERRO SOLO AND TECHADO NEGRO, TORRE GLACIER VALLEY, SANTA CRUZ PROVINCE, ARGENTINA	Daniela SCHMIDT	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3812
SUSCEPTIBILITY TO LANDSLIDES IN AN AREA OF 48 KM2 IN THE SURROUNDINGS OF BIOTOPO MARIO DARY RIVERA NATURE RESERVE, PURULHÁ, BAJA VERAPAZ, GUATEMALA	Gabriel MORALES RECINOS	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3814
Study on coastal flooding from Probable Maximum Storm Surge(PMSS) by the changes in Probable Maximum Typhoon Intensity at the nuclear power plant site	JAEWOONG RYU	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3813
Estimation of debris flow damage areas using influencing factors and empirical formula	Jaeho LEE	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3815
T32 Mitigation and Adaptation in the Climate Crisis					
S1+S2 Geoscience Contributions to Climate Change Mitigation Strategies		Session Chair: Scientific Program Committee			
Soil CO2 change and rainfall effect in growing season in a karst grassland of Slovenia	Cheng ZHANG	C106	2024-08-30 08:00	2024-08-30 08:15	3824
Integrated assessment of gully erosion susceptibility for risk informed urban planning: A case study of Rundu, Namibia	Giesberta Naipopya Shaanika	C106	2024-08-30 08:15	2024-08-30 08:30	3821
Carbon Capture, Utilisation, and Storage opportunities in South Africa's highest carbon dioxide emissions hub: opportunities for the Just Transition	Taufeeq DHANSAY	C106	2024-08-30 08:30	2024-08-30 08:45	3823
Solid Carbon: Safe, durable and scalable geological carbon storage in the ocean crust	Martin SCHERWATH	C106	2024-08-30 08:45	2024-08-30 09:00	3817
Impact of Climate Change and Rapid Urbanization: A need for Climate Resilience Plans- based on Flash Flood Analysis in Hyderabad Metropolitan area through a Geospatial approach	Anoop V M	C106	2024-08-30 09:00	2024-08-30 09:15	3819
Evaluation of energy saving effects in university campus rooftop greening through the use of high concentrations of carbon dioxide in lecture rooms	Jeongwoo PARK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3826
Artisanal Biochar Production: A Sustainable Pathway for Climate Resilience in Rwanda	Magalie NTAHOKAJA	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3828
Application of Petrography to the Assessment of Philippine Coastal Concrete Structures Exposed to Extreme Weather Conditions	Chelly Mei Nacional TANPOCO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3829
Investigation of hydrochemical and stable carbon isotope compositions as effective tracers for tracing CO2 leakage: lessons from two controlled CO2 release tests	Hyunkwon Do	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3831
Enhanced basalt weathering for CO2 sequestration under wheat-corn rotation pattern in Xuyi County, China	Yijaing XU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3833
S3+S4 Offshore Monitoring Technology and its Application for CO2 Storage		Session Chair: Scientific Program Committee			
[Keynote] Building on Bedrock: Geosciences' Role in Mitigation and Adaptation	Lisa GRAUMLICH	C106	2024-08-30 09:30	2024-08-30 09:45	3842
Non-repeatable Noise Attenuation on Time-lapse Prestack Data using Fully Convolutional Neural Network	Hanjoon Park	C106	2024-08-30 09:45	2024-08-30 10:00	3837
Artificial CO_2 release experiments for the development of stationary monitoring system in Korea	JONGHA HWANG	C106	2024-08-30 10:00	2024-08-30 10:15	3838
Numerical modeling of subsurface fluid injection using the poroelastic finite element code	Chan-Hee JANG	C106	2024-08-30 10:15	2024-08-30 10:30	3840
Research on a CO2 Internet of Things online monitoring system for marine carbon storage	JUNXI TU	C106	2024-08-30 10:30	2024-08-30 10:45	3835
Repeatability analysis of time-lapse OBC data for CCS in the offshore of Pohang, Korea	YONGHWAN JOO	C106	2024-08-30 10:45	2024-08-30 11:00	3841
Unraveling the Complex Nexus of Geology, Water Quality, and Forage Impact on Enteric Methane Emissions: A Case Study from North Kivu, Democratic Republic of the Congo	Tomple Byamungu Mayange	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3843
Feasibility study for subsurface imaging using onshore VSP geophone and DAS data	Hanjoon PARK	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3845
Numerical Modeling of Two-Way Coupled Simulation for Geological Carbon Storage	Hyun Chul YOON	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3846
Reservoir simulation study for the injectivity and geomechanical stability in the Gunsan basin	Taehun LEE	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3847
Building an initial velocity for 3D OBC seismic data processing in the Gunsan basin, offshore western Korea	Woohyun SON	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	3848

Title	Presenter	Venue	Start	End	Page
T33 Big Data and Artificial Intelligence (AI) in Geoscience					
S1+S2 Application of AI algorithms in natural hazards modelling		Session Chair: Biswajeet PRADHAN, Saro LEE			
Development of a surrogate model to improve the efficiency of groundwater level fluctuation pattern-based hydrologic properties evaluation	JIHO JEONG	M217	2024-08-27 08:00	2024-08-27 08:15	3849
Machine-learning-based microearthquake detection for the southern Korean Peninsula	Byeongwoo Kim	M217	2024-08-27 08:15	2024-08-27 08:30	3850
Investigation of Important Factors on the Field-scale DNAPLs Contamination by Applying Polynomial Chaos Expansion and Random Forest	Taehoon Kim	M217	2024-08-27 08:30	2024-08-27 08:45	3851
Improvement of performance of in-situ virtual monitoring system of the occurrence probability for high concentrations of naturally occurring radioactive materials in groundwater through the solution of the data imbalance problem	Hyeongmok LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3853
Pollution Sources Identification and Sustainable Management Strategy of Groundwater in Volcanic Islands: A Case Study of Jeju Island Using an Integrated Multivariate Statistical and Machine Learning Approach	Hyuntai AHN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3854
Evaluation of the Feasibility of Applying Machine Learning Techniques for Landslide Prediction	Hyeyeon JEON	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3856
Convolutional LSTM networks for predicting spatio-temporal variability of standardized groundwater level index in South Korea	Sanghoon LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3857
Oil spill analysis around Small Island Developing States through multimodal large model	Xiaohui YU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3858
Prediction of groundwater levels of National Groundwater Monitoring Network in South Korea using LSTM (Long Short-Term Memory)	hyowon AN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3859
S3 Prediction of reservoir response using machine learning and data integration		Session Chair: Scientific Program Committee			
A deep learning-based proxy model for 3D channel reservoir characterization	Youjun LEE	M217	2024-08-27 14:30	2024-08-27 14:45	3860
Carbonate structures and reservoir identification based on machine learning methods: A case from the Lower Paleozoic of Jiyang Sub-Basin	Chenglong LIU	M217	2024-08-27 14:45	2024-08-27 15:00	3861
Intelligent logging identification of petrophysical facies	Xinhao ZHANG	M217	2024-08-27 15:00	2024-08-27 15:15	3863
Productivity Prediction of shale basins in the USA using machine learning and data integration	Sungil KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3864
Fracture identification based on graph convolutional network in continental shale oil reservoirs	Guoqing LU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3865
S4 Data-driven or AI-driven Discovery in Geosciences		Session Chair: Guoxiong CHEN			
Cascade Effects of Global Supply Chains Induced by Regional Conflicts Increase Global Inequality	Rongtian Zhao	M217	2024-08-27 16:00	2024-08-27 16:15	3866
Innovative input-output geographical cascading model for detection and simulation of induced negative shocks in global supply chains	Mo Zhang	M217	2024-08-27 16:15	2024-08-27 16:30	3867
Research on Petroleum Geological Reserve Prediction Based on Machine Learning	XIAOYU AN	M217	2024-08-27 16:30	2024-08-27 16:45	3868
Leveraging Machine Learning, Natural Language Processes and Knowledge Representations to Facilitate the Discovery of Insights and Analogues in Unstructured Geoscience Literature	Phoebe MCMELLON	M217	2024-08-27 16:45	2024-08-27 17:00	3871
An ensemble model for predicting mineral prospectivity: a case study in the Malipo W-Sn mineral district, Yunnan Province, China	Jie ZHAO	M217	2024-08-27 17:00	2024-08-27 17:15	3873
Drivers of Phanerozoic Marine Biodiversity: Insights from Machine Learning	Guoxiong Chen	M217	2024-08-27 17:15	2024-08-27 17:30	3875
Intelligent Identification of Target Properties of Downhole Rockfall Funnels in Pulang Copper Mine	JIANGUO CHEN	M217	2024-08-27 17:30	2024-08-27 17:45	3876
AusGeochem: Unveiling Earth through 4D Geochemistry	Halimulati ANANUER	M217	2024-08-27 17:45	2024-08-27 18:00	3878
Decoding Informative Factors for Large Earthquake Occurrence Recognition from the Earthquake Catalogs with Explainable Machine Learning	Jinsu JANG	M217	2024-08-27 18:00	2024-08-27 18:15	3880
Explainable machine learning to uncover hydrogen diffusion mechanism in clinopyroxene	Anzhou LI	M217	2024-08-27 18:15	2024-08-27 18:30	3881
Time-limited lithogeochemistry of marine and terrestrial alternation on the Tibetan Plateau	Xinwei Liu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3882
Calculation of crustal thickness and characterization of its spatial distribution in the South American Andes magmatic arcs	Kunyi WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3884
A data-driven approach for adaptive utilization of geothermal energy worldwide by examining top 100 geothermal cities	Wang XU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3886
Quantitative analysis of fluid inclusions characteristics based on data drive	Xia QINGLIN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3888
Comprehensive Evaluation of Tobacco-planting Soil Fertility Based on Machine Learning: A Case Study of Hezhou City, Guangxi	JUNXI TU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3869

Title	Presenter	Venue	Start	End	Page
Machine Learning and Magma Fertility Determination: Revealing Spatio-temporal Variation of the Favorability of Porphyry Copper Formation	Yuanzhi ZHOU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3890
The formation and evolutionary process of the North China Craton during early Precambrian: Implications from big data analysis	Zhenjie ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3891
Application of remote sensing to identify Copper–Lead–Zinc deposits in the Heiqia Area of the West Kunlun Mountains, China	yuhai FAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3892
Machine learning models for investigating the primary water content of pyroxene in mantle-derived magmas	Huan CHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3893
Development of clustering model for XRD experimental data from the Ulleung Basin, Korea	Ju Young PARK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3894
A Method of Geological Mapping Based on Deep Learning	Fengdan LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3896
Data-driven Automated Detection and Characterization of Dinosaur Footprints	Yeoncheol HA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3898
Deep Learning 3D Mineral Segmentation with micro-CT and micro-XRF	Yiming WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3899
Multi-scale full waveform inversion based on a convolutional neural network	Hong LIU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3900
Improvement of YOLO Model for Borehole Breakout Detection Using Data Augmentation	Juyeol YEOM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3902
Mineral Identification and Mapping Algorithm Based on X-ray Fluorescence Spectroscopy and Self-supervised Strategy	Weiming JIANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3904
GIS Tool Learning with Large Language Model	Zhizhen YU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3905
Improvement and Evaluation of the RAG Application	Jiarui CAI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3906
Predicting Methane Concentration in Chromitites: An Application of Ensemble Learning Algorithms in Chro-mitites from Greece	Elena IFANDI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	3907
S6 Big Data and Artificial Intelligence (AI) in Geomodeling		Session Chair: Scientific Program Committee			
Characterizing subsurface structures from hard and soft data with multiple-condition fusion neural network	Zhesi Cui	M217	2024-08-28 09:30	2024-08-28 09:45	3911
Forecast of Shale Lithofacies Types in the Dongying Fault-depressed Lacustrine Basin Based on Machine Learning	Zhengwei FANG	M217	2024-08-28 09:45	2024-08-28 10:00	3909
A new sedimentary facies geo-modeling method based on CGAN deep-learning algorithm	Yiming YAN	M217	2024-08-28 10:00	2024-08-28 10:15	3912
A method using convolutional interactive perception network for well logging data prediction.	Xin LUO	M217	2024-08-28 10:15	2024-08-28 10:30	3910
Deep learning-based multiscale digital rock modeling integrating 2D and 3D rock images	Peng Chi	M217	2024-08-28 10:30	2024-08-28 10:45	3908
Application of BPNN neural network algorithm driven by data and model in bitumen content prediction of Silurian Kepingage Formation reservoir in Tazhong area	Yanjun Lu	M217	2024-08-28 10:45	2024-08-28 11:00	3913
Predicting the lithofacies of Longdong lacustrine shale oil based on the intelligent fusion of multi-scale well logging data	Quansheng MIAO	M217	2024-08-28 11:00	2024-08-28 11:15	3914
Research on Knowledge Sharing of WRF Meteorological Simulation Based on Knowledge Graph Structure	Chunxiao ZHANG	M217	2024-08-28 11:15	2024-08-28 11:30	3915
Diagenetic facies characteristics and quantitative prediction via wireline logs based on machine learning	Liqiang ZHANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3917
Machine learning-based approach for intermediate volcanic rock tectonic setting determination.	FengRui JIN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3918
Assessment of the effectiveness of a convolutional autoencoder for digital image-based automated core logging	Jaesung PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3919
Method of Segmenting the Origin of Soil samples in South Korea Using Deep Learning-based Feature Extraction Technology	SUBI LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3920
Integration of Dense Well Network Architecture Unit Geological Knowledge Base into Generative Adversarial Networks for Modeling Reservoir Architecture in Fan Delta	Chao Jiang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3921
Identification method of low-order faults in ultra-deep carbonate rocks based on convolution neural network	Hao LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3922
Improvement of Deep Learning-based Inverse Model with Reconstruction of Dynamic Data	Hayoung KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3923
Fault detection based on 3D seismic images using an integration of GCN and U-Net	Guoqing LU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3925
Seismic attribute optimization and fracture prediction model establishment based on artificial intelligence-A case study of dense sandstone reservoirs in the Northern Ordos Basin	Ziyi YANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3927
Carbonate Lithofacies Logging Identification Based on Machine Learning: A Case Study of Longwangmiao Formation in Moxi Area, Sichuan Basin	Mingqiang LI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3929
S7+S5 General Topics		Session Chair: Scientific Program Committee			
Development and Application of an Intelligent QA System for Knowledge of Global Petroliferous Basins	LI DAWEI	M217	2024-08-28 08:00	2024-08-28 08:15	3931

Title	Presenter	Venue	Start	End	Page
Artificial Intelligence and Machine Learning for the Automated Classification of the Seabed	Umberto DI LAUDO	M217	2024-08-28 08:15	2024-08-28 08:30	3932
Predicting Pegmatite-Derived Lithium Anomaly in Stream Sediment Using Machine Learning Methods: A Case Study of South Korea	Jeong-Ho LEE	M217	2024-08-28 08:30	2024-08-28 08:45	3933
Physics-Guided Unsupervised Deep Learning Approach for the Inversion of Receiver Functions	BIJAYANANDA DALAI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3934
Research on data integration system development for excavation construction equipment fleet management	Skhan Park	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3935
AI in solving geological problems using the example of uranium deposits in Kazakhstan	Abish SHARAPATOV	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3936
A new approach of mineral targeting in a concealed shear zone complex by Knowledge-Driven multi-thematic Mineral Prospectivity Mapping	PRASHANTH KUMAR K	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3938
Intelligent Identification Technology for Sandstone Thin Sections	Yili REN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3940
A study on the analysis and prediction model of lime dosage for artificial intelligence-based mine drainage treatment	SEONG-SOOK PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3942
The intelligent identification and regional capacity estimation of submarine polymetallic nodules based on Segment Anything Model	Jingpeng LIU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3944
T34 Energy and Carbon Neutrality					
S1 Geothermal energy, geoenergy, geopower, geoheat, earth energy		Session Chair: Scientific Program Committee			
Borehole Thermal Resistance Estimation and Optimization for In-Situ Borehole Heat Exchangers	Byoung Ohan SHIM	M214	2024-08-26 16:00	2024-08-26 16:15	3946
Interdisciplinary and shared 3D geomodels of the Los Humeros and Acoculco geothermal systems (Mexico)	Philippe CALCAGNO	M214	2024-08-26 16:15	2024-08-26 16:30	3947
CEEGS - Novel CO2-based electrothermal energy and geological storage system	Marko KOMAC	M214	2024-08-26 16:30	2024-08-26 16:45	3949
On Policies and Mechanisms for Collaborative Promotion of Electricity Market and Carbon Market under the Dual Carbon Goals	Jia LIU	M214	2024-08-26 16:45	2024-08-26 17:00	3953
Geothermal Water Chemistry and Water Rock Interaction in the Olkaria Geothermal Reservoir, Naivasha Kenya.	Edwin Wafula WANYONYI	M214	2024-08-26 17:00	2024-08-26 17:15	3954
Transgeo Project - How to reuse abandoned oil and gas exploration wells, opportunities and constraints in Hungary	Ferenc FEDOR	M214	2024-08-26 17:15	2024-08-26 17:30	3955
Hydrochemical features of geothermal waters in the Namaqua-Natal Province, South Africa	Musarrat SAFI	M214	2024-08-26 17:30	2024-08-26 17:45	3956
The Impact of Fluid-Rock Interaction on Environment in Geothermal Sites of Kuril-Kamchatka Island Arc	JULIA Vladimirovna FROLOVA	M214	2024-08-26 17:45	2024-08-26 18:00	3951
Fracture-matrix interactions of deep geological systems in the context of energy geosciences and carbon management	Qinhong Hu	M214	2024-08-26 18:00	2024-08-26 18:15	3957
Optimal Selection and Development Plan Design for Buried Hill-Type Hot Dry Rock Targets in the Jiyang Depression	Shaozheng Wang	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3959
Feasibility analysis of thermal solar energy storage in heterogeneous deep aquifer	Yating W	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3960
The potential for GigaWatt-Hour Subsurface Thermal Energy storage in Mine shafts	Zoe SHIPTON	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3961
New understanding of Mesozoic-cenozoic tectonic features and geothermal potential evaluation in Weibei Basin	Xiaoxin SHI	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3962
Characterizing geothermal heat pump system in relation to thermal property of different rocks by laboratory and field tests	Youngjin KIM	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	3963
S2 Offshore renewable energy systems and submarine geohazards		Session Chair: Shinji SASSA			
[Keynote] Submarine Geohazards Resistant Design Concept for Anchors and Cables of Floating Offshore Wind	Shinji Sassa	M214	2024-08-27 08:00	2024-08-27 09:30	3965
Toward Sustainable Development of Offshore Wind Power at Active Margins -Importance of Submarine Geohazard Risk Assessment-	Yasukuni Okubo	M214	2024-08-27 08:30	2024-08-27 08:45	3964
Numerical simulation of the flow impact due to submarine landslide exerting on offshore wind turbines with a monopile type foundation	Kazuki MURATA	M214	2024-08-27 08:45	2024-08-27 09:00	3967
Wave-Induced Liquefaction and the Stability of Offshore Structures in Seabed Soils in a Drum Centrifuge	JUNJI MIYAMOTO	M214	2024-08-27 09:00	2024-08-27 09:15	3968
Assessment of Submarine Geological Risks to Offshore Wind Power in Japan Coastal Areas	Koki KIMURA	M214	2024-08-27 09:15	2024-08-27 09:30	3969
Seismic characteristics of Changyun Rise western offshore central Taiwan (eastern Taiwan strait) and their possible connections to Late Pleistocene - present Choshui River system	Yi Hao WANG	Exhibition Hall	2024-08-27 09:15	2024-08-27 09:30	3970
S3 Assessment of innovation necessary for sustainable use of geothermal resources		Session Chair: Yasukuni Okubo			
Significance of Strong Amplitude Reflectors Observed in Geothermal Areas for Deep Geothermal Resource Exploration	Jun MATSUSHIMA	M214	2024-08-28 08:00	2024-08-28 08:15	3973

Title	Presenter	Venue	Start	End	Page
DEVELOPMENT OF THE RENEWABLE GEOTHERMAL ENERGY IN UZBEKISTAN	Elena Aleksandrovna GOLOVKO	M214	2024-08-28 08:15	2024-08-28 08:30	3974
Porous media heat transport experiments reveal local thermal non-equilibrium (LTNE) and non-uniform flow	Haegyeong LEE	M214	2024-08-28 08:30	2024-08-28 08:45	3975
Experimental investigation of formation damage potential during thermal water reinjection on Upper Miocene (Pannonian) sandstones from Szentes geothermal field, Hungary	Péter János KORONCZ	M214	2024-08-28 08:45	2024-08-28 09:00	3976
Study of seasonal characteristics of near-surface geo-temperature obtained by long-term monitoring in Japan	Osamu MATSUBAYASHI	M214	2024-08-28 09:00	2024-08-28 09:15	3977
Application of play fairway analysis to identifying geothermal prospect areas in Sulawesi Island, Indonesia	Angga Bakri PRATAMA	M214	2024-08-28 09:15	2024-08-28 09:30	3978
Incorporating Mineral Compositions in Shallow Wells into Multicomponent Geothermometer to Improve Reservoir Temperature Estimation in the Patuha Field, Indonesia	Brenda Ariesty Kusumasari	M214	2024-08-28 09:30	2024-08-28 09:45	3979
The role of the upper crustal thermal structure in defining the global Golden Zone of hydrocarbons	Carlos Alberto Vargas	M214	2024-08-28 09:45	2024-08-28 10:00	3980
Turning point of geothermal resources development in the world	Yasukuni Okubo	M214	2024-08-28 10:00	2024-08-28 10:15	3981
Combination of Fuzzy Logic and Geostatistics for Detecting Potential Zones of Geothermal Resource over Java Island, Indonesia through Multi-Sensor Satellite Image Data	Tedi Atmapradhana	M214	2024-08-28 10:15	2024-08-28 10:30	3985
Thermolithospheric Model (THERMOMAG) to Curie Isotherm Calculations	Suze Nei Pereira GUIMARAES	M214	2024-08-28 10:30	2024-08-28 10:45	3971
PTA and TTA the fundamental difference in Geothermal prospect well test	Fathia ABDI ATTEYE	M214	2024-08-28 10:45	2024-08-28 11:00	3984
S4+S6+S7 Critical Minerals Governance for Carbon Neutrality		Session Chair: Yasukuni Okubo			
Underground Resources and their Uses in the Energy Transition: Hydrocarbon exploration, geothermal energy, and natural gas, CO2 and H2 storage in the Polish Basin as a part of the Central European Permian–Mesozoic Basins.	JAROSLAW ZACHARSKI	M214	2024-08-28 11:00	2024-08-28 11:15	3982
Carbon emission reduction: Contribution of geothermal energy and practice in China	Liqiong JIA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3986
Colombia's natural hydrogen potential: first exploration insights	Valeria RAMIREZ JUYA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3988
Sustainable and ethical mining: future challenges and new perspective	Daniele SPIZZICHINO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3990
Research on the Effect of Pressure on Thermal Cracking of Immature/Low Mature Source Rocks	Fengtian BAI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3992
Oxidative pyrolysis characteristics and kinetic analysis of low-medium maturity organic rich shale	Sunhua DENG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3994
Design and simulation of a high-efficiency cooling system for high temperature drilling fluid	Rui JIA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3995
Projection of natural gas demand in China based on a hybrid model from sector perspective under carbon-neutral strategy	Xiaoqian GUO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3997
Magnetite powder as an enhancer in biogasification of phenolic pollutants	Minjae KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3998
A spectroscopic assessment of the microstructural evolution in a suite of Indian coals and their potentiality for energy storage applications	Archchi Sarkar	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	3999
S5 Unconventional Oil and Gas Resources & CO2 Geological Sequestration		Session Chair: Dameng LIU			
Characterization of pore structure in semi-deep and deep lacustrine tight sandstones: A case study of the Triassic Chang 6 in Longdong area, Ordos Basin, NW China	Taping He	M214	2024-08-27 09:30	2024-08-27 09:45	4000
Two decades of research on injection-induced seismicity: What have we learned?	David William EATON	M214	2024-08-27 09:45	2024-08-27 10:00	4001
Applications of low-field NMR techniques in CO2 sequestration in hydrocarbon reservoirs	Yanbin YAO	M214	2024-08-27 10:00	2024-08-27 10:15	4003
Advancements in the Exploration and Production of Coal-Associated Unconventional Natural Gas in China: Geological Insights and Technological Innovations	Dameng LIU	M214	2024-08-27 10:15	2024-08-27 10:30	4004
Material Balance Equation for CO2 Storage Capacity Estimation in Saline Aquifer	Sangkeon PARK	M214	2024-08-27 10:30	2024-08-27 10:45	4009
Anisotropic reservoir characteristics influencing the CO2 sequestration behavior in shale with simultaneous enhanced gas recovery and a case simulation	Li LI	M214	2024-08-27 10:45	2024-08-27 11:00	4010
Exploration of shale gas from lower Gondwana shale beds of Jharia Coalfield, India– a potential game changer in clean energy domain	KAUSIK KUMAR GHOSH	M214	2024-08-27 11:15	2024-08-27 12:00	4014
Experimental Study on Interaction of Sc-CO2 with Feldspar and Clay Minerals and its Implication to Carbon Sequestration in Sandstone Reservoirs	Yiming Luo	M214	2024-08-27 14:15	2024-08-27 14:30	4011

Title	Presenter	Venue	Start	End	Page
Effect of the surfactant on the storage ratio of supercritical CO2 in pore spaces of the subsurface CO2 reservoir rock: based on laboratory experiments	Jeonghyeon BYEON	M214	2024-08-27 14:30	2024-08-27 14:45	4007
Effect of intraformational mudstone on CO2 plume migration and distribution: Insights from Sleipner geological storage project	Huixing ZHU	M214	2024-08-27 15:00	2024-08-27 15:15	4005
Comparison of Gas-bearing Parameter Evaluation Methods for Deep Shale Based on Pressure-holding Coring Technique	Xiao LI	M214	2024-08-27 15:15	2024-08-27 15:30	4024
Utilization of porous media for CO2 and H2 storage in Hungary	Gyorgy FALUS	M214	2024-08-27 15:30	2024-08-27 15:45	4021
A novel method to enhance hydrate production and CO2 sequestration in clayey silty reservoir via splitting grouting	Xiaochu WANG	M214	2024-08-27 16:00	2024-08-27 16:15	4020
Pore-scale Investigation of the Effect of Surfactant on Storage Efficiency in CO2 Geosequestration	Chan Hee KIM	M214	2024-08-27 16:15	2024-08-27 16:30	4019
Fracture Diagnosis and Inter-Well Interaction Analysis - Correlating Fiber Optic Data with Coupled Geomechanics-Thermal-Flow Simulations	Juliana Y Leung	M214	2024-08-27 16:30	2024-08-27 16:45	4017
Structural deformation and microstructure evolution of marine shale from the upper Yangtze region of China	Yiwen JU	M214	2024-08-27 16:45	2024-08-27 17:00	4016
Preliminary assessment of CO2 storage capacities in the northern portion of the offshore Orange Basin, South Africa.	Nangamso DUNGA	M214	2024-08-27 17:00	2024-08-27 17:15	4026
Molecular simulation of CO2 injection in methane-bearing coal models with different pore structures	Ruikang CUI	M214	2024-08-27 17:15	2024-08-27 17:30	4012
Nano-petrophysical studies for energy geosciences in the context of carbon neutrality.	Qinhong Hu	M214	2024-08-27 17:30	2024-08-27 17:45	4028
Acoustic Simulation Study of Coal Rock	Xiaojuan SUN	M214	2024-08-27 17:45	2024-08-27 18:00	4023
Carbon fixation mineral—Geological characteristics and synthetic experiments of Dawsonite	Yangchen ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4029
Multi-objective optimization of impure CO2-EOR implementation using CNN-GRU neural network and NSGA-II algorithm: a case study on H59 block of Jilin oilfield China	guangxu CHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4030
Geochemical Characterization of Pimienta Formation, Mexico as a Potential Hydrogen Source	Alexis Rosa NUMMER	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4031
Comprehensive division of exploration and development units: case studies from three blocks in the southern Qinshui Basin	HUI WANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4033
Evaluation of Multi-scale Natural Fractures in Coalbed Methane Reservoirs	Yidong CAI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4034
Numerical Simulation Study on the Effect of Horizontal Well Reservoir Stimulation for Gas Hydrate Production	Xiaoyang LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4035
Early-Stage Risk Assessment for a Potential Commercial-Scale Geological Carbon Storage Site in Utah, USA	Ting XIAO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4036
Microscale gas occurrence mechanism in coalbed methane reservoirs	Fengrui SUN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4037
Effect of SCCO2-H2O-Coal Reaction on the Pore Structure of High-rank coal	Junyan Jun ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4038
Monitoring methane gas emissions in coal mine areas of North Korea based on Sentinel-2 satellite data	Minju KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4039
Simulation study of the high-temperature nitrogen injection in-situ conversion process: a case study in Songliao Basin shale formation	Chaofan ZHU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4040
Numerical Simulation of Oil Recovery Performance and Long-term CO2 Storage Potential after Different CO2-EOR Operations	Zejin FAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4041
Autothermic Pyrolysis in situ Conversion Process for Oil Shale Recovery	Wei GUO	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4042
Study on promoting mechanism of electric field on pyrolysis and seepage of oil shale products	Qiang LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4043
Altering Pore Morphology of Organic-Rich Shale through SC-CO2 Exposure	Ogochukwu OZOTTA	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4044
Unveiling the Sub-10 Nanometer Realm: Innovative FIB-HIM Approach to Shale Nanopore Characterization	Jianguo WU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4045
Formation dry-out from CO2 injection into coal seam: Salt precipitation and injectivity alteration	Xiaoxiao SUN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4046
Influence of sediment properties on methane hydrate enrichment in fine-grained sediments	Chenyang BAI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4047
The Geochemical characteristics and Genetic mechanism of tight gas in Shahezi Formation,North Songliao Basin, China——Take Xujiaweizi Fault Depression as an example	YiXuan RAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4048
Sensitivity analysis of non-condensable gas in SAGP method on 3-dimensional heterogeneous oil sands reservoir	Sunghyun KIM	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4049
Prediction of CO2 flooding channels based on seismic azimuthal anisotropy	Mei YANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4051
Investigation of Characteristics of Gas Hydrate Decomposition under Microwave Stimulation	Baochang Liu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4053
Fatigue life analysis of oil shale in-situ conversion combustion heater	Shui haoche	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4054
Numerical Simulation Study on the Influence of Intermittent Gas Injection on the in-situ Conversion Development Effect of Oil Shale Autothermic Pyrolysis	Yijian ZENG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4055

Title	Presenter	Venue	Start	End	Page
Numerical Simulation Study on the Impact of Complex Fracture Network on In-Situ Conversion of Oil Shale	Yanwei LI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4056
Evaluation of Nong'an oil shale reservoir stimulation based on gas injection	Qingfeng BU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4057
Carbon Dioxide Storage Potential of Cenozoic Saline Aquifers in the South Yellow Sea Basin	Yong YUAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4058
Experimental Study and Numerical Simulation of Rock Fracturing Based on High Voltage Electric Pulse	LI XIAOLE LI XIAOLE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4059
Evaluation of CO2 Storage Potential in Offshore East Sea, Korea	Eunsil Jung	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4060
Evolution of fluid occurrence states during oil shale pyrolysis under inert and oxidative conditions	Junfan PAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4061
Research on the inherent mechanism of rock mass deformation of oil shale in-situ mining under the condition of thermal-fluid-solid coupling	Shuo ZHANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4062
Effect of decrease in pore water salinity induced by depressurization in clayey silt gas hydrate reservoirs on the migration characteristics of illite	Jiang LEI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4063
Enhancement on the development of methane hydrate in the clayey silty reservoir by stratified split grouting	Hangkai Chen	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4064
Fracture propagation and evaluation of dual wells, multi-fracturing, and split-time in Fuyu oil shale	Bin Zhu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4066
Calculation method and application of cap rock's effective thickness of X Gas Reservoir	Zhengchun SHEN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4067
Hydrocarbon migration and accumulation in shale play	Rujiao CHENG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4068
A novel approach for predicting in-situ stress in coal reservoirs based on acoustic emission: Analysis, comparison, and application	Shuheng TANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4070
Identifying Miocene sedimentary rocks for CO2 storage in the Gunsan Basin	CHANGYOON LEE	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4072
T35 Geoscience and Policy					
S2+S4 / T22-S4 Geological Survey Organizations and Land Use Planning: From Geoscience Data to National Policy		Session Chair: Christopher Keane, Young Joo LEE			
The Australian national geological survey organisation's (Geoscience Australia) provision of geoscience data to inform national policy and decisions using the Digital Atlas of Australia	Steve HILL	M311	2024-08-29 08:05	2024-08-29 08:18	4077
The key role of NGSOs and transnational associations in supporting policy making process for mitigating and adapting to the global climate change	Christophe POINSSOT	M311	2024-08-29 08:18	2024-08-29 08:31	4096
U.S. Invests in Foundational Geoscience Data Collection, Mapping, and Analysis to Inform Infrastructure Policy	David APPLEGATE	M311	2024-08-29 08:31	2024-08-29 08:44	4091
Geological Surveys in Ibero-America and land use planning	Enrique Armando CASTELLANOS ABELLA	M311	2024-08-29 08:44	2024-08-29 08:57	4073
Geological Survey Ireland, supporting national policy through geoscience on land and at sea.	Koen M VERBRUGGEN	M311	2024-08-29 08:57	2024-08-29 09:10	4082
Public geoscience: a foundation for strategic land use decisions in Canada	Sonia TALWAR	M311	2024-08-29 09:10	2024-08-29 09:23	4087
The Important of Geoscience Data for Land Use Planning in Malaysia	Zamri bin RAMLI	M311	2024-08-29 09:36	2024-08-29 09:49	4101
Geoscience information in Dutch land use planning: showcase for comprehensive planning?	Tirza van DAALEN	M311	2024-08-29 09:49	2024-08-29 10:02	4084
Role of Czech Geological Survey in Siting of Deep Geological Repository of Radioactive Waste	Zdenek Venera	M311	2024-08-29 10:02	2024-08-29 10:15	4100
Contribution of geoheritage and geoconservation research to land use planning and new policies in the post-eruptive recovery phase of 2021 Tajogaite volcano (La Palma Island, Spain)	Juana VEGAS	M311	2024-08-29 10:15	2024-08-29 10:28	4078
Navigating Extreme Landslide Events: Insights from Slovenia's August 2023 Disaster and the Role of the National Geological Survey	Miloš BAVEC	M311	2024-08-29 10:28	2024-08-29 10:41	4089
New Arabian Shield Lithostratigraphic and Lithodemic Code (ASLLC) and its Application to the Terranes of the Arabian Shield	Alan S. Collins	M311	2024-08-29 10:41	2024-08-29 10:54	4075
Subsurface environment, a key asset for the global ecological transition	Christophe POINSSOT	M311	2024-08-29 14:35	2024-08-29 14:48	4094
The importance of raw materials for the Energy Transition	Teresa PONCE DE LE ÃO	M311	2024-08-29 14:48	2024-08-29 15:01	4098
The European Critical Raw Materials Act – How can geoscience programmes support the Act and build collaborations	Ana Luisa LAVADO	M311	2024-08-29 15:01	2024-08-29 15:14	4080
EU International Centre of Excellence on Sustainable Resource Management in support of the United Nations Resource Management System	Miloš BAVEC	M311	2024-08-29 15:14	2024-08-29 15:27	4093
OneGeology Projects: Climate Action, Geohazards and of course, the Global Geological Map	Steve Hill	M311	2024-08-29 15:27	2024-08-29 15:40	4086
Developing QGIS Plugins for 3D Geological Modelling	Michel M. NZIKOU	M311	2024-08-29 15:40	2024-08-29 15:53	4074
Professionals in Earth Sciences in municipal administrations, a contribution to the development of the territory: a case study in Colombia, South America	Clemencia GOMEZ	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4102
OneGeology's impact: shaping the development of digital cartography in the Polish Geological Survey	Katarzyna JÓŹWIK	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4103

Title	Presenter	Venue	Start	End	Page
PanAfGeo: A unique pan-African training programme for African Geological Surveys	Nicolas CHARLES	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4105
IGME's contribution to the Critical Raw Materials pan-European map: GSEU project	Iván MARTÍN-MÉNDEZ	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4107
What we have learned from operating OneGeology Portal	Amaya FUENZALIDA VELASCO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4108
The national geological service of Senegal : an instrument for managing geoscience data that benefits policy makers.	Raymond SAGNA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4109
S3+S1+S6 Responsible Mining of Critical Minerals and the Importance of Environmental Justice		Session Chair: Adam Simon			
SOCIAL REPORT OF THE GEOLOGICAL SERVICE OF BRAZIL, AN ESG TOOL	Patricia DURINGER Jacques	M317	2024-08-29 08:00	2024-08-29 08:15	4111
Geothermal energy research supporting national policy and regulation; a European case study from Ireland	Aoife K. BRAIDEN	M317	2024-08-29 08:15	2024-08-29 08:30	4113
Geoscience for Sustainability – A new initiative to promote the role of geosciences in society	Jonathan ARTHUR	M317	2024-08-29 08:30	2024-08-29 08:45	4117
Integrated geoscience mapping toward minerals and energy development: a case study for lithium prospectivity in the Northern Cape of South Africa	Taufeeq DHANSAY	M317	2024-08-29 08:45	2024-08-29 09:00	4121
Insights on the evolution of mineral policies, acts, rules and their association with mineral targeting geosciences in India	Debkumar BHATTACHARYYA	M317	2024-08-29 09:00	2024-08-29 09:15	4119
Geoscience Policy Advocacy for the Public Good: Making an Impact through Policy!	Munira Raji	M317	2024-08-29 09:15	2024-08-29 09:30	4115
Communicating with Non-Scientists: A Review of Select EU Horizon Projects and their Degree of Public Transparency	Maureen Gallagher	M317	2024-08-29 09:30	2024-08-29 09:45	4122
IGCP 735 project: Rocks and the Rise of Ordovician Life	Wenhui Wang	M317	2024-08-29 09:45	2024-08-29 10:00	4123
Intergovernmental Action on Sustainability and the Role of Geoscience	Janice Lachance	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4124
The Brazilian Geological Survey: Unveiling a World of Geodiversity and Scientific Expertise for Global Collaboration	Deborah MENDES	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4125
S5 Empowering women in geoscience for gender equality		Session Chair: Heejung Kim			
[Keynote] Advancing Earth Science and women's equity through research, community building and professional societies	Carol FINN	M211	2024-08-28 16:20	2024-08-28 16:40	4130
East to West collaboration for a gender equality in Geosciences	Minha LEE	M211	2024-08-28 16:40	2024-08-28 16:55	4127
GeoLatinas: six years embracing, empowering and inspiring Latinas in Earth and Planetary Sciences	Monica Alejandra GOMEZ CORREA	M211	2024-08-28 16:55	2024-08-28 17:10	4128
Africa-Europe: working together to close the gender gap in Geosciences.	Lola PEREIRA	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4132
T36 Management of Radioactive Resources and Waste					
S1+S5 Advances in natural and engineering barriers for underground nuclear waste repositories		Session Chair:			
Inversion of Barcelona Basic Model Parameters for Thermo-Hydro-Mechanical Simulation of High-Level Radioactive Waste Disposal System	Yeongju KIM	M212	2024-08-29 09:30	2024-08-29 09:45	4134
Micro CT and NMR studies in the very compact Boda Claystone, in connection with the Hungarian HLW project	Ferenc FEDOR	M212	2024-08-29 09:45	2024-08-29 10:00	4135
Microbial Reactions by Bentonite Indigenous Microbes under Varied Temperatures and Irradiation Conditions	Kanghyun PARK	M212	2024-08-29 10:00	2024-08-29 10:15	4136
Investigation of Characteristics of Bentonite Samples in Natural Analogue Study Sites	Yoonah BANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4137
3D and 4D insights into barrier behaviour	Katherine DOBSON	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4138
Analysis of the Current Status of Siting Criteria and Factors for High-Level Radioactive Waste Disposal in Leading Countries	Taeyoo NA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4139
Characterization of Ca-type bentonite in contact with corrosion product of copper canister	Gha-Young Kim	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4140
Site Characterization and Investigation Requirements (draft) for High-Level Radioactive Waste Disposal Facilities	Hyeondong Woo	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4141
R&D of KAERI for development of base technologies for demonstration of the deep geological system	Geon Young KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4143
Enhancing HLW Disposal Safety Through Global NA Study insights	HunSuk IM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4145
Integrating Advanced Technologies and Safety for a Susainable Spent Nuclear Fuel Waste management	HunSuk IM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4147
Investigating Measurement Methods for Grain Bulk Modulus of Sandstone: An Experimental Approach	Min-Jun KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4149
S2 Investigation and evaluation techniques related with nuclear power plants and waste disposal sites		Session Chair:			

Title	Presenter	Venue	Start	End	Page
[Keynote] Current Status and Future Outlook on IAEA Safety Standards Development and Research Regarding the Site Safety for Nuclear Facilities	Heanu LEE	M212	2024-08-28 14:30	2024-08-28 14:45	4151
Kinematic and Paleostress Analysis for Long-term Structural Evolution: A Preliminary Analysis in the KURT Site	Ho-Seok Choi	M212	2024-08-28 14:45	2024-08-28 15:00	4150
Volcanic Tephra-Fallout Hazards and the Safety of Nuclear Installations	Hyun Woo LEE	M212	2024-08-28 15:00	2024-08-28 15:15	4153
Integrating multi-disciplinary data to evaluate a potential deep geological repository site	Jakub KRYL	M212	2024-08-28 15:15	2024-08-28 15:30	4155
GeM-DB – A searchable database, linking exploration objectives and geoscientific methods for the German nuclear waste repository siting process	Thies BEILECKE	M212	2024-08-28 15:30	2024-08-28 15:45	4157
Integrated analysis of deep brittle structures using borehole images and drill cores for high-level radioactive waste disposal	Ji-Min CHOI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4159
Geochemical and Geochronological Study of the Crystalline Rocks through Boreholes in the KURT Site: Implications for Long-term Evolution of a Deep Geological Repository	Nak Kyu KIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4160
Morphostructural analysis of the LIDAR terrain model applied in the selection of a site for the Deep Geological Repository for Radioactive Waste	Jan JELÍNEK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4161
GPR, a fundamental tool for 3d mapping of the complex internal salt structures by investigations in drifts and boreholes	Thies BEILECKE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4162
Investigation of host rocks and geotechnical barriers for the disposal of radioactive waste by means of Electrical Resistivity Tomography (ERT)	Thies BEILECKE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4163
Comparison of geological and mechanical properties of crystalline and sedimentary rocks through deep drilling cases	Dae-Sung Cheon	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4164
Applying deep learning to detect fractures from GPR data	Ain LEE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4165
Investigating Deep Groundwater Recharge Processes: A Combined Isotopic, Hydrochemical, and GIS Methodology	JAEHOON CHOI	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4167
Characteristics of radiogenic heat production rate in fractured rock mass	Yeonguk JO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4168
S3 Transport of radionuclides in deep geological repositories and nuclear-related facilities		Session Chair: Benny (Chuan-Pin) LEE, Young-Jin Park			
[Keynote] Overview of research and development (R&D) activities on radionuclide migration in Taiwan	CHUAN-PIN LEE	M212	2024-08-28 16:00	2024-08-28 16:15	4169
Assessment of Water-Rock Interactions of Uranium through Laboratory Batch and Column Experiments	Sung-Wook JEEN	M212	2024-08-28 16:15	2024-08-28 16:30	4170
Characterization of radionuclide mobilization using environmental tracers at natural analogue site in Boeun, South Korea	Ye Ji KIM	M212	2024-08-28 16:30	2024-08-28 16:45	4171
Methodology development for optimal remediation strategies for nuclear facility sites	In-Ho YOON	M212	2024-08-28 16:45	2024-08-28 17:00	4172
A current status of natural analogue studies in Korea for high-level radioactive waste disposal	Ji-Hun RYU	M212	2024-08-28 17:00	2024-08-28 17:15	4173
Multiple sulfur and uranium isotope compositions of uraniferous slates in the Bibong Formation of the Okcheon Metamorphic Belt	Eunje OH	M212	2024-08-28 17:15	2024-08-28 17:30	4174
Examining Uranium Behavior Through Column Experiments Using Artificial Groundwater and Coaly Slate from a Natural Analogue Study Site in Korea	Soyeon LIM	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4175
Hydrochemical Characteristics of Deep Groundwater by Depth in Granite site for Disposal of High-Level Radioactive Waste	JIWON PARK	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4177
Examination of Uranium Migration within Bentonite Employing the Reactive Transport Model	Won Woo YOON	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4178
Investigation of geochemical evolution and radionuclide migration in engineered barrier systems using an adaptive process-based total system performance assessment framework	Jeonghwan HWANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4179
S4 Techniques for assessment and control of nuclide behavior in the HLW geological repository		Session Chair: Minhee LEE			
Sorption characteristics of the cesium on the improved coal mine drainage treated sludge (CMDS) by the addition of Na and S	Soyoung JEON	M212	2024-08-29 08:00	2024-08-29 08:15	4180
Gas and nuclide migration model study by using parameter values derived from laboratory experiments	Danu KIM	M212	2024-08-29 08:15	2024-08-29 08:30	4182
Characterization of Granitic Groundwater Colloids in KAERI Underground Research Tunnel for Evaluating Radionuclides Transport	Sang-Ho LEE	M212	2024-08-29 08:30	2024-08-29 08:45	4184
Sorption Mechanisms and Thermodynamics of Highly Soluble Fission Products onto Ca-type Bentonil-WRK Montmorillonite	Seonggyu CHOI	M212	2024-08-29 08:45	2024-08-29 09:00	4185
Assessing nuclides migration across multi-barrier interfaces using reactive transport models	Heewon JUNG	M212	2024-08-29 09:00	2024-08-29 09:15	4187
Interrogating reactive surface distribution at the pore-scale using dual tracer breakthrough curves	Sunwong LIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4188
Effect of gas originated from the deep geological SNF (spent nuclear fuel) repository on the sorption of Cs (I) and Sr (II) on bentonite	Daehyun SHIN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4189
Experimental Investigation into Nuclide Diffusion on Compacted Bentonite under the Influence of Reactive Gas	Jin-Seok KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4191

Title	Presenter	Venue	Start	End	Page
Preliminary results of nuclide migration and retardation in engineering-scale natural fractured rock	Seonyi NAMGUNG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4193
Accelerating geochemical calculations in reactive transport simulations with an artificial neural network based surrogate model for nuclear waste repository management	Yehoon KIM	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4194
T37 Deep-Time Digital Earth: IUGS DDE Sessions					
S1 Evolution of life and biodiversity changes through deep time		Session Chair: Shuzhong Shen			
[Keynote] Mesozoic origin and evolution of coccolithophores documented by their biodiversity and calcification	ELISABETTA ERBA	C110	2024-08-28 14:30	2024-08-28 14:45	4201
[Invited] Reconstructing High-Resolution Biodiversity Patterns in Deep Time: Innovations, Challenges, and Future Directions	Junxuan FAN	C110	2024-08-28 14:45	2024-08-28 15:00	4200
An enigmatic macrofossil from the terminal Ediacaran Liuchapo Formation in South China	Qing TANG	C110	2024-08-28 15:00	2024-08-28 15:15	4205
A Deep Learning Approach to Synthesizing Phanerozoic Paleoclimate and Biogeochemical Cycles	Dongyu ZHENG	C110	2024-08-28 15:15	2024-08-28 15:30	4199
The Basal Emsian boundary – the only pending stage issue in the Devonian stratigraphy	Ladislav SLAVÍK	C110	2024-08-28 15:30	2024-08-28 15:45	4195
Foraminiferal biodiversity changes to interpret the paleoenvironmental perturbation across the Late Cretaceous Oceanic Anoxic Event 2 at southern high latitudes (IODP Sites U1513 and U1516, SE Indian Ocean)	Maria Rose PETRIZZO	C110	2024-08-28 15:45	2024-08-28 16:00	4212
Heterogeneous selectivity and morphological evolution during the Permian-Triassic mass extinction	Xiaokang Liu	C110	2024-08-28 16:00	2024-08-28 16:15	4198
Early Palaeozoic biodiversifications: Plus ça change	David A. T. HARPER	C110	2024-08-28 16:15	2024-08-28 16:30	4211
Palaeo-environmental insights into late Ediacaran "mass extinctions"	Brennan O'Connell	C110	2024-08-28 16:45	2024-08-28 17:00	4206
Unraveling Marine Biodiversity Dynamics in North China during the Middle-Late Cambrian: Insights from a High-resolution Species-level Richness Analysis	Yujie Shi	C110	2024-08-28 17:00	2024-08-28 17:15	4203
Morphological complexity as a potential predictive indicator of evolutionary rates in ammonoids	Luyi Miao	C110	2024-08-28 17:15	2024-08-28 17:30	4207
Building a numerical high-resolution geological timeline	Shuzhong SHEN	C110	2024-08-28 17:30	2024-08-28 17:45	4197
Recognition and timing of Early-Middle Devonian extinction events in South Polar regions	Cameron Roy PENN-CLARKE	C110	2024-08-28 17:45	2024-08-28 18:00	4209
Pioneering Data-Driven Discoveries from DeepBone.org	Zhaohui PAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4214
Latitudinal Shift Patterns of Taxa Through the Phanerozoic	Shuhan Zhang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4216
S2 Quantifying plate tectonics and deformation in four dimensions		Session Chair: Shaofeng Liu			
[Keynote] Topography and deformation of the Polar regions measured with thermochronometry	Matthew Fox	C110	2024-08-27 08:00	2024-08-27 08:15	4220
[Invited] Toward a “best-fit” tectonic reconstruction for the Caroline Plate: Oceanic plateau-subduction zone interaction as a driver for plate boundary reorganization?	Samuel MARTIN	C110	2024-08-27 08:15	2024-08-27 08:30	4218
Dynamic Linking of Progressive Exhumation to Mendocino Triple Junction Migration	yudan SI	C110	2024-08-27 08:30	2024-08-27 08:45	4217
Non-cylindrical Slab Subduction and Tearing beneath Southern Iberia	Pengfei MA	C110	2024-08-27 08:45	2024-08-27 09:00	4221
High-elevation Tibetan Plateau before India–Eurasia collision recorded by triple oxygen isotopes	Xiangrui Liu	C110	2024-08-27 09:00	2024-08-27 09:15	4222
Tectonic and topographic evolution of the Eastern Himalayan Syntaxis	Zhicheng Yu	C110	2024-08-27 09:15	2024-08-27 09:30	4223
S3 Deep probing of 3D-4D lithospheric architecture and metallogenic processes		Session Chair: DDE			
[Keynote] Archean lithospheric mantle beneath Neoproterozoic Central Asia Orogenic Belt: significance of Archean lithosphere in the evolution of younger terranes	Kuo-Lung WANG	C110	2024-08-28 08:00	2024-08-28 08:20	4225
Lithospheric thermochemical structure beneath the southwestern Central Asian Orogenic Belt from joint inversion	Xuewei BAO	C110	2024-08-28 08:20	2024-08-28 08:35	4237
The crustal and uppermost mantle Vs structure of the middle and lower reaches of the Yangtze River Metallogenic Belt: implications for metallogenic process	Yingjie YANG	C110	2024-08-28 08:50	2024-08-28 09:05	4224
Water Reservoirs and Speciation in the Lithospheric Mantle	Halimulati ANANUER	C110	2024-08-28 09:05	2024-08-28 09:20	4229
[Invited] Dense passive source seismic array reveals detailed shallow lithospheric structures: a case study from Western Australia	Huaiyu YUAN	C110	2024-08-28 09:20	2024-08-28 09:40	4236
[Invited] Kinematics, Tectonic Events and Orogens	Manuel Pubellier	C110	2024-08-28 09:55	2024-08-28 10:15	4232
Crustal architecture of the Newfoundland Appalachians and its control on metallogeny	Chaoyang WANG	C110	2024-08-28 10:15	2024-08-28 10:30	4227
Continental growth and orogenic types：Big data of magmatic rocks	TAO WANG	C110	2024-08-28 10:30	2024-08-28 10:45	4228

Title	Presenter	Venue	Start	End	Page
Crustal modification influenced by multiple convergent systems: Insights from Mesozoic magmatism in northeastern China	He HUANG	C110	2024-08-28 10:45	2024-08-28 11:00	4231
Geochronology and geochemistry of metamorphic rocks in the Khutag Uul block of the Khatanbulag Massif, South Mongolian Orogenic Belt: Timing of formation and metamorphism and tectonic implications	Narantsetseg TSERENDASH	C110	2024-08-28 11:00	2024-08-28 11:15	4233
Comparative Orotomy of the Archean Superior, North China, and Phanerozoic Altaid orogenic systems	Tim Kusky	C110	2024-08-28 11:15	2024-08-28 11:30	4234
Petrogenesis of late Carboniferous garnet-bearing, strongly-peraluminous granites in the West Junggar oceanic arc, NW China: implication for crustal maturation and rapid supracrustal recycling	Jiyuan Yin	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4238
Formation, Preservation, and Metallogenic Fertility of Juvenile Crust in the Eastern Tethyan Collisional Orogen	Zengqian HOU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4239
Geophysical data constraint on the nature of the basement of the Junggar Basin, the southwestern Central Asian Orogenic Belt	XIAOSAN ZHU	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4240
Early Mesozoic architecture and processes of the Qinling orogen, central China: Nd-Hf isotope mapping	Xiaoxia WANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4241
Evolution of the Proto-Tethys Ocean in the West Kunlun Orogenic Belt, Northwestern Tibet: Insights from the Sub-Arc Crust and Lithospheric Mantle Modification	Zaili TAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4243
S4 Marginal Seas - Past and Future		Session Chair: Joanna dudzinska-nowak			
[Keynote] Competing Natural and Anthropogenic Influences on Sediment Supply to the Global Ocean	Peter Dominic Clift	M312	2024-08-28 14:30	2024-08-28 15:00	4246
A Marine Spatial Data Infrastructure for the Adriatic Sea: Managing Multidisciplinary, Heterogeneous, and Fragmented Geodata with a FAIR Approach to Support Research Life Cycle Management	Federica FOGLINI	M312	2024-08-28 15:00	2024-08-28 15:15	4250
Towards a Marginal Seas Taxonomy	Jan HARFF	M312	2024-08-28 15:15	2024-08-28 15:30	4254
THE 4F NUMERICAL MODEL – a solution for past reconstructions of coastal and glacial dynamics and future simulations	Jerzy Jan FRYDEL	M312	2024-08-28 15:30	2024-08-28 15:45	4247
Numerical paleogeographic modeling of marginal seas – Holocene evolution of Baltic Sea as a case study	Jakub Miluch	M312	2024-08-28 15:45	2024-08-28 16:00	4252
Classification of the morphodynamics of the coast - how we can improve projections of the coastline changes	Joanna DUDZINSKA-NOWAK	M312	2024-08-28 16:00	2024-08-28 16:15	4255
Analyzing the impacts of spatiotemporal coastline changes on sustainable development in the Pearl River Estuary and Hong Kong of northern South China Sea	Yingying LIU	M312	2024-08-28 16:45	2024-08-28 17:00	4258
Linking the past to the future of tide-domianted estuarine changes under human activities and climate changes, case study at the Pearl River Estuary	Junjie DENG	M312	2024-08-28 17:00	2024-08-28 17:15	4245
Regional Relative Sea Level Changes Influenced by Geological Settings: Insights from InSAR Analysis	Zhaoquan Huang	M312	2024-08-28 17:15	2024-08-28 17:30	4249
Characteristics and origin of Quaternary mass transport deposits in the Qiongdongnan basin, northern South China Sea	Tao JIANG	M312	2024-08-28 17:30	2024-08-28 17:45	4257
Mapping the sedimentary change in South China Sea over Last Glacial Cycle and Holocene	Jinpeng ZHANG	M312	2024-08-28 17:45	2024-08-28 18:00	4259
Huatung Basin in West Pacific Marginal Seas: a linkage of West Philippine Sea and South China Sea	Hongfang GAO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4261
Origin of rapid sedimentation since Late Miocene in the western continental margins of South China Sea	Xinong XIE	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4263
Study on changes of coastline morphology and submarine geomorphology in Caofeidian Area, the North Bohai Sea	Wenqin JIANG	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4265
S5 Knowledge & Data Co-boosted Discovery in the Co-Evolution of Minerals, Microbes and Environments		Session Chair: DDE			
[Keynote] Data-Driven Discoveries in Mineralogy	Robert M HAZEN	C110	2024-08-27 09:30	2024-08-27 10:00	4270
Endolithic microbes catalyze aragonite dolomitization	Geng WU	C110	2024-08-27 10:00	2024-08-27 10:15	4277
AI for minerals: Electron transfer rules under pressure informed by machine learning	Yanzhang LI	C110	2024-08-27 10:15	2024-08-27 10:30	4276
Characterizing early earth environment and searching for signs of life: Data-driven methods to answer questions about Earth and other planets	Anirudh Prabhu	C110	2024-08-27 10:30	2024-08-27 10:45	4269
Mineralogical phases and redox evolution of manganese in Precambrian manganese deposit: Implications for diagenesis	Huan LIU	C110	2024-08-27 10:45	2024-08-27 11:00	4281
[Invited] New phenomena in high-pressure chemistry, and implications for planetary interiors	Artem R. OGANOV	C110	2024-08-27 14:30	2024-08-27 14:45	4274
Advent of different Iron mineral corresponding to the Eh evolving of Precambrian sea water	Yuanfeng CAI	C110	2024-08-27 14:45	2024-08-27 15:00	4278
Mineralogical and Fe Isotopic Constraints on the Origin of the Banded Iron Formations: A Case Study of the Kuruman Formation in South Africa	He Zhang	C110	2024-08-27 15:00	2024-08-27 15:15	4280
A preliminary study on the evolution and ecology of arsenic minerals	Minghao TANG	C110	2024-08-27 15:15	2024-08-27 15:30	4279

Title	Presenter	Venue	Start	End	Page
An expansive Ediacaran lagoon: clay mineralogy and geochemistry evidences for the spatiotemporal extent of evaporitic conditions in the Doushantuo Formation	Shujun HAN	C110	2024-08-27 15:30	2024-08-27 15:45	4266
Photoinduced ring-opening of native sulfur in driving synthesis of prebiotic building blocks	Huan YE	C110	2024-08-27 16:00	2024-08-27 16:15	4282
Evolutionary dynamics of redox-sensitive minerals	ziyi zhuang	C110	2024-08-27 16:15	2024-08-27 16:30	4268
The co-evolution of Earth and life: biosignatures in Earth's mineral networks	Shaunna MORRISON	C110	2024-08-27 16:30	2024-08-27 16:45	4283
Optimizing the infrared radiation performance of tourmaline under γ-ray irradiation	Ming GUO	C110	2024-08-27 16:45	2024-08-27 17:00	4271
Control mechanism of iron speciation on spontaneous polarization of tourmaline containing Fe	Lin ZHOU	C110	2024-08-27 17:00	2024-08-27 17:15	4272
Co-evolving N-Fe redox processes controlled iron minerals in banded iron formation	LIUQIN HUANG	C110	2024-08-27 17:30	2024-08-27 17:45	4273
Phyllosilicates-based nanozymatic microsystems and their significance in geological processes	Shiyong SUN	C110	2024-08-27 17:45	2024-08-27 18:00	4285
Organic minerals: definition, classification and characteristics	Guanghua Liu	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4286
Mineralogical Differences of Ooids and Evolution of Water Environment in Xuanlong-type Iron Ore.	Ganyu TANG	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4288
S6 Time Machine: Earth's deep-time geography -- data, reconstructions, challenges		Session Chair: DDE			
[Keynote] A dynamic evolution of Earth history over the past two billion year	Zheng-Xiang Li	C110	2024-08-29 14:30	2024-08-29 14:50	4299
[Keynote] Orogenic Deformation and Kinematic Reconstructions; Is there a good match?	Camille FRANÇOIS	C110	2024-08-29 14:50	2024-08-29 15:10	4295
The influence of Earth's thermal cycles on instigating significant geological activities	Chun'an TANG	C110	2024-08-29 15:10	2024-08-29 15:25	4308
Models, mysteries and mayhem: Tectonic reconstructions at the dawn of animal life	Marissa J BETTS	C110	2024-08-29 15:25	2024-08-29 15:40	4300
[Keynote] A web-based and data-driven approach to paleogeographic reconstructions: Application to Asian Cenozoic evolution	Guillaume Dupont-Nivet	C110	2024-08-29 15:40	2024-08-29 16:00	4306
Online databases of the geologic formations of Asia and Africa with display onto plate reconstructions	Wen Du	C110	2024-08-29 16:10	2024-08-29 16:25	4290
TimeScale Creator and the TSC Online for Visualizing Earth History	Jaehyuk Lee	C110	2024-08-29 16:25	2024-08-29 16:40	4292
Deep Time Geography of the McArthur-Yanliao Gulf—New ways of looking at a frontier resource-rich basin.	Alan S. Collins	C110	2024-08-29 16:40	2024-08-29 16:55	4297
Palaeogeography of salt deposition prior to the opening of the Central Atlantic Ocean	Julie TUGEND	C110	2024-08-29 16:55	2024-08-29 17:10	4302
Sedimentary Geochemistry of Major Metal Hosting sub-basins within the Palaeoproterozoic Batten Fault Zone, McArthur Basin, Australia	Dana IMBROGNO	C110	2024-08-29 17:10	2024-08-29 17:25	4304
Application of explainable machine learning to geophysical data	JIACHUN YOU	C110	2024-08-29 17:25	2024-08-29 17:40	4293
African geologic formation databases with visualizations onto plate reconstructions	James G OGG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4309
China and southeast Asia geologic formation databases with visualizations onto plate reconstructions	Gabriele OGG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4310
Indian Plate and Middle East geologic formation databases with visualizations onto plate reconstructions	O'Neil MAMALLAPALLI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4311
New Permian Tethyan Paleogeographic Reconstruction and its implication to the collapse of the Late Paleozoic Ice Age	Qiang Ren	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4313
Leveraging Large Language Models for Sedimentary Environmental Interpretation: A New Approach To Addressing The Non-Uniqueness Problem In Paleogeography	Haipeng LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4314
Plate Tectonics & Paleogeography during the Last 1.5 Billion Years	Christopher Robert SCOTESE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4315
Critical depths of the vertical transition zone between modern infiltration water and fossil groundwater in China	Ying YU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4316
Heterogeneity in spatiotemporal evolution of groundwater storage in the North China Plain and its driving mechanisms	Xiaowei ZHAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4317
Web GPlates: The Next-Generation Research Platform of Paleogeographic Reconstruction	Han CHENG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4318
Provenance Evolution Across the North Australian Craton from 1.8 to 1.3 Ga: Basin Analysis and Plate Tectonic Evolution.	Morgan L. BLADES	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4319
The progress and perspective of digital intelligence paleogeographic reconstruction	MINGCAI HOU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4321
"Paleotopographic Mapping": A Tool for Creating New Paleotopographic Models	Fan SHU	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4322
Construction of a fluvial facies knowledge graph and its application in sedimentary facies identification	Lei ZHANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4323

Title	Presenter	Venue	Start	End	Page
S7 Geothermal Energy: Theory, Practice, and Global Opportunities		Session Chair: Higinia Terregrosa Morales			
[Keynote] A Global Energy Outlook: Implications for Geothermal Energy	Richard J Chuchla	C110	2024-08-26 16:00	2024-08-26 16:30	4326
Project InnerSpace's GeoMapTM: Unlocking Geothermal Potential Worldwide	Jamie BEARD	C110	2024-08-26 16:30	2024-08-26 16:45	4331
Heat extraction performance and seismic potential estimation of horizontal well doublets in enhanced geothermal systems: insights from coupled thermo-hydro-mechanical modeling	Wei JIANG	C110	2024-08-26 16:45	2024-08-26 17:00	4325
A fast approach predicting geothermal play fairways using machine learning to multidisciplinary big data-Case studies in Africa and China	Shu JIANG	C110	2024-08-26 17:00	2024-08-26 17:15	4327
Target Optimization for Hot Dry Rock Resources in the Jizhong Depression	XIAOXUE JIANG	C110	2024-08-26 17:15	2024-08-26 17:30	4328
Characterization of structurally controlled geothermal systems	Gemma Mitjanas	C110	2024-08-26 17:30	2024-08-26 17:45	4330
Physics-based Machine Learning Model for Predicting Geothermal Heat Flow in Henan Province, China	Kewen LI	C110	2024-08-26 17:45	2024-08-26 18:00	4324
Prediction of heat flow distribution in North China, based on digital geomorphic and multi-geophysical data	Chuanqing ZHU	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	4333
Integrations of geothermal exploration techniques in the Guguan geothermal potential area, Taiwan	Rou-Fei CHEN	Exhibition Hall	2024-08-26 16:00	2024-08-26 18:00	4334
S8 Deep-time Digital Earth (DDE) – Progress, Challenges and Plans for 2024-2030		Session Chair: Natarajan Ishwaran			
[Keynote] Deep-time Digital Earth: an overview of progress since 2019, and a look into the future	Michael H Stephenson	C110	2024-08-29 08:00	2024-08-29 08:30	4336
[Keynote] The Deep-time Digital Earth Program in the Evolving Global Research Data Landscape	Kerstin Annette Lehnert	C110	2024-08-29 08:30	2024-08-29 08:45	4343
Unlocking the Deep-time Earth with Open Keys: Collaboration, Platform and Research projects.	Chao LI	C110	2024-08-29 08:45	2024-08-29 09:00	4338
Data-driven Hydrogeology Research Hatched by the OneGroundwater Platform	Jianmei Cheng	C110	2024-08-29 09:00	2024-08-29 09:15	4339
DDE OneSediment: a comprehensive sedimentological and palaeogeographic database and research platform	Xiumian Hu	C110	2024-08-29 09:15	2024-08-29 09:30	4341
Building the Earth System History Machine: A Dynamic Simulation of Plate Tectonics, Paleogeography, Paleoclimate and Paleobiogeography.	Christopher Robert SCOTESE	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4345
DDE scholar report: a new open and Ai frontier and innovative reflect for solid earth	Meng WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4346
IMMERSIVE VIRTUAL EXPERIENCE: A NEW "LOOK UP" TO THE GSSPs	Simonetta Monechi	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4347
S9 Progress and Opportunities in Deep-time Paleomagnetism		Session Chair: DDE			
[Invited] Building Stacked Relative Paleointensity Records for Chron C18: Insights into the Geodynamo Characteristics Over Extended Timescales	Yuhji YAMAMOTO	M312	2024-08-29 09:30	2024-08-29 09:45	4348
The reliability of Cretaceous redbed paleomagnetic datasets from the Tibetan Plateau	Jiahui MA	M312	2024-08-29 09:45	2024-08-29 10:00	4349
Closing the Unimos Ocean and assembling Rodinia	Nicholas SWANSON-HYSELL	M312	2024-08-29 10:00	2024-08-29 10:15	4352
Neoarchean plate mobilism: constraints from paleomagnetic results of Wyoming and Superior	Jikai Ding	M312	2024-08-29 10:15	2024-08-29 10:30	4353
Combined paleomagnetic and geochronological data from the ca. 1240 Ma mafic dikes in the North China Craton (NCC) and its implications	Jikai Ding	M312	2024-08-29 10:30	2024-08-29 10:45	4355
The Balanced Billion	Ross N MITCHELL	M312	2024-08-29 10:45	2024-08-29 11:00	4350
Analyzing the paleosecular variation of Earth's geomagnetic field 1.1 billion years ago and its implications for understanding ancient field morphology	Hanqing ZHAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4357
New paleomagnetic and geochronology data from Early Cretaceous volcanic rocks of the central Tethyan Himalaya: insights into the size of Greater India	Xianwei JIAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4358
New paleomagnetic results from the late Mesoproterozoic Luanshigou Formation of the Shennongjia Group in south China, and their paleogeographic implications	Yixuan Liu	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4360
Paleomagnetic and geochronologic results from the Zenong Group and Yeba Formation volcanic rocks in the Lhasa terrane: New insights into the closure time of the Meso-Tethyan Ocean	Tianshui YANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4362
Exploring rock-magnetic parameters for efficient sample preselection on the Tsunakawa–Shaw paleointensity method: a study from data of Cenozoic basalts	Hyeon-Seon AHN	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4364
New Early Permian Paleomagnetic Data from the Northern Margin of the North China Block and its Implications for Regional Climate and Biological Evolution	Qiang Ren	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4365
The rock-magnetism and natural remanent magnetization of the Ordovician sedimentary rocks in the southwest Ordos Basin (Central China)	Shuang DAI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4366
How did the Jurassic True Polar Wander meet plate motion in Asia?	Yangjun GAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4368
New paleomagnetic results from the late Ediacaran Dengying Formation in South China	Haiyan LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4370

Title	Presenter	Venue	Start	End	Page
Exploring sedimentary records of sea level and carbon cycling as independent tests of true polar wander: Case studies from the Paleoproterozoic to Cretaceous	Yu-Shu Liu	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4372
Paleomagnetic studies of the Neoproterozoic Jinchuan Ultramafic rock Unit and Paleozoic dykes inside it, revealing its affinity to North China Block since Cambrian	Ronghua Wang	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4373
A Review of True Polar Wander in the Tonian (~850-750 Ma)	Joseph MEERT	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4375
S10 Geoscience Data Standards and Knowledge Graph		Session Chair: Zhang Minghua, Young Joo LEE			
[Keynote] Standards: a challenge for the future of geosciences	Francois Robida	C110	2024-08-30 08:15	2024-08-30 08:30	4388
DataExpo: A One-Stop Dataset Service for Open Science Research in Geosciences	Bin Lu	C110	2024-08-30 08:30	2024-08-30 08:45	4378
Geoscience information metadata standard supports DDE resources Open and FAIR	Minghua ZHANG	C110	2024-08-30 08:45	2024-08-30 09:00	4381
A Geoscience Temporal Ontology Incorporating ISO Standards and Allen Temporal Relations	Shu WANG	C110	2024-08-30 09:00	2024-08-30 09:15	4383
Construction and Sharing of CGS National Geological Database	Shoutao JIAO	C110	2024-08-30 09:15	2024-08-30 09:30	4385
Progress and challenge in geoscience standards of the IUGS Deep-time Digital Earth program	Minghua ZHANG	C110	2024-08-30 09:30	2024-08-30 09:45	4376
A comprehensive knowledge base for representing version information in geologic time scale knowledge graph	Hongwei Wang	C110	2024-08-30 09:45	2024-08-30 10:00	4389
Paleobiogeographic Knowledge Graph: An Ongoing Work with Fundamental Support for Future Research	Linna ZHANG	C110	2024-08-30 10:00	2024-08-30 10:15	4390
Creating Open Standardized Global Networks of All Types of Geochemical Data from Multiple Countries, Repositories, and Researchers: The OneGeochemistry and WorldFAIR Initiatives	Kerstin Lehnert	C110	2024-08-30 10:15	2024-08-30 10:30	4391
DDE OnePetrology Database and Standard (Igneous Rocks)	Ying TONG	C110	2024-08-30 10:30	2024-08-30 10:45	4393
The Methodology, Progress and Challenges of Geoscience Knowledge Graph in International Big Science Program of Deep-Time Digital Earth	Yunqiang Zhu	C110	2024-08-30 10:45	2024-08-30 11:00	4379
Construction and application of an ontology-based domain-specific knowledge graph for petroliferous basin evaluation		C110	2024-08-30 11:15	2024-08-30 11:30	4387
Research on the standard of building database of Geophysical-Geochemical-Remote Sensing data based on data model	wei REN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4395
Study on the Crowdsourcing and Sharing System Model for Lithogeochemical and Geochronological Data	Rui YU	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4397
Knowledge Graph Schema of Mineral Deposit: The Design, Application, and Significance	Chengbin WANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4398
Joint inversion of gravity and magnetic 2-3D for the structure of hidden phosphorus deposit	xingting WANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4399
Master	YU MENG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4400
An One-Stop Application for DDE Metadata	Wei YAN	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4401
Construction and application of geophysical knowledge graph in Antarctica	Yuanyuan ZHANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4403
Geospatial-aware representation learning model for point of interest(POI) matching	Xiaoliang DAI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4405
How do Earth Sciences Contribute to Advancing the Sustainable Development Goals? A Bibliometric Analysis	Yu ZHAO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4406
Research on the method of signal-to-noise separation for aerial gamma ray spectrometry data based on curvelet transform	HUAIYUAN LI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4407
Underground spatial distribution of uranium and radium elements in Barun uranium deposit, Erlian Basin, Inner Mongolia	Nan Gan	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4409
Paleontology knowledge graph for data-driven discovery	Yiying Deng	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4410
S11 Deep-time climate change – novel insights from paleoclimate modelling and the geologic record		Session Chair: DDE			
[Invited] The development of a Mediterranean climate resulted from the rise of SE Tibet	Lin DING	M312	2024-08-29 14:30	2024-08-29 14:45	4414
Phanerozoic Paleotemperatures and CO2 Levels	Christopher Robert SCOTESE	M312	2024-08-29 14:45	2024-08-29 15:00	4412
Steep oceanic DIC δ13C depth gradient during the Hirnantian Glaciation	Shengchao Yang	M312	2024-08-29 15:00	2024-08-29 15:15	4416
Modelling the dramatic atmospheric and oceanographic changes during the end-Permian crisis	Yadong Sun	M312	2024-08-29 15:15	2024-08-29 15:30	4417
Modelling Phanerozoic Climates and Biogeochemistry	Paul VALDES	M312	2024-08-29 15:30	2024-08-29 15:45	4411
[Invited] Mass extinctions make way for metabolic makeovers: the rise of dinosaurs and the avian metabolism	Jasmina WIEMANN	M314	2024-08-28 08:00	2024-08-28 08:15	4421
Dinosaur distribution under long-term climate changes	Qi Cui	M314	2024-08-28 08:15	2024-08-28 08:30	4420
The first Cretaceous dinosaur fossil assemblage in Southwest China	Hui DAI	M314	2024-08-28 08:30	2024-08-28 08:45	4419
How important is palaeogeography in simulating the evolution of the East Asian monsoon?	Alex James Farnsworth	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4418
S13+S14 Encouraging Early Career Scientists' (ECS) Engagement with DDE		Session Chair: DDE			

Title	Presenter	Venue	Start	End	Page
[Keynote] Data and model-driven paleogeographic research: some recent progress	Haipeng Li	M312	2024-08-30 08:00	2024-08-30 08:15	4423
One-step Database Construction Based on Knowledge System: A Practice with the Example of DDE OnePetrology Database	DING YI	M312	2024-08-30 08:15	2024-08-30 08:30	4425
Digital geological maps on the Global Layer platform	YANG SONG	M312	2024-08-30 08:30	2024-08-30 08:45	4426
The need for Open Multidisciplinary Geodatabases in Earth Sciences: from the World 5M to Basement Geology and Water Circulation	Benjamin SAUTTER	M312	2024-08-30 08:45	2024-08-30 09:00	4427
Global Layer and Geological Map of the World at a scale 1/5M	Xingchen YANG	M312	2024-08-30 09:00	2024-08-30 09:15	4429
The Digital Transformation of Geological Data in Cambodia	KEAT LENARITH	M312	2024-08-30 09:15	2024-08-30 09:30	4422
T38 Anthropocene					
S1 Anthropocene, History and the Geosciences: contributions to contemporary debates		Session Chair: Claudine COHEN			
[Keynote] The decision in favor of the Anthropocene	Juergen RENN	M314	2024-08-29 08:00	2024-08-29 08:30	4441
The Historiography of the Earth and 'Anthropocene': Regional Geo-history and Possible Worlds in the Steno-Leibniz Process	Toshihiro YAMADA	M314	2024-08-29 08:30	2024-08-29 08:45	4436
The Anthropocene, Crawford Lake and Human-Geological Interactions	Ernst HAMM	M314	2024-08-29 08:45	2024-08-29 09:00	4439
Why the concept of the Great Acceleration is crucial to defining the Anthropocene	Francine M.G.McCarthy	M314	2024-08-29 09:00	2024-08-29 09:15	4434
Climate change revealed by the sedimentary record of the Pearl River Estuary and its implications for the Anthropocene	Jianfang HU	M314	2024-08-29 09:15	2024-08-29 09:30	4435
Anthropocene scepticism?	Michael WAGREICH	M314	2024-08-29 10:00	2024-08-29 10:15	4432
Georjuridicality: law, forensics and the Anthropocene	Alexander DAMIANOS	M314	2024-08-29 10:15	2024-08-29 10:30	4430
Soils and Sciences in the Anthropocene: Historiographic Considerations	Robert M. BRAIN	M314	2024-08-29 10:30	2024-08-29 10:45	4431
EARLY-MODERN VISIONS OF THE « EARTH SYSTEM » LEIBNIZ, TELLIAMED, HUTTON	Claudine COHEN	M314	2024-08-29 10:45	2024-08-29 11:00	4437
S2 UNESCO IGCP 732 and the Stratigraphy of the Anthropocene		Session Chair: Michael WAGREICH			
[Keynote]Evolution of stratigraphy in the Anthropocene Across Africa	Lydia A. OLAKA	M314	2024-08-29 14:30	2024-08-29 15:00	4449
Introduction to UNESCO IGCP 732 LANGUAGE of the Anthropocene and the International Geoscience Program	Veronika Koukal	M314	2024-08-29 15:00	2024-08-29 15:15	4443
Radioactive fallout defining the base of the proposed Anthropocene Series in the varved sediments of Crawford Lake	Francine M.G.McCarthy	M314	2024-08-29 15:15	2024-08-29 15:30	4445
Impacts of plastic-rich sediments on the geological processes: A numerical investigation	Eun Young Lee	M314	2024-08-29 15:30	2024-08-29 15:45	4442
Progress on the Anthropocene study in China	Luyuan ZHANG	M314	2024-08-29 16:00	2024-08-29 16:15	4450
Does anthropogenic interference disturb sedimentation in closed lakes? Evidence from the Kalar Kahar Lake, Potwar Plateau, Pakistan	MEHWISH BIBI	M314	2024-08-29 16:15	2024-08-29 16:30	4447
Anthropocene 129I record in the Yellow Sea sediments and its indication for river-delivered radioactive pollution to marginal seas	Yanyun WANG	M314	2024-08-29 16:30	2024-08-29 16:45	4452
Carbon Stock and Organic Matter Changes Three Decades After Mangrove Tree Planting Efforts in Kalibo (Aklan), Philippines	Caroline Marie Brinas Jaraula	M314	2024-08-29 16:45	2024-08-29 17:00	4454
A Marine Geological Park Concept for volcano-tectonic and Hydrothermally Induced Submarine Groundwater Discharge Features and Their Implications to Coral Reefs in Mabini, Batangas	Caroline Marie Brinas Jaraula	M314	2024-08-29 17:00	2024-08-29 17:15	4453
Anthropogenic stratigraphic signals downstream a metropolis: Extracting Vienna's signature from Danube river plain archives (Austria)	Diana HATZENBÜHLER	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4455
The geological usefulness of a defined chronostratigraphic Anthropocene for urban deposits of Karlsplatz, Vienna (Austria)	Michael WAGREICH	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4457
Anthropogenic sediments in the urban setting of Karlsplatz, Vienna (Austria)	Maria MESZAR	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4458
Geochemical evaluation of anthropogenic depositions in Brazil: case study in Rondonópolis-Mato Grosso	ÉRIKA CRISTINA NESTA SILVA	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4460
Introduction and first results from FT-IR microplastics identification in natural sediments	Veronika Koukal	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4462
Anthropogenic activities tamper with Laguna Lake's (Philippines) 20th century record of the Pacific Decadal Oscillation	Caroline Marie Jaraula	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4464
S3+S4 From the Holocene to Anthropocene - reading the geological and archaeological records of interplay between the nature and human		Session Chair: Scientific Program Committee			
[Keynote] Time to explore more of the Anthropocene	Buhm Soon PARK	M314	2024-08-30 08:00	2024-08-30 08:15	4481
Stratigraphic signals of human-environment interactions on the Meghalaya Plateau: Implications for defining the Anthropocene boundary	Pawel PROKOP	M314	2024-08-30 08:15	2024-08-30 08:30	4471
Deciphering Social-Ecological Transitions in the Anthropocene: An Evolutionary Framework Reveals Dynamics and Decoupling in China's Yangtze River Delta	KE ZHANG	M314	2024-08-30 08:30	2024-08-30 08:45	4478
Anthropocenic significance of waste strata	Wook-Hyun NAHM	M314	2024-08-30 08:45	2024-08-30 09:00	4480
Lithostratigraphic Study on Human-made strata in Kirishima City, Kagoshima Prefecture, Japan	Hiroshi TAKASHIMA	M314	2024-08-30 09:00	2024-08-30 09:15	4473

Title	Presenter	Venue	Start	End	Page
Geomorphic Succession of an Abandoned Paddy Field in Mountain Area	Junho LEE	M314	2024-08-30 09:30	2024-08-30 09:45	4468
Vegetation and land-use changes during last two millennia in the Baspa valley, Kinnaur, Western Himalaya	NIDHI TOMAR	M314	2024-08-30 09:45	2024-08-30 10:00	4475
Anthropogenic large-scale dune remobilization in medieval–early modern Central Europe, evidenced by multi-proxy data and radiocarbon dating	Krzysztof Ninard	M314	2024-08-30 10:00	2024-08-30 10:15	4465
Anthropogenic landscape changes with planting pines on coastal dune fields	Kwang Hee CHOI	M314	2024-08-30 10:15	2024-08-30 10:30	4467
Anthropogenic beachrock analogues and their significance for the Anthropocene stratigraphy	Agnieszka GAŁUSZKA	M314	2024-08-30 10:30	2024-08-30 10:45	4479
Interplay of climate forcing and human impact during the Holocene: a case study from an inner marine basin in the Mediterranean region	Gabriele NICCOLINI	M314	2024-08-30 10:45	2024-08-30 11:00	4469
Anthropogenic changes in river landforms and application of nature-based solutions in South Korea	Dahae GO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4482
How palaeontological signatures of the Anthropocene are stratigraphically unique.	Colin WATERS	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4483
Mapping of submerged landforms by dam construction using historical aerial photos	Jae Hyun HWANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4485
The lagoon of Venice (Italy) in antiquity: insights into settlement dynamics, adaptive behaviours, and palaeoenvironmental reconstructions	Adele BERTINI	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4486
Radiogenic Isotopes, Geochemistry, Petrography of Raw Materials: A Case of Archaeological Ceramic Circulation in the Atacama Desert (Iluga Túmulos, Tarapacá, Northern Chile)	Camila RIERA-SOTO	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4488
The duration of the Anthropocene epoch	Martin J. Head	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4492
Tracing Anthropocene signatures: Sediment core analysis along the west coast of Korea, Yellow Sea	Tae Soo CHANG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4490
T39 Geoethics and Societal Relevance of Geosciences					
S1+S2 GEOETHICS AT THE HEART OF ALL GEOSCIENCE: SERVING THE PUBLIC GOOD		Session Chair: Scientific Program Committee			
Bridging Continents: Building Environmental Awareness and Sustainability with geoscience communication through EuroGeoSurveys' PanAfGeo and GSEU projects	Patrick Wall	C205	2024-08-27 08:00	2024-08-27 08:15	4503
Regulating Geoscience in a Diverse Federation of Independent Regulators – The Canadian Example	MARK PRIDDLE	C205	2024-08-27 08:15	2024-08-27 08:30	4513
Bias in accepting diversity of interpretation in Earth Sciences – historical perspectives and modern challenges	Rob BUTLER	C205	2024-08-27 08:30	2024-08-27 08:45	4514
Responsible Earth/Geosciences and Planetary-Scale Anthropogenic Change	Giuseppe Di Capua	C205	2024-08-27 08:45	2024-08-27 09:00	4501
Geological and Natural Inheritance of Uzbekistan: Research and Conservation of Wealth	Ziyoda Kamunalovna AKHMEDOVA	C205	2024-08-27 09:00	2024-08-27 09:15	4511
Geotourism and geoethics as support for rural development in the Sundarbans Wetlands - a Ramsar site of West Bengal, India	Sayani KHAN	C205	2024-08-27 09:15	2024-08-27 09:30	4507
Ethical Solutions: Climate Intervention Research, Experimentation, and Potential Deployment	Mark SHIMAMOTO	C205	2024-08-27 09:45	2024-08-27 10:00	4505
Operational ethics for researching geohazards	ILAN KELMAN	C205	2024-08-27 10:00	2024-08-27 10:15	4496
Towards Integrating Indigeneity and Geoethical Practice – Case Studies from Aotearoa New Zealand	Matthew W. HUGHES	C205	2024-08-27 10:15	2024-08-27 10:30	4494
An infrastructure designed for the research and global promotion of geoethics	Giuseppe Di Capua	C205	2024-08-27 10:30	2024-08-27 10:45	4499
Geoscience Across Borders: Leveraging Geoscience Diplomacy for International Cooperation.	Munira Raji	C205	2024-08-27 10:45	2024-08-27 11:00	4497
Ethical Frontiers and Legal Landscapes: The ethics of geoengineering the Moon, Mars and other celestial bodies	Dov GREENBAUM	C205	2024-08-27 11:00	2024-08-27 11:15	4506
Synthetic Seas: Ethical, Legal, and Social Dimensions of Genetically Engineered Phytoplankton for Climate Mitigation Contrast with Ocean Iron Fertilization	Dov GREENBAUM	C205	2024-08-27 11:15	2024-08-27 11:30	4509
Geological Surveys, Mining Industry Cycle and Government management! Sustainable development or conflict in national interests!	shirin safavi	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4516
Fossils, museums and ethics – from site based conservation to institutional acquisition	Kevin Page	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4517
Science of Geoethics: Challenges and Opportunities	Devesh WALIA VIILLACORTA CHAMBI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4519
T40 History of Geological Sciences					
S1 History of women in the Geological Sciences: trailblazers, leaders and those in the shadows		Session Chair: Scientific Program Committee			

Title	Presenter	Venue	Start	End	Page
[Keynote] Mexican Women in the Paleontology and Oil Industries	Lucero MORELOS-RODRIGUEZ	M314	2024-08-26 16:00	2024-08-26 16:15	4531
Etheldred Benett (1776-1845) and the Unacknowledged Contributions of an Early English Woman Geologist	Renee M CLARY	M314	2024-08-26 16:15	2024-08-26 16:30	4522
Anna Hietanen (1909–1994) – from Finland to the world	Elina LEHTONEN	M314	2024-08-26 16:30	2024-08-26 16:45	4529
Geological Scenes from Two Marriages – Mary Elizabeth Lyell and Emma Darwin Compared	Martina KÖLBL-EBERT	M314	2024-08-26 16:45	2024-08-26 17:00	4525
Marie Stopes (1880-1958) and Kono Yasui (1880-1971)- the beginning of paleobotany in Japan	Michiko dvan Yajima	M314	2024-08-26 17:00	2024-08-26 17:15	4523
Martha Cornelius-Furlani (1886-1974) and Adelheid Kofler (1889-1985) - the First Female Geoscientis at the University of Vienna	Margret HAMILTON	M314	2024-08-26 17:15	2024-08-26 17:30	4520
Women and diamonds	Leonid R. KOLBANTSEV	M314	2024-08-26 17:30	2024-08-26 17:45	4526
Mrs A. H. Foord and G. M. Woodward: 19th century translators and illustrators of cephalopod studies	Catherine (Kathleen) HISTON	M314	2024-08-26 17:45	2024-08-26 18:00	4528
S2 History of Geoscientific Travels in Asia and Beyond		Session Chair: Scientific Program Committee			
[Keynote] Takla Makan, Pamirs, Karakorams, Indogangetic Plain, Singhala and Java: The Buddhist topography of Faxian (Fa-Hien), at the beginning of the 5th Century CE.	Sharad MASTER	M314	2024-08-27 14:30	2024-08-27 14:45	4532
Ennin's Pilgrimage Travel in China: Japanese Buddhist Geo-consciousness in the Ninth Century	Toshihiro YAMADA	M314	2024-08-27 14:45	2024-08-27 15:00	4547
Drainage work at the Clausthal mine in the Harz region in the 17th century: Achievements of the Japanese Peter Hartzing（1637-1680）	Takeshi Ozawa	M314	2024-08-27 15:00	2024-08-27 15:15	4537
The first geophysical studies, and descriptions of mineral deposits, in Thailand: The French Jesuits under Guy Tachard, and Simon de la Lubère, at the Siamese Court in 1687 and 1689.	Sharad MASTER	M314	2024-08-27 15:15	2024-08-27 15:30	4534
Professional Travelers -– Considering Expanding Process of Professionalism in the Nineteenth-Century United States --	Tomomi NAKAGAWA	M314	2024-08-27 15:30	2024-08-27 15:45	4545
Prussian geographer J. J. Rein travelled to Japan in 1873-76 and introduced Japan to the world	Michiko dvan Yajima	M314	2024-08-27 15:45	2024-08-27 16:00	4544
Crossing the Urals: A Glimpse into Asia in 1841	John DIEMER	M314	2024-08-27 16:15	2024-08-27 16:30	4536
Charles Gould: Travels in Asia	Carol Anne Bacon	M314	2024-08-27 16:30	2024-08-27 16:45	4538
BRONISŁAW GRĄBCZEWSKI AND LEON BARSZCZEWSKI, THEIR TRAVELS IN CENTRAL ASIA IN XIX CENTURY AND CONTRIBUTIONS IN GEOLOGY	Piotr KRZYWIEC	M314	2024-08-27 16:45	2024-08-27 17:00	4548
The Early History of Graptolites Discovery in Asia	Muhammad Aqqid Saparin	M314	2024-08-27 17:00	2024-08-27 17:15	4542
Geological travels and mapping in the Himalayan region between the 19th and the 20th century	Ezio VACCARI	M314	2024-08-27 17:15	2024-08-27 17:30	4540
Multifaceted Nature of Japanese Geological Explorations amid Japanese Imperial Expansion to China in the early 20th century	Shigeo KATO	M314	2024-08-27 17:30	2024-08-27 17:45	4550
Western scholars' geoscientific travels in China during the late 19th and early 20th centuries	Chengsheng SUN	M314	2024-08-27 17:45	2024-08-27 18:00	4552
Legacy etched in Stone: Field Inscriptions of BGS Geologist E. Vredenburg Enduring for 125 Years in the Chagai Desert, Pakistan	Mukhtiar GHANI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4553
S3+S4 General Contributions to the History of Geological Sciences		Session Chair: Scientific Program Committee			
[Keynote] Exposing Earth Sciences History: challenges and perspectives (invited Keynote)	Maddalena NAPOLITANI	M314	2024-08-27 08:00	2024-08-27 08:15	4557
Geological and Hydrological Knowledge of the Aztecs	Sharon LOCKE	M314	2024-08-27 08:15	2024-08-27 08:30	4562
The "Treatises on How to Recognise Gems" of Al-Biruni (11th century) and the development of mineralogy in The Muslim world.	khallaf EL GHALBI	M314	2024-08-27 08:30	2024-08-27 08:45	4555
Image Builders between Mineralogical Knowledge, Possession and Perception in the 18th Century: Catalogues, Collections and Credibility	Marianne Dr. KLEMUN	M314	2024-08-27 08:45	2024-08-27 09:00	4556
James Dwight Dana and his geological excursions in New South Wales, 1839-40	Wolf Mayer	M314	2024-08-27 09:00	2024-08-27 09:15	4559
The heydays of geological research in Finland – Storylines from the museum collections	Jaana HALLA	M314	2024-08-27 09:15	2024-08-27 09:30	4561
The Geological Commission of the Shevchenko Scientific Society: Institutions, Personalities, Publications	Ihor BUBNIAK (BUBNYAK)	M314	2024-08-27 09:30	2024-08-27 09:45	4558
Learning the Soviet Union and Earth Sciences of China: An investigation centered on Specialty Settings of Geography in Peking University In the 1950s	Chao LIU	M314	2024-08-27 09:45	2024-08-27 10:00	4560
Geological maps throughout the hundred years of the Czech Geological Survey (1919–2024)	Vladimir ZACEK	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4563
From Mines to Strata: The Spatial Sciences of the Earth in Britain in the Long Eighteenth Century	Joshua HILLMAN	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4564
150 years of the Italian Geological Survey and the new database of national georesources	Mauro LUCARINI	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4565

Title	Presenter	Venue	Start	End	Page
Solving the Urgent Situation: Analysis of Local Mineral Resource Survey Institutions during the period of the Republic of China	weiwei HU	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4567
The collection of geological wall maps and their importance in teaching	Maria MESZAR	Exhibition Hall	2024-08-27 10:00	2024-08-27 18:00	4568
T41 Mathematical and Computational Methods for the Geosciences					
S1 AI-driven mineral prospectivity mapping		Session Chair: Scientific Program Committee			
Mapping geology using textural feature extraction and unsupervised community detection models on airborne geophysics	Katie L Silversides	M217	2024-08-29 09:30	2024-08-29 09:45	4578
Lithological mapping based on multi-source geoscience data and deep learning algorithms	Ziye WANG	M217	2024-08-29 09:45	2024-08-29 10:00	4575
Geological data mining in mineral resources national survey database	Zhao TING	M217	2024-08-29 10:00	2024-08-29 10:15	4590
Decision-tree models used to detect mineral deposits in Uzbekistan by analyzing ring, lineament structures, and faults	Oksana Gennadevna TSAY	M217	2024-08-29 10:15	2024-08-29 10:30	4573
A hybrid deep learning model of superpixel graph convolutional network and 1DCNN for geochemical anomalies identification	Ying Xu	M217	2024-08-29 10:30	2024-08-29 10:45	4572
Dual branch convolutional neural network and its post-hoc interpretability for mapping mineral prospectivity	Fanfan YANG	M217	2024-08-29 10:45	2024-08-29 11:00	4571
Predictive Mapping of Exploration Targets with Interpretable Machine Learning and Moderated Prediction Values	Emmanuel John CARRANZA	M217	2024-08-29 14:30	2024-08-29 14:45	4570
Automated boundary detection in drillhole data by leveraging AI and machine learning algorithms	Hamid ZEKRI	M217	2024-08-29 14:45	2024-08-29 15:00	4588
A semi-supervised learning method applied in designing optimal infill drillings, a case study at the Dalli porphyry Cu-Au deposit in Iran	Hooshang Asadi	M217	2024-08-29 15:00	2024-08-29 15:15	4576
Detailed mineral, grade, and potential mapping by applying deep neural network-based methods to remote sensing, drilling, and seafloor data	Katsuaki KOIKE	M217	2024-08-29 15:15	2024-08-29 15:30	4582
Neural kriging-based specification and 3D modeling of concentrated zones of rare earth elements in deep-sea mud layers	Vitor Ribeiro de Sa	M217	2024-08-29 15:30	2024-08-29 15:45	4580
Research on Key technology of 3D ore-forming field simulation of Caixiashan Pb-Zn deposit, Eastern Tianshan area, Xinjiang autonomous Region	Li SUN	M217	2024-08-29 16:15	2024-08-29 16:30	4591
Machine learning-based 3D mineral prospectivity mapping	Bingli Liu	M217	2024-08-29 16:30	2024-08-29 16:45	4586
The 3D/4D high precision modeling and AI-driven for 3D Au targeting in the gold districts of North China Craton	Gongwen WANG	M217	2024-08-29 16:45	2024-08-29 17:00	4574
Three-dimensional mineral prospectivity mapping based on positive-unlabeled learning algorithm and return-risk analysis in the Lannigou Au district, Guizhou Province, China	Zhongzheng WANG	M217	2024-08-29 17:00	2024-08-29 17:15	4587
3D Mineral Prospectivity Mapping from 3D Geological Models Using Return –Risk Analysis and Machine Learning on Imbalance Data	Qingming PENG	M217	2024-08-29 17:15	2024-08-29 17:30	4584
Advances in Mineral Resource Assessment: A Comprehensive Overview	keyan XIAO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4592
Convolutional Neural Network and numerical modeling-based 3D mineral prospectivity modeling for targeting concealed mineralization	Xiaohui LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4593
Feature optimization of machine learning and its application in mineral prospectivity mapping	Ke GUO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4594
Machine Learning-based approach to exploration targeting of porphyry Cu-Mo deposits in the Duobaoshan district of Heilongjiang province,China	Xiumei LV	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4595
Numerical simulation and prediction of mineralization using a physical information neural network surrogate model: A case study of the Fankou lead-zinc mine.	tang AO	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4596
S2 Fractals and Singularity in Geosciences		Session Chair: Fan XIAO, Wenlei Wang			
Fractal modeling of the analytical signal for interpreting gravity and magnetic data: A case study from the Eastern Tianshan orogenic belt	Fan XIAO	M217	2024-08-29 08:00	2024-08-29 08:15	4598
Multifractal modeling of current and past Earth's climate	Frits AGTERBERG	M217	2024-08-29 08:15	2024-08-29 08:30	4599
Singularity Analysis and Dynamic Mechanisms of Extreme Geological Events Originating from Plate Motion and Occurring at Their Boundaries	Qiuming Cheng	M217	2024-08-29 08:30	2024-08-29 08:45	4600
Modelling spatial uncertainty of geochemical anomalies integrating C-A fractal and geostatistical simulation methods	Haicheng WANG	M217	2024-08-29 08:45	2024-08-29 09:00	4601
Fractals and Multifractals in Geosciences: An Introduction to a New Reference Book	Behnam Sadeghi	M217	2024-08-29 09:00	2024-08-29 09:15	4597
Ocean singularity analysis and global heat flow prediction reveal anomalous bathymetry and heat flow	Yang ZHANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4602
Unveiling geothermal anomalies in South America: machine learning predictions and spatial correlations with multiple geothermal activities	Junjie JI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4603
A study of thermal gradient effects in the North China Craton magmatic rock	Jinming LI	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4604
Multifractal and singularity analysis in support of new discoveries of mineral deposits	Wenlei WANG	Exhibition Hall	2024-08-29 10:00	2024-08-29 18:00	4605
S3 Compositional data in geosciences: Methods and applications		Session Chair: Scientific Program Committee			

Title	Presenter	Venue	Start	End	Page
Collaborative Seismic Impedance Inversion based on Bayesian Estimation	Jianguo YAN	M217	2024-08-28 14:30	2024-08-28 14:45	4606
Exploratory functional data analysis of multivariate distributions for the identification of agricultural soil contamination by risk elements	Karel Hron	M217	2024-08-28 14:45	2024-08-28 15:00	4608
Geochemical diagrams and exploratory data analysis with CODA	Solveig POSPIECH	M217	2024-08-28 15:00	2024-08-28 15:15	4610
Advancing Mineral Characterization Through Integrated Sensor Fusion and Machine Learning: A Preliminary Study	Chryselle Ultima Ortiz MANCENIDO	M217	2024-08-28 15:15	2024-08-28 15:30	4612
Specifying control factors on Ore Chemical Composition of hydrothermal deposits over Japan through Factor Analysis	Michiharu ENATSU	M217	2024-08-28 15:30	2024-08-28 15:45	4614
Development of a Software Platform for the Real-Time Hyperspectral Interpretation of Samples from the Vaca Muerta (Argentina) Formation within a Virtual Reality Environment.	Douglas Bazo DE CASTRO	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4615
Spatial Estimation of Grain Size Distributions using Compositional Kriging	stephen tyson	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4617
S4 Geostatistical prediction and simulation for complex geological settings		Session Chair: Scientific Program Committee			
Optimal drilling for exploration: an iterative approach	Guillaume PIROT	M217	2024-08-30 08:00	2024-08-30 08:15	4621
A comprehensive rapid updating of resource models with complex geology	Sultan ABULKHAIR	M217	2024-08-30 08:15	2024-08-30 08:30	4624
Enhancing Geothermal Resource Assessment: Well-Correlation and Analysis of Depositional Facies in the Szentes Region, Hungary	Catarina C. CASTRO	M217	2024-08-30 08:30	2024-08-30 08:45	4625
Comparative study of the Hybrid Domaining Framework (HDF) for lithological domain modelling and updating	Yerniyaz ABILDIN	M217	2024-08-30 08:45	2024-08-30 09:00	4627
GEOFRAC-based 3D fracture modeling combined with borehole investigation data for groundwater and hydrothermal fluid flow systems	Taiki KUBO	M217	2024-08-30 09:00	2024-08-30 09:15	4630
A training image-free direct mulitpoint algorithm based on Artificial Neural Networks	Raimon TOLOSANA-DELGADO	M217	2024-08-30 09:15	2024-08-30 09:30	4633
Prospectivity mapping in complex geological settings using Machine Learning and Multiple Criteria Decision Analysis: application to British Columbia (Western Canada)	Antoine BOUZIAT	M217	2024-08-30 09:45	2024-08-30 10:00	4634
Assessment of Theoretical CO2 Storage Capacity in Gas Field and Its Uncertainty Using Integrated Three-Dimensional Structural and Petrophysical Modeling	Baoyi ZHANG	M217	2024-08-30 10:00	2024-08-30 10:15	4639
Unveiling Spatial Correlation between Heat-Affected Coal and Igneous Intrusions: A Probabilistic Analysis Using Indicator Kriging	Mohamad Nur Heriawan	M217	2024-08-30 10:15	2024-08-30 10:30	4640
Three-dimensional stratigraphic modeling via adaptive search strategy-based multiple-point geostatistical simulation	Fang-Hongfeng	M217	2024-08-30 10:30	2024-08-30 10:45	4629
SA-RelayGANs: A Novel Framework for the Characterization of Complex Geological Structures Based on GANs and Self-Attention Mechanism	Qiyu Chen	M217	2024-08-30 10:45	2024-08-30 11:00	4628
Automatic Reconstruction of Geological Reservoir Models Based on Conditioning Data Constraints and BicycleGAN	Wenyao FAN	M217	2024-08-30 13:45	2024-08-30 14:00	4626
Integrating Multivariate Data in Constructing 3D Geological Structure by Multiple-point statistics Method	Weisheng hOU	M217	2024-08-30 14:15	2024-08-30 14:30	4622
Decoding the Dynamic Impact of Clay-Coated Quartz Grains in Sandstone through Multiphase-Field Modeling	AKASH KUMAR	M217	2024-08-30 14:30	2024-08-30 14:45	4619
The evolution of fluid pressure in fault zone and its response to hydrothermal mineralization	Yihui XIONG	M217	2024-08-30 14:45	2024-08-30 15:00	4618
Ab-initio calculations and molecular dynamics simulations of In and Cu repalceing Zn in ZnS with different structures: implications for In enrichment in Pb-Zn mineralization	Zongcong HE	M217	2024-08-30 15:15	2024-08-30 15:30	4632
Numerical estimation of fracture network permeability based on GEOFRAC model for groundwater modeling in a tin mine	Lei LYU	M217	2024-08-30 15:30	2024-08-30 15:45	4636
The joint modeling of correlated gold grades and rock types using the geostatistical multivariate method and the machine learning method in Xincheng gold deposit, China	Xiaoning LIU	M217	2024-08-30 15:45	2024-08-30 16:00	4638
Enhancing lithological classification in high-resolution CT scan data using Convolutional Neural Networks for domain allocation	Milena Nasretdinova	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4642
Mining-induced Soil Contamination Mapping using a Combined Model of Random Forest and Ordinary Kriging	Hosang Han	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4644
Research on multi-parameter warning threshold and discriminant model of landslide disaster	Yi DONG	Exhibition Hall	2024-08-30 10:00	2024-08-30 16:00	4645
S5 General Topics		Session Chair: Scientific Program Committee			
Density Estimation in Mineral Deposits: Tracing the Evolution from Archimedes to Contemporary Methods	Joao Felipe Coimbra Leite Costa	M217	2024-08-28 16:00	2024-08-28 16:15	4646
Genetics and statistical topology of holy stones	Tamas JASKO	M217	2024-08-28 16:15	2024-08-28 16:30	4648
The role of mathematical geoscience in exploring the complexity of human-environment-climate relations: The IAMG 2024 Krumbein Medal.	Jennifer M MCKINLEY	M217	2024-08-28 16:30	2024-08-28 16:45	4650
Optimizing Geothermal Operations While Mitigating Induced Seismicity Risks: An AI-based Framework for Decision-Making Under Uncertainty	Sofia Mantilla Salas	M217	2024-08-28 16:45	2024-08-28 17:00	4651
A Mathematical Model of Early Earth Magma Ocean Differentiation	SEEMA KUMARI	M217	2024-08-28 17:00	2024-08-28 17:15	4653

Title	Presenter	Venue	Start	End	Page
Geoscience model assessment	Jeff BOISVERT	M217	2024-08-28 17:15	2024-08-28 17:30	4656
Effect of the mesh size near the fault on finite source inversion: 3-D finite element earthquake modeling	Minsu KIM	M217	2024-08-28 17:30	2024-08-28 17:45	4657
A Geologically Variational Autoencoder for Geochemical Anomaly Detection by Ad-Hoc and Post-Hoc Interpretability Algorithms	Zijing LUO	M217	2024-08-28 17:45	2024-08-28 18:00	4654
Source apportionment of heavy metal contamination in urban-agricultural-aquacultural soils near the Bohai Bay Coast based on cokriging and land-use classification	Ling Zeng	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4658
Geochemical characteristics and Exploration implications of the Shangyi region, Zhangjiakou City	Lujia PAN	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4659
Lithology mapping based on machine learning: a case study of the Eastern Tianshan Mountains	Huaqing Yang	Exhibition Hall	2024-08-28 10:00	2024-08-28 18:00	4660

[Plenary] VANISHED OCEAN: How Tethys Re-shaped the World

Dorrik STOW[1]*, Heriot- Watt University (D.Stow@hw.ac.uk)

Abstract

A hundred million years ago, a mighty ocean dominated the equatorial world. Its vast waters bore witness to many of most dramatic episodes in the story of our planet. It played host to a plethora of fascinating organisms, saw great mass extinctions and then nurtured the ensuing rebirth of new life forms. It endured its own secret drama of submarine quakes and powerful currents, at one point quaking under evening skies lit by the outpourings of a super-volcano that exploded along its northern margin. For long ages, its quiet central gyres were more desolate and empty than anything seen in today's world. But then, five and a half million years ago, it quite simply disappeared. It was called the Tethys Ocean and this is a kaleidoscope of images from that lost world, pieced together from myriad clues, which are now scattered through the rocks that stretch from Morocco to China, from the depths of the Caspian Sea to the highest Himalayan peaks. Though imperfect and incomplete, the record is varied and captivating, telling something of the assembly and splintering of continents, the rise and fall of mountain ranges, the changing ocean currents and their link to Earth’s climate, the remarkable story of oil and gas, and other deep-ocean treasures. Such changes in the land and ocean have been strongly instrumental in shaping the colourful pageant of life through the past 250 million years of Earth history, and in painting the template
for the oceans of today.

Keyword

[Plenary] THE NETWORK TOPOLOGY OF FRACTURES, TECTONIC PLATES AND GEOLOGICAL MAPS

David SANDERSON[1]*, University of Southampton (d.j.sanderson@soton.ac.uk)

Abstract

Many geological features are encountered and represented as networks on a surface, e.g. a map, cross-section or field sketch of an exposure surface. A network of fracture or stratigraphic traces can be represented by branches (B) that end or intersect at nodes (N) and sub-divide the surface into regions (R) - the node-branch model of Sanderson and Nixon (2015). Whereas geometry is used to describe the location, length, shape, and orientation of elements within the network, topology is used to describe the relationships between these elements. Thus, topology compliments geometry and enhances geological mapping. A range of tectonic and geological examples will be discussed to illustrate both the added-value and efficiency gained by including topology. Graph theory can be used to analyse a node-branch representation of networks (Sanderson et al. 2019), which usually form simple, planar graphs with well-established, mathematical properties. The description is straightforward and intuitive, usually forming a part of the initial mapping procedures and easily adapted to remotely sensed data. The mathematics is simple, requiring little more than counting the nodes and branches. To date, most applications in tectonics have been applied to fault and fracture networks, usually at a small-scale. These will be extended to consider superposed networks, and methods that allow extraction of kinematic and sequence information from maps. The scale can be extended to the plate tectonic system, which represents a good example of a simple graph on a sphere that obeys Euler's formula that $|N|-|B|+|R| = 2$, one of the simplest and most important formula in mathematics. A geological map can be considered as a network made up of traces of stratigraphic boundaries and superposed tectonic elements, mainly faults. GIS software can make use of topology in constructing geological maps, but little use is made of topological parameters, axioms, and proofs in their analysis. The potential of topology to revolutionise interpretation of geological maps will be briefly discussed.

Keyword

[Plenary] The future of geosciences through the lens of geoethics

Silvia PEPPOLONI[1]*, Italian Institute of Geophysics and Volcanology (silvia.peppoloni@ingv.it)

Abstract

The increasing human impact on the Earth system is leading to an unprecedented ecological crisis at a planetary scale, recognized by science worldwide. Global warming, climate change, pollution, biodiversity loss, represent together a multifaceted challenge, a global "polycrisis," intertwining social, economic, political, and cultural factors with environmental concerns, and outlining a complex landscape for action. Geosciences emerge as vital disciplines for understanding and managing the intricate interactions between humanity and the Earth system, offering pathways and providing essential insights to address this polycrisis. Through informing
decision-making processes and guiding geo-environmental education across various levels, geosciences empower individuals to engage in discussions, influence outcomes, and implement solutions to socio-environmental issues on local, regional, national, and global scales. However, the effectiveness of geosciences in addressing societal challenges depends on geoscientists' awareness of the ethical, social, and cultural implications of their work. Acknowledging the historical contributions of geoscientists to unsustainable and contestable practices in the past is the first step to gain public trust, advocate for knowledge-based societies, and urge governments to adopt measures for mitigating climate change, and adapting to environmental shifts. Geoscientists possess the indispensable knowledge and the right intellectual and material tools to comprehend and manage Earth's processes. They know the meaning of concepts, such as planetary boundaries, tipping points, carrying capacity of ecological systems, that are essential to address the polycrisis and to shift the way in which human communities manage their land, resources, and natural heritage, even going so far as to influence common perceptions of the natural world. For these reasons, they have the ethical duty to actively engage as agents of social change. By transparently sharing knowledge within the scientific community and effectively and
properly communicating findings to the public, geoscientists fulfill their responsibility to guide political decisions and inform and educate society, contributing to the construction of a more ecologically sustainable and just world. At the core of this endeavor lies geoethics, emphasizing the ethical responsibility of geoscientists towards themselves, colleagues, society in all its components, including future generations, and the Earth system. Geoethics guides geoscientists in navigating the complex socio-ecological landscape of our time, by urging them to respect scientific rigor and pursue the public good in their work. Geoscientists are called upon to address particularly delicate issues which concern the responsible use of mineral resources, water and energy, the relationship with decision-makers and various stakeholders in the defense against natural risks, the application of geoscientific knowledge in sustainable management of the territory, in the pursuit of citizens' health, in the protection of the biosphere. Furthermore, geoscientists should ponder and collaborate to address other sensitive issues, such as deep-sea mining, the use of geoengineering, and the applications of artificial intelligence. The geoethical

perspective radically reshapes the ethical, social, and cultural meaning of the geosciences, by redefining their objectives towards the pursuit of well-being while respecting ecosystems.

Keyword

[Plenary] Unveiling Active Fault Zone Dynamics: Harnessing Emerging Fiber Optic Sensing Technology

Kuo-Fong MA[1]*, Institute of Earth Sciences, Academia Sinica, Taiwan (fong@earth.sinica.edu.tw)

Abstract

The opportunity to observe fault zone behavior at depth with high spatial resolution is rare, and identifying the fault zone itself poses a significant challenge. The MiDAS (Milun-fault Drilling and All-inclusive Sensing) project in Taiwan recently has successfully overcome the challenge of observing fault zone behavior at depth with high spatial resolution. By retrieving the fault core associated with the Milun fault zone, visible in geophysical logs displaying low velocity and resistivity, and utilizing Optical Fiber Sensing techniques, the project effectively maps and analyzes fault behavior. The Milun fault, known for frequent slip events and generating significant earthquakes, namely the 2018 M6.4, and 1951 M7.1 earthquakes, was drilled and cored between 2021 and 2022, deploying a 3D multi-cross-fault fiber array. This array included a down-hole loop at a depth of 700m (Hole-A) crossing the fault, a surface array using commercial fiber across the fault rupture zone, and a 500m fiber downhole loop (Hole-B) at the Footwall site. The combination of high-resolution data from distributed acoustic sensing (DAS) and retrieved core samples, alongside geophysical logs, facilitates a detailed characterization of the fault structure. Within the Milun fault zone, a 20m thick fault core comprising grey and black gouge was uncovered. This fault gouge displays a unique seismic feature, consistently amplifying strain records from DAS with a ratio of approximately 2.5-3 for different event types, when compared to deeper channels consisting of consolidated rock material. Despite the narrowness of the fault gouge, its significant material contrast contributes to the observed strain amplification. These findings enhance our understanding of fault zone dynamics, particularly in terms of remote earthquake triggering and near-fault ground movements. Similar features were noted at the surface, with a wider rupture zone of about 200m evident in DAS data, supported by geophones crossing the surface rupture of the 2018 Hualien earthquake. As we delve into depth, downhole optical fiber and cores reveal a high-resolution asymmetric feature of this active fault. Moreover, borehole DAS recordings from the M7.0 Chishang earthquake on September 18, 2022, indicate static-strain changes throughout the depth, potentially aiding in the mapping of a 3D strain-field related to significant earthquakes. The direct exploration of the fault zone through this emerging high-resolution technology is a promising development that holds potential for gaining innovative insights into fault zone dynamics.

Keyword

[Plenary] The role of Medical Geology in achieving the UN SDGs in Africa

Hassina MOURI[1]*, University of Johannesburg, Republic of South Africa (shmouri@uj.ac.za)

Abstract

The African continent is facing serious and continuous interlinked geo-environmental and health challenges affecting the socio-economic development of the continent.

The continent is known for its long and complex geological history and volution, geohazards including landslide, frequent earthquakes and volcanic eruptions in tectonically active regions. Furthermore, water toxicity due to its interaction with rocks and soils, and air pollution due to dust storms especially in dry parts of the continent are amongst the most common issues encountered on the continent. Drought and flood, which are also frequent in several parts of the continent, impact severely on the food crops uptake of essential elements released to the soils by weathering processes of rocks, forming a serious threat to food security. Moreover, the continent is known for its widespread, often uncontrolled mining operations and oil exploitation, which enhance the release of chemical elements and inhalable nanoparticles of minerals into the environment. Although some chemical elements such as Ca, Mg, Fe, I, F and Li are essential for our well-being, their deficiency or excess in soils, water or food as well as the presence of toxic elements such as As, Pb, Cd, Hg, Tl, U and the decay products of the latter can be detrimental to health.

From a health point of view, according to the WHO reports, the African continent is known for the high mortality rate due to the non-communicable diseases (NCDs) such as cardiovascular, chronic respiratory tract diseases and cancer. These diseases account for over 50% of deaths in some African countries. However, the primary causes of such diseases and mortality in general remain unclear in many cases and attention is mostly given to their risk factors and treatment. It is worth noting that some of the most common NCDs on the continent such as thyroid disorder, asthma and fluorosis, do not necessary cause death, but prohibit patients from working, enhancing poverty especially in rural areas, hence creating social inequalities, and affecting economic development of the continent in general.

In order to ascertain the geo-environmental causes of some of the common NCDs on the continent, it is crucial to integrate Earth Science with Public Health through Medical Geology, a field of science that deals with the impacts (positive or negative) of the geo-environment (including processes and materials) on the health of humans, animals and the ecosystems in general. This field of science is based on multi, cross- and inter-disciplinary approaches bringing together experts from various fields of science. Understanding the geological history and environment, will help provide insight into natural hazards that can (directly or indirectly) affect our health and ecosystems in general. This understanding can mitigate impacts, prevent widespread and serious health problems, which impact the socio-economic development of the continent, and save lives in a longer term.

The development of the field of Medical Geology in Africa is proved to be necessary in addressing several United Nations Sustainable Development Goals (SDGs) through partnership

[Plenary] Order in the rocks: A global language for the stratigraphy of 4.6 billion years of Earth history

David A.T. HARPER[1]*, Durham University (david.harper@durham.ac.uk)

Abstract

Stratigraphy is the oldest of the geological disciplines; its roots can be traced back to the Italian Renaissance and firmly established by the paradigm shifts of Nicolaus Steno (Superposition), Giovanni Arduino (Order), William Smith (Correlation using Fossils) and others. 19th century savants established the concepts of evolution, mass extinctions and palaeodiversity with reference to the definition and use of geological systems, series, stages and zones in terms of loosely-defined unit stratotypes. During the past 50 years, however, the concept of the Global Boundary Stratotype Section and Point (GSSP) has superseded that of the unit stratotype for the Phanerozoic. Each global chronostratigraphic unit, i.e., systems, series and stages, has a defined base marked by a ‘Golden Spike’. Almost 80% of global stages are now robustly defined in this way. This substantially increases the prospect of tuning the passage of Phanerozoic time using cyclostratigraphy and radioisotopes, together with software programs such as Stratobayes which aligns stratigraphic sections, opening new windows on the rates of biological and geological processes in deep time. The majority of Precambrian units are defined in terms of numerical ages, Global Standard Stratigraphic Ages (GSSAs), in the lack of criteria such as fossils and nonbiologic proxies to correlate them. There is, however, a real prospect that the bases of many Precambrian units can also be related to rock, in a manner similar to a GSSP.

Keyword

Chronostratigraphy, Phanerozoic, GSSPs

[Plenary] 1100 years of large earthquakes in the southern San Andreas fault system: The effects of lake loading on local and regional seismicity on a fast-slipping plate boundary

Thomas ROCKWELL[1]*, SDSU (trockwell@mail.sdsu.edu)

Abstract

Paleoseismic data from several dozen paleoseismic sites in the southern San Andreas fault system (SSAF) allows for sequencing of the past 1100 years of large (M6.5+) earthquakes for the southern 200 km of the main plate boundary fault system. The SSAF lies within the larger Salton Trough, which has periodically filled and desiccated over the past millennium with a large lake (236 km3), known as ancient Lake Cahuilla. Here, we show that Lake Cahuilla has filled six times in the past 1100 years and provides time-correlative stratigraphy across many of the faults in the southern San Andreas system. At least five generalizations are clear from the paleoseismic and lake record: 1) M7 and larger earthquakes account for most of the moment release in the southern SSAF over the past 1100 years; 2) large earthquakes along the southernmost “Coachella” section of the SSAF were modulated by filling of Lake Cahuilla, with 6 of the past 7 earthquakes occurring during the six high lake stands; 3) seismic production on the southernmost San Andreas, Superstition Mountain and Imperial faults, all within the footprint of Lake Cahuilla, increased in the few hundred years after an extended dry period when the basin once again filled with water, presumably due to a change in fault strength from increased pore pressure; 4) large earthquakes on individual faults are quasi-periodic but display a relatively high coefficient of variation in recurrence time, similar to most long California records; and 5) moment release has spatially and temporally varied during the past 1100 years but within potentially predictable bounds. Together, the record suggests that the southern San Andreas fault is late in the cycle but not necessarily “overdue” as commonly reported in the media, and that a systems-level approach may be more accurate in long term earthquake forecasting than estimates made from individual faults.

Keyword

San Andreas Fault, Lake loading and seismicity, Lake Cahuilla, Pore pressure triggering

[Plenary] Journey to the center of the Earth: a modest revisit

Yongjae LEE[1]*, Yonsei University (yongjaelee@yonsei.ac.kr)

Abstract

Since the fictional journey by Jules Verne in 1864, more than 100,000 non-fictional articles have been published to follow the journey to the center of the Earth. Instead of deciphering the Runic manuscript to set the passage for the journey, seismologists constructed their own maps of the Earth's interior, on which geochemists were able to color resident minerals. While the team of professor Liedenbrock embarked their epic journey through a volcano in Iceland, modern mineral physicists subject minerals to the conditions expected in the Earth's interior. As the protagonists in the novel could not complete their journey to the very center of the Earth, the scientific journey deep into our planet still awaits much more to be discovered.

In this talk, I will showcase what has been added through our own scientific journey to the Earth's interior. We set water, one of the most important volatile species on the Earth's surface, as the supporting actor in our journey. We used diamond anvils as a vehicle to have water meet minerals under the conditions expected deep inside the Earth and irradiated synchrotron X-rays to watch their interactions. As the fictional team found a subterranean river during their journey, we observed how much more water can be added into mineral carriers during subduction processes (1), how deep they can be delivered by transferring the carriers (2), and what would happen when they reach the destination at the core-mantle boundary (3). Deep past in time, the role for water in the Earth's evolution could have been quite different as depicted in the novel by a subterranean ocean with lightening clouds. By simulating the interaction conditions in the early magma ocean using the brightest and fastest X-ray light, we found how water could have played to nurture the conditions required for the origin of life on the Earth (4).

References
(1) Hwang, et. al., "A role for subducted super-hydrated kaolinite in the Earth's deep water cycle", Nature Geoscience, 10, 947-953, 2017; (2) Yun, et. al., "Super-hydration and reduction of manganese oxide minerals at shallow terrestrial depths" Nature Communications, 13:1942, 2022
(2) Hwang, et. al., "A role for subducted albite in the water cycle and alkalinity of subduction fluids" Nature Communications, 12:1155, 2021; Bang, et. al., "The stability of subducted glaucophane with the Earth's secular cooling" Nature Communications, 12:1496, 2021
(3) Kim, et. al., "A hydrogen-enriched layer in the topmost outer core sourced from deeply subducted water", Nature Geoscience, 16, 1208-1214, 2023.
(4) Choi, et. al., Oxidation of iron by giant impact and its implication on the formation of reduced atmosphere in the early Earth, Science Advances, 9, eadi6096, 2023

[Plenary] Anatomy of the solar system oldest rocks, Ca-Al-rich inclusions

Hisayoshi YURIMOTO[1]*, Hokkaido University (yuri@ep.sci.hokudai.ac.jp)

Abstract

Meteorites called chondrites are fragments of planetesimals that formed in the Solar System. Chondrites contain Ca-Al-rich inclusions (CAIs), which are known to be the oldest rocks formed in the Solar System. The bulk compositions suggest that the CAIs were formed by materials condensed in hot solar compositional gas. However, significant mass-independent isotopic variations have been observed among the CAIs. When the isotopic and elemental distributions of the CAIs were anatomized at sub-micrometer resolution, the isotopes and elements were heterogeneously distributed between minerals as well as within a mineral. Their distributions do not appear to correlate clearly with each other. Recently, comprehensive analyses based on crystal growth studies have been applied to the CAIs. The results show that the CAIs continued to form in a hot region of the protoplanetary disk during the first 0.5 million years of the solar system formation, based on the distributions of a short-lived nucleus Al-26. On the other hand, the formation timescales of individual CAIs were much shorter, completed within a several weeks. Kinetic experiments in the laboratory simulating the protoplanetary environment show that pressure and temperature were fluctuated drastically during each CAI formation. Especially, the pressure fluctuations reached as high as three orders of magnitude. In addition, the isotopic composition of the protoplanetary disk gas changed significantly, while the elemental composition remained almost unchanged. These new anatomical results from CAIs suggest that new and unknown violent astrophysical phenomena occurred around the proto-sun.
In this talk, I will show how to anatomize the CAIs using combinations of isotope microscopy, secondary ion mass spectrometry (SIMS), electron microscopy, electron backscatter diffraction (EBSD), and X-ray mapping, and discuss the physicochemical conditions and the time evolution of the CAI formation region in the protoplanetary disk summarized above based on the anatomical results. This anatomy would also be useful for geochemical studies of rocks.

Keyword

meteorite, isotope, oxygen, Al-26, Ca-Al-rich inclusions

[Plenary] Metamorphosis of Magmas in Planetary Interiors

Sung Keun LEE[1]*, Seoul National University (sungklee@snu.ac.kr)

Abstract

From molten silicates comprising the deep Hadean silicate magma ocean in early Earth to complex amorphous oxides on the surfaces of fault planes during co-seismic slip, non-crystalline oxides in earth and planetary surfaces and interiors have played essential roles in chemical and physical evolution of earth and rocky planets. Despite importance, deciphering the detailed nature of these non-crystalline silicate melts and magmas remains one of the challenging problems in earth and planetary sciences. In this talk, the recent advances and experimental efforts to reveal the properties and structures of silicate magmas are summarized. In near surface environments, we establish a new frictional melting model involving both equilibrium (controlled by particle size and composition) and metastable melting, providing insights into fault-weakening and the mechanism for large earthquakes (Lee et al. Nature Geoscience 10, 436, 2017). In upper mantle, entanglement of the melt network in basaltic melts at high pressure increases the configurational entropy. We explain how the configurational entropy can be used as a tool to explain the anomalous behavior of melts under compression (Lee et al. PNAS 117, 22938, 2020). When compressed above multi-megabar pressures, silicate magmas undergo structural evolution that are not observed at ambient pressures and substantially differ from those in the crystalline silicates. Particularly, the melt densification is accompanied with the prevalence of triply and quadruply coordinated oxygens above multi-megabar pressures. The extreme densification paths with compressed oxygens may account for anomalous negative buoyance of the complex partial melts in the deeper part of the mantle and those in the super-Earth bodies (Lee et al. PRL 123, 235701, 2019; Kim et al. JACS 144, 10025, 2022; Lee et al. Science Advances, 9, eadg415, 2023). Finally, conceptual advancement as to how these findings contribute to better understand igneous, impact, deformation, and seismic processes in the Earth and planetary surfaces and deep interiors are highlighted.

Keyword

magmas, pressures, planetary interiors, igneous processes

[Plenary] Impact of Climate Change on Groundwater Resources and Way Forward

Elango LAKSHMANAN[1]*, Indian Institute of Technology Madras, Chennai-600036, Tamil Nadu, INDIA. (elango34@hotmail.com)

Abstract

Climate change and other issues, such as increasing urbanisation and food and energy requirements, affect groundwater resources. Climate change affects groundwater resources in multiple ways. The coastal groundwaters are more vulnerable to climate change-induced stresses. Climate change's adverse impacts on water quality are of emerging interest and importance. Coastal groundwaters are affected by changes in rainfall patterns, urbanisation, and rising sea levels. This study brings out the impact on coastal regions of India. The study analysed the long-term groundwater level data and used numerical modelling. The study indicates that parts of coastal aquifers in India are affected by seawater intrusion. The fresh coastal groundwater resources are diminishing due to rising sea levels and overuse. Improving recharge and reducing the pumping are some of the mitigation measures to overcome this problem. On the other hand, analyzing water quality also provides insights into how weathering within a river basin impacts climate change and the carbon cycle. Carbon dynamics within catchments and river basins are pivotal to climate change processes. This session will delve into these topics, examining current research on water quality, surface water-groundwater interactions, the carbon cycle, riverine flux, organic and inorganic carbon, models, and more, all within the context of climate change.

Keyword

Climate change, hydrologic cycle, groundwater, coastal aquifers, sustainablity

[Plenary] Significance of bathymetric features on tsunami propagation in Indianan Ocean

Kirti SRIVASTAVA[1]*, CSIR-NGRI (kirtingri722@gmail.com)

Abstract

The Indian Ocean Tsunami in 2004 damaged several areas along the east coast of India, ruining many structures along the coasts and causing loss of human life. Tsunamis are giant waves caused by undersea earthquakes, landslides, meteorites, or volcanic eruptions. Their severity depends on the magnitude and distance from the shore. The tall and fast-moving waves destroyed property on a very large scale and rebuilding them is a huge task. Designing the coastal structures to resist or at least reduce the damage caused by a tsunami wave would save a lot of time and money. It also helps to reduce impact forces and inundation of the wave. Challenging questions need to be addressed and looked into the tsunami propagation and the hazard associated with the tsunamis in the Indian Ocean. Different aspects of the tsunami propagation over ridges, islands, and along the east and west coast of India due to tsunamigenic earthquakes from the Andaman-Sumatra and Makran Subduction zones are studied. Also, tsunami forces on different beaches and also the effect of varying bathymetry in the Indian Ocean will be brought out. The effectiveness of having rock boulders along the coast for reducing the tsunami impact on the coast is quantified. Due to their structure, the waves hit the boulders in different directions causing the wave energy to dissipate in all directions. Eventually, the surge wave breaks and loses its velocity. Hence, no inundation or a slight overflow is observed. The tsunami-induced forces study earlier was not given importance due to the low frequency of tsunamis. After the destructed buildings and many other damaged structures during the 2004 tsunami, importance is being given to tsunami forces in engineering constructions along tsunami-prone areas. Hence, instead of building sea walls if we use rock boulders along the populated coastal areas the damage can be minimized. Keeping in view the destructive tsunamis in the Indian Ocean and other possible destructive tsunami events due to landslides and meteorites are investigated and their findings shall be discussed.

Keyword

Tsunami, Makran, Andaman-Sumatra, Meteorite, Landslide

[Plenary] Artificial Intelligence (AI) - a new era for the modeling and interpretation of natural hazard assessments in the spatial domain

Biswajeet PRADHAN[1]*, University of Technology Sydney (biswajeet24@gmail.com)

Abstract

In this keynote talk, we explore the transformative impact of Artificial Intelligence (AI) on natural hazard assessments within spatial domains, heralding a new era in disaster management. AI technologies have emerged as powerful tools, revolutionizing the way we model and interpret natural hazards. By harnessing machine learning algorithms and big data analytics, AI enables the efficient processing and analysis of vast spatial datasets, leading to highly accurate and timely hazard assessments. Real-time integration of geospatial information empowers proactive disaster preparedness, ensuring swift and precise responses to evolving threats.

Crucially, AI brings a paradigm shift in interpretation, unraveling intricate spatial patterns and relationships in natural hazard data. Its advanced algorithms discern subtle correlations and hidden trends, enhancing our understanding of complex environmental processes. This newfound insight not only refines hazard models but also informs adaptive strategies for risk reduction and resilient infrastructure development. Through case studies and cutting-edge applications, this keynote explores how AI-driven models and interpretations are reshaping our approach to natural hazard assessments. By embracing this innovative intersection of technology and geoscience, we pave the way for a safer and more resilient future, where AI becomes a cornerstone in our collective efforts to mitigate the impact of natural disasters and protect vulnerable communities.

Keyword

Spatial intelligence, Machine Learning, Natural hazard, Remote sensing

[Plenary] The Roles Geoscientists Can Play to Achieve the United Nations Sustainable Development Goals

Adam SIMON[1]*, University of Michigan (simonac@umich.edu)

Abstract

The United Nations Sustainable Development Goals call for, among other things, correcting asymmetric access to energy that will allow all members of our global community to have a quality of life common for citizens of more advanced economies such as the Republic of Korea, European Union and the United States. Access to at the country level can be evaluated by using the United Nations Development Programme Human Development Index that considers the life expectancy at birth, the expected years of schooling and the gross national income per person. The magnitude of income inequality within a country can also be used as a fourth dimension to yield an IHDI, as can gender equality and the level of individual freedom that yield an Augmented HDI (AHDI). An assessment of the AHDI values for all countries reveals stark differences among countries and regions. The AHDI value is 0.759 for the United States, Canada, Australia and New Zealand, 0.748 for Western Europe, 0.546 for Eastern Europe, 0.457 for Latin America, 0.432 for East Asia, 0.343 for the Middle East, 0.340 for North Africa, 0.336 for South Asia and 0.275 for Sub Saharan Africa. Certainly, there are differences among countries within each region, but the data reveal stark differences that indicate where capacity building is most needed. Capacity building requires capital in the form of one or more resources that a country can export to generate revenue for development. Resources include human labor, agricultural products and natural resources such as cobalt, copper, gold, lithium, nickel, etc. The latter group of resources to varying degrees are abundant in all regions, but unlocking the value of these resources requires the careful work of Geoscientists to explore for, discover, and determine the quantity of a particular resource. Essentially, geoscientists are treasure finders and hold the keys to unlocking the value of resources that can be used for capacity building and human development. Providentially, global demand for all of these metal resources is at an all-time high and will only increase over the next several decades. Geoscientists also play the important role of minimizing impacts to the environment during exploration and mine development. In this talk, I will discuss our current understanding of the global locations of mineral resources, their potential value if they could be exploited, and related this value to what is required to achieve the United Nations Sustainable Development Goals.

Keyword

capacity building, sustainable development, energy equity, critical minerals, energy transition

[Plenary] A Trip to Dinosaur Time - Records from Continental Scientific Drilling of Cretaceous Songliao Basin

Chengshan WANG[1]*, Research Center for Tibetan Plateau Geology, China University of Geosciences (Beijing) (chshwang@cugb.edu.cn)
Yuan Gao[2], School of Geosciences and Resources, China University of Geosciences (Beijing)
Pujun Wang[3], College of Earth Sciences, Jilin University
Huaichun Wu[4], School of Ocean Sciences, China University of Geosciences (Beijing)
Qingtian Lv[5], Chinese Academy of Geological Sciences

Abstract

Over the past centuries, the Earth's climate has been consistently warming, and may enter a greenhouse climate state with ice-free poles in the future. The Cretaceous was a typical period of greenhouse climate in deep time, and thus understanding the Cretaceous climate is significant for interpreting past climate changes and predicting future trends. The International Continental Scientific Drilling Project of the Songliao Basin is the world's first continental scientific drilling project to penetrate the Cretaceous continental strata within the framework of the ICDP. This project is aimed to investigate Cretaceous terrestrial climate and environmental changes, and to explore the mechanisms of massive terrestrial organic matter accumulation and enrichment. Spanning 16 years, this project achieves a continuous and complete 8187-meter core with a recovery rate exceeding 97%, establishes a high-precision chronostratigraphic framework for the Cretaceous continental strata in the Songliao Basin, reconstructs multi-temporal-scale terrestrial climate cycles and climate events during the Cretaceous period, reveals the mechanisms of Cretaceous sea-level fluctuations, and confirms marine incursion events in the Songliao Basin. The International Continental Scientific Drilling Project of the Songliao Basin has promoted global collaboration among geologists to study Cretaceous greenhouse climates, leading to a series of high-level academic achievements. It has provided crucial scientific support for the sustainable development of oil and gas exploration in the Songliao Basin, and has generated significant social benefits and substantial international and domestic influence. The International Continental Scientific Drilling Project of the Songliao Basin represents a milestone stage in exploring deep-time Earth, and it is foreseeable that in the future, with the aid of scientific drilling, humanity will continually enhance the understanding of deep-time climatic and environmental evolution.

Keyword

International Continental Scientific Drilling Program (ICDP), Songliao Basin, Cretaceous, paleoclimate, terrestrial records

Geochemistry and detrital zircon U–Pb geochronology of Neogene sedimentary rocks from offshore Bengal Basin, Bangladesh: Implications for provenance and tectonic setting

Julleh Jalalur RAHMAN[1]*, Jahangirnagar Universty (rahman65@juniv.edu)
Tanusree Datta[2], Jahangirnagar University
Abu Sadat Md. Sayem[3], Jahangirnagar University
Md. Sakawat Hossain[4], Jahangirnagar University

Abstract

The Bengal Basin is one of the most productive sedimentary basins in the world for hydrocarbons and is situated in the northeastern section of the Indian subcontinent. The basin contains dominantly shallow-marine to continental clastic and minor carbonates and attains a thickness of about 18 km of mainly Tertiary to Recent sediments, with more than 6 km of Neogene sediments. The thickness of the sediment gradually increases from the north-west to the south-east. The Sangu Gas Field is located in Block SS 04 at the eastern part of the Hatiya Trough of the Bengal Foredeep and the western extremity of the Chittagong-Tripura Fold Belt (CTFB). This research aims to understand the provenance and tectonic evolution of the offshore Neogene sequences encountered in Sangu -1 and Sangu-5 wells from the Sangu Gas Field, Bay of Bengal, based on framework mineralogy, geochemistry and U-Pb dating of detrital zircons. Framework composition reveals that the Neogene sandstones are more quartzose ones with low feldspar, very few volcanic grains, and abundant sedimentary and low-grade metamorphic lithic clasts, indicating that the sandstones were derived from a quartzose recycled orogen province, such as a fold-thrust belt and a collision suture. Major and trace element geochemical studies show that these Neogene sediments originated from an active continental margin (ACM) tectonic setting related to the recycled orogen province that is in good agreement with the framework composition of the sandstones. The recycled sources are characterized by felsic source rocks and underwent low to moderate chemical weathering, as indicated by the CIA (Chemical Index of Alteration) values ranging from 55 to 73, which are supported by the PIA (Plagioclase Index of Alteration) (57-84, avg. 70) and the ICV (Index of Compositional Variability) (average 1.2) values. The U-Pb dating data of detrital zircons show that most of the zircon grains of the Neogene succession in the Sangu Gas Field of the Hatiya Trough are Proterozoic and early Paleozoic in age. The U-Pb ages of the Pliocene-Pleistocene Tipam Group and the Miocene Surma Group range from 22.49 to 2794.45 Ma and 28.04 to 3168.21 Ma, respectively. The detrital zircon U-Pb age spectra of the Miocene Surma Group and Pliocene Tipam Group reveal that the main source of the detrital zircons was a mixture of the three Himalayan litho-tectonic units; the Tethyan Himalaya, the Higher Himalaya, and the Lesser Himalaya. The dominant peak of zircon ages at ~440-620 Ma from the Tipam and Surma Group sandstones resembles those of the Tethyan Himalaya (TH), Upper Lesser Himalaya (ULH), and Indo-Burman Ranges (IBR). The subordinate peaks at ~ 1500-2000 Ma reflect the ages of the Higher Himalaya (HH). The other subordinate peaks at ~ 700-1200 Ma and ~ 2500

Ma, reflect the age of the Lower Lesser Himalaya (LLH). There is a significant rise in the younger detrital zircons (<200 Ma) population in the Pliocene Tipam Group (~22%), which may be attributed to the possible source from the Gangdese arc, the Trans-Himalayan Batholiths, and the Burma magmatic arc.

Keyword

Geochemistry, U-Pb ages, Neogene Succession, Sangu Gas Field, Bay of Bengal

Future drilling in Bengal Fan revealing the plateau uplift and its effects from the seafloor spreading to the climate change

Gang HU[1]*, Qingdao Institute of Marine Geology (qimghgang@gmail.com)

Abstract

The Bengal Fan is not only a source-sink transition zone connecting the plateau and the deep sea, but also an important product of plates drift and collision. Its deep sedimentary records are the natural archives of the India-Eurasia plate collision, the uplift and erosion process of the Qinghai Tibet Plateau and the evolution of climate and environment. We summarized the drilling expeditions and the latest research progress focusing on the sedimentary process and climate evolution since the late Miocene, the nature and evolution of the 90°E Ridge, and the formation of the South Asian monsoon in the Bengal Fan. However, constrained by drilling capacity and scientific targets, the full time sedimentary strata, the age and structural characteristics of the underlying oceanic crust in the Bengal Fan have not been effectively revealed which hinders the research on the long-time scale source to sink transition, the South Asia Monsoon formation and plate reconstruction. Based on the recently acquired high-quality multi-channel seismic data, the basement fluctuation, sedimentary structure and tectonic development characteristics of the Bengal Fan downstream are interpreted. Furthermore, we proposed three future scientific drilling locations which aim at the scientific drilling objectives including the complete sedimentary strata, age of oceanic crust basalt, and special structure characteristics. Well calibration and lithology prediction are carried out for these proposed sites respectively. These proposed sites are not only contributed to the reserve of scientific drilling for Chinese Ocean Drilling Vessel, but also significant for solving the frontier scientific issues of the Qinghai Tibet Plateau.

Keyword

Bengal Fan, Ocean Drilling, Source to Sink, Climate Change, Sedimentary Records

Cenozoic forearc and backarc basin-filling stratigraphy as an archive of tectonic controls on depositional styles and cycles along the north-western Pacific margins

Osamu TAKANO[1]*, JAPEX Research Center (osamu.takano@japex.co.jp)

Abstract

Basin-filling stratigraphy can be defined as “the study of basin-filling sediments from the standpoints of unconformity events, succession trends and three-dimensional development patterns of depositional systems with consideration of their controlling factors such as background basin tectonics and plate tectonic conditions.” The basic unit of basin-filling stratigraphy can be a tectono-sequence unit, which can be bounded by regional major unconformities, or the turning points of basin evolution stages and succession trends of depositional systems such as upward shallowing and deepening trajectories. This paper attempts to examine the forearc and backarc basin-filling stratigraphy of the NE and SW Japan arcs to obtain the background tectonics as major controlling factors, which might be reflecting the plate tectonic scenarios along the north-western Pacific convergent margins.

The basin-filling stratigraphy of the NE Japan forearc basins can be divided into the lower Cretaceous to Paleogene succession and the upper Neogene succession. The Cretaceous to Paleogene succession below the “Ounc” unconformity was deposited under the trench slope break-uplifted, overfilled-type forearc setting, which formed thick aggradation of bay to coal-bearing fluvial systems, whereas the Neogene succession above the “Ounc” unconformity was deposited under the deeper-marine sloped to submerged ridge-type forearc setting, which formed a transgressive succession of deeper marine turbidites or shales. This drastic change in the forearc basin type and successions is considered to have reflected by the onset of tectonic erosion of the subducting Pacific Plate.

The basin-filling stratigraphy of the SW Japan forearc basins can be divided by the latest Oligocene to Middle Miocene gap into two parts: the lower Cretaceous to Paleogene Shimanto-type forearc/accretionary complex and the upper Neogene normal forearc succession. The Neogene forearc succession is mainly composed of deeper marine submarine-fan turbidite successions and slope-to-basin-floor mudstones. The Neogene basin-filling succession is frequently interrupted by regional unconformities, which commonly show a systematic diachronicity, possibly reflecting gradual shifts of a tectonic event.

The basin-filling stratigraphy of backarc to intraarc basins along the NE and SW Japan arcs is characterized by the basin evolution stages, since these backarc/intraarc basins were initiated as rift basins, and followed by tectonic inversion into a compressional stress field. The mass balance between the accommodation space created by subsidence and sedimentation may control the succession trends for the syn-rift, post rift and tectonic inversion stages. The syn-rift to early post rift stage usually shows a transgressive upward-deepening succession trend, whereas the tectonic inversion stage causes an upward-shallowing trend due to increasing sediment supply from the

provenance.

Keyword

Basin-filling stratigraphy, Basin tectonics, Forearc basins, Backarc basins, Succession trend

Geochemical Investigation in the Yellow Sea Reveals the Integration of the Modern Yellow River

Xiangtong HUANG[1]*, State Key Laboratory of Marine Geology, Tongji University
(xiangtong@tongji.edu.cn)
Xi Mei[2], Qingdao Institute of Marine Geology
Shouye Yang[3], State Key Laboratory of Marine Geology, Tongji University

Abstract

The South Yellow Sea is an important sink for sediments delivered by the Yellow and Yangtze rivers in East Asia. We conducted a high-resolution geochemical analysis on the bulk sediments retrieved from a marine drill core (CSDP-1) using the method of X-ray fluorescence (XRF). Our results show large geochemical variations along the core. As demonstrated by linear correlations along with the Al-Si link in a compositional principal component analysis (PCA), the variations in elemental ratios among Al, K, Zr, Ba and Si are primarily controlled by the sediment grain-size or sorting effect. A closer examination of these geochemical proxies regarding the present Yangtze and Yellow rivers indicates a gradual shift of sediment provenance from the Yangtze to the Yellow River catchment in the core. With the help of a fuzzy c-means cluster analysis on elemental ratios of Al/Si, Al/Ti, K/Si as well as the chemical index of alteration (CIA), the timing of a major provenance change in the core is narrowed down to 1.5-1.7 Ma. This timing corresponds to a major seismic and sedimentary boundary (T2) in the Yellow Sea Basin and coincides with the onset of fluvial terrace deposition and incision in the middle and upper reaches of the Yellow River. As a result, we argue that the major provenance change derived from geochemical variations in the Yellow Sea sedimentary basin can be linked with the integration of the modern Yellow River. The provenance change is likely caused by a coupling between regional tectonic deformation and the Asian summer monsoon enhancement in the early Pleistocene.

Keyword

Yellow Sea, Yellow River, river integration, geochemistry

Late Quaternary mineral magnetic record of the continental shelf sediments along the south-eastern coast of India: Implications for variations in the weathering and climate

RESHMA K V [1]*, DEPARTMENT OF GEOLOGY CENTRAL UNIVERSITY OF KERALA (reshmakv143@gmail.com)
Ammoose K J[2], CENTRAL UNIVERSITY OF KERALA
Rafaz A K[3], CENTRAL UNIVERSITY OF KERALA
Sandeep K[4], Central University of Kerala
Sijinkumar A V[5], Central University of Kerala
Jithin Jose[6], Department of Marine Geology, Mangalore University, Mangalagangotri
Kurian P J[7], National Centre for Polar and Ocean Research, Headland Sada, Vasco da Gama
Rajveer Sharma[8], Inter University Accelerator Center (IUAC), New Delhi 110 067, India.

Abstract

The input of peninsular Indian rivers to the sediment load of the continental shelf in south-eastern India, the western Bay of Bengal, is relatively less appreciated. The present study infers terrigenous influx, palaeo-weathering, and palaeo-rainfall conditions over the past 23 ka, employing mineral magnetic proxies which is corroborated by particle size, diffuse reflectance spectroscopic, and Fourier Transform Infrared Spectroscopic techniques. The changes in terrigenous influx and chemical weathering are understood by the parameters like magnetic mineral concentration (SIRM, χARM, χlf), grain size (χARM/SIRM, SIRM/χlf, and χARM/χlf), and mineralogy (s-ratio). The magnetic data is substantiated by proxies such as hematite/goethite ratio, particle size (percentages of sand, silt, clay), CaCO3, and kaolinite content. A gradual increase in the winter monsoon is documented during the period from 23000-17000 cal. years B.P. (Last Glacial Maxima), followed by a steady phase (17000-10000cal. years B.P.). However, a brief decline in rainfall is observed around ~13900cal. years B.P. (Bølling-Allerød), with an increase during ~12900-11800 cal. years B.P. (Younger Dryas). The Early Holocene period is characterized by increased detrital influx to the core site, strong pedogenesis, and chemical weathering in the continental areas in response to high rainfall conditions. A significant shift in sediment provenance in the continental shelf region of the core site, coupled with a weakening of monsoon, is observed since 4900 cal. years B.P.

Keyword

Continental shelf, terrigenous influx, mineral magnetism, Monsoon, Provenance

Continental weathering signal propogation in East Asian continental margins

Shouye YANG[1]*, Tongji University (syyang@tongji.edu.cn)

Abstract

East Asia continental margin is unique because it bridges the largest Euroasian continent and largest Pacific and receives huge terrestrial materials from surrounding landmasses. It is featured by two major types of fluvial sediment routing systems: the mega-rivers in Eurasian continent, e.g. the Changjiang (Yangtze) River, and the small mountainous rivers in Taiwan Island and SE China, e.g. the Zhuoshui River and Mulanxi River. Among which, the small mountainous rivers are relatively less investigated although they play a disproportionate role in sediment discharge and greatly influence the terrestrial material cycle in the West Pacific. Here, we present the data of multiple isotopic proxies (Be, Sr, Nd, Li) to trace the silicate weathering and sediment source-to-sink processes in the large river systems and small mountainous catchments (Zhuoshui and Mulanxi Rivers) in the East Asian continental margin, and particularly the weathering mechanisms and environmental signal propagation in the catchments will be discussed. We observed the conservative behaviour of dissolved Sr-Li during the mixing processes of Changjiang Estuary, while the particulate forms display fractionations. The small dynamic mountains rivers in Taiwan exhibit large sedimentary geochemical and provenance heterogeneity despite their fast sediment transfer from land to sea, which limits the silicate weathering intensity. Comparatively, the transport-limited weathering regime is observed in the small river basins in SE China and the river sediment source-to-sink processes are greatly influenced by strong tide in the estuaries. Our study provides more constraints on the earth surface processes in East Asia continental margin.

Keyword

silicate weathering, East Asia, continental margin

A long-term decline of δ26Mg values of clay-sized sediments in the past 430ka: the weakening of East Asian monsoon since the Mid-Brunhes Event?

Zhongya HU[1]*, Tongji Univeristy (zhongyahu@tongji.edu.cn)
Shouye Yang[2], Tongji Univeristy
Simon Hohl[3], Tongji Univeristy

Abstract

studies of weathering profiles demonstrate that the octahedrally bound structural Mg in clay minerals is generally enriched in heavy Mg isotopes and δ26Mg values of saprolite generally increase at higher degrees of weathering. At present, magnesium isotopic compositions in clay-sized sediments deposited in marginal sea environments show the potential to trace the variation of silicate weathering on a continental scale. In this study, to refine the response of silicate weathering to the climatic variability on the orbital scale, we performed systematic analyses on the mineralogical, elemental and Mg isotopic compositions of clay-size silicate fractions from the MD05-2901 drill core in an upwelling region of the open South China Sea (SCS). Pre-leached clay-size silicate fractions have flat UCC-normalized REE distribution patterns, with a relative depletion of mobile elements in the sediments, well matching the order of elemental mobility during chemical weathering (Na > Ca ≈ Sr > Mg > K), indicating products of silicate weathering as primary source. Our obtained δ26Mg values display a long-term decline over the past 430 kyr, ranging from ca. 0.02 ‰ to -0.10 ‰, revealing no correlation with glacial-interglacial cycles or the relative proportion of different clay minerals. Instead, these results are analogous to the temporal decline in boron isotopic compositions from a loess-paleosol sequence in Northeast (NE) China that was previously linked to the weakening of the East Asian Summer Monsoon (EASM) after the Mid-Brunhes Event. We infer that the gradually declined intensity of the EASM potentially led to a reduced degree of silicate weathering on continental Asia, ultimately recorded in decreasing δ26Mg values in clay-size fraction sediments deposited in the SCS in the past 430ka.

Keyword

Mg isotopes, marine sediments, East Asian Summer Monsoon

Re-examination the Sediments Provenance of the Eastern Sunda Slope Since the Last Deglaciation with Geochemical Methods

Junfei CHEN[1]*, State Key Laboratory of Marine Geology, Tongji University (geojfchen@tongji.edu.cn)
Chao Li[2], State Key Laboratory of Marine Geology, Tongji University
Albert Galy[3], Centre de Recherches Pétrographiques et Géochimiques, CNRS, Université de Lorraine
Shouye Yang[4], State Key Laboratory of Marine Geology, Tongji University

Abstract

The Sunda Shelf (SS), located in the low-latitude tropical region, has remained tectonically stable since the late Quaternary. It is the largest and shallowest continental shelf with the least slope, making it highly sensitive to sea level changes. The SS is influenced by the Asian monsoon, which receives a significant amount of terrigenous detritus, making it a natural laboratory for studying low-latitude material cycling, climate change, and carbon cycling. However, studies on the sediment provenance of the SS and the southern South China Sea (SCS) since the late Quaternary are limited, with most focusing on qualitative sedimentology, which hinders research on climate change and global carbon cycling. This study collected three types of samples from the SS: surrounding land river sediments, shelf surface sediments, and slope core sediments. Bulk carbonate-depleted detrital component analyses of Sr, Nd, and elements were conducted. Previously published Sr, Nd, and element data of surface sediment samples from the SCS were also analysed. By integrating and analyzing a large amount of geochemical data, this study re-examined the sediment provenance and controlling factors of sediments on the eastern slope of the SS since the last deglaciation. The results indicate that during high sea level period, sedimentation rates were very low, and slope sediments mainly originated from the SS. This mechanism involved disturbances to local shelf surface sediments by storms, which were then transported along the slope and deposited. Current studies suggest that deposits near the coast (islands) of the SS is predominantly from nearby sources, while sediments in the central and most areas of the SS originates from large rivers in the north (e.g., the Mekong River, Red River, and rivers in Thailand). Therefore, it can be inferred that during high sea level periods, sediments primarily originate from large northern rivers. During low sea level periods, the SS was exposed as vast land, with the development of two paleoriver systems. During this period, sedimentation rates on the slope were ten times higher than that during high sea level period, with large amounts of island sediments transported directly to the slope through paleoriver channels. At the same time, geochemical data also indicate an increased proportion of material from southern islands, such as Sumatra and Borneo. In conclusion, sediment provenance on the eastern slope of the SS has undergone a transition since the last deglaciation, shifting from younger southern island sources during low sea level period to older landmass in the north during high sea level period.

Keyword

Provenance, Sunda shelf, Geochemistry, Last deglaciation

Holocene geomorphological evolution of a sediment-starved coastal embayment in response to sea level change: Insights from the Qing'ao Embayment, southern China

Fengling YU[1]*, Xiamen University, China (fengling.yu@xmu.edu.cn)
Adam D. Switzer[2], Nanyang Technological University
Zhuo Zheng[3], Sun Yat-Sen University
Bishan Chen[4], Lingnan Normal University
Jeremy Pile[5], Nanyang Technological University
Harry Jol[6], University of Wisconsin – Eau Claire
Zhaoquan Huang[7], Xiamen University
Annie Lau[8], The University of Queensland

Abstract

Aiming to gain a better understanding of the response of sediment-starved coastal systems to the climate-driven sea level change, this study examines the Holocene evolution history of Qing'ao Embayment, southern China, as a case study. Results suggest three distinct stages of the evolution history: Stage 1 (8400-6000 cal yr BP) relates to an early Holocene basin-wide shell-rich clayey silt sequence, that is found overlying the bedrock or weathered sediments. This facies records an initial sedimentation phase associated with the early Holocene marine transgression into the embayment. Stage 2 (6000-3000 cal yr BP) relates to the development of fine- and medium-sandy inshore/open-bay facies. This facies records early sediment deposition under relatively strong hydrodynamic environment during early marine regression. Stage 3 (3000 cal yr BP to present) records two substages: Stage 3a relates to the semi-enclosed bay, intertidal and lagoonal salt marsh facies between 3000 and 1300 cal yr BP, and Stage 3b records the final infilling of the embayment into a lagoonal plain. This evolution model suggests that the rates of sea level change and sediment accretion are the two major controlling factors for the Holocene geomorphological evolution of sediment-starving coastal systems.

Comparison of the evolution of Qing'ao embayment with sediment-supply rich large-river estuary/deltas reveals unique features in the response to Holocene sea level change of this sediment-starved embayment: During the early Holocene marine transgression, sediment starts to accumulate in the small embayment around 8400 cal yr BP, hundreds of years later than in large river estuaries. During 8400-6000 cal yr BP, sediment accretion rate remains dramatically lower than sea level rise rate, which results in the quick growth of sediment accommodation space during this stage. Around 6000 cal yr BP, though sea level has remained relatively stable and large-river deltas have been growing for about 1000 years, the sediment-starved embayment was still under shallow marine and/or open bay conditions. At 3000 cal yr BP, shoreline started to prograde in sediment-starved embayment, which is about 3000 years later than large river deltas. Finally, agricultural activity started around 1300 cal yr BP in the embayment, thousands of years later than large river deltas. Limited or minimal fluvial sediment supply to the small embayment has constrained the land expansion during the sea level stabilization since mid-Holocene, and the

limited living space might result in the much later agricultural activity in such coastal system.
Due to the different balances between sea level change and sediment flux, sediment-starved coasts are expected to be under higher risks than large river deltas. However, earlier and more extensive human activities in large river basins have resulted in the reduction of sediment discharge that heighten the risks of large river deltas against future sea level rise. Thus, more attention should be paid to the coastal sediment supply budgets in the context of the background of rising sea level.

Keyword

Sediment-starved coastal embayment, Sedimentary environment, Sea level change, Sediment supply, Holocene

Marine to Continental transition in Chakrata to Rautgara Formation, Inner Lesser Himalaya (ILH), Uttarakhand, India

ALOK DEEP[1]*, DEPARTMENT OF GEOLOGY, UNIVERSITY OF DELHI, DELHI, INDIA (alokdeepgeo@gmail.com)
PARTHA PRATIM CHAKRABORTY[2], DEPARTMENT OF GEOLOGY, UNIVERSITY OF DELHI, DELHI, INDIA
ADITI SHARMA[3], DEPARTMENT OF GEOLOGY, UNIVERSITY OF DELHI, DELHI, INDIA

Abstract

A 80 km long traverse in the north-northeast of the Chakrata town, Uttarakhand, India allowed documentation of marine shelf (sandstone-shale heterolithic Chakrata Formation) to continental fluvial (arenaceous Rautgara Formation) transition in the Paleoproterozoic Inner lesser Himalayan (ILH) succession. Decimeter to meter-thick fine-grained sandstone-fissile grey to black shale (phyllite) alternation represents the shelf succession. Storm intervention on the Chakrata shelf is attested in the presence of hummocks and gutters within the sandstone intervals. Lower surfaces of hummocky beds are downcurved at places in form of gutters, truncating the underlying shale lamination. In cross-section gutters are both symmetrical and asymmetrical in geometry and gutter fills are massive, symmetric or asymmetric in character. In contrast, amalgamated sheet-like beds of poorly-sorted medium to coarse grained sandstone with occasional interbeds of conglomerate represents the continental fluvial succession of Rautgara Formation. In terms of 'architectural element' the sheet sandstones are recognized as 'SS' element, internally constituted of facies units Sm (massive), Sh (plane-laminated), St (trough cross-stratified) and Sr (ripple laminated). Interbedded matrix-supported conglomerate units are identified as Gsm facies unit. A distal braided fluvial model is proposed for the Rautgara Formation in the studied section.

Intense deformation of strata often restricts the observation of relationship between different lithosomes of ILH. The Chakrata- Rautgara contact in present case is also no exception. Despite this hindrance, the contact is identified as sharp and mild erosional. Incoming of a fluvial system right onto the shelf is interpreted as signature of forced regression. High feldspar content in the fluvial sandstone, presence of pebble/cobble sized extra-basinal clasts in the Gsm facies unit bear indication of tectonic perturbance behind the forced regression event. Additionally, presence of meters-thick channelized conglomerate unit within the fluvial succession bear indication of prolonged tectonic seiches in course of Rautgara sedimentation.

Keyword

Paleoproterozoic Inner Lesser Himalaya, Marine to continental transition, Braided fluvial system, Forced regression, Chakrata-Rautgara Formation

SEDIMENTATION AND GROWTH OF PROTEROZOIC CRATONIC BASINS: LESSONS FROM PURANA BASINS, INDIA

SHILPA PATIL PILLAI[1]*, IISER PUNE (shilpatil24@gmail.com)
VIVEK KALE[2], ACWADAM, PUNE

Abstract

The Purana Basins of Peninsular India host significant sedimentological, environmental and tectonostratigraphic data of the Proterozoic geohistory of the Greater Indian cratonic block. They are (i) Vindhyanchal (ii) Chattisgarh, (iii) Khariar - Indravati, (iv) Cuddapah, (v) Bhima, (vi) Kaladgi, and (vii) Pranhita-Godavari basins. These seven basins are the repositories of marginal marine to shallow marine sedimentary successions deposited in peri-, intra-, & inter-cratonic settings. The sediments of these basins rest uncomformably on the continental crust of Archean to Paleoproterozoic ages, but often also display tectonic contacts with them and the adjoining contemporary mobile belts.

In the present study, we examine the sediment accumulation patterns within each of the basin (as a proxy for their subsidence history) to assess the tectonic evolution of the Purana basins within the framework of Proterozoic supercontinental cycles. It has been shown that while detrital siliciclastic sedimentation dominated during phases that were coeval with supercontinental assembly, the intervening phases had a dominance of carbonate and argillaceous sediments.

We have constructed synthetic subsidence curves for each basin using formation-level de-compacted thickness, depositional depths and the available geochronological data. Thermal sag interspersed with tectonic subsidence can be demonstrated to have driven basin dynamics in most of these poly-history basins, with sedimentation patterns akin to intracontinental and modern passive continental margin settings. The synthetic subsidence curves of these basins match well with Phanerozoic analogues. When interpreted in conjunction with other allied aspects such as their structural configuration and coeval tectonic events in the adjoining crustal blocks, it can be shown that they have a close affinity to contemporary global supercontinental cycles.

Keyword

Proterozoic Basins, India, Subsidence Analysis, Polyhistory basins

Glauconite a marker horizon for understanding paleoenvironment and depositional systems in the Mesoproterozoic Vindhyan Basin, Central India

Satya PRAKASH[1]*, Geological Survey of India (satya.prakash@gsi.gov.in)
Vivek Prakash Malviya[2], Department of Applied Geology, Dr. Harisingh Gour Viswavidiyalaya, Sagar-470003 India
Jai Prakash Verma[3], Institute of Environmental and Sustainable Development, Banaras Hindu University, Varanasi-221005, India
Kezhasilie Chiezou[4], Geological Survey of India, North Eastern Region, Shillong- 793006, India

Abstract

Glauconite is one of the indicator minerals of sedimentary facies, widely developed in the Proterozoic and Cambrian era. Due to the limited number of palaeoproxies in the Vindhyan basin, it is very difficult to deduce the deposition environment.The present study of glauconite from Semri Group, lower Vindhyan sequences of Paleoproterzoic age provides tremendous geological significance for the reconstruction of paleogeographic setting in basins.

The Vindhyan basin represents one of the largest Proterozoic intra-continental basins in central India. The Semri Group of rocks are lower Vindhyan strata of Son valley, composed of calcareous, argillaceous sediments with glauconitic layers in the marine environment, and Kaimur Group represent the Upper Vindhyan composed of arenaceous sediments formed in the fluviatile and estuary environments.

The detailed stratigraphic section and facies level studies of Semri strata revel three glauconite facies associations occurring from deeper to shallower levels, viz. i)green shale-silt- glauconite ii) glauconitic-calcareous siltstone and iii)glauconitic sandstone. The three levels of glauconite facies represent the phase of continuous shallowing of the Vindhyan basin. Glauconite facies sequences of Semri Group reflect that green shale-silt- glauconite facies formed at the deeper level, Glauconitic-calcareous siltstone formed at the intermediate level, and finally the dominant glauconitic sandstone association formed at the shallower level. Total glauconite content increases upward from lowstand systems tract (LST) (glauconitic-green shale facies) to transgressive systems tract (TST) (calcareous-silt shale, minor glauconitic facies) and to condensed section (CS) of glauconitic sandstone. The maximum glauconite contents are found in condensed section (CS). The glauconite decrease towards the highstand systems tract (HST) and is absent in the overlying strata represented by Rohtas limestone and shale. The glauconite itself is indicative of a larger sediment starvation period, which is representative of the transgressive-retrogressive phase. However, the overlying limestone and shale-dominated facies represent the submergence of the basin.

Petrographic studies show that glauconitic sandstone (CS) comprises glauconite and quartz grains with a minor amount of K-feldspar, plagioclase, and lithic fragments. Modal analysis classification suggests the glauconitic sandstone (CS) as quartz arenitic of arkosic-subarokic nature. Further thin section studies reveal that the grain of glauconite becomes coarser as we go

higher in the stratigraphic position.
Glauconitic shale contains large amounts of illite with glauconite in LST. The relative abundance of matured form of glauconite particle morphologies are more inclined to contain glauconite pellets (CS), while minor detrital glauconite is regularly observed in the LST and TST, which are authigenic in nature. Glauconitization took place on the substrate of detrital K-feldspars and clay peloids, as evident from the petrographic studies. Glauconite minerals mostly occur in grain and pellet form, and the cementing materials are siliceous and ferruginous. On the basis of geochemical results, glauconitic sandstones are classified into arkose, sub-litharenite, and quartz arenitic. The CIA values indicate that the weathering in the source region was moderate to intense. Glauconitic facies of the Semri Group represent a condensed stratigraphic section formed in the littoral to sub-littoral zone of the continental shelf under transgression and suggests the sequential upliftment of the Vindhyan basin.

Keyword

Glauconitic sandstone, Glaucony, Semri Group, Vindhyan basin

Extensive chemical weathering and its response to Quaternary glacialinterglacial cycles in the South China Sea: Evidence from Li isotope systematics

Fangbing LI[1]*, Tongji University (fangbingli@tongji.edu.cn)
Simon Hohl[2], Tongji University
Marc Weynell[3], Freie Universität Berlin
Shouye Yang[4], Tongji University

Abstract

Climate is the crucial factor controlling continental chemical weathering. While warm and humid conditions at low latitudes and altitudes during interglacial periods promote chemical weathering, cooler and dryer conditions suppress weathering rates during glacial periods. However, moderate temperature and precipitation rates at low latitudes, in combination with exposed shelf sediments during sea level low stands, may also promote increased secondary mineral formation even during glacial periods.

This study reports major and trace element compositions and stable Li isotopic compositions obtained in clay-sized silicate sediments of the drill core MD 05-2901 off the coast of Central Vietnam. The core comprises 14 marine isotope stages reaching back ~450 kyr and presumably records glacial-interglacial cycles in an upwelling regime of the South China Sea. After removing any effects from grain size and sediment provenance compared to previously published clay mineralogy from the same core, Li isotopic compositions of the silicate fraction show interglacial-glacial fluctuation (δ^7Li =-1.06 to 0.52 ‰). lighter values (~-1.06 ‰) in chlorite and illite-dominated sediment beds, deposited during glacial periods, i.e., at heavier δ^{18}O in associated benthic foraminifera, indicate stronger weathering (and secondary mineral formation) than sediments deposited during interglacials. The here-reported enhanced chemical weathering during glacial periods likely resulted from exposed shelf sediments onshore during lower sea level stands. As a result, sea-level change is the second dominant but easily neglected factor for strengthening the chemical weathering and secondary mineral formation and its archiving in shelf sediments during glacial-interglacial periods.

Keyword

glacial-interglacial, South China Sea, chemical weathering, Li isotopes

Coupling of climate and catchment erosion in the Himalaya during the late Quaternary

Mohd AMIR[1]*, National Sun Yat-sen University, Taiwan (mamiransar@gmail.com)
Debajyoti Paul[2], Department of Earth Sciences, Indian Institute of Technology Kanpur, Kanpur 208016, India
Yuan-Pin Chang[3], Department of Oceanography, National Sun Yat-sen University, Kaohsiung 804, Taiwan
Shouye Yang[4], State Key Laboratory of Marine Geology, Tongji University, Shanghai 200092, China

Abstract

The Indo-Gangetic Plain, a foreland basin, was formed by deposition of sediments derived from the Himalaya. The alluvial sediments of the Indo-Gangetic Plain are originated as a result of tectonic and climatic factors governing the exhumation and erosion of the Hinterland Himalaya and delivered to the plain via several large rivers. However, erosion distribution over the Himalaya and sediment delivery to the plain, on a shorter millennial timescale, are reported to be mainly controlled by the climatic factors such as intensity of Indian summer monsoon (ISM) rainfall and glacial cover over the Himalaya. But there exist contradictory records on the catchment erosion in response to climate change along the strike of the Himalaya. Here we present Sr and Nd isotope compositions in bulk sediment samples from two ~48 m long sediment cores collected from a buried channel of the paleo-Yamuna River in the northwest Indo-Gangetic Plain, Haryana to better understand the link between the climate and distribution of erosion over the Himalaya during the late Quaternary. Significant temporal variations in 87Sr/86Sr (0.73424–0.79241) and 143Nd/144Nd (εNd: –14.0 to –19.7) ratios of the sediments are observed, suggesting variable contributions from isotopically distinct Higher Himalaya and Lesser Himalaya end-member sources in the catchment. Down-core variability exhibits an increase in εNd values (and decrease in 87Sr/86Sr) during early and late marine isotope stage (MIS) 3 and early MIS 1 periods. This indicates increased contribution from the Higher Himalaya end-member due to receding glacial cover over the Himalaya, and intense ISM and its migration into the deeper part of the Higher Himalaya during early and late MIS 3 and early MIS 1 periods resulting in more erosion of the Higher Himalaya.

Keyword

Indo-Gangetic Plain, Sediment provenance, Sr-Nd isotope ratios, Himalaya, Climate and erosion

Relative Sea Level Controls and Depositional Dynamics in a Neoproterozoic rimmed shelf of Narji Limestone Formation, Kurnool Group, India: Insights from Facies Analysis and Isotope Signatures

RASIKH BARKAT[1]*, CoEES, Oil India Limited (rasikhbarkat@gmail.com)
PARTHA PRATIM CHAKRABORTY[2], UNIVERSITY OF DELHI

Abstract

The mixed siliciclastic-carbonate system of Neoproterozoic Kurnool Group, India evokes interest for outcrop-based studies to frame a better understanding on the mechanism and control of its deposition. Narji Limestone Formation records a 250 m thick succession within the Kurnool Group. While documenting the underlying clastic Banganapalle Formation it was revealed that a concomitant rise in relative sea level turned the coastline from a clastic to a carbonate system. Carbonate platforms where in general dominated by ramp systems in Neoproterozoic timeframe. A rimmed platform geometry is visualised from documentation of reef, fore slope and shelf lagoon products from the Narji Formation. In contrast to Paleo- and Mesoproterozoic carbonate platforms where biohermal stromatolites dominate carbonate rimmed platforms in form of reefal structures, the Neoproterozoic carbonates are dominated by laminated microbialites, thrombolites and dendrolites.

Ten carbonate facies types were characterized and clubbed together under seven facies associations belonging to four different paleo-environmental settings viz. Forereef (intertidal to shallow subtidal and shallow to deep subtidal), peritidal reef and back-reef lagoon. Whereas crinkly microbial laminites with subordinate domal stromatolites constitute the reef part, the fore slope deposition in the platform largely remained tide-and storm-dominated. Grey to black colored pyrite bearing bedded limestone-shale alternation without any current or wave imprint represents the back-reef lagoon deposition. A high carbonate saturation and productivity in the Narji inner and mid shelf is suggested from an overall dominance of microalgal laminite and microdigitate stromatolites over columnar stromatolites. From documentation of decimeter-to meter-thick shallowing-upward depositional hemicycles, embedded within an overall aggradational Narji lithosuccession, a combined control of sea level and carbonate productivity is inferred in course of Narji sedimentation. It is suggested that a short-duration medium-to large-scale rise in the base level led to the aggradation in shallow water rim of the Narji platform margin; interruption of this overall motif by short thickening- and shallowing-upward progradational hemicycles bear testimony for higher productivity in the Narji mid-to inner shelf areas. The present study intends to correlate shallowing-upward hemicycles with keep-up to catch-up depositional cycles with signature of apparent sea level fall. The control of relative base level variation in Narji depositional history is strengthened with multiple signatures including secular δ13C composition, total organic carbon (TOC) content and siliciclastic content from the entire Narji litho-succession. Further, the secular δ13C signature, TOC value and siliciclastic content through the Narji succession allowed interpretation of open ocean circulation in the Narji carbonate platform and

roles of transgression and regression in framing the isotopic character of the Narji succession. It is proposed that higher saturation and productivity at times of transgression in the shelf resulted in local progradational stacking motif in Narji succession, which otherwise register aggradational stacking motif with near balance between subsidence and productivity.

Keyword

Narji limestone, Kurnool Group, Neoproterozoic, Rimmed platform, Carbon Isotope

Preliminary study on coupling between clinoform type and along-strike variability of shelf-edge stacking pattern

EUNHYUN CHO[1]*, Seoul National University (cho91@snu.ac.kr)
JUSUN WOO[2], Seoul National University

Abstract

In this study, we used 3D seismic data in the southwestern margin of the Ulleung Basin. The Middle Miocene clinoformal deposits were analyzed to assess the relationship between clinoform types and their spatial variation in shelf-edge stacking patterns. A total of 7 clinothems were recognized and classified into three types: 1. Sigmoidal, 2. Sigmoidal-Oblique, and 3. Oblique based on foreset configuration, lapout geometry and relative thickness of topeset and bottomset. The clinothems exhibited a cyclic stacking pattern, transitioning from sigmoidal to sigmoidal-oblique or oblique type. This cyclicity suggests the variations in accommodation conditions, with the sigmoidal type developed during relative sea-level highstand and sigmoidal-oblique and oblique type formed during relative sea-level lowstand. The sigmoidal clinothems were well-extended in all studied sections but were truncated in some parts, especially the south-eastern part of the study area. The sigmoidal-oblique type changes to oblique type along the strike. The oblique clinothems were recognized in south-eastern part of the study area, primarily resting on the truncated sigmoidal clinothem. Antithetic shelf-edge stacking patterns were perceived from sigmoidal and sigmoidal-oblique and oblique clinothem. Sigmoidal clinothems have higher progradation rates of shelf-edge in the north-western part, gradually decreasing towards the southeast. Conversely, sigmoidal-oblique and oblique clinothem show an inverse trend in shelf-edge growth, with higher progradation rates in the south-eastern part gradually decreasing towards the northwest.
This study introduces the antithetic along-strike variability of shelf-edge stacking patterns during relative sea-level highstand and lowstand.

Keyword

clinothem, shelf-edge stacking pattern, seismic stratigraphy

Inefficient burial of terrestrial organic carbon in deltas

Yonggui YU[1]*, First Institute of Oceanography, Ministry of Natural Resources
(yuyonggui@fio.org.cn)

Abstract

The world's deltas are estimated to store ~58±17 Tg of terrestrial organic carbon (OCterr) annually, indicating their significant role in the global carbon cycle. However, these estimates are based on the proto burial efficiency (PBE) of OCterr in surface sediments of subaqueous deltas, which assumes that OCterr burial is spatially and temporally homogenous. Yet, the time-dependent OCterr burial and degradation in subaqueous delta deposit is poorly constrained due to the difficulty in determining the chronology of the deposits. By using a novel bathymetry-based method to date core sediments from the subaqueous Yellow River Delta (hereafter YRD), we show that the OCterr burial efficiencies in age-labeled deltaic sediments are highly heterogenous due to different sediment pathways and time-dependent OCterr degradation. River floods lead to an initial OCterr burial efficiency of up to ~62%±18% and negligible marine-derived OC in the flood deposits at the delta front. Subsequent sediment remobilization and early diagenesis, however, lead to substantial attachment of marine OC and degradation of OCterr, eventually resulting in different OC compositions and lower burial efficiencies ranging from 36%±12% to 57%±10%. Despite the refractory nature of OCterr, the post-burial OCterr degradation rate is estimated to be 0.7% per year, further lowering the initial OCterr burial efficiency to ~36% after 56 years. Our multi-decadal net OCterr burial efficiency is at least 50% lower than previous PBE-derived estimates from the YRD. This pattern likely extends to deltas globally, calling for a re-assessment of river delta influence in the global carbon cycle.

Keyword

Yellow River Delta, sediment dynamics, organic carbon isotopes (13C and 14C), organic carbon burial efficiency

Development of submarine canyon from East Brazilian Passive Continental Margin

Daniela de Andrade MOREIRA[1]*, University of Rio Grande do Norte (daniandrade.m@gmail.com)
Helenice Vital[2], Federal University of Rio Grande do Norte, Postgraduate Program in Geodynamics and Geophysics (PPGG), Brazil

Abstract

The formation and development of submarine canyons can record geological information about the regional sea-level, climate change, ancient deep-sea sedimentary process and tectonic activities. Some studies revealed erosive turbidity currents can drive their development by reworking the canyon's shapes. The purpose of this study is to comprehend the sedimentary processes involved in the genesis of submarine canyons in East Brazilian Passive Continental Margin. The methodological approach includes seabed mapping with multibeam bathymetry – MB and sub-bottom profiles – SBP. The results show that the canyon displays notable prominence and It's indented on the shelf edge. Exhibit high continuity and high sinuosity near the shelf edge, transitioning to an approximately straight basinward. In addition, it begins with a dendritic pattern and shows terraces near it. The thalweg undergoes variations as, initially on the canyon head, the depth is shallower, ranging from ~450-750 m and deep as basinward, reaching up to ~2.000 m in depth. The width ranges from ~1.000 m wide and widens as the depth increases towards the basin, reaching up to ~4.000 m. The length extends up to ~12 km. These are evidence that it has been shaped by erosive flow possibly due the close association with fluvial continental sources and can be regarded as a sediment conduit the shelf to the deep basin. Moreover, turbidity currents can act as the driving force, reshaping and resulting in the current canyon morphology. Also, due this region has no tectonic prominent scope, the development of this canyon could be especially controlled by sedimentary processes. It's essential to categorize features in this region to comprehend their stability since the successful implementation of offshore structures depends on a thorough understanding. This sector is gaining significance amidst the global energy transition. In addition, this scientific outcome contributes to advancing the goals of the United Nations' Ocean Decade initiative.

Keyword

submarine canyon, continental margin, bathymetry, sedimentary process

with experts from various fields of science, which is the basis of research in this field. Training of a new generation of scholars in Africa, can have several socio-economic benefits, including understanding of the causes as well as therapy for many common health issues. Identification of the geological sources of toxic and potentially harmful elements and minerals in the environment, which are transferred to human/animals body through water, air and food, and identification of areas lacking essential elements for a healthy living, are necessary to reduce the health impacts caused by such anomalies and ensure wellbeing. The identification of such geo-anomalies and related health issues is followed by the development of geospatial distribution modelling and techniques for the prediction of their occurrences and removal. Furthermore, the continuous demand of safe and adequate water and energy supply in Africa grows due to population increase on the continent. Consequently, communities especially in rural areas often consider unsafe alternatives (uncontrolled water sources and burning coal for daily consumption) which often contain high concentrations of toxic and/or potentially harmful elements/minerals. The naturally hidden occurrences of such elements and minerals can have serious short and/or long-term health impacts. Therefore, the assessment of the nature and composition of these commodities is necessary to prevent the health damage and to create a safer living environment for the communities.

Keyword

Deep-water sedimentation controlled by interaction between bottom current and gravity flow: A case study of Rovuma Basin, East Africa

Jianan WU[1]*, Petrochina Hangzhou Research Institute of Geology (642837124@qq.com)
Guoping Zuo[2], PetroChina Hangzhou Research Institute of Geology
Guozhang Fan[3], PetroChina Hangzhou Research Institute of Geology

Abstract

As the main depositional process that transports terrigenous material into deep-water areas, turbidity flows are commonly the focus of deep-water sedimentology. However, increasingly, studies are showing that bottom currents also play important roles in deep-water terrigenous deposition.

By using 3D seismic dataset recently acquired in offshore Mozambique, we address the distribution pattern of a Cenozoic channel-levee-lobe complex in deep-water of Rovuma Basin. The results show that the unique levee of this complex asymmetrically developed only on one side of the channel course. We attribute this asymmetric levee development to the interaction between the western slope bottom current from south to north and the gravity flow from west down slope. Due to the winnowing and sorting by the western slope bottom current, the sorted fine grain sediments of the gravity flow were blown and deposited to aside remaining clean sand from the gravity flow deposited within the channel. The lateral deposits steepened northern channel banks and forced the southward migration of channel axes.

On the other hand, reservoir quality variations for 5 main lithofacies have been analyzed combined with core and well-log data. Some medium- to coarse-grained sandstone cores with parallel- to cross-stratification show higher permeability compared to the massive ones, which may imply the existence of bottom current can develop laminated sandstones and improve the reservoir quality.

Keyword

turbidity current, bottom current, channel migration, Rovuma Basin

Li isotopic behaviors of particulate and dissolved load in the Changjiang (Yangtze River) Estuary

Chengfan YANG[1]*, Tongji University (cfyang@tongji.edu.cn)
Shouye Yang[2], Tongji University

Abstract

Chemical weathering plays an important role in regulating biogeochemical cycle and global climate. Based on the high-resolution sedimentary records, numerous studies on paleo-environment reconstruction have been carried out in the continental margin. However, several lines of evidence have confirmed the alteration of elemental composition during materials passing through the estuary. How weathering signal responds to river and sea water mixing is still debated. Thus, the geochemical behaviors of particulate and dissolved load in the estuary need to be further investigated. In this study, suspended particulate matter (SPM) and dissolved load were collected in the Changjiang (Yangtze River) Estuary, and their elemental and Li isotopic compositions were analyzed.

Results show a conservative mixing of dissolved Li and its isotopes between the Changjiang River water and seawater. The dissolved δ7Li yields a non-linear increase with salinity, and a significant increase occurs during the initial water mixing. In order to verify this conservative phenomenon, a sequential leaching method was performed on SPM samples. We find that Fe-Mn oxyhydroxide is the largest reservoir of non-silicate Li, accounting for ~5% of Li in bulk SPM samples. However, possibly due to short interaction time during SPM passing through the estuary, incorporation of Li into non-silicate phases cannot drive a detectable alteration of estuarine dissolved Li concentration. Scavenging processes thus have negligible influence on aqueous Li behavior, at least in the Changjiang-like basins and estuaries, which verifies the assumption of a conservative behavior for using Li isotopes in marine authigenic archives to reconstruct past continental weathering variations and related carbon cycles

Through the studied transect, estuarine flocculation and resuspension processes cause the homogenization of offshore particulate δ7Li that is close to the average composition of upper continental crust. This process is distinct from the general control of hydrodynamic sorting on elemental geochemical compositions during river sediment source-to-sink transport. The indication of detrital δ7Li for tracing past continental weathering in the coastal and marginal seas seems to be more complicated relative to dissolved phase. Caution should then be taken when using δ7Li, and other similar sediment geochemical proxies, measured in bulk sediments from marginal seas to reconstruct past continental weathering.

Keyword

Li isotopes, the Changjiang Estuary, sequential leaching

Stratigraphic architecture of the Morondava Basin (western margin of Madagascar): geo-acoustic quantification from high-resolution multi-trace seismic data

Dhishna BULJORE[1]*, Ifremer (dhishna.buljore@ifremer.fr)

Abstract

The Morondava Basin is situated to the east of the Mozambique Channel and to the west of the Madagascan margin. It was formed during the Jurassic period due to the separation of Madagascar and East Africa along the Davie transform ridge. The basin accumulated sedimentary deposits from the Toarcian to the Pleistocene, originating from Madagascar and Juan de Nova. The sediment organisation have been little documented by academic studies and the objective of this study is to detail the stratigraphic pattern of this sedimentary basin and the geo-acoustic properties of the stacked sequences.

The Shom conducted the SOUSACOUS2021 campaign using high-resolution seismic imaging to describe the sedimentary architecture of the deposits from the Upper Cretaceous to the Pleistocene. The sequential analysis of stratigraphy was achieved by describing seismic facies and discontinuities. The sequences' interval velocities were quantified using RMS velocities (Vel_Analysis, Ifremer).

The stratigraphy successions in the Morondava Basin recorded major changes in the depositional processes and the sediment fluxes. It reveals sharp evolutions through the Cenozoic of the deep ocean circulation in the Mozambique Channel and the close link between geomorphological changes in Madagascar and the sedimentary deposits in the Morondava Basin. The basin is divided into two sub-basins by a North-South central tectonic-sedimentary ridge, which constrains the gravitational (MTD) sediments in the east and the dominant hemipelagic sedimentation in the west. In the Paleogene, this paleo-morphology favoured the establishment of two contourite systems: one in the deep basin (to the west of the central ridge) and the other in the Juan de Nova basin (to the east of the central ridge). This setting suggests a more intense deep-sea circulation and bottom currents flowing from south to north (Southern Component Water - SCW) during the Paleogene. The Neogene deposits document the events linked to the evolution of continental geomorphology of Madagascar and the consequent changes in catchment areas. The sedimentary deposits reveal the significant tectonic and paleogeographic changes driving the continental alteration and sediment production.

The main stratigraphic boundaries are also distinguished by variations in acoustic wave propagation velocities at the transition of the major seismic facies in the Morondava Basin. The decrease in interval velocities towards the western part of the Morondava basin seems to be closely linked to the nature and processes of sedimentary input into the deep basin. Higher

propagation velocities are observed in carbonate-rich MTDs, whereas hemipelagic sediments exhibit lower velocities. The increasing variations in velocity with depth are related to the increasing compaction of the sedimentary column.
This study enhances comprehension of the sedimentary deposits' architecture, provides a quantified characterisation of the seabed's geo-acoustic properties and a more accurate estimate of the thickness of the different stratigraphic sequences deposited in the Morondava basin since the Cretaceous.

Keyword

seismic stratigraphy, Morondava basin, contourite depositional systems, P wave velocities

Lacustrine environment evolution in the Mesozoic North Yellow Sea Basin, Eastern China: insight from the transition of Jurassic grey mudstones to Cretaceous red successions

REN WANG[1]*, China University of Geosciences (rwang@cug.edu.cn)

Abstract

During the Cretaceous period, terrestrial red beds emerged in various global regions. Previous reports have suggested that these red beds may be intricately linked to hot paleoclimates and unique paleogeographic configurations. This study focuses on petrological, mineralogical, and geochemical analyses conducted on samples from grey to red successions dating from the Middle Jurassic to Early Cretaceous within the North Yellow Sea Basin, to investigate the evolution of lacustrine environments and paleoclimates during their deposition. Some mudstone samples have identified positive Eu anomalies, but the hydrothermal signal may not be as strong due to the open lake environment. The findings revealed four episodes of hydrothermal activity occurring during the deposition of Jurassic grey mudstone to the Cretaceous red successions. Hf vs La/Th and ∑REE vs La/Yb graphs indicate that most grey mudstones originate primarily from upper crustal felsic sources, while certain red mudstones contain mantle material. Analytical diagrams such as Th-Co-Zr/10, Th-Sc-Zr/10, and La-Th-Sc suggest the presence of active continental margins and island arcs, showing analogous characteristics in REEs distribution patterns. Noteworthy indicators like Sr/Ba, B/Ga, U/Th, Ni/Co, V/Cr and V/(V+Ni) values denote that the sedimentary environments of both grey and red mudstones were oxidized, deviating from conventional viewpoints. However, this deviation may stem from hydrothermal contamination impacting trace elements such as Ni, Co, and Sr. Assessment using indicators like ICV and CIA reflects a transition from a warm and wet Jurassic climate to a hot Early Cretaceous climate. Variations in lake levels, prompted by climate fluctuations, led to increased oxygenation at the lake bottom, resulting in the deposition of red mudstone. These findings suggest a close correlation between the red mudstones and the hot climate driven by tectonic evolution of Eastern China. The transformation from grey to red mudstones during the Middle Jurassic to Early Cretaceous period signifies a response to paleoclimatic and paleoenvironmental changes.

Keyword

Lacustrine environment, grey mudstones, red successions, paleoclimate

An improved FT-TRA system and its application to element analysis of sediments and foraminifera

Juan XU[1]*, Tongji University (juanxu@tongji.edu.cn)
Shouye Yang[2], Tongji University

Abstract

In recent decays, various sequential leaching procedures targeting the element budgets associated with different fractions of the mixed sediments, were proposed in environmental and sedimentary geochemical studies. Also, elements and isotopes of foraminiferal shells are potentially valuable paleo-proxy for paleoceanography research. The standard hand-on batch method for elemental and isotopic analysis often results in substantial loss of sample, as well as contamination by secondary calcite and clay, thus biasing the data toward a more variable and anomalous result. These potentially significant sources of error can be overcome with a flow-through time-resolved (FT-TRA) sequential leaching method that makes time- and labor-intensive pretreatments unnecessary. Moreover, the detailed elemental composition during the whole leaching process can be documented and retrieved from the time series data when using FT-TRA analysis. In this study, we developed an accessible, multi-faced FT-TRA module which allows a wide variety of applications can be developed, by customizing key system parameters such as sample cell types (volumes varying from 25 µL to 50 mL). It also offers the choice between on-line analysis or fraction collection for off-line. To verify the reliability and accuracy of our FT-TRA system, systematic analysis was carried out, including dissolution of foraminifera and sediment standard samples. Comparing FT-TRA and laser ablation measurements of cleaned foraminifer shells indicate that, while thorough manual cleaning can remove adhering clay minerals, it cannot effectively remove Fe-Mn oxides or Mn-carbonates incrustations. FT-TRA is thus preferable to LA-ICPMS because it does not rely on questionable cleaning procedures.

Keyword

Flow-Through Time-Resolved Analysis (FT-TRA), Element Analysis, Sediment Samples, Foraminifera

An improved understanding of the magnetic proxies of marine sediment in the South China Sea

Meinan SHI[1]*, China University of Geosciences, Beijing 100083, China (beijiying@foxmail.com)

Abstract

The magnetism research of South China Sea (SCS) sediments and surrounding rivers have significantly improved over the past decade, vigorously promoting the understanding of the environmental development of the SCS and reconstruction of the history of the orbital-scale East Asian monsoon evolution. Studies have revealed that magnetic minerals of sediment source in the northwestern part of SCS is dominanted by coarse magnetite, while fine grain magnetite containing variable amounts of hematite is mainly magnetic mineral in southern SCS. The variation in magnetic characterization of sediments in the SCS results from an interplay of provance, transport path and transport efficency which in turn depends on change in sea level and oceanic circultions, evolution of global climate and East Asian monsoon and regional tectonic activity However, the interpretation of paleoclimatic implications of magnetic parameters obtianed from the SCS marine sediments can be complex and ambiguous, which are attributed to the specific enivormental quantificial meaning and the complexd environmental in south China sea. This study provides insights into the long-term variation of magnetic fraction cored from ODP Sites 1143, 1148 and IODP Sites U1501 drilled in the South China Sea, and IODP Site C0011 in the Shikoku Basin, and pay attention to whether the responses of magnetic indicators are consistent in north-south SCS and how they respond to environmental changes. This work suggests that variation of magnetic parameters of SCS marine sediment respond differently to the environmental process on the long-term time scale. The concentration of magnetic particle is related to detrial input associated with East Asian monsoon, while the magnetic mineralogical composition and grain size are mainly related to provenance associated with oceanic circulation on glacial/interglacial timescale.

Keyword

South China Sea, Magnetic mineral, astronomicall forcing

Paleoenvironmental reconstruction of the Colombian Maastrichtian Coals: Insights from facies analysis and coal petrology. Northern Andes

JUAN SEBASTIAN GOMEZ NEITA[1]*, UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL (juan.gomezneita@uptc.edu.co)
Ana Maria Mizusaki[2], UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
Tais Freitas[3], UNIVERSIDADE FEDERAL DO RIO GRANDE DO SUL
Sandra Rocio Manosalva[4], UNIVERSIDAD PEDAGÓGICA Y TECNOLÓGICA DE COLOMBIA

Abstract

Understanding the paleoenvironmental conditions during the final phase of the Cretaceous period in Colombia is essential for unraveling the Eastern Cordillera Basin geological history and its impact on coal formation processes. This study employs sedimentary facies analysis and coal petrology to elucidate the paleoenvironmental settings of Maastrichtian coals from the Guaduas Formation in the Colombian Andes. In this way, our results offer valuable insights into ancient ecosystems and depositional environments in response to sea level fluctuations, sediment input, and kind of vegetation. The primary purpose of this research is to reconstruct the depositional systems that influenced the accumulation of terrestrial-derived organic matter during the Maastrichtian period in the Checua-Lenguazaque Syncline coal-bearing. Maceral and microlithotypes analysis, combined with sedimentological characteristics, provides a detailed understanding of changes in the depositional processes. Furthermore, coal petrology offers crucial information regarding organic matter composition, allowing for a comprehensive assessment of coal formation dynamics.

Results from facies analysis reveal a diverse range of depositional systems such as lagoon, tidal flat, delta plain, and fluvial settings indicative of fluctuating environmental conditions along the Guaduas Formation. Variations in the maceral composition suggest changes in water depth, kind of vegetation, oxidation, and accommodation during time. The coal composition indicates dominance in macerals of the vitrinite group followed by macerals of the inertinite group, which indicates periods of oxidation related mainly to subareal exposure and forest fires. According to the petrographic indices (TPI, GI, VI, and GWI), coals from the Guaduas Formation originated from reed and forest communities on limno-telmatic to telmatic conditions. The terrestrial organic matter was accumulated in mesotrophic to ombrotrophic paleomires. The restriction of the peats from groundwater circulation explains the low ash field of these coals. The occurrence of pyrite (>1.5%) indicates the influence of marine waters, confirming the coastal setting of the Guaduas Formation. Microlithotypes of these coals are represented mainly by vitrite and vitrinertite which suggests deposition in fluvial to deltaic settings.

Conclusions drawn from this study highlight the significance of facies analysis and coal petrology in reconstructing paleoenvironmental conditions during the upper Maastrichtian in the Colombian Andes. The integration of sedimentological and petrological data provides a robust framework for

understanding coal formation processes and environmental dynamics in coastal settings. These findings contribute to our broader understanding of ancient ecosystems and serve as valuable insights for geological and paleoenvironmental studies in the most representative bituminous coal bearing in South America (Checua-Lenguazaque Syncline). In summary, the combined approach of facies analysis and coal petrology offers a holistic understanding of changes in paleoenvironments from tidal flats to fluvial settings in response to a main regressive process in the basin. This research not only enhances our knowledge of past environments but also provides critical information for resource exploration and environmental management in coal-bearing regions.

Keyword

coal, organic petrology, Colombian Andes, Eastern Cordillera Basin, Coastal depositional systems

Influence and model of deep hydrothermal solution on organic matter enrichment in fault basin

zhou FANG[1]*, China University of Petroleum, Beijing (18811328897@163.com)
fujie Jiang[2], China University of Petroleum, Beijing
DI Chen[3], China University of Petroleum, Beijing
ZhenGuo Qi[4], China University of Petroleum, Beijing
Renjie Zhao[5], China University of Petroleum, Beijing

Abstract

In continental oil and gas basins, unconventional resources such as shale oil and tight oil are extensively distributed. The sweet spots in unconventional oil and gas resources are highly coupled with frequent global or regional geological events that occurred during various geological historical periods. Deep hydrothermal activity, as a typical geological event, significantly influences the enrichment of organic matter. This study focuses on the Paleogene Shahejie Formation in the miaoxi Sag of the Bohai Bay Basin. It elucidates the geochemical characteristics of source rocks in the area, reconstructs the water medium conditions and hydrothermal activities of different geological periods, and reveals the mechanism of organic matter enrichment influenced by hydrothermal activity.

The analysis of rock pyrolysis and vitrinite reflectance (Ro) data reveals significant differences in the geochemical characteristics among hydrocarbon source rocks from different interval. The organic matter in the hydrocarbon source rocks of the fourth member of Shahejie Formation(E2s4) is primarily of type II1, with a relatively low organic abundance, averaging at 0.5%.The organic matter in the hydrocarbon source rocks of the first to second members of Shahejie FormationE3s1-2and the third member of the Shahejie FormationE2s3 is predominantly of Type I, with higher organic abundance, averaging 2.61% and 1.96% respectively. Overall, the vitrinite reflectance (Ro) values range between 0.31% and 0.7%, indicating that the rocks are in a low maturity stage.

The analysis of trace elements, biomarkers, and paleontological data indicates that with the intensification of hydrothermal activity, total organic carbon (TOC) ,Corg: P, Ph/Pr and Gammacerane Index (GI) all exhibit a trend of increasing first and then decreasing, with a critical value around $\delta Eu = 4$. When $\delta Eu<4$, the nutrients brought by deep hydrothermal upwelling promotes the algae blooms, leading to a rapid increase in paleo-productivity. Simultaneously, the reducing conditions in the bottom water gradually intensify, resulting in a gradual increase in TOC. However, when $\delta Eu>4$, the continuous enhancement of hydrothermal activity brings a significant amount of salt substances. As a result, the population of organisms in the basin rapidly decreases, and the curve depicting the changes in paleo-productivity gradually levels off. In addition, the intense eruption of hydrothermal fluids disrupted the stable stratification of the water column, leading to increased oxygen dissolution and extensive degradation of OM, resulting in a gradual decrease in TOC.

In summary, during the deposition period of the Es4, the preservation conditions crucial for

organic matter enrichment are primarily influenced by the dominant role of intense hydrothermal activity. During the deposition period from the E2s3 to the E3s1-2, the main controlling factors for the enrichment of organic matter in hydrocarbon source rocks are the preservation conditions characterized by moderate hydrothermal activity, high productivity, and reduced oxygen levels. This study not only contributes to the further refinement of organic matter enrichment theories but also holds valuable insights for the study of dominant hydrocarbon-producing biological species in different aquatic environments.

Keyword

Organic matter enrichment, Deep hydrothermal, Enrichment mode, Rare earth elements, Lacustrine basin

Evolution of a small forarc basin associated with the change in the plate motion: an example of the Pliocene Kakegawa Group central Japan

HARUKI SONE[1]*, Nippon koei L.t.d (tanjou@outlook.jp)
TETSUYA SAKAI[2], Department of Geoscience, Shimane University

Abstract

This study investigates the evolutionary dynamics of the early forearc basin (Kakegawa Basin) by analyzing turbidite characteristics within the lower section of the Plio-Pleistocene Kakegawa Group (approximately 4.0 – 1.0 Ma). Situated near the arc-arc collision zone of the Honshu and Izu-Bonin arcs, and adjacent to the present subduction zone (Suruga Trough) in central Japan, the Kakegawa Basin likely experienced significant tectonic events such as the collision of a northward-migrating island (present-day Izu Peninsula) and a shift in the motion of the Philippine Sea Plate around 3.0 Ma. Our detailed analysis of paleoflow and paleoslope directions within fine-grained turbidites of the lower Kakeagwa Group has allowed for the reconstruction of basin morphology, even along the sections normal to the dominant paleoflow trend.

Within the southeastern distal margin of the basin fill, three distinct units were identified within the lower part of the group (Horinouchi Formation) based on paleoflow and paleoslope directions. These units unconformably overlay Mio-Pliocene forearc basin fill (Sagara Group), which inclines towards the northwest at an angle of approximately 60°. Unit 1 (3.8-2.9 Ma) exhibits dominant paleoflows towards the east (offshore-ward), indicating the presence of an east-dipping trough within the basin. Unit 2 (2.9-2.6 Ma) likely onlaps Unit 1 in the southern region, displaying similar paleoflow and paleoslope patterns. Unit 3 (2.6-2.5 Ma) shows turbidites with characteristics of reflected currents, suggesting paleoflows in both east and west directions, indicative of outer ridge upbuilding preceding its deposition.

Our analysis reveals an east-west trending basin with its outer ridge located to the south, subjected to westward tilting of the basin. The presence of an east-west trending trough before 4 Ma aligns with the northward subducting Philippine Sea Plate. The subsequent uplift of a new outer ridge to the east of the basin may be attributed to the northwestward motion of the Philippine Sea Plate and the migration of the proto-Izu Peninsula, possibly inducing east-west or northwest-southeast compression within the basin.

Keyword

turbidite, forearc basin, outer rim, Philippine Sea Plate

Sedimentary facies and evolution of fluvio-estuarine depositional system during late Pleistocene to Holocene in the Nakdong valley, southeastern Korea

Seok-Hwi HONG[1]*, Korea Institute of Geoscience and Mineral Resources (shhong@kigam.re.kr)
Woo Hun Ryang[2], Jeonbuk National University
Dong-Geun Yoo[3], Korea Institute of Geoscience and Mineral Resources
Jin Cheul Kim[4], Korea Institute of Geoscience and Mineral Resources
Gwang-Soo Lee[5], Korea Institute of Geoscience and Mineral Resources

Abstract

Evolutions of transition zones between fluvial and marine systems were recorded in the Nakdong valley fills in response to relative sea-level changes. We aquired five cores in the Nakdong valley fills consisting of late Pleistocene to Holocene deposits. Sixteen facies are defined and grouped into eight facies association; alluvial plain, fluvial channel and floodplain, oxidized fluvial channel, tidal flat, tidal bar, central basin and bayhead prodelta, bayhead delta front, and bayhead delta plain. The associations are compiled up three depositional units in the Nakdong valley fills. Unit 1 consists of alluvial plain and fluvial channel in the lowermost part of cores. Unit 2 contains tidal flats, tidal bars, and central basin in an estuary system adjacent to Unit 1. The topmost Unit 3 is bayhead delta deposits consisting of bayhead delta plain, bayhead delta front, and bayhead prodelta after the depositions of Unit 2. The sequence stratigraphy of the Nakdong valley fills can be divided into three systems tract; a lowstand systems tract (LST), a transgressive systems tract (TST), and highstand systems tract (HST). Synthesization of sixteen sedimentary facies, eight facies associations, 833 sediment textures, and 118 age data propose six depositional stages of the developing Nakdong fully filled bayhead delta. The depositional model is able to output the reconstruction of relative sea-level (RSL) rise in the Nakdong valley after 12 ka during the early to late Holocene.

Keyword

estuarine system, bayhead delta, late Pleistocene, Holocene, sedimentary facies

A modern tale of the Yellow River sand: insights from provenance analysis on detrital rutile trace elements and U-Pb ages

Yuan Shang[1]*, Geological Survey of Finland (shangy2010@gmail.com)
Xiangtong Huang[2], Tongji University
Katja Bohm[3], University of Helsinki
Matti Kurhila[4], Geological Survey of Finland
Hugh O'Brien[5], Geological Survey of Finland
Anu Kaakinen[6], University of Helsinki
Thomas Stevens[7], Uppsala University
Maarten A. Prins[8], Vrije Universiteit Amsterdam
Christiaan J. Beets[9], Vrije Universiteit Amsterdam
Bin Wang[10], Shaanxi Normal University
Feifei Jia[11], Liaoning Normal University
Weiguo Zhang[12], East China Normal University

Abstract

Sediment source-sink process of the mega rivers has been a key research subject. It is always a challenge to develop robust fingerprints for large river sediment routing systems due to the complexity of geological, geomorphological and hydrodynamic characteristics of the river basins, which result in mixing and overprinting of raw source signals. The Yellow River or Huang He, one of the most sediment-laden rivers on Earth, pumps tremendous amounts of debris from the Asian continent to the marginal seas. In the middle reaches of the Yellow River, where the fluvial system encounters an aeolian system, formed and shaped the famous Chinese Loess Plateau (CLP), making the Yellow River a unique river system among the other global mega rivers. Here we provide a comprehensive sediment source-sink study of the modern Yellow River sand based on provenance analysis of detrital rutile trace element composition and U-Pb ages. We collected modern riverbank samples both from the trunk (from its headwaters in the Tibetan Plateau to the river estuary) and main tributaries of the river basins. Our sampling also included aeolian sediment from the CLP and marine sediment from the East Asian marginal seas of Bohai Sea and Yellow Sea. An extensive dataset of detrital rutile trace elements and U-Pb ages were generated by in-situ LA-ICP-MS analysis of the representative samples. The main objectives of this study are 1) to establish source signatures of different reaches of the river based on the coupled information of the rutile trace elements and U-Pb ages, 2) to investigate the effect of erosion and hydrodynamic sorting on grain size and further impact on the distribution of rutile U-Pb ages and trace elements, 3) to untangle the source-sink relationship of the aeolian sediment and fluvial sediment in the middle reaches of the Yellow River. The outcome of this study would provide insights into understanding the sediment transport process of the large river system, the interaction between aeolian and fluvial system, and sedimentary process in the continental margin.

Keyword

Source-sink, Single-grain analysis, Aeolian system, Land-sea interaction, Geochemical fingerprints

Continental crustal evolution revealed through sedimentary rocks: a case study from India

ESHA RAY[1]*, PhD (eshaiitk@gmail.com)
DEBAJYOTI PAUL[2], PhD
RAJNEESH BHUTANI[3], PhD
RAMANANDA CHAKRABARTI[4], PhD
SHOUYE YANG[5], PhD

Abstract

Sedimentary rocks (primarily shale and sandstone) consist of ~10% of the overall mass of the continental crust. Therefore, the chemical composition of the fine-grained terrigenous clastic sedimentary rocks represent the exposed part of the upper continental crust (UCC). Therefore, the Nd isotopic compositions of sediments can be used as a reliable proxy for provenance. Therefore, by selecting and analyzing sedimentary rock, particularly shales, from various basins covering a wide range of geological time, it is possible to use the τDM of shale samples to determine the growth pattern of the continental crust.

This study reports the Sm-Nd isotopic composition of Indian shale samples (n = 54) ranging from Archean to Recent age, collected and compiled from different litho-units of Archean cratons and Proterozoic basins. Using the isotope data, we calculated the Nd model ages of these shales and estimated the growth rate of the Indian continental crust. Present-day average 143Nd/144Nd (0.51170 ± 0.00028; εNd(0) = –18.8 ± 5.4) and 147Sm/144Nd (0.111 ± 0.009) isotopic ratios of Indian shales (this study) are comparable to those of average global clastic sediments (primarily shales), North American shales, and sediments from the Ganga River. but exhibit slight differences compared to those of the Upper Continental Crust (UCC), loess, and average river/aeolian particulates in terms of Nd isotopic composition (with εNd(0) approximately –10), despite having similar Sm/Nd ratios ranging from 0.17 to 0.19. The remarkable similarity of Sm/Nd ratios and 143Nd/144Nd in present-day UCC-derived erosional products like the Ganga River sediments, implies that the isotopic compositions of average Indian shale might be representative of Indian UCC. Finally, we used a two-stage box model approach (dividing the crust into juvenile and older shield areas) to model the growth of the Indian continental crust from Hadean to Recent using a dimensionless erosional parameter K which accounts for the effect of preferential erosion. In our model, we assumed K = 1 for the Archean (no erosion) and K = 6 for the post-Archean to Recent. The model result suggests that the ~80% of the continental crust was formed by the end of Archean (with mean age of the continent of 2.42 Ga). This study represents a first-ever estimate of the growth rate of the entire Indian shield and indicates a rapid growth of the Indian continental crust in the Archean period, followed by a long-term slow-progressive growth in the post-Archean which can be modulated by the supercontinent cycles and mantle plume activities. Unfortunately, this model fails to predict the amount of crustal recycling through time. Therefore, for future research, new approach should be adopted which can forecast the volume of

continental crust being destroyed and recycled back both at present and back in time into the mantle to represent variations in the mantle chemistry.

Keyword

Sedimentary rock, Isotope geochemistry, Crustal growth, Indian shield, Archean to Recent

Isotopic fingerprinting of benthic dissolved iron cycling and iron sources in the Changjiang Estuary

Zhiwei HE[1]*, Tongji University (hezw@tongji.edu.cn)
Min Zheng[2], Tongji University
Shouye Yang[3], Tongji University

Abstract

The Changjiang Estuary, an active zone of land-sea interaction influenced by a large river, is a key representative in the study of global source-to-sink systems. Iron (Fe), the most abundant redox-sensitive metal in the Earth's crust and an essential micronutrient for marine primary production, plays a critical role in the early diagenetic cycle. This cycle significantly influences the migration and transformation of biogenic elements in estuaries, the burial and remineralization of organic carbon, as well as the geochemical behavior of various trace elements.

This study reports on the depth and spatial distribution characteristics of sediment and porewater Fe isotope compositions and related geochemical parameters at six stations in the Changjiang Estuary. The results show that the total organic carbon (TOC) content in the sediments is generally low (~0.1 to 0.7 wt%), with variations with depth reflecting different degrees of organic matter degradation during the early diagenetic process. The Fe/Al ratios in sediments from different stations are similar and close to the average value of the continental crust. The speciation of iron in the sediments indicates that the muddy area of the Changjiang Estuary is conducive to dissimilatory Fe reduction. The whole-rock Fe isotope composition (δ^{56}Fe = -0.1‰ to 0.1‰) in the sediments is also close to the average value of the continental crust, suggesting that despite the migration and transformation of Fe during the early diagenetic process, the variation in the solid-phase Fe isotope characteristics of the sediments is not significant. This is mainly because the sediments in the Changjiang Estuary receive a large amount of terrigenous detrital material carried by the Changjiang River, which weakens the impact of the early diagenetic process on the sediment Fe isotope composition.

Conversely, some sediment porewaters show significant variations in dissolved Fe concentrations (~1-200 μmol L-1) and isotopic compositions (δ^{56}Fe = -2‰ to 1‰). The profile variations of porewater Fe content and δ^{56}Fe indicate that Fe isotopes can sensitively trace different diagenetic cycling paths of Fe, such as dissimilatory Fe reduction and bacterial sulfate reduction, and precipitation of iron sulfides and oxides, during the early diagenetic process, and can be quantitatively reproduced through a reaction-transport model. Further studies show that the Fe flux and δ^{56}Fe characteristics at the sediment-water interface, obtained by the ^{224}Ra/^{228}Th disequilibrium method, are mainly controlled by the dissolved oxygen concentration in the bottom water. Nonetheless, the Fe released from the sediments of the Changjiang Estuary into the water body is primarily characterized by light Fe isotopes (δ^{56}Fe < 0‰), indicating the influence of dissimilatory Fe reduction. This work is of great significance for identifying the isotopic characteristics of dissolved Fe in different sedimentary environments of estuaries and their

contributions to seawater dissolved Fe, as well as for deepening our understanding of the source-to-sink patterns of Fe in the global ocean.

Keyword

Changjiang Estuary, Fe isotopes, porewater, early diagenesis, continental margin sediment

Slope canyon evolution and its implications for gas hydrate accumulation in the northwestern Qiongdongnan Basin, South China Sea

Zigui Chen[1]*, China University of Geosciences (chenzigui@cug.edu.cn)
Tao Jiang[2], China University of Geosciences
Wenzhao Sun[3], Zhanjiang Branch of China National Offshore Oil Corporation Limited
Yue Chen[4], Zhanjiang Branch of China National Offshore Oil Corporation Limited
Cong Cheng[5], Institute for Advanced Marine Research, China University of Geosciences

Abstract

Submarine canyons are important channels for sediment transport on the continental slope and are also key locations for the accumulation of gas hydrates and shallow gas. Understanding the evolution of submarine canyons and the fluids containing gas is crucial. In this study, we integrated high-resolution bathymetry, seismic data, as well as log and lithologic data to examine the shape and filling of submarine canyons in the Qiongdongnan Basin. We also illustrated the distribution of gas chimneys and bottom simulating reflectors in this area. Moreover, the stacking patterns, formation and evolution of these submarine canyons, gas hydrate accumulation, and their interaction between the canyon development and gas hydrate accumulation are discussed. The results show that there are five NW-SE oriented slope-confined submarine canyons in the study area, ranging in water depth from 300 m to 1700 m. The filling deposits of these canyons can be categorized into five types: turbidity-dominated muddy deposits (Seismic facies A), mass transport deposits (Seismic facies B), slumps (Seismic facies C), slides (Seismic facies D), and bottom current-dominated muddy deposits (Seismic facies E). Significant gas chimneys and bottom simulating reflectors are mainly located in the ridge strata of the canyons. These submarine canyons have been developing since approximately 5.5 Ma and NE migrated. Their development can be divided into three stages: primary turbidite channels, linear canyons, and dendritic canyons. Gravity flow activity and continuous bottom currents play important roles in the evolution of the canyons. Gas hydrate accumulation is associated with both thermogenic and biogenic gases, with deep faults and gas chimneys serving as the main migration pathways. The evolution of the canyons is closely linked to the accumulation and decomposition of hydrates. Multiple stages of mass transport deposits control the formation and accumulation of gas hydrates within the submarine canyon ridges. Additionally, hydrates located in the upper layer are prone to decomposition, which promotes the dendritic development of the upper segments of these canyons.

Keyword

Slope-confined submarine canyons, MTDs, Gas hydrate, Bottom current, Gravity flow

Coupling of Source-sink System of Paleogene Enping Formation in Baiyun Sag

Zetong YU[1]*, School of Geosciences, China University of Petroleum (East China), Qingdao, 266582, ShandongPR China (yzt3210@163.com)
Taixun Liu[2], School of Geosciences, China University of Petroleum (East China), Qingdao, 266582, ShandongPR China
Guangrong Peng[3], CNOOC (China) Co., Ltd. Shenzhen Branch
Xiangtao Zhang[4], CNOOC (China) Co., Ltd. Shenzhen Branch
Hui Sun[5], CNOOC (China) Co., Ltd. Shenzhen Branch

Abstract

In recent years, the Baiyun Seg has revealed significant exploration potential in exploration and development. However, due to the limitations of sparse drilling exposure and low seismic resolution in the deep Enping Formation, there is a lack of understanding of the sequence stratigraphic division and source-to-sink system characteristics of the Enping Formation, severely constraining further oil and gas exploration and development deployment in the Baiyun Seg. By applying 3D seismic, drilling data, and zircon dating, and in conjunction with regional tectonic evolution characteristics, this study analyzes the Baiyun Seg's Enping Formation material source system and sediment dispersal system from the perspective of source-to-sink system research, guided by sequence stratigraphy and seismic sedimentology theories. It clarifies the formation and sourcing action of the material source, ancient geomorphology and valley transport systems, sedimentary outcomes and distributions, and the coupling relationship between source-to-sink systems.

The main achievements of this thesis are as follows:1)The Enping Formation can be divided into three third-order sequences from top to bottom: EPSQ4+3 (Enping Sections 1 and 2), EPSQ2 (Enping Section 3), and EPSQ1 (Enping Section 4)2)The tectonic environment of the material source area during the Enping Formation's depositional period was a passive continental margin arc. The material source areas were the peripheral Panyu Low Uplift, Yunli Low Uplift, and Baiyun East Low Bulge, showing characteristics of proximal deposition. The overall lithology of the material source areas was mainly mature continental quartz, with the material source areas overall experiencing moderate weathering intensity3)The Baiyun Seg's Enping Formation depositional period mainly developed braided river deltas. Based on the depositional characteristics of the braided river delta, it can be divided into three sub-facies: braided river delta plain, braided river delta front, and pro-delta of the braided river4)Through the coupling of ancient geomorphology and the Enping Formation's source-to-sink system, four proximal material source systems developed in the Enping Formation: Panyu, Yunli Low Uplift, Yun East Low Bulge, and Yunkai Low Bulge. During the deposition of the Enping Section 4, the Baiyun Seg was in the late stage of rifting (i.e., Rifting II stage). A proximal-gentle slope-shallow water source-to-sink system developed on the southern slope of the eastern part of the Panyu Low Uplift, using ancient valleys as transport channels, forming a medium-sized braided river delta in the sedimentary convergence area. A small-scale proximal-gentle slope-shallow water source-to-sink system

developed in the Liuhua area in the northern part of the Baiyun East Low Bulge, depositing a small-scale braided river delta5)This paper establishes three stages of source-to-sink coupling models for the Paleogene Enping Formation in the Baiyun Seg: distal-gentle slope-shallow water, proximal-gentle slope-shallow water, and proximal-steep slope-deep water source-to-sink system types. It provides a reservoir prediction basis for subsequent deepwater deep natural gas exploration.

Keyword

Baiyun Sag, Enping Formation, Paleogene, Source-sink System

Microfacies and depositional environment of the Lower Jurassic Tagling Formation in the Spiti Valley of the Indian Himalayas

Ketan Avinash CHASKAR[1]*, KSKV Kachchh University (ketan.chaskar@gmail.com)
Dhirendra Kumar Pandey[2], Department of Earth and Environmental Science, KSKV Kachchh University, Bhuj – 370001, India
Franz Fürsich[3], Universität Erlangen-Nürnberg, GeoZentrum Nordbayern, FG Paläoumwelt, Löwenichstraße 28, 91054 Erlangen, Germany
Matthias Alberti[4], Geologisches und Mineralogisches Museum, Institut für Geowissenschaften, Christian-Albrechts-Universität zu Kiel, Ludewig-Meyn-Straße 12, 24118 Kiel, Germany
Jörg Habermann[5], Universität Erlangen-Nürnberg, GeoZentrum Nordbayern, FG Paläoumwelt, Löwenichstraße 28, 91054 Erlangen, Germany
Suraj Bhosale[6], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai – 400076, Maharashtra, India

Abstract

The Tagling Formation is widely spread along the Tethyan Himalaya, from Hazara basin of Pakistan in the North-west to Nepal in South-east, and is Rhaetian to Lower Jurassic in age. A study of its section from the Spiti Valley reveals that it is dominated by limestones and dolostones with its top being characterized by at least one hardground surface with bivalve borings and encrusting oysters pointing to a pronounced gap in sedimentation. Quantitative analysis was carried out on the thin sections for microfacies identification, which resulted in establishing the facies change in the limestone including mudstone facies, wackestone facies, grainstone facies and packstone facies indicating changes in the depositional environment from storm-dominating offshore environment to calm and low energy environment setting and many in between. Thin-section studies also advocate for burrow-selective dolomitization at multiple levels in the TST. In the HST, in contrast, dolomitization is only sporadic and represents a mix of matrix and burrow types. Thin-bedded units rich in fossils characterize the transgressive systems tract (TST) with the top of the bed being highly bioturbated with Balanoglossites suggesting firm-ground conditions. The occurrence of Ferruginous Oolite Formation and the subsequent Spiti shale Formation after the Tagling Formation is no coincidence as carbonate platforms throughout the world has seen similar facies change about the early Toarcian Oceanic Anoxic event (TOAE).

Keyword

Carbonate, Lower Jurassic, Microfacies, Tethyan, Toarcian

Fine-grained turbidites in the southern Okinawa Trough and its implication for earthquakes activity over the past 700 years

Yang YAMIN[1]*, China Geological Survey Natural Resources Comprehensive Survey Command Center (yangyamin@mail.cgs.gov.cn)

Abstract

Understanding recurrence intervals of earthquakes is an essential prerequisite for improving seismic hazard assessment (Moernaut et al., 2018; Satake and Atwater, 2007). Due to the short time span of earthquake time, it is difficult to record the time and constrain the average recurrence rates. However, turbidite deposits may potentially provide valuable complementary records and reliable constrain on the recurrence intervals and frequency of large earthquakes. And this method has been widely applied along the tectonic activity plate margin such as the Chile(Bernhardt et al., 2015), Japan (Nakajima and Kanai, 2000), New Zealand (Pouderoux et al., 2012), the Cascadia margin of North America (Goldfinger et al., 2003), Alaska (Williams et al., 2019). The southern Okinawa Trough (SOT) near Taiwan is one of the most seismically active areas in the world and features well-developed turbidite deposits. To better evaluate the coupling between the turbidite deposits and the paleo-seismological activity in this area, we investigate a high temporal resolution sediment core HOBAB4-S2, retrieved from the SOT off eastern Taiwan. Based on core photographs, core descriptions, grain size analysis, elemental ratios, and coarse-grained composition analysis, a total of 15 turbidite events (T1-T15) between 1445 AD and 2003 AD were identified in this core (Fig.1), including 3 types of turbidite facies (TI-TIII): thin clay-medium silt turbidites (TI), thick coarse silt turbidites (TII) and fine sand turbidites (TIII). Most of these turbidite events can be correlated with contemporary turbidite events recorded in previously reported sediment cores and/or can be directly related to instrumental and historical earthquake records, indicating that earthquakes are likely the dominant triggering mechanisms for these turbidite events. However, our new sediment core shows an increase in the thickness and occurrence frequency of turbidites during the Little Ice Age (LIA) compared to post-1950 AD. We suggest that the formation of turbidity currents was favored by an enhanced sediment supply due to frequent typhoon-induced heavy rainfalls during the LIA, leading to elevated sensitivity of the source region to earthquakes. This study supports the conclusion that turbidite records from seismically active areas can be used to reconstruct the history of local paleo-earthquakes with the caveat that such studies should be placed in a well-considered climatic context.

Keyword

Turbidites, grain size, paleoseismic, southern Okinawa Trough

Identification and Sedimentary Model of Shallow-water Deltas: A Case Study of the Funing Formation, Subei Basin, Eastern China.

Ziyi Yang[1]*, China University of Petroleum(Beijing) (847297220@qq.com)
Lianbo Zeng[2], China University of Petroleum (Beijing)
Guiyu Dong[3], North China University of Science and Technology

Abstract

The Shallow water deltas are not only a hot spot for sedimentological research, but also a key target for oil and gas exploration. In this paper, Taking the third member (E1f3) of the Funing Formation in the Upper Jurassic as the example, based on the observation of core samples, well logging, cathode luminescence characteristics, and analytical assay, the development conditions, sedimentary characteristics, and sedimentary models of shallow water delta were summarized. These shallow water deltas were deposited in the condition with a gentle terrain platform, the subtropical climate with ample rainfall, abundant supply of source, strong hydrodynamic force, shallow water-body and frequently eustatic lake level. The shallow-water delta is characterized by sediment deposition from traction currents, numerous underwater distributary channel scour structures, overlap scouring structures, sand body distribution with planar features, underwater distributary channels as skeletal sand bodies, and undeveloped mouth bar. Based on these, it is believed that during the deposition period of E1f3, the Gaoyou sag in the Subei Basin has favorable geological conditions for the development of shallow-water delta deposition. The shallow-water delta deposition during the sedimentary periods of the five major sand units in the Funing Formation is all characterized by the front sub-facies, with underwater distributary channels as the framework for sand bodies and multiple intermittent positive rhythm overlapping vertically with the Jianhu Uplift as the source of material supply. Finally, the depositional model for shallow-water delta deposition, during the E1f3 deposition period in the Gaoyou sag has been established, expanding the scope of oil reservoir exploration in the north slope region of the Gaoyou sag and providing important geological evidence for the selection of favorable subtle zones.

Keyword

shallow-water delta, sedimentary characteristics, sedimentary model, Gaoyou sag, E1f3

Stratigraphy and depositional history of the late Quaternary deposits in the inner shelf of the Korea Strait, SE Korea

Dong-Geun YOO[1]*, Korea Institute of Geoscience and Mineral Resources (dgyoo@kigam.re.kr)
Seok-Hwi HONG[2], Korea Institute of Geoscience and Mineral Resources
Gwang-Soo LEE[3], Korea Institute of Geoscience and Mineral Resources
Gil-Young KIM[4], Korea Institute of Geoscience and Mineral Resources
Seong-Pil KIM[5], Korea Institute of Geoscience and Mineral Resources

Abstract

The inner shelf sequence in this area consists of four sedimentary units, which comprise a set of lowstand, transgressive, and highstand systems tracts formed since the last glacial maximum: incised-channel fill (SU1), estuary (SU2), sand veneer (SU3), and subaqueous delta (SU4). The lowermost unit (SU1), which overlies the sequence boundary, is interpreted as fluvial deposits formed during the last glacial period and belongs to the lowstand systems tract. The lower middle unit (SU2) lying below the ravinement surface represents a paralic component that consists of estuarine sandy mud or muddy sand developed between approximately 13 and 8 cal kyr BP, whereas the upper middle unit (SU3) above the ravinement surface corresponds to a marine component that consists of sand veneer produced by the inner shelf erosion during the ensuing sea-level rise (ca. 8 - 6 cal kyr BP). These two units (SU2 and SU3) belong to the transgressive deposits. The uppermost unit (SU4) regarded as the highstand systems tract formed the Nakdong subaqueous delta including the proximal and distal systems developed after the highstand sea level at approximately 6 cal kyr BP. The lateral transition from the proximal to distal facies suggests a prograding delta system in the Nakdong River, Korea.

Keyword

Late Quaternary, Sequence stratigraphy, Holocene sea-level change, Korea Strait

Sandstone Petrography and Whole Rock Geochemistry of the Ashio Terrane, a Jurassic Accretionary Complex in Japan: Implications for Provenance and Tectonic Setting

Kyeongtae KIM[1]*, Pukyong National University (rlarudxo0526@naver.com)
Yong Il Lee[2], Seoul National University
Young Ji Joo[3], Pukyong National University

Abstract

As a result of paleo-Pacific plate subduction, which has continued since the late Paleozoic on the East Asia continental margin, a number of accretionary complexes containing Paleozoic and Mesozoic sediments were formed, which and now make up a large part of the Japanese islands. Since these accretionary complexes would have received sediments from the adjacent continent at the time of deposition, the tectonic history and paleogeographic configuration of the East Asian continental margin can be reconstructed by interpreting their provenance. The Ashio terrane, distributed in central Japan, consists of the Upper Paleozoic-Jurassic sedimentary complex and is considered equivalent to the Mino-Tamba terrane in Southwest Japan. This study explores the sandstone petrography and whole-rock geochemistry of sandstone and shale of the Ashio terrane to interpret their provenance and tectonic setting. The Ashio terrane is subdivided into the Kurohone-Kiryu, Omama, and Kuzu complexes, and sandstone and shale samples for this study were collected from the coherent units and a mélange unit of the Kuzu complex. The studied Ashio terrane sandstones are sub-angular to sub-rounded and poorly sorted. The major framework grains are quartz, plagioclase, K-feldspar, and lithic fragments (metamorphic, plutonic, and sedimentary, including radiolarian chert), with minor mica and heavy minerals. The sandstones of the coherent units are classified as lithic arkose, while the mélange sandstones are classified as feldspathic litharenite. In the Qt-F-L diagram of provenance tectonic setting, they are all interpreted to be derived from the recycled orogen provenance. Based on the presence of radiolarian chert grains in the sandstone samples, we hypothesize that at least part of the pre-Jurassic accretionary complexes were probably uplifted and exposed in the hinterland during deposition of the Ashio terrane sediment. Compared to the Post-Archean Australian Shale (PAAS), the Ashio terrane sandstones are enriched in SiO2 and Na2O, while the mélange samples are significantly enriched in MnO, unlike the samples from the coherent units. The shale samples are slightly depleted in major elements compared to the PAAS, except for SiO2, Na2O and K2O. In A-CN-K compositional space, the Ashio terrane sediments from the coherent and mélange units display two slightly different weathering trends, the former from granodioritic composition and the latter from tonalite. They both deviate from the ideal weathering trend from the inferred source, indicating possible effects of diagenetic K-enrichment (i.e. K-metasomatism). The scatter of the samples along the weathering trend suggests that they are products of non-steady-state weathering conditions in the source area. In the tectonic discrimination plots proposed by previous studies, the Ashio terrane sediments fall within the felsic igneous and quartzose sedimentary

provenance fields; only the mélange unit samples are plotted in the quartzose sedimentary provenance field. We will parse the processes that could account for the observed differences in the sediments of the coherent units and mélange unit, such as possible difference in their provenance and/or post-depositional alteration processes, as well as the tectonic history of the East Asia continental margin.

Keyword

East Asia, Ashio terrane, Sandstone petrography, Whole rock geochemistry, Provenance

Sandstone Petrography and Geochemistry of the Icheonri Formation in Gijang-gun, Busan: Implications for Provenance and Tectonic setting

Heeseon YANG[1]*, Pukyong National University (gmltjs2133@naver.com)
Kyeongtae Kim[2], Pukyong National University
Hyun Joo Kim[3], Pukyong National University
Yong-Un Chae[4], Pukyong National University
Hyoun Soo Lim[5], Pusan National University
Young Ji Joo[6], Pukyong National University

Abstract

During the Cretaceous period, several non-marine sedimentary basins were formed on the Korean Peninsula around volcanic arcs developed as a result of the subduction of the Paleo-Pacific (Izanagi) Plate beneath the East Asian continent. The Gyeongsang Basin, the largest non-marine Cretaceous basin, is situated in the southeastern part of the Korean Peninsula. Although numerous studies of the sediments (Gyeongsang Supergroup) of the Gyeongsang Basin have revealed the tectonic history of East Asia, most of them have been conducted in the western part of the basin, while the strata in the eastern part have been less extensively studied. The Cretaceous Icheonri Formation is distributed in Gijang-gun, Busan, the eastern margin of the Gyeongsang Basin. This study investigates the provenance and tectonic setting of the Icheonri Formation based on sandstone petrography, detrital mineral chemistry, and whole-rock geochemistry. We also aim to compare them with sandstones from the Sindong and Hayang Groups of the Gyeongsang Supergroup for possible stratigraphic correlation. The analyzed sandstone samples of the Icheonri Formation are very fine- to coarse-grained, subangular to angular, and moderately to poorly sorted. The major framework grains are quartz, plagioclase, and rock fragments. Other minor grains include chromian spinel, epidote, wollastonite, and heavy minerals such as ilmenite. Based on the point-counting results, the sandstones are classified as feldspathic litharenite to litharenite. They are interpreted to have been derived from the transitional arc to undissected arc provenance in the Qt-F-L compositional space of provenance tectonic discrimination. These petrographic characteristics are similar to the sandstones of the Hayang Group, which are dominated by lithic or feldspathic sandstones. The composition of the detrital plagioclase is predominantly albite, suggesting their felsic igneous and/or felsic metamorphic origin, although the effect of albitization is possible. In addition the presence of detrital chromian spinels suggests the existence of ultramafic bodies exposed in the provenance. The chromian spinels were also reported from the Sindong Group sandstones, and they were interpreted to have been supplied from fore-arc mantle peridotite bodies exposed to the west of the Gyeongsang Basin during the Cretaceous. Since their chemistry is similar to that of chromian spinels from the Icheonri Formation, it is possible that the chromian spinels of two strata were supplied from the same source area. This suggests that part of the drainage system that supplied sediments to the western Gyeongsang Basin likely extended to the eastern part of the basin during deposition of the Icheonri Formation. In the tectonic discrimination plots, the bulk geochemical composition of the Icheonri sandstone indicates

deposition in an active continental margin setting, which is consistent with the result of petrographic analysis. Elements reflecting the presence of mafic rocks in the provenance (Sc, V, Cr, and Ni) show a range similar to UCC, while Cr and Ni concentrations are slightly enriched compared to those of active margin sediments. The result of this study is expected to advance our understanding of the tectonic developments in the Gyeongsang Basin and the eastern Asian continental margin during the Cretaceous period.

Keyword

Icheonri Formation, Volcanic arc, Modal composition, Chromian spinel, Sandstone geochemistry

Detrital zircon U-Pb ages of the Cretaceous Icheonri Formation in the southeastern Gyeongsang Basin, East Asian continental margin: implications for the depositional age and provenance

Ga-Yeon KIM[1]*, Pusan National University, Geological Sciences, Busan, Korea (gayeon081@naver.com)
Yong-Un Chae[2], Pukyong National University, Earth and Environmental Sciences, Korea
Young Ji Joo[3], Pukyong National University, Earth and Environmental Sciences, Korea
Taejin Choi[4], Korea National University of Education
Hyoun Soo Lim[5], Pusan National University, Geological Sciences, Busan, Korea

Abstract

The Cretaceous Gyeongsang Basin is a basin formed in an active continental margin caused by the subduction of proto-Pacific plates beneath the East Asian continent. The Gyeongsang Supergroup, which fills the Gyeongsang Basin, comprises the lowermost Sindong Group (with few volcanic materials), Hayang Group (containing some volcanic materials), Yucheon Group (dominantly composed of volcanic materials), and the Bulguksa intrusive rocks. Unlike the Sindong and Hayang groups, which consist mainly of detrital sediments, the Yucheon Group shows an intercalated pattern with volcanic materials, posing challenges in correlating or determining its provenance, especially given its isolated nature within the Gyeongsang Basin. The Cretaceous Icheonri Formation, belonging to the Yucheon Group, is located in southeastern part of Korea. So far, no systematic dating has been conducted for this formation. The recent discovery of radiolarian-bearing chert pebbles believed to have been originated from southwestern Japan has raised interest in the provenance of this formation. In this study, LA-MC-ICPMS U-Pb dating was conducted to constrain the depositional age, and to interpret its provenance. The analysis of two samples from the lower part shows a wide age distribution from the Cambrian to the Cretaceous, with a significant proportion in the Cretaceous (44%), Permian (33%), and Proterozoic (11%). The weighted mean 206Pb/238U ages for the youngest age clusters were calculated to be 99.76±0.58 Ma (n=10, MSWD=1.5, 2σ) and 99.86±0.38 Ma (n=25, MSWD=1.5, 2σ), corresponding to the Late Cretaceous Cenomanian stage. In this age spectrum, the notable feature is the significant proportion of mid-Permian zircons, differing from other samples of the Gyeongsang Group. Previous research suggests these mid-Permian zircons may have been transported from Japan. Moreover, radiolarian-bearing chert pebbles were discovered in the upper part of the Icheonri Formation, inland compared to previously reported locations. These findings suggest southwestern Japan as a potential source area. This study provides insights into the paleogeographic relationship between the Korean Peninsula and Japan during the Late Cretaceous, preceding the opening of the East Sea. However, further studies, including paleocurrents analysis of the Icheonri Formation, are necessary for a more precise interpretation of the provenance.

Keyword

U-Pb dating, Icheonri Formation, Late Cretaceous Cenomanian stage, SW Japan, East continental margin paleogeography

Facies Dependency obvious - Carbon Isotopy fails to be a stratigraphic tool within Lower Toarcian (OAE)

Hans-Joachim ROEHL[1]*, act4carbon (jochenroe@googlemail.com)

Abstract

This talk will focus on the nessessity of interdisciplinary investigations in geological work rather than just on geochemical measurements in the laboratory. Since decades geochemists stubbornly follow the theory that datasets resultig from carbon isotopy analysis proves a global atmospheric signal within the Lower Toarcian (LT) and therefore that Carbon Isotopic analysis can be used as a stratigraphic tool. The so-called Toarcian Carbon Isotope Excursion (T-CIE) also derives from this assumption. In addition such announcements led to the presumption that the trigger for black shale deposition in some marine basins during LT occurred due to climatic changes. But according to literature studies, and there exists a really high amount of publications from many LT locations worldwide, I will point out that a strong facies dependency between changes in Carbon Isotopy and changing lithology exists.

The most important argument for an atmospheric signal is based on especially one author's publications about extracted δ13Corg analysis from "wood"-fragments that show very low δ13Corg values. It remains doubtful and is hard to believe that a more than 185 million years burried "wood" is still carrying the original atmospheric signal. Especially when Coal petrology analysis and other important pre-analyses on this terrestrial derived material is missing.

At some LT locations δ13C values oscillate like an electrocardiogram and do not show a clear T-CIE. Such weak verifyability economists won't use for reliable decisions.

If there had existed a strong atmospheric anomaly on a global scale it should be present in all sections very distinct. The oposite is the case. In regionally independent LT-sections, the datasets do not show a correlation to locations where a clear signal is visible. If it represented a global signal it would be expressed at every location in a similar way.

Without any hint from biostratigraphy, that unfortunately is not well present at every location, the theory of δ13C-Isotopy as a stratigraphic tool would have never been raised.

The data from Carbon Isotopy in LT is much more likely deriving from local to regional oceanic circumstances than showing a global atmospheric Carbon Isotopic constallation. Maybe the T-CIE clearly visible from some rare sections represents a hint for the situation within the waterbody e.g. an oxigen depletion existing within the photic zone and / or biomass recycling processes.

However, from my point of view it is much more important for earth history investigations to focus on the sedimentary development. Observations and correlations to changes in sedimentology are most reliable and can be used to evaluate Sequence stratigraphy in combination with the poor given biostratigraphy in most LT locations. This leads to point out a global development during LT and not the "frantic" attempt to find a very unprominent δ13C T-CIE at every LT-location.

It is most likely that during LT a sea-level driven development caused all phenomenons observed.

The question remains what have been the driving forces for sea-level drop at Pliensbachian /

Toarcian transition.

Keyword

Lower Toarcian, facies dependencies, black shale, chemostratigraphy, sequence stratigraphy

Sequence stratigraphy in the middle Ordovician shale successions, mid-east Korea: Stratigraphic variations and preservation potential of organic matter within a sequence stratigraphic framework

Uk Hwan BYUN[1]*, Korea institute of Geoscience and mineral resources (buh@kigam.re.kr)
Kwon Yi Kyun[2], Kongju National University
Lee Hyun Suk[3], Korea institute of Geoscience and mineral resources

Abstract

The Jigunsan Formation, a middle Ordovician shale-dominated transgressive sequence in the Taebaeksan Basin, located on the eastern margin of the North China platform, exhibits a distinct distribution pattern in total organic carbon (TOC) content and geochemical properties. This pattern is closely tied to redox conditions associated with decomposition, bulk sedimentation rate (dilution), and productivity. In an effort to clarify this unique distribution, this study aimed to construct a high-resolution sequence stratigraphic framework for the Jigunsan Formation.

The shale-dominated Jigunsan Formation is characterized by a lower layer of dark gray shale deposited during transgression and an upper layer of greenish-gray siltstone deposited during highstand and falling-stage systems tracts. In this study, we adopted the concept of a back-stepped carbonate platform to distinguish early and late transgressive systems tracts (early and late TST), while changes in stacking patterns from aggradation to progradation helped identify highstand systems tracts and falling-stage systems tracts.

The late TST initiates on a rapidly back-stepping sediment surface, displaying a notable peak in TOC content just above this surface, followed by a gradual upward decrease. This distinct TOC distribution pattern in the late TST extends to the maximum flooding surface (MFS). The perplexing nature of this TOC distribution within the late TST is likely a result of both a gradual reduction in productivity during this phase and a gradual increase in dilution effects near the MFS interval.

The reduced production of organic matter during the late TST results in decreasing TOC content toward the MFS, particularly because productivity was primarily governed by benthic biota, as planktonic organisms were not widespread in the Ordovician. The findings of this study will contribute to an improved understanding of source rock distribution in mixed carbonate–siliciclastic successions within a stratigraphic framework, especially relevant for unconventional shale reservoirs.

Keyword

TOC, Shale, TST, MFS, Sequence stratigraphy

Shale lithofacies classification criteria: discussion and application

Xinyu JIANG[1]*, China University of Petroleum (East China) (15764250476@163.com)
Nengwu Zhou[2], Sanya Offshore Oil & Gas Research Institute, Northeast Petroleum University
Shuangfang Lu[3], Sanya Offshore Oil & Gas Research Institute, Northeast Petroleum University

Abstract

The term lithofacies refers to the rock or rock assemblage formed in a certain sedimentary environment. Lithofacies classification is the foundation for shale oil and gas evaluation, and numerous papers have reported various shale lithofacies classification methods. Notably, existing methods ignore the significance of organic matter as rock composition, resulting in inaccurate classification results in shale with high organic matter content. Organic matter not only be served as a hydrocarbon generation indicator, but also constitutes shale along with inorganic minerals. Lithofacies classified only by inorganic minerals could not accurately reflect components characteristics of organic-rich shale, which has been discussed by Camp et al.,2016 and Milliken,2014. In this paper, the quaternary diagram lithofacies classification method is proposed, and the volume proportions of the organic matter, siliceous minerals, calcareous minerals, and clay minerals in shale are calculated and served as the four end members. According to the classification boundaries of 25% and 50% volume proportions, all shale lithofacies are theoretically classified into 5 categories and 56 types. This method is applied and compared with the classical ternary diagram in seven sets of typical shale formations in China and the USA. The results show that the lithofacies classified by these two methods are similar with low organic matter content while they vary with high organic matter content in shale. For shales with high organic matter content, the lithofacies types identified by ternary diagram differ greatly from the microscopic observation results, while the lithofacies types identified by quaternary diagram match well with the microscopic observation results, indicating that the quaternary diagram method is suitable for shales with different organic matter content. This work standardizes the shale lithofacies classification process, increased the geological understanding of shale lithofacies, and ultimately provides important insights for the potential guiding significance of quaternary diagram method in shale oil and gas exploration.

Keyword

Shale lithofacies classification method, Volume proportion, Organic matter, Quaternary diagram, Ternary diagram

Coupling C-N-S-P-Fe systems to reveal bottom euxinia in ancient lakes: Implications on lake-water ventilation and paleowind orientation

Xubin WANG[1]*, Peking University (xubinwang@pku.edu.cn)
Lin Dong[2], Peking University

Abstract

Water circulation is the key to regulating spatial heterogeneity in modern oceans, impacting crucial factors such as nutrients, salinity, and dissolved oxygen concentration. Among them, the dissolved oxygen concentration is closely linked to the ventilation of water mass. While the ancient marine settings have attracted much attention, whether the water ventilation existed in ancient lacustrine environments, as well as how it influenced biogeochemical processes in the lakes, remains a largely unexplored domain. In modern lakes, water circulation is predominantly driven by wind stress, which directly affects oxygen content in the water column. Therefore, the identification of spatial heterogeneity of paleoredox conditions, represented by unevenly distributed euxinia at the bottom water, holds great potential in indicating lake-water ventilation and paleowind orientation. Here, we conducted a systematic investigation of the Triassic Ordos Basin during the Carnian Pluvial Episode, to reveal the paleoredox heterogeneity by analyzing the coupled C-N-S-P-Fe systems. Temporally, the boundary of bottom euxinia contracted from the lake center to the southwestern sections, aligning with the drop of the lake level and the decrease of organic matter loading. Spatially, the southwestern sections exhibit a more anoxic condition than the northeastern sections, which is commonly observed both at large scales (entire lake composed of multiple depocenters) and small scales (part of the lake that belongs to one depocenter). Additionally, the reconstructed distribution of euxinia cannot be solely attributed to changes in water depth and organic matter loading. By comparison to modern oxygen minimum zones, the heterogeneous euxinia of bottom water is probably driven by lake-water ventilation, suggesting a prevailing northeastward paleowind direction. These deductions are supported by the distribution of turbiditic depositions (development of local euxinia) and tuffaceous layers (an indicator of paleowind) during this period. Thus, the reconstruction of paleoredox conditions in ancient lacustrine basins provides a unique opportunity to analyze paleowind, as lake-water ventilation is more sensitive to wind than the oceanic systems.

Keyword

Ventilation, Paleowind, Nitrogen isotopes, Pyrite sulfur isotopes, Ordos Basin

The marine phosphorus crisis postponed the Cambrian radiation of animals

Kang-Jun Huang[1]*, State Key Laboratory of Continental Dynamics, and Department of Geology, Shaanxi Key Laboratory of Early Life and Environment, Northwest University, Xi'an, China (hkj@nwu.edu.cn)
Pengcheng Ju[2], State Key Laboratory of Continental Dynamics, and Department of Geology, Shaanxi Key Laboratory of Early Life and Environment, Northwest University, Xi'an, China
Zhenfei Wang[3], International Center for Isotope Effects Research, Nanjing University, Nanjing, China
Chao Chang[4], State Key Laboratory of Continental Dynamics, and Department of Geology, Shaanxi Key Laboratory of Early Life and Environment, Northwest University, Xi'an, China
Yigui Han[5], State Key Laboratory of Continental Dynamics, and Department of Geology, Shaanxi Key Laboratory of Early Life and Environment, Northwest University, Xi'an, China
Xingliang Zhang[6], State Key Laboratory of Continental Dynamics, and Department of Geology, Shaanxi Key Laboratory of Early Life and Environment, Northwest University, Xi'an, China

Abstract

Nutrient supply, particularly phosphorous, has been invoked to be the prerequisite for the early Cambrian radiation of animals. Phosphorus-based hypotheses suggest an adequate supply of reactive phosphorus during this period, supported by the extensive sedimentary record of phosphorites and bedded cherts successions across multiple plates. Furthermore, the elevated concentration of dissolved silica in the oceans further impedes the use of ferric oxyhydroxide particles as shuttles for transporting phosphorus into sediments, because silica could effectively compete with phosphate. However, this hypothesis currently lacks concrete evidence, as the intricate patterns of phosphorus cycling in the Early Cambrian oceans remain unclear.

To address this issue, a comprehensive reconstruction of reactive phosphorus cycling processes in the Early Cambrian oceans is essential. In this study, we utilized SEDEX and P K-edge XANES to assess the partitioning of phosphorus phases and their concentrations in the earliest Cambrian sediments from the Tarim Basin, Northwest China. Our results show that excessive deposition of phosphorus-bearing minerals effectively removes reactive phosphorus from water, leading to oligotrophic environments with a lower C/P ratio in the earliest Cambrian ocean. Subsequent redox-controlled carbon-oxygen-phosphorus biogeochemical feedback mechanisms dominate marine phosphorus cycling, leading to enhanced phosphorus recycling back to the surface water column. Concurrently, nitrogen fixation intensified gradually, signifying a more efficient utilization of nitrate by organisms. The transformation of the phosphorus cycle resolved the prior nutrient crisis and promoted the oxidation of marine photic zones in the earliest Cambrian. Our findings suggest that a phosphorus-starved condition temporarily impeded the pace of Cambrian animal radiation, and overcoming this crisis facilitated a deferred explosion in animal diversity.

Keyword

Early Cambrian, Phosphorus cycling, X-ray Absorption Near-Edge Structures, Redox conditions,

Black shales

Composition, concentrations and strategic resources of metals in Russian black shales (Volga and Baltic sedimentary basins)

TIMUR ALEKSANDROVICH DIU[1]*, Southern Federal University, Rostov-on-Don, 344006, Russia (dyu.timur94@gmail.com)
VLADIMIR I. VYALOV[2], A.P. Karpinsky Russian Geological Research Institute, Saint-Petersburg, Russia
ALEKSEI V. NASTAVKIN[3], Southern Federal University, Rostov-on-Don, Russia
EVGENY P. SHISHOV[4], A.P. Karpinsky Russian Geological Research Institute, Saint-Petersburg, Russia

Abstract

The new results of a study on the concentrations of strategic metals (Re, U, REE, and other) in black shales from the Volga basin (flammable or oil shale), and Baltic sedimentary basins (dictionema shale) are presented.

Shale analysis was carried out using inductively coupled plasma mass spectrometry.

In the Volga basin, 25 shale samples from boreholes and rock outcrops were studied.

In Baltic basins has been analysed more than 750 geological samples which have been selected from 96 boreholes on the area 593 sq. km.

The association of metals with Re in oil shales from Volga basin was identified – max concentrations, ppm: Mo -143, U - 19, Sc – 11, Co - 46, Ni - 281, Cu - 97, Zn- 252, Cr – 109, V – 137, Ti – 0,4 %, and others. The organic matter of oil shales acts as a concentrator of Re and Mo and U. The preferred petrographic type of oil shales for the concentration of Re (max 0,17 ppm), Mo, U, Co, Ni, Cu, Zn, Se, Ag, Sb in them is the colloalginite–vitrinite–clay type of shales.

The metal resources in the explored reserves (2000 million tons) of oil shale of only one Kashpirskoye deposit in the Volga basin are, tons: Re - 192, U - 20600, Sc - 13400, Mo - 151600, V - 172800, Cu - 164000, Zn – 328000, Ti – 8000000.

Valuable metals (Re, U, Mo, Sc and many others) are enriched in the dycthionema shales of the Baltic basin with an increased (up to 15-20%) content of organic matter.

The predicted resources of strategic and other valuable metals in the productive layer of Dictyonema shale in the studied area of the Baltic sedimentary basin (layer thickness 1.8 m, specific gravity of shale 2.4 g/cm3, shale resources 2570 million tons), are (tons): Re (average concentration 0.14 ppm – also and further) – 427, U (219) – 630817, PGE (0.034) – 103, REE (264) – 776990 tons in terms of oxides (TR2O3), Sc (9) – 26450, Mo (223) – 649600, V (950) – 2772550, Cu (102) – 297120, Zn (1340) – 3724280, Ti (3518) – 10413630.

Source of Re and other metals in shales of Volga and Baltic basins was material from the source area and ash material (volcanic activity in nearby regions).

Oil shales of the Volga basin can be considered as a potential raw material source of acutely deficient rhenium, since its content in shales corresponds to (or even higher than) traditional types of rhenium-containing ores (tungsten-molybdenum – Re - 0.03 ppm), molybdenum (0.02 ppm), porphyry copper - 0.11 ppm) of ore deposits of Russia.

Dictionema shales of the Baltic sedimentary basin are believed to be a new nonconventional type of complex ore for Re and U, platinoids, rare-earth and other valuable metals.

This study was supported by the Russian Science Foundation project № 23-27-00427, https://rscf.ru/project/23-27-00427/

Keyword

strategic metals, black shales, Baltic basin, concentrations, strategic resources

Analysis of the Differences in Diagenetic-Porosity Evolution of Organic-Rich Shale in the First Member of Qingshankou Formation, Central Depression, Songliao Basin

min YAN[1]*, Northwest University (2113365437@qq.com)
lan jin LUO[2], Northwest University
hui zi FENG[3], Research Institute of Exploration & Development, PetroChina Daqing Oilfield Company
ting dan LUO[4], Northwest University
bo GAO[5], Research Institute of Exploration & Development, PetroChina Daqing Oilfield Company
ze TAN[6], Northwest University
fang hui PAN [7], Research Institute of Exploration & Development, PetroChina Daqing Oilfield Company

Abstract

Diagenesis plays an important role in porosity evolution of shale reservoir. The study of petrography from macro to micro-nano scale on organic-rich shale in the first member of Qingshankou Formation, Central Depression, Songliao Basin, was investigated by using core observation, thin section identification, scanning electron microscopy observation, cathodoluminescence analysis and TIMA analysis. Based on the above research, a series of analytical tests were conducted, including electron probe microanalysis, micro-drilling sampling for carbon and oxygen isotopes, rare earth elements analysis, nitrogen adsorption experiments and high-pressure mercury intrusion experiments to reveal the differences in diagenesis among organic-rich shales, as well as the impact of diagenetic on the evolution of porosity. They indicate that the study area can be divided into organic-rich quartz-feldspathic shale (OQF-shale) and organic-rich dolomitic shale (OD-shale). Due to the distinct differences in mineral composition, the diagenesis and pore evolution of these two types of shale differ significantly, as detailed below. OD-shale has undergone several diagenetic-porosity evolution processes, manifesting successively as porosity reduction by compacting, porosity increase by clay mineral dissolving, porosity reduction by ankerite cementing, porosity increase by ankerite and clay mineral dissolving, porosity reduction by clay mineral cementing and porosity increase by organic matter cracking. The pore types of OD-shale are dominated by micron-inorganic pores such as dolomite intergranular pores, ankerite and clay mineral dissolution pores, followed by nano-organic pores and tectonic fractures. The current effective porosity of them ranges from 3.4% to 12.5%, with an average of 8.6%. OQF-shale has undergone several distinct diagenetic-porosity evolution processes, which are specifically manifested as porosity reduction by compacting, porosity increase by clay mineral and detrital feldspar dissolving, porosity reduction by clay mineral cementing, porosity increase by organic matter cracking and clay mineral dissolving. OQF-shale are primarily dominated by nano- organic pores and organic hydrocarbon generation fractures, followed by inorganic pores such as micro-clay mineral dissolution pores, nano-clay mineral intercrystalline pores, and nano-pyrite intercrystalline pores. The current effective porosity of

them ranges from 2.1% to 14.6%, with an average of 6.4%. Thus, the OD-shale may serve as indicators of potential source rocks for hydrocarbon accumulation in the study area.

Keyword

diagenesis, pore evolution, different petrography types of shale, the first member of Qingshankou Formation, Central Depression of Songliao Basin

Uranium and rare-earth elements in dictyonema shale of the Baltic sedimentary basin

TIMUR ALEKSANDROVICH DIU[1]*, Southern Federal University, Rostov-on-Don, 344006, Russia (dyu.timur94@gmail.com)

Abstract

The results of long-term research into dictionema shales from the Baltic basin (in the Leningrad region and the Kaibolovo-Gostilitsky area in Russia) for uranium and rare earth elements, as a promising, unconventional source for scarce strategic raw materials, are presented. New data on the material and petrographic composition of the shales and their metalliferous content are presented, as well as information on the specific features of uranium mineralization in the shales. The distribution of uranium within the shale formations, both in terms of area and well profiles, is detailed. For the first time, data on the concentration of rare earth elements (REE) in dictionema shale samples from a large analytical sample size (672) is presented. The distribution patterns of REE within the research area are also illustrated for the first time.This information can be used to develop strategies for extracting and managing these elements from a promising source of raw materials. The distribution of REE (rare earth elements) over the search area has been noted, as well as in the sedimentary strata of the wells. An additional study of the mineral impurities in the shale has been conducted using a new technique of area scanning with an electron probe microanalyser, using the Feature software module. Correlations between the concentration of uranium and other elements have been clarified. The bonds between uranium and REEs with organic carbon have been described. Various forms of uranium and REEs in the shales have also been described, as well as the role of organic matter in their concentrations. In addition, the conditions for the formation of mineralization of uranium and REEs in black shale have been detailed.The uranium content in the shales within certain areas of the Kaibolovo-Gostilitskaya region was estimated, and the potential cost of possible recoverable industrial reserves of potential uranium ore raw materials from the studied regions was clarified. It was also determined that the mineral resources of uranium and rare earth elements in Russia and around the world could be significantly increased through their presence in these black shales.

Keyword

dictionema shales, uranium, rare earth elements, Baltic basin, mineral resources

Differential enrichment of organic matter in saline lacustrine black shales: an example from the Chezhen Sag in Bohai Way Basin, China

ZHI CHAI[1]*, School of Geoscience, China University of Petroleum (chaizhi5137@163.com)
ZHONGHONG CHEN[2], School of Geoscience, China University of Petroleum
Moïse Luemba[3], School of Geoscience, China University of Petroleum

Abstract

Organic matter-rich black shale in the salt lacustrine basin is of great significance as a source rock for conventional oil and gas exploration, and has become a prominent target for unconventional oil and gas exploration and development in recent years. However, the mechanism of differential organic matter enrichment in saline lacustrine black shales is still controversial and needs to be further clarified. In this study, taking the Chezhen Sag in Bohai Bay Basin as an example, total organic carbon, rock pyrolysis, molecular markers, and inorganic elements analyses were performed on the black shales from the fourth member of the Palaeogene Shahejie Formation. The abundance and type of organic matter, paleoclimate, paleowater depth, paleoproductivity, paleo-salinity, and paleo-redox conditions were investigated. The results show that the eastern part of the Chezhen Sag has higher organic matter abundance and is dominated by type II1 and type I. On the contrary, the western part of the Chezhen Sag has lower organic matter and is dominated by type III and type II2. The differential enrichment of organic matter between the eastern and western regions is related to the different evolution of the lake. The highly evaporative environment led to reducing paleowater in the eastern region, and the greater water depth led to reducing paleowater in the western region. Compared with the western region, the eastern region has high salinity and paleoreductivity. Hereby, the paleosalinity and paleoreductivity are the main factors for the organic matter enrichment of the black shales. This is due to the fact that higher salinity favors activities such as halophilic bacteria, which leads to higher paleoproductivity. Redox conditions had little effect on organic matter enrichment, which is related to the fact that black shales as a whole developed under anoxic-redox conditions. In conclusion, high paleoproductivity and paleosalinity conditions paly a key role in the enrichment of organic matter in lacustrine black shales.

Keyword

black shales, organic matter enrichment, paleoproductivity, paleosalinity

Algal δ13C reveals variations in atmospheric CO2 during the Cambrian explosion

Chao Chang[1]*, Northwest University, Xi'an, China (changchao@nwu.edu.cn)
Mingyu Zhao[2], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
Dongjing Fu[3], Northwest University, Xi'an, China
Pengcheng Ju[4], Northwest University, Xi'an, China
Kangjun Huang[5], Northwest University, Xi'an, China
Robert R. Gaines[6], Pomona College, Claremont, CA 91711, USA
Xingliang Zhang[7], Northwest University, Xi'an, China

Abstract

Carbon dioxide is an essential component of atmosphere that determines climatic and environmental conditions of Earth. However, atmospheric CO2 levels (pCO2) during the explosive diversification of animals during the Ediacaran–Cambrian transition is poorly constrained. Here we explored using carbon isotope signatures of carbonaceous algal fossils from seven black shale fossil deposits (~553 to ~508 Ma) to track pCO2 variations during this critical geological period. Our results reveal an increase of pCO2 from ~5 to ~16 PAL during ~553–529 Ma, followed by a progressive decrease to ~9 PAL and ~5 PAL at ~517 Ma and ~508 Ma, respectively. Temporal pCO2 changes interpreted here are consistent with contemporaneous marine strontium isotope variations, providing robust evidence for validity of the results and tectonic control on pCO2. Box modelling results further confirm that the pCO2 variation can be well explained by changes in the rate of deep-source CO2 input through outgassing. The pCO2 variations suggest a three-stage greenhouse–hothouse–greenhouse trajectory of planetary climate during the Cambrian explosion, which could have significantly impacted marine environments and accordingly animal diversification. Taken together, our results suggest a close interplay of tectonic, climatic, and biotic processes during the Cambrian explosion, and emphasizes the importance of black shale as a unique archive for the paleoenvironmental history of Earth.

Keyword

algal fossil, pCO2 calculation, tectonic control, climatic condition, biological implication

ORGANIC GEOCHEMICAL CHARACTERIZATION OF THE LOWER GONDWANA CARBONACEOUS SHALES OF THE EAST SIANG DISTRICT IN THE ARUNACHAL HIMALAYA, INDIA

DIPJYOTI BORSAIKIA[1]*, DEPARTMENT OF GEOLOGICAL SCIENCES, GAUHATI UNIVERSITY, INDIA (dipjyoti.borsaikia@gmail.com)
SARAT PHUKAN[2], DEPARTMENT OF GEOLOGICAL SCIENCES, GAUHATI UNIVERSITY, INDIA

Abstract

The study area forms a part of the Eastern Himalayas which characterize the Lower Gondwana Group of rocks. The present study aims to conduct hydrocarbon source rock geochemistry of the outcrop samples of carbonaceous shales, exposed along the Pasighat-Aalo road section of East Siang District, Arunachal Pradesh, India belonging to the Bhareli Formation of the Lower Gondwana Group. The organic geochemical studies of the carbonaceous shale of this Formation area have been investigated using Proximate analysis, Ultimate analysis (CHNSO), Total Organic Carbon (TOC), and Rock-Eval Pyrolysis techniques. The analytical results have been used to assess the richness of organic matter and its hydrocarbon potentiality, types as well as thermal maturity of organic matter. Proximate analysis of the carbonaceous shale samples shows low moisture content (0.49 to 1.8 wt%), low volatile matter (4.69 to 9.84 wt%), and very high ash content (81.94 to 94.06 wt%) in air-dried basis. The sulfur content obtained from ultimate analysis is almost negligible except for a few samples which range from 1.64 to 2.56 %. The Total Organic Carbon (TOC) values of the carbonaceous shales, ranged from 3.27 to 11.52 % with a mean of 6.70 % indicating promising potential source rock with very good to excellent organic richness. However other parameters like S1 and S2 values that are derived from Rock-Eval Pyrolysis have a very low range of values with a mean of 0.16 (mgHC/gTOC) and 1.60 (mgHC/gTOC) respectively, indicative of poor to fair hydrocarbon source condition for hydrocarbon generation. Values of Hydrogen Index (HI) (mean of 24.24 mg HC/gm TOC) and OI (mean of 9.18 mg HC/gm TOC) that are being plotted in the modified Van Krevelen diagram indicate Type IV kerogen signifies that the organic matter may be formed from various origins which have undergone significant oxidation or might be in a certain situation perhaps detrital organic matter might be oxidized directly by thermal maturation, sedimentological recycling of materials, or organic facies that has been reworked from a previous depositional cycle. Based on the Rock-Eval thermal maturity parameters such as Tmax (pyro), and PI, the plot of PI versus Tmax (pyro) indicates that the organic matter of carbonaceous shale samples falls in the hydrocarbon generation zone which is indigenous. Accordingly, the organic matter of carbonaceous shale samples of the Bhareli Formation as indicated by the HI vs Pyro Tmax (mean of 449 ºC) plot is characterized by a Type IV dry gas category that falls within the mature stage of the Oil window zone.

Keyword

Gondwana carbonaceous shale, rock-eval pyrolysis, hydrocarbon potential, thermal maturity, Bhareli Formation

Sulfate-reducing microfossil Qingjiangonema from the early Cambrian black shale of South China

Xingliang ZHANG[1]*, Northwest University (xzhang69@nwu.edu.cn)

Abstract

Sulfate reduction is an essential metabolism that maintains biogeochemical cycles in marine and terrestrial ecosystems. Sulfate reducers are exclusively prokaryotic, phylogenetically diverse, and may have evolved early in Earth's history. However, their origin is elusive and unequivocal fossils are lacking. Here we report a new microfossil, Qingjiangonema cambria, from ~518-million-year-old black shales that yield the Qingjiang biota. Qingjiangonema is a long filamentous form comprising hundreds of cells filled by equimorphic and equidimensional pyrite microcrystals with a light sulfur isotope composition. Multiple lines of evidence indicate Qingjiangonema was a sulfate-reducing bacterium that exhibits similar patterns of cell organization to filamentous forms within the phylum Desulfobacterota, including the sulfate-reducing Desulfonema and sulfide-oxidizing cable bacteria. Phylogenomic analyses confirm separate, independent origins of multicellularity in Desulfonema and in cable bacteria. Molecular clock analyses infer that the Desulfobacterota, which encompass a majority of sulfate-reducing taxa, diverged ~2.41 billion years ago during the Paleoproterozoic Great Oxygenation Event, while cable bacteria diverged ~0.56 billion years ago during or immediately after the Neoproterozoic Oxygenation Event. Taken together, we interpret Qingjiangonema as a multicellular sulfate-reducing microfossil and propose that cable bacteria evolved from a multicellular filamentous sulfate-reducing ancestor. We infer that the diversification of the Desulfobacterota and the origin of cable bacteria may have been responses to oxygenation events in Earth's history.

Keyword

Black Shale, Cambrian, Sulfate reduction, Qingjiangonema, Microfossil

Application of in situ Rb-Sr geochronology for dating of black shale

Zhongwu LAN[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (lzw1981@126.com)
Kyle Larson[2], University of British Columbia
Darwinaji Subarkah[3], University of Adelaide
Qin Ye[4], China University of Geosciences
Jun Hu[5], China University of Geosciences
Jinnan Tong[6], China University of Geosciences

Abstract

Shale is widespread in the geological record and contains important information about biological evolution, seawater chemical composition, hydrothermal mineralization, and oil and gas migration. As such, quantifying the timing of deposition or hydrothermal alteration of shale is critical to decoding these geological, biological and environmental processes. Geochronology of shale, however, can be challenging, particularly where biostratigraphy is inapplicable. A number of direct and indirect dating methods have been attempted but often can only provide information on maximum and minimum depositional ages. The recent development of in situ Rb-Sr geochronology methods, via tandem inductively coupled plasma–mass spectrometry, now allows the assessment of Rb-Sr age information in K-bearing specimens without losing the associated textural context of each targeted laser spot. Because black shale contains abundant authigenic K-bearing clay minerals, it is possible to date using the Rb-Sr decay system. In situ Rb–Sr geochronology has been successfully applied to date Proterozoic shale in the McArthur Basin of northern Australia to constrain their depositional and post-depositional, fluid-induced metasomatism or hydrothermal alteration events. Herein, we expand the application of this technique to date the Mesoproterozoic, Neoproterozoic, and Phanerozoic black shale in South China and North China cratons. A Rb-Sr isochron age of 1078 ± 78 Ma was obtained from the Mesoproterozoic black shale of Xiamaling Formation from the North China Craton, which is interpreted to represent the timing of fluid-induced metasomatism or hydrothermal alteration. In addition, an Rb-Sr isochron age of 231 ± 12 Ma, obtained from the Mesozoic black shale of Ordos Basin in the North China Craton, is interpreted as depositional age. Finally, both depositional and post-depositional hydrothermal alteration events have been identified from the Marinoan black shale in South China Craton. An Rb-Sr isochron age of 630 ± 27 Ma from Marinoan black shale strata represents the timing of deposition, whereas additional Rb-Sr isochron dates in the same rocks of 554 ± 27 Ma and 545 ± 17 Ma are consistent with the timing of a regional hydrothermal event potentially related to the large-scale Bingdongshan Pb-Zn deposit proximal to the study area.

Keyword

shale, Rb-Sr dating, in situ, North China Craton, South China Craton

Shale gas sweet spots comparison between marine shale and transitional shale of China

Qin ZHANG[1]*, PetroChina, Research Institute of Petroleum Exploration and Development (zhangqin2169@petrochina.com.cn)
Zhen Qiu[2], PetroChina, Research Institute of Petroleum Exploration and Development
QUN Zhao[3], PetroChina, Research Institute of Petroleum Exploration and Development
Wen Liu[4], PetroChina, Research Institute of Petroleum Exploration and Development
Weiliang Kong[5], PetroChina, Research Institute of Petroleum Exploration and Development

Abstract

The geological reserves of shale gas in China are 134.42×1012m^3, with marine and transitional shale gas resources accounting for 43.95% and 29.82% respectively. More than 50% of the discovered conventional natural gas reserves in China have derived from transitional shale. In 2022, shale gas production from Longmaxi shale has reached 240×108m^3. Transitional shale gas is mainly distributed in the Carboniferous-Permian strata, and horizontal wells in the eastern margin of the Ordos Basin have yielded high production (1.1-7.9×104m^3/d). However, the degree of exploration in transitional shale is far behind of the marine shale. In order to fully understand the characteristics of transitional sweet spots and avoid blindly applying experiences from marine shale gas, it is crucial to conduct a comparative analysis of the marine and transitional shale.

Core observation, thin section identification, organic geochemistry, reservoir analysis, gas occurrence, and elemental analysis have been carried out. The research shows the two have significant differences in 5 aspects: (1) Differences in continuity. The sweet spot of the Longmaxi Formation is mainly distributed in the middle-lower section of the Long1 11, showing strong lateral continuity and stable distribution; sweet spots in Shanxi Formation are unevenly distributed in both bottom (well DJ51) and the middle section of the Shanxi Formation (well DJ3-4); (2) Differences in organic geochemistry. TOC of the Longmaxi shale is above 4%, with predominantly sapropelic organic matter, Ro generally exceeding 2.5%, and even reaching graphitization; TOC of the Shanxi shale is higher, ranging from 4.19% to 43.9% and the maceral of organic matter is mainly vitrinite, with Ro ranging from 2.0 to 2.61%; (3) Differences in reservoir characteristics. The sweet spot in Longmaxi shale is dominated by quartz (average 77.5%) and the clay minerals are dominated by illite (>80%). The pore types are mainly organic pores, with both mesopores and micropores well developed. In Shanxi shale, the clay content is higher than quartz with average value of 50.2%, and the clay minerals is dominated by kaolite (average 46%). The organic matter mainly develops micropores, and the mesopores and macropores are mainly developed in clay minerals. (4) Differences in gas occurrence. The marine Longmaxi shale is dominated by free gas (57%-87%), exhibiting early high production followed by rapid decline (average decline rate of 65% per well in the first year), whereas the Shanxi Formation is dominated by adsorbed gas (average 64%), showing early low production but stable production afterward (20-30% decline rate in the first year); (5) Differences in the formation mechanisms. The sweet spots in marine shale is mainly controlled by redox conditions and

paleoproductivity, with geological events such as volcanic activity, glacier melting, and biologic extinction playing indirect roles. While in the transitional shale, in addition to paleoproductivity and redox conditions, the unique detrital inputs also play an important role in the formation of sweet spot.
Because of the significant differences, it’s necessary to formulate specific methods and techniques to promote transitional shale gas exploration.

Keyword

sweet spots, shale gas, comparison study, transitional shale, marine shale

The black shale distribution pattern on the Middle Yangtze Region, South China during Ordovician-Silurian transitional period

Chuanshang WANG[1]*, Wuhan Center of China Geological Survey (wangchuanshang@163.com)
Kai Wei[2], Wuhan Center of China Geological Survey
Xiaofeng Wang[3], Wuhan Center of China Geological Survey
Jörg Maletz[4], Institute of Geology, Free University of Berlin, Germany

Abstract

To study the distribution pattern of the black shale during Ordovician-Silurian transitional period is essential for the optimization of the target zone for shale gas exploration and commercial exploitation in South China. The black shale was deposited in the foreland basin and the intracratonic basin during the Guangxi Movement period when the Yangtze Block subducted southward to the Cathaysia Block. However, the black shale shows strong heterogeneous from place to place. Four typical sections for different facies from south to north, i.e., the Kapeng section, Jinglongqiao section, Hamadong section and Longtoupo section, were measured to decipher the tempo-spatial distribution pattern of the black shale.

The south most section is the Kapeng section in Baojing County, western Hunan Province. The black shale is rather thin and much more silty at the lower part of the section, comparing with other sections on the middle Yangtze region. The age of the black shale is from Katian of Late Ordovician to Rhuddanian of early Llandovery (Silurian) according to the graptolite zonations. The most spectacular deposit of this section is the turbidite sandstone of ca. 100 m in thickness, which shows the cycles of coarsening upward successions from siltstone or silty shale to sandstone.

The sequence was dominated by chert beds in the Jinglongqiao section of Cili County, western Hunan. The Hirnantian bed and probably the earliest Silurian strata are missing in this area since the common graptolite fossils *Rectograptus* and the typical Silurian graptolite fossil *Avitograptus* were found below and above the O/S boundary, respectively. Similar to the Jinglongqiao section, the graptolite fossils of *Tangyagraptus* and *Paraorthograptus* were found just below the O/S boundary at Hamadong section in Yongshun County, western Hunan. The evidence shows that the Cili-Yongshun area was once occupied by the underwater uplift or the peripheral bulge during the Ordovician-Silurian transitional period, and the bulge was then migrated northward and the area was subsided as the foreland basin during the earliest Silurian.

The north most section is the Longtoupo section in Zigui County, western Hubei Province. The section is the typical section for the intracratonic basin, where the black shale sequence from Rhudanian to mid-Aeronian were revealed by the abundant graptolite fossils.

To sum up, the tempo-spatial distribution of the black shale, as the response to the migration of the foreland basin, can be depicted more precisely by the constrain of graptolite zonations. The diachronous boundaries of the black shale and the time interval of the gaps within the black shale can be a good proxy to illustrate the migration of the intracratonic basin, the peripheral bulge and

the foreland basin from south to north.

Keyword

black shale, foreland basin, Yangtze Region, Ordovician-Silurian Transitional period

Sedimentary features and their hydrocarbon significance of lacustrine shale under different hydrodynamic conditions

Zhenglian PANG[1]*, Research institute of petroleum exploration and development (zhenglian20@126.com)

Abstract

According to the traditional view, shale deposits are usually regarded to be deposited in a relatively slack and deep water environment. However, as the lacustrine shale oil and gas have been developed continuously in recent years, shale is revealed that can deposit under different hydrodynamic conditions. The Upper Triassic Chang 7 Member in the Ordos Basin, which contains thick black shale and well developed gravity flow deposits provides an good opportunity to investigate the sedimentary features of lacustrine shale under different hydrodynamic conditions caused by gravity flows.

We integrate core observation, thin section petrography analysis, X-ray diffraction, major and trace element analysis, total organic carbon testing, electron microscopy, energy spectrum analysis, rock pyrolysis and analysis of group composition of hydrocarbon on shale to carry out the lithofacies classification, palaeoenvironment analysis, depositional models reconstruction, and hydrocarbon significance study.

Based on the development of silty laminas and thickness of the laminaset/bedding, the Chang 7 shale was classified into five lithofacies, including Thick silty laminaset shale (Type Ⅰ), horizontal bedding shale (Type Ⅱ), massive shale (Type Ⅲ), Thick laminaset shale (Type Ⅳ), and Thin laminaset shale (Type V), and 11 subtypes of laminas according to the lamina morphology. By studying the paleo-water depth, paleo-settling rate, paleo-productivity, paleo-redox, and clastic influx of each lithofacies, combined with the abundances of organic matter, palaeoenvironment and depositional processes of each lithofacies were studied, and depositional models of Chang 7 shale influenced heavily by gravity flows were proposed. In these models, the diversity both of hydrodynamic conditions and clastic influx induced by gravity flows, combing the variation of paleo-productivity, led to the heterogeneity of shale.

Based on the relation between TOC and five paleoenvironmental proxies, paleo-productivity has the strongest influence on the accumulation of organic matter. The rock pyrolysis, analysis of group composition of hydrocarbon, and mineral composition of different lithofacies reveal that Type Ⅰand Ⅱ lithofacies contain more light hydrocarbons, and are much easier to be fractured, which are more suitable for the technologies of horizontal well and hydrofracture. By contrast, Type Ⅲ, Ⅳ, V lithofacies are more suitable for the technology of in-situ conversion process.

According to this work, sedimentary features and heterogeneity of lacustrine shale under different hydrodynamic conditions were researched, and their hydrocarbon significance was also analyzed.

Keyword

Ordos Basin, Shale, Lithofacies, Deposition, Hydrocarbon significance

Research on Seismic Response Characteristics and Prediction Methods of Shale Lithofacies Assemblages in Jiyang Depression,Bohai Bay Bain,China

Zhengchun SHEN[1]*, China university of petroleum,Geophysical Research Institute,Shengli oilfield,SINOPEC (shenzhengchun.slyt@sinopec.com)
Chengyan Lin[2], China university of petroleum
Hongwei Han[3], Geophysical Research Institute,Shengli oilfield,SINOPEC
Zhipeng Qu[4], Geophysical Research Institute,Shengli oilfield,SINOPEC
Jingqiang Yu[5], Geophysical Research Institute,Shengli oilfield,SINOPEC

Abstract

Jiyang Depression in Bohai Bay Basin is a typical Cenozoic continental rift basin with abundant shale oil resources. The fine-grained sedimentary lithofacies of continental rift basins shale in China change rapidly, with diverse facies and strong heterogeneity,which lead to many uncertain factors in later stage of exploration and development of shale oil.

Based on the complex lithological characteristics of shale in Jiyang Depression, the concept of "lithofacies assemblages" was proposed in shale oil exploration and development in the oilfield. However, due to factors such as insufficient logging and core data, and low seismic data resolution, it is still difficult to accurately describe the distribution pattern of lithofacies aessemblages.

Takes the upper 4th member of Shahejie formation(E2S4S)in Dongying sag of Jiyang Depression as an example,a lithofacies assemblages division scheme that can match the current seismic data resolution was established, and three lithofacies assemblages models were constructed: One interlayer with variable thickness models, variable interlayer quantity with the same thickness models, variable interlayer quantity with variable thickness models. Then the seismic response characteristics of different lithofacies assemblages were clarified through forward modeling of wave equation.Based on this, the seismic waveform clustering method and geostatistical inversion techniques were studied to predict the distribution characteristics of different lithofacies assemblages.

The main lithofacies developed in the upper sub section of E2S4S in Dongying sag are laminated argillaceous limestone and laminated calcareous mudstone, which are interbedded,or form different lithofacies assemblages as interlayers.The seismic response characteristics of different lithofacies assemblages vary greatly,as the number and thickness of interlayers increase, the seismic amplitude of the top interface of layers shows a downward trend,The variation characteristics of the bottom interface are more complex,The seismic amplitude of the layer bottom interface decreases with the increase of the thickness of a single interlayer, and significantly increases with the increase of the number of interlayers,the variation degree of seismic amplitude at the bottom interface of different layers is quite different.A negative polarity reflection is formed by a single interlayer, and the reflection of multiple intelayers produces a composite wave, and the polarity of seismic reflection also changes. As the thickness of the interlayer increases, the seismic reflection amplitude of the interlayer increases.

The seismic waveform clustering method can predict the distribution characteristics of lithofacies on a large scale, especially for areas with limited or no drilling data.The geostatistical inversion method can predict the spatial distribution of different lithofacies on a small scale, and five types of lithofacies have been identified. The vertical and horizontal changes in lithofacies are clear. The prediction results of each layer are in agreement with drilling results to a degree of 90%.

Keyword

shale lithofacies assemblages, seismic response characteristics, wave equations forward modeling, seismic waveform clustering, geostatistical inversion

The Carnian Pluvial Episode(late Triassic) in northeastern Tethys: Lacustrine sedimentary records,petroleum geological significance from the Yanchang Formation,Ordos Basin, central China

Xiangbo Li[1]*, Northwest Branch, Research Institute of Petroleum Exploration and Development, PetroChina (yang_zl@petrochina.com.cn)
Huaqing Liu[2], Northwest Branch, Research Institute of Petroleum Exploration and Development, PetroChina

Abstract

The Carnian Pluvial Episode (CPE) is among the most remarkable climate abrupt event registered on earth. The CPE is characterized by abrupt changes in climate with consequences in depositional environments, source rocks, and hydrocarbon accumulation in lake basins. The case study deals with the Triassic Yanchang Formation in the Ordos Basin, a major onshore petroliferous basin in China. The analysis of global palaeoclimatic changes through outcrop and core observation, lab tests, and seismic interpretation, allow to review the sedimentation and hydrocarbon habitats of the Yanchang Formation. After this study, five conclusions have been achieved.

(1) The significance of the CPE in the Yanchang Formation was stablished. At the boundary between Chang 7 and Chang 8, a sudden facies change was found, which was related to the CPE event. Chang 7 black shales are considered the sedimentary response of CPE event.

(2) Three palaeoclimatic conditions were recognized: arid (Ladinian), warm-humid (Carnian), and semiarid-subhumid (Norian-Rhaetian).

(3) During the Carnian Age and CPE, the lake basin experienced a rapid transgression followed by a slow fluctuating regression characterized by periodic lake water concentration, flourishing organisms, high organic productivity, small consumption, and weak diluting effects, which may have facilitated the accumulation of organic rich source rocks.

(4) Ladinian and Norian-Rhaetian Ages were characterized by a relatively arid palaeoclimate, with limited precipitation and seasonal rainstorms developed before and after the CPE. In consequence, flood events dominated the occurrence and distribution of large-scale sands in central basin areas.

(5) Owing to the influence of the CPE and abrupt changes in palaeoclimate before and after the episode, two xenoconformities turned up vertically inside the Yanchang Formation and dominated lithologic-stratigraphic traps and hydrocarbon distribution. This study fills a gap in understanding the sedimentary response of the CPE in the Pangea at the east margin of the Paleo-Tethys.

Keyword

Carnian Pluvial Episode, palaeoclimatic conditions, xenoconformity, Yanchang Formation, Ordos Basin

Lithofacies Characteristics and Sweet Spot Distribution of Lacustrine Shale Oil Reservoirs: A Case Study of the Second Member of the Kongdian Formation in the Cangdong Sag, Bohai Bay Basin

Yuan ZHAN[1]*, China university of petroleum (east china) (zy2k19@163.com)
Chengyan LIN[2], China university of petroleum (east china)

Abstract

In contrast to marine shale oil reservoirs, lacustrine shale exhibits rapid lithofacies changes and strong mineral compositional heterogeneity, posing new challenges for the evaluation and distribution prediction of shale oil sweet spots. The oiliness, reservoir properties, oil fluidity, and fracability of different lithofacies were analyzed using emission-scanning electron microscopy (FE-SEM) observation, low-pressure nitrogen physisorption (LNP) analysis, mercury intrusion porosimetry (MIP), nuclear magnetic resonance (NMR), and triaxial compression testing. Based on the mineral composition obtained from X-ray diffraction (XRD) analysis, total organic carbon (TOC) content, and sedimentary structure, four lithofacies were classified, which are organic-rich laminated calcareous shale (LC), organic-rich laminated siliceous shale (LS), organic-rich laminated mixed shale (LM), and organic-poor massive calcareous shale (MC). Considering the factors of oiliness, reservoir properties, oil fluidity, and fracability, the LC and LS lithofacies were determined as being high-quality sweet spots (type I). Within the stratigraphic sequence divided by GR-INPEFA curves, random forest algorithm of sensitive well logs was used to classify the lithofacies, after which the distribution of sweet spots was predicted. The results reveal that the sweet spots exhibit regular changes in their vertical distribution and a ring-like pattern in their planar distribution, influenced by variations in the sedimentary environment. This finding can offer valuable guidance for the future exploitation of shale oil in the Guandong region.

Keyword

lacustrine shale, shale oil, lithofacies, sweet spot, Kongdian Formation

Analysis of favorable lithofacies for the development of lamellar sparry calcite veins in Paleogene lacustrine black shale of Jiyang Depression, China

YUNJIAO ZHANG[1]*, China University of Petroleum (East China) (1184548291@qq.com)
GUANMIN WANG[2], China University of Petroleum (East China)
ZIYUAN YIN[3], China University of Petroleum (East China)

Abstract

The lamellar sparry calcite vein, a significant outcome of shale diagenesis and organic matter evolution in the Paleogene lacustrine black shale of Jiyang Depression, serves as a crucial indicator for evaluating shale exploitability. However, its heterogeneous distribution poses challenges in predicting its occurrence, limiting shale oil exploration and development. This study focuses on the Upper Es4 - Lower Es3 black shale of the Paleogene, employing various analytical methods such as petrology, petrography, isotope geochemistry, cathodoluminescence, inclusion temperature measurement, and electron probe. The analysis reveals that lamellar sparry calcite veins are predominantly found in organic-rich lamellar calcareous mudstone and argillaceous limestone. Statistical data indicates that lithofacies with lamellar structure, TOC (total organic carbon) > 2%, carbonate content of 10% - 70%, and argillaceous content of > 20% are conducive to vein development. The formation mechanism of lamellar sparry calcite vein determines its differential distribution in shale. These veins is tied to the semi-mature to mature stage of organic matter. Micritic calcite in the lake undergoes dissolution by organic acids, forming vein-forming fluids alongside fluids resulting from clay mineral conversion. Hydrocarbon generation pressure leads to the creation of horizontal micro-fractures along weak bedding planes in lamellar shale, providing channels for fluid migration. The vein-forming fluid converges, recrystallizes in the surrounding pressure relief area, and develops into lamellar sparry calcite veins. The study identifies TOC content as a major factor influencing vein development, with significantly reduced development when TOC is < 2%. Carbonate and clay minerals play pivotal roles in providing the material and fluid basis for calcite vein development, while the lamellar structure enhances shale cracking. Considering the organic matter evolution and burial history in Jiyang Depression, lamellar sparry calcite veins are primarily generated at depths ranging from 2500 m to 3500 m, with diminished formation beyond 3500 m.

Keyword

sparry calcite vein, favorable lithofacies, formation mechanism, lacustrine black shale, Jiyang Depression

In-situ heating-induced pore structure evolution in low-medium-maturity Paleogene lacustrine shale, Bohai Bay Basin, China: Insights from integrated experimental and numerical approaches

Guoshuai Bai[1]*, China University of Geosiciences(Wu Han) (baiguoshuai@cug.edu.cn)
Guohui Chen[2], Nepu Sanya Offshore Oil&Gas Research Institute
Zhongxian Cai[3], China University of Geosiciences(Wu Han)
Shu Jiang[4], China University of Geosiciences(Wu Han)

Abstract

The effective development of shale reservoirs with low to medium maturity necessitates a comprehensive understanding of pore evolution dynamics during in-situ heating. These dynamics are investigated through experimental analysis and numerical simulation using shale samples selected from the lower sub-member of the fourth member of the Paleogene Shahejie Formation in the Damintun Sag, Bohai Bay Basin, China. Seven shale samples, exhibiting a maturity range of 0.54% to 2.5%, were analyzed to assess pore characteristics across varying maturity stages, using low-temperature gas adsorption (LTGA), mercury intrusion capillary pressure (MICP), field emission scanning electron microscopy (FE-SEM), and nuclear magnetic resonance (NMR) techniques. Subsequently, a 3D geological model of in-situ heating in the Damintun Sag was developed using the COMSOL Multiphysics software. This model enabled the simulation of temperature, maturity, and porosity distribution and their evolution during heating. The results revealed that the evolution of organic and inorganic pores in shale was predominantly influenced by hydrocarbon generation, clay mineral transformation, and dissolution. Organic pores consisted mainly of mesopores and macropores, while inorganic pores were predominantly mesopores. An increase in maturity led to a transformation of some organic pores into inorganic ones. It was observed that, from low to high maturity stages, shale porosity and pore volume initially increased significantly—by 209.6% and 616.2%, respectively—followed by a decrease of 8.6% and 19.5%. The contribution of organic porosity to the total porosity could reach as high as 84.9%. Under a constant temperature of 600°C in horizontal heating wells, all organic matter within the shale of the hexagonal well network reached an overmature stage after 2,580 days of heating. Notably, after 2,100 days of heating, the most substantial increase in shale porosity was observed within the bounds and extending an additional 5 m beyond the periphery of the entire hexagonal well network.

Keyword

In-situ heating, Numerical simulation, Pore evolution, Low-medium maturity shale, Damintun Depression

Evaluation of organic matter, thermal maturity and hydrocarbon potential of source rocks from southwest of Rwanda

THEOPHILE MUGERWA[1]*, University of Rwanda (luanmugerwa@gmail.com)

Abstract

Researchers have identified areas of hydrocarbon potential in Lake Kivu Graben, especially as a source of power supply. However, organic geochemical prospecting for hydrocarbon and energy content assessment is inadequate for the identified areas. The study aimed at determining the organic petrography of peat deposits in Western Province, Rwanda

Forty (40) subsurface peat samples (1 to 10 m depth) from three locations: Gishoma, Mashya, and Gihitasi were collected, air-dried, and pulverized and screened based on Von Post degree of humification. Fourteen samples were subjected to geochemistry and organic petrographic analysis. The macerals variations are as follows: huminite (57.5 Vol %) > liptinite (28.8 Vol %) > inertinite (13.7 Vol %). The bulk geochemical parameters are TOC (14.0-40.0%), S1 (2.8-19.9 mg HC/g), S2 (27.9-103.7 mg HC/g rock), S3 (12.7 mg HC/g to 33.43mg HC/g), Tmax (406 - 428oC) and production index (PI) (0.09 to 0.16).
.The sediments are excellent source rocks and may generate mixed oil and gas at appropriate maturation. The organic matter is classified as type II and III Kerogen. The Tmax was less than 4300C, and the ratios of Ts/Tm and M/H indicated that the peat deposits are thermally immature.
The peat deposits in Western Province, Rwanda are very rich in organic matter of mainly terrestrial precursor and capable of generating gas and some oil at appropriate maturation

Keyword

Peat, Source rock, organic petrography, Pyrolysis, Maturity

Coupling of nitrogen biogeochemical cycling and phytoplankton community structure before and after the Late Ordovician mass extinction in South China

Ruining HU[1]*, Central South University (huruining611@163.com)
Wenhui Wang[2], Central South University
Jingqiang Tan[3], Central South University

Abstract

The Ordovician–Silurian transition (OST) is a crucial geological interval in Earth history, coinciding with the first of the 'Big Five' Phanerozoic mass extinction events (ca. 445 Ma). In addition to the dramatic loss of biodiversity, significant environmental change course such as redox conditions and nutrient availability have been the focus of debate. Previous studies have used isotopes of nitrogen (N) to reconstruct the redox evolution of the paleo-ocean and have identified biological nitrogen fixation as the main mode of nitrogen cycling during the OST. However, low δ15N values, ranging from -2‰ to +1‰, possibly correspond to four different redox conditions. The precise roles of these redox conditions and the spatial distributions of phytoplankton communities under different nitrogen cycles remain elusive. Here we present high-resolution nitrogen isotope, carbon isotope and lipid biomarker datasets from two drilled sections located on a submerged high of the Yangtze Basin to unravel the coupling between nitrogen biogeochemical cycling and phytoplankton community structure across the OST. The results suggest that there was a dominantly biological nitrogen fixation with local aerobic nitrogen cycling in the Yangtze Sea, and the nitrate inventory during the OST was smaller than that in the modern ocean. Particularly, before the Late Ordovician mass extinction (LOME), N-fixing cyanobacteria were likely extensively developed in the photic zone, while eukaryotic algae were limited. After the LOME, sea levels rose and the chemocline was higher than before the LOME. There was probably some NO3- that did not undergo denitrification in the surface ocean, favoring the development of eukaryotic algae. The ecological diversification from prokaryotic cyanobacteria to eukaryotic phytoplankton to eukaryotic zooplankton is likely to be a response to the enhanced biological pump, which generates positive feedbacks among the evolution of eukaryotic phytoplankton, organic matter enrichment, ocean oxygenation and atmospheric oxygen levels.

Keyword

Nitrogen cycling, phytoplankton community, Yangtze Sea, black shale, Ordovician–Silurian transition

Depositional environment and mineralization mechanism of the gaint Ortokarnash manganese carbonate deposit in the Western Kunlun Mountains

Bang-Lu Zhang[1]*, Development and Research Center, China Geological Survey (zhangbanglu2008@126.com)
Yong-Sheng Li[2], Development and Research Center, China Geological Survey
Zhi-Cheng Lv[3], Development and Research Center, China Geological Survey

Abstract

The recently discovered Malkansu Mn carbonate metallogenic zone, in the West Kunlun Orogenic Belt, represents a significant breakthrough for economic prospecting in China. The Mn-mineralized intervals are stratigraphically continuous, with an average thickness of 6 *m, and are the highest-grade Mn carbonate ores (average Mn* >37% *by weight) identified in China to date.The Ortokarnash is the only ore body being actively mined, affording complete access to a continuous stratigraphic section of the underlying and overlying strata. Although previous work focused on the ore-controlling factors, geological features, and geochemical characteristics of the Mn ores in the Malkansu district, limited information is available on the mechanism(s) of Mn mineralization and the depositional environment. To aid in resolving both, we present the first comprehensive set of field and petrologic data, together with detailed geochemical analyses of both the Mn ore and associated host rocks of the Ortokarnash ore deposit. The Malkansu manganese carbonate metallogenic zone is hosted in the sedimentary rocks of the Upper Carboniferous Kalaatehe Formation, which is composed of three members: (i) the* 1*st Member is a volcanic breccia limestone; (ii) the* 2*nd Member is a sandy limestone; and (iii) the* 3*rd Member is a dark grey to black marlstone containing the manganese carbonate mineralization, which, in turn, is overlain by sandy and micritic limestone. Zircons from the volcanic-bearing breccia limestone and the interlayered tuff of the Kalaatehe Formation at Ortokarnash yield* $^{206}Pb/^{238}U$ *ages of* 322.9±1.8 *Ma and* 322.0±5.3 *Ma, respectively, which place the deposition of the manganese-bearing strata at the beginning of the Pennsylvanian (ca.* 323 *Ma). The manganese ore is dominated by fine-grained rhodochrosite (*$MnCO_3$*), dispersed in Mn-rich silicates (e.g., friedelite and chlorite), and trace quantities of alabandite (*MnS*) and pyrolusite (*MnO_2*). The size distribution (*>10 μ*m) and framboidal morphology of pyrite, low* $\delta^{34}S$ *values (*–16.18 *to* –5.28‰*), shale-normalized REE+Y patterns from the carbonate ores and associated rocks, and* ^{13}C*-depleted characteristics of the carbonate ores, were indicative of Mn(II)*

carbonates formed as a result of Mn(III/IV)-oxide reduction during burial diagenesis. This is consistent with the replacement of pyrolusite by rhodochrosite. The mineralization processes can be summarized as follows: During the transgression, dissolved Mn^{2+} upwelled to where the Mn(II)/Mn(III/IV) redoxcline intersects the seafloor, and Mn(III/IV) oxides were precipitated. Excess organic matter together with Mn(III/IV) oxide precipitates would have been buried and subjected to the microbial reduction of the oxide minerals. As a result, high concentrations of dissolved Mn^{2+} linked with carbonate alkalinity from the oxidation of organic carbon likely accumulated in the sediment porewaters, leading to conditions favorable for the formation of authigenic manganese carbonates. Besides, the marked strong positive Ce anomalies of the carbonate ores indicates the deposition rate of precursor Mn(III/IV) oxides are very slowly and these precursor Mn(III/IV) precipitates were chemically equilibrant with the ambient seawater. This slowly deposition rate may resulted from the dynamic glaciation in the south hemisphere Gondwana during the Late Paleozoic age (ca. 340–285 Ma).

Keyword

sedimentary manganese carbonate deposit, Late Carboniferous, depositional environment, mineralization mechanism, Malkansu manganese metallogenic zone

OIL SHALE OF UZBEKISTAN - COMPLEX RAW MATERIALS OF MULTI-PURPOSE

MAKSUD ISOKOV[1]*, University of Geological Sciences (isokov.maksud1971@gmail.com)

Abstract

There is an increasing trend in the world to search for alternative raw materials sources of critical minerals, which are vital for modern high technologies. One of these alternatives is oil shale. The total reserves of oil shale, containing from 10 to 65% of organic matter on the globe, are estimated at 1,500 billion tons, including (in billion tons): in Africa 370, Asia 500, Australia 90, Europe 120, North America 220, South America 180.

Uzbekistan has deposits of Paleogene oil shale, which are complex multi-purpose raw materials. They are located in three regions of oil shale development: Gissar, Bukhara-Karshi region and Kyzylkum. Oil shale reserves in Uzbekistan are estimated by experts at 47 billion tons

Oil shale of Uzbekistan has the largest potential resources of hydrocarbon raw materials, as well as unique concentrations of Mo, Re, U, V, Au, Ag, platinum group metals, rare earths and other elements.

The studies carried out made it possible to establish the mechanism of concentration of industrially valuable elements in the original mineral-geochemical system, to identify carrier minerals, concentrators and forms of occurrence of industrially valuable elements V, U, Mo, Re, Au, Ag, platinoids, rare earths in oil shale for creating optimal technologies for their extraction.

The developed technology for processing oil shale makes it possible to obtain liquid and gaseous hydrocarbons through thermal decomposition (500-550ºC) without access to oxygen and metal-bearing semi-coke ash.

The subsequent chemical decomposition of the ash with various reagents made it possible to obtain metal-bearing solutions containing all these metals in different concentrations.

Analytical studies of ash showed that the contents of metals (molybdenum, vanadium) in oil shale of the Baysun deposit are significant and comparable to those of large and medium-sized deposits of these metals of other genetic types. The ash of oil shale occurrence Uchkyr-Kulbeshkak (Bukhara-Karsha region) contains: vanadium pentoxide – 0.34%; molybdenum – 0.072%; tungsten trioxide – 0.07%; rhenium – 0.6 g/t; uranium – 0.007%.

The ash of oil shale from the Sangruntau deposit contains vanadium pentoxide - 0.1-0.33%; nickel - 0.02-0.03%; cobalt - 0.001-0.002%; molybdenum - 0.01-0.073%; tungsten trioxide - 0.01-0.06%; rhenium - 0.0001-0.0002%, titanium - 0.30-0.49%. In the oil shales of the Aktau deposit, almost all metallic chemical elements were found in quantities close to or exceeding clarke ones, including lithophile (actinides were not determined), lithophile-chalcophile, siderophile-chalcophile and siderophile (including platinoids). The highest values, in descending order of degrees of concentration compared to the average content in the earth's crust, are given for rhenium, molybdenum, tellurium, selenium, cadmium, vanadium, bismuth, thallium, silver, nickel, zinc, lead, tungsten, copper, gold, antimony, chromium, rubidium, tantalum, thorium, hafnium,

samarium, lutetium, cerium, terbium, ytterbium.
The conducted studies made it possible to prove the significant contribution of metals to the overall geological and economic assessment of the development of oil shale deposits. This work is the first step towards diversifying certain industries of the Republic of Uzbekistan, taking into account providing them with alternative sources of mineral raw materials and energy resources.

Keyword

Oil shale, hydrocarbon, raw materials, critical minerals, processing

Origin of Calcareous Concretion zone in the organic-rich Qusaiba Shale, Saudi Arabia

Mohamed Omar Abouelresh[1]*, King Fahd University of Petroleum & Minerals
(abouelresh@kfupm.edu.sa)

Abstract

Widely exposed zone of circular platy fossiliferous concretions dominated in the lower part of the Lower Silurian organic rich Qusaiba Shale, NW Saudi Arabia. Concretions are large and spherical or slightly flattened along the vertical axis. The identified zone of concretions also includes numerous large, commonly round or knobby, pale grey concretions up to 0.7 min diameter. Most of the existing concretions have a few millimeters, pale green outer rim caused by an enhanced content of clastic material. Both the oxygen and carbon isotope data show mainly negative values, revealing little difference between the values obtained from the cores and rims of the concretions. The range of δ18O values is rather wide (−14.4 to −2.6‰ PDB); the range of δ13C values is more limited (−5.0–0.2‰ PDB). However, the carbon isotope values for the calcite cement range between −5.0 and −3.7‰, with a mean value of −4.4‰ (PDB). For the septarian cracks, the δ13C values vary between −4.4 and −3.3‰, with mean value of−3.9‰(PDB). The preservation of successive accumulations of shells showing patterned distribution over much the same large area is taken as strong indication that the assemblages resulted from recurrent mass mortalities with relatively little disturbance by current action before burial. The cause of the mortalities is not known. Sparse evidence seems to favor burial under conditions of excessive turbidity and lowered salinity, possibly brought about by repeated influx of sediment-charged fresh water from rivers in flood.

Keyword

Concretions, Qusaiba Shale, organic rich, deposition

The dominant lithofacies combination and genesis of the Kong2 shale in the Cangdong Depression of the Bohai Bay Basin

WEIHAO LA[1]*, China University Of Petroleum (East China) (jushrgs@gmail.com)
YUE SHI CHEN[2], China University Of Petroleum

Abstract

The K2 shale in the Cangdong Depression of the Bohai Bay Basin is a typical deep-lake to semi-deep-lake laminated shale formation, characterized by diverse mineral composition, high organic matter content, and abundant types of laminations. Influenced by early complex sedimentary environments, its lithofacies distribution is uneven, with significant differences between different lithofacies combinations. Therefore, conducting differential comparisons between different lithofacies in the study area to identify dominant lithofacies is of crucial importance. In this study, focusing on the K2 shale in the Cangdong Depression, lithofacies types were finely divided through core observation, thin section identification, X-ray diffraction, scanning electron microscopy, and other experimental methods. Differential comparisons were made based on lithofacies combinations, classified according to organic matter content, mineral content, and lamination type. The dominant lithofacies identified were argillaceous shale, mixed shale, and silty shale. Building upon lithofacies classification, major and trace element analyses, combined with core description and microscopic observations, were utilized to reconstruct sedimentary paleoenvironmental characteristics. Due to the Cangdong Depression being an inland fault basin, with overall climatic control predominating, differences in distribution are mainly attributed to terrigenous inputs and episodic sedimentation: under humid conditions, terrigenous debris from the basin margins enters the lake basin with surface water, resulting in stratification due to seasonal temperature differences, primarily forming laminated argillaceous shale and mixed shale lithofacies; under alternating wet and dry climatic conditions, increased salinity in the water body due to stratification and intermittent arid climate leads to the formation of laminated argillaceous shale and silty shale lithofacies; under arid climatic conditions, decreased terrigenous inputs and higher water salinity content primarily develop laminated and blocky silty shale lithofacies and mixed shale lithofacies.

Keyword

Shale, lithofacies combination, Second Member of the Paleogene Kongdian Formation, sedimentary paleoenvironment, dominant lithofacies

Exploring CO2 Utilization Strategies in Shale: Enhancing Hydrocarbon Production, Sealing Efficiency, and Long-term CO2 Storage

Chioma ONWUMELU[1]*, University of North Dakota (anaesjudy@yahoo.co.uk)
Oladoyin Kolawole[2], New Jersey Institute of Technology
Ogochukwu Ozotta[3], University of North Dakota

Abstract

Shales, known for their low to ultra-low porosity and permeability, present a promising avenue for carbon dioxide (CO2) utilization in both CO2-enhanced oil recovery (CO2-EOR) and geologic CO2 storage (GCS). These rock formations, acting as source rocks, experience transformative induced diagenetic processes as they mature at greater depths, resulting in changes to their properties. Nevertheless, considerable gaps persist in our comprehension of CO2 utilization during thermal maturation and its viability for long-term CO2 storage.

This investigation explores the potential of CO2 utilization and storage within shale, particularly under in-situ conditions where thermal maturation is induced. It further delves into the implications of CO2 injection before maturation, specifically focusing on GCS and CO2-EOR. The Bakken and Green River shales were treated with supercritical CO2 and maturation to scrutinize their properties.

The outcomes divulged that early CO2 interaction with shales contributes to increased hydrocarbon production but compromises their mechanical strength as they mature. In contrast, CO2 treatment of already mature shales leads to alterations in their mineral composition and a decrease in total organic content. These revelations underscore that injecting CO2 into immature shales represents an immediate, practical choice for storage while concurrently enhancing CO2-EOR. Additionally, the proposed pre-maturation CO2 interaction process can rejuvenate mature shales, amplifying hydrocarbon production via CO2-EOR, improving their sealing capabilities, and mitigating long-term CO2 storage concerns.

This study provides critical insights that advance the deployment of CO2 utilization strategies in immature Bakken and Green River shales, particularly for GCS and CO2-EOR applications. As we strive toward the global net-zero objective by 2050, these findings pave the way for sustainable CO2 management and utilization in the energy sector.

Keyword

Shales, Carbon Dioxide (CO2) Utilization, Thermal Maturation, Geologic CO2 Storage (GCS), CO2-Enhanced Oil Recovery (CO2-EOR)

The development characteristics of continental shale laminae in China and its petroleum geological significance

Jiankang Lu[1]*, China University of Petroleum, Beijing (1956656429@qq.com)
lianbo Zeng[2], China University of Petroleum, Beijing

Abstract

The development characteristics of continental shale laminae in China and their petroleum geological significance are investigated in this study. The abundant shale oil resources in China are primarily found in black shale formations dominated by continental lacustrine deposits, which exhibit a distinctive feature of extensive laminated structures. It has been observed during the practice of shale oil production processes that the presence of lamina structure significantly impacts reservoir quality, as well as the enrichment and production potential for oil and gas within continental shale formations. However, there is currently a lack of systematic studies on the characteristics and impact of laminae on hydrocarbon production. Therefore, this research focuses on various formations including Triassic Yanchang Formation in Ordos Basin; Qingshankou Formation from Paleogene era in Gulong Sag located within Songliao Basin; Upper Es4 and Lower Es3 Sub-member from Paleogene era situated within Jiyang Depression at Bohai Bay Basin; Permian Lucaogou Formation in Jimsar Sag; Permian Fengcheng Formation in Mahu Sag at Junggar Basin; Qianjiang Formation from Paleogene era present at Qianjiang Depression within Jianghan Basin. A comprehensive comparison was conducted regarding the characteristics and combination types exhibited by laminae across different sedimentary environments such as freshwater lakes, freshwater-brackish lakes, brackish lakes, saline lakes, saline-alkaline lakes, and saline-saline lakes. Furthermore, the microscopic pore structure features, fracture development patterns and material differences associated with lamina structures were analyzed. The results indicate that clay laminae and felsic laminae are the predominant types in freshwater and freshwater-brackish water environments, while carbonate laminae are not well-developed. Conversely, brackish water and saltwater lakes exhibit carbonate lamina as the primary type. In saltwater-alkali water and saltwater-salt lake environments, carbonate lamina is also dominant, accompanied by alkaline mineral lamina and salt lamina development. A statistical comparison of pore structure, fracture development characteristics, and measured physical properties between laminated shale and non-laminated shale in different aquatic environments was conducted. The findings reveal that laminated shale possesses superior pore structure characterized by a bimodal distribution primarily within the 2 ~ 100 nm range and > 10,000 nm range. Non-laminated shale exhibits a unimodal distribution mainly within the 2 ~ 100 nm range due to bedding fractures commonly found in laminated shale providing greater reservoir space for this type of rock formation. Additionally, laminated shale demonstrates higher porosity compared to non-laminated shale with values ranging from 1 to 2 times greater. The impact of laminar layer development on permeability is more pronounced as it significantly enhances reservoir seepage capacity horizontally. Layers exhibiting favorable physical properties offer increased space for oil and gas

seepage, facilitating their enrichment; thus, becoming key targets for continental shale exploration and development.This study provides an effective reference for reservoir evaluation and dessert optimization of continental shale.

Keyword

continental shale, lamina, shale oil

Sedimentary Characteristics, Distribution and Development Control Factors of Lower Cambrian Marine High Organic Matter Abundance Shale in Lower Yangtze Area

Jun WANG[1]*, CNOOC China Limited, Tianjin Branch (varran@163.com)
Haifeng YANG[2], CNOOC China Limited, Tianjin Branch
Bo YANG[3], CNOOC China Limited, Tianjin Branch
Rucai ZHANG[4], CNOOC China Limited, Tianjin Branch
Xiaoling WANG[5], CNOOC China Limited, Tianjin Branch

Abstract

1 Study background

Lower Cambrian marine shale with high organic matter abundance (∈1) is developed in upper Yangtze area, which is the major source rock of Paleozoic Anyue giant gasfield with gas reserves over 1×1012 m3. In contrast, there is no major gas field discovered in lower Yangtze area due to lack of research and development of intense tectonic movement. In this study, Sedimentary characteristics, distribution and development control factors of ∈1 shale in lower Yangtze area are analyzed and there is bright prospect for gas exploration.

2 Structural environment

The ∈1 shale is deposited on the passive continental margin with transgression widely developed under the global greenhouse climate, and it is widely developed in the Yangtze plate. The distribution of ∈1 shale is mainly controlled by the structural pattern of "two basins and one shelf" (the northern Chuhe basin, the southern Qiantang basin and the middle Nanjing deep-water shelf) in lower Yangtze area.

3 Sedimentary characteristics and distribution

The thickness of ∈1 source rock in the northern Chuhe and southern Qiantang basins is over 400m and the TOC content is over 4%. The thickness of ∈1 source rock in the middle deep-water shelf is about 150m and the TOC content is about 3%. The carbon isotope of kerogen is lower than - 26 ‰, and the type of organic matter is type I-II. The average biogenetic barium contents of basin and deep-water shelf are 1583 and 203 μg/g respectively, reflecting high level of paleoproductivity, and V / (V + Ni) index ranges from 0.74~0.92, reflecting the reduction-sulfide environment. The ∈1 source rock with high organic matter abundance in the lower Yangtze area is mainly controlled by the high level of paleoproductivity and good preservation conditions.

The deep-water shelf ∈1 source rock in upper Yangtze Sichuan Basin is mainly developed in the Mianyang-Changning rift trough. The thickness of the ∈1 shale in the rift trough is simillar to that of the ∈1 in the lower Yangtze area, but the average TOC is just 2.17 %, lower than that in lower Yangtze area.

4 Development control factors

Low latitude greenhouse paleoclimate: the lower Yangtze are is located near the equator during the Early Cambrian, and the warm climate conditions are conducive to biological prosperity.

Frequent and widespread upwelling: upwelling in the lower Cambrian under the structural background of "two basins and one shelf" is widespread in lower Yangtze area, and upwelling can significantly improve the paleoproductivity of algae and form reduction environment conducive to the preservation of organic matter.
Input of terrigenous clasts: lower Yangtze area is far away from the ancient land, and this reduces the input of terrigenous clasts, which is conducive to the enrichment of organic matter. In contrast, the ∈1 shale in the upper Yangtze Sichuan Basin is mainly developed in the rift trough, far away from the upwelling and close to the ancient land. The high input of terrigenous debris dilute the organic matter of ∈1 shale, and accordingly the TOC content is lower.

Keyword

sedimentary characteristics, distribution and development control factors, Lower Cambrian marine high organic matter abundance shale, Lower Yangtze Area

senior engineer

baiyunfeng Yun-feng BAI[1]*, Institute of Daqing Oilfield Co.Ltd (84478917@qq.com)
wangxiaojun Xiao-jun WANG[2], Daqing Oilfield Co.Ltd
wangrui Rui WANG[3], Institute of Daqing Oilfield Co.Ltd
liuxin Xin LIU[4], Institute of Daqing Oilfield Co.Ltd
mashengming Sheng-ming MA[5], Institute of Daqing Oilfield Co.Ltd
liuzhao Zhao LIU[6], Institute of Daqing Oilfield Co.Ltd
chengxinyang Xin-yang CHENG[7], Institute of Daqing Oilfield Co.Ltd

Abstract

In order to solve the problems of unclear enrichment law of Gulong shale oil and difficult evaluation and prediction of sweet spots, Daqing Oilfield, through independent research, established the theory of in-situ reservoir formation of continental shale oil and the comprehensive evaluation technology of geological engineering "double sweet spot". By creating new experimental methods, It is clear that clay minerals can inhibit the conversion of organic matter, the water between clay layers can hydrogenate to reduce the disproportionation rate of crude oil, the ratio of light hydrocarbon to heavy hydrocarbon increases from 1:1 to 2:1. it is found that the Gulong shale kerogen → adsorbed oil → free oil formation evolution model, shale oil favorable formation window is Ro 0.9~1.6%. Nano-pores and foliation form a unique dual medium reservoir. it is found that pore throat gradually decreases from top to bottom, and displacement pressure increases. After Ro>1.3%, Pf <Pd, and forming a self-sealing mechanical reservoir. The theory of in-situ reservoir formation of continental shale oil was innovatively established. The correlation analysis between shale oil evaluation parameters and productivity shows that the higher S1 is, the higher the oil recovery intensity is. The higher the porosity of large pores characterized by nuclear magnetic, the higher the production of every kilometer of horizontal interval. The comparison of microseismic monitoring shows that high Young's modulus, high brittle mineral content, low foliation density and low fracture pressure section have larger compressive fracture height. Based on the core evaluation parameters of geology and engineering, the first geological engineering integrated dessert classification quantitative evaluation standard.The quantitative evaluation of shale oil sweet spot is realized, and the optimal evaluation of gold target layer is supported. The results won 13 patent granted for an invention, and two group company patent gold award, issued more than 10 standards. The forecast reserves of 1.268 billion tons and proved reserves of 204 million tons have been submitted,

effectively promoting the construction of a national demonstration zone, and it is expected to build the largest continental shale oil production base in China

Keyword

Gulong shale oil, In-situ reservoir formation theory, double sweet spot evaluation technique

Three-Dimensional Microstructure Analysis: Application of Confocal Laser Scanning Microscopy in the Study of Shale Oil Reservoir Spaces and Crude Oil Occurrence Characteristics in the Jurassic Shale

Xianda SUN[1]*, Northeast Petroleum University (sunxianda@nepu.edu.cn)
Hongyu WANG[2], Northeast Petroleum University
Manfei CHEN[3], Exploration and Development Research Institute of PetroChina Southwest Oil & Gas Field Company
Chengwu XU[4], Northeast Petroleum University
Limin SUO[5], Heilongjiang Bayi Agricultural University
Wenying SUN[6], Northeast Petroleum University
Chunzhu YAN[7], Northeast Petroleum University
Xudong QIN[8], Northeast Petroleum University
Mengzhen ZHANG[9], Northeast Petroleum University

Abstract

As the development of unconventional oil and gas resources progresses, shale oil occupies an increasingly important position in the global energy market. The study of reservoir spaces and crude oil occurrence characteristics in Jurassic shale oil reservoirs is crucial for assessing and enhancing the efficiency of shale oil and gas extraction. This research utilizes Confocal Laser Scanning Microscopy (LSCM) technology, employing high-resolution three-dimensional imaging techniques, to conduct a detailed analysis and study of the reservoir spaces and crude oil component occurrence characteristics in the Jurassic shale of the Sichuan Basin.

We collected shale samples from different lithofacies and conducted in-depth observations of their microstructures using LSCM technology. The study successfully revealed the three-dimensional characteristics of pore structures, organic matter distribution, and hydrocarbon occurrence states in the shale. The results demonstrate that confocal laser scanning technology can effectively identify micro-pores and fractures in the rock, as well as the complex interactions between organic components and inorganic minerals, providing a significant scientific basis for the assessment of shale oil and gas reserves and the formulation of effective extraction strategies.

Furthermore, based on the confocal laser scanning data, we have developed a three-dimensional visualization model of the shale oil occurrence state, enhancing our understanding of the microscopic occurrence mechanisms of shale oil. These research findings not only offer new scientific tools and methods for the exploration and development of unconventional oil and gas resources but also have significant theoretical and practical implications for optimizing shale oil and gas extraction technologies and improving resource utilization efficiency.

The innovative application of this research highlights the immense potential of confocal laser scanning technology in the field of shale oil geology research, paving new technical paths and perspectives for the exploration and development of future unconventional oil and gas resources.

Keyword

Confocal Laser Scanning Microscopy (CLSM), Jurassic Shale, Organic Matter Distribution, Three-Dimensional Imaging, Sichuan Basin

A record of mixed carbonate and volcanic sediments in the foothills of Zelee and Geyser carbonate banks (NW Madagascar)

Dhishna BULJORE[1]*, Ifremer (dhishna.buljore@ifremer.fr)

Abstract

The northern Mozambique Channel, located in the southwest of the Indian Ocean, is impacted by climatic changes, such as changes in temperature, salinity and eustatism, which affect the production of calcium carbonate. Additionally, the NW area of Madagascar has experienced regional volcanism since the Tertiary period. This study focuses on Zelee and Geyser banks and enhances our understanding of the evolution of the reef productivity at glacial-interglacial frequencies. It also aims to estimate the impact of volcanism on coral reef growth and deep-sea sediment stacking since the Plio-Quaternary.

To establish an age model of one sediment core, stable isotopes (δ18O and δ13C) were measured on planktonic foraminifers (white Globigerinoides ruber). Other methods such as physical core logger (MSCL) and X-ray fluorescence spectrometry (WD-XRF) have allowed the identification of high magnetic susceptibility events containing volcanic particles within the almost fully carbonated stratigraphy. Furthermore, SEM images and EMP measurements helped to characterise the volcanic content.

The isotope stratigraphy and elemental components were compared to establish the relationships between aragonite and calcite productivity and isotope stages and associated past sea-levels. During periods of highstands, aragonite production is high, and conversely, during periods of lowstands, it is low. However, as the percentage of aragonite increases, the calcite percentage decreases. An inverse relationship is observed between these two minerals. The core records at least four glacial-interglacial events (MIS 8) and major volcanic accumulations that occurred during the Quaternary period. The first volcanic event recorded during the Holocene has been identified in other cores located in the northern Mozambique Channel, and is probably associated with volcanic activity on Mayotte. However, the older volcanic elements contain minerals with a continental origin, such as biotite, which suggests an origin from Madagascar.

There is a correlation between the growth of carbonate platforms and volcanism activity in the area, with a marked decrease in the percentage of aragonite deposited in relation to volcanic events. This can lead to a temporary interruption in the production of the reef at the time of the eruption on the platform due to a disturbance in the environment of the coral reef. It is followed by a significant increase in the percentage of aragonite shortly after the volcanoclastic deposits. The increase in carbonate production may be attributed to the resumption of reef production once the platform is submerged, resulting in a stack of carbonate sequences.

Keyword

Indian Ocean, carbonate, volcanism, stratigraphy

Unravelling the Influence of Volcanism on Sedimentary Systems: Insights from the Early Paleozoic World

Eelika Kiil[1]*, Department of Geology, University of Tartu, ESTONIA (eelika.kiil@ut.ee)
Peeter Somelar[2], Department of Geology, University of Tartu, Ravila 14A, 50411 Tartu, Estonia
Kaarel Lumiste[3], Department of Geology, University of Tartu, Ravila 14A, 50411 Tartu, Estonia
Kalle Kirsimäe[4], Department of Geology, University of Tartu, Ravila 14A, 50411 Tartu, Estonia

Abstract

Information regarding weathering in sedimentary rocks is mainly carried by the terrigenous component, comprising sediment particles formed during weathering, which are subsequently eroded, transported, and deposited in sedimentary basins. The degree of chemical weathering of the terrigenous fraction can be estimated using different weathering indices. However, sedimentary rocks typically encompass detrital and various authigenic and/or biogenic phases that mute the weathering estimates. In marine sediments, particularly in tectonically active basins, aside from authigenic-biogenic phases, varied amounts of pyroclastic material occur either dispersed or as distinct tephra/tuff layers. These materials can introduce significant bias into detrital material source area weathering estimates but quantifying dispersed ash from detrital terrigenous and/or authigenic components poses challenges. Our research focuses on the Upper Ordovician carbonate deposits of the Baltic Basin containing numerous altered volcanic ash layers (bentonites) indicative of past volcanic activity during the background sedimentation. Our aim is to unravel the amount of volcanic material dispersed in sediments and its influence on the chemical weathering indices.

Geochemical analysis shows that the influence of volcanic material extends beyond the discrete bentonite layers, and volcanic material is dispersed throughout the limestone strata, comprising a substantial portion of sedimentary rocks (up to 50-90%). The presence of the volcanic component in sediments significantly influences weathering intensity estimates in the terrigenous fraction, and intervals with higher volcanic components exhibit significant variability in chemical index values, depending on the dominant authigenic silicate mineralogy — phyllosilicates (smectite and mixed-layer illite-smectite) or K-feldspar.

This implies that interpretations of weathering regimes and intensities in sedimentary sequences, particularly in active margin settings, should be carefully analyzed for potential impacts from pyroclastic material. The terrigenous fraction of the Upper Ordovician sediments in the Baltic Basin, corrected for volcanic components and diagenetic K addition, suggests an intermediate weathering level consistent with the paleocontinent Baltica's position at southern paleolatitudes between 40-30°S during the Katian. Interestingly, the corrected weathering intensity does not exhibit any changes in the interval with several thick bentonite beds or in sediments immediately above, indicating that even if a cooling effect related to intensified volcanism occurred in the Upper Ordovician, it was either too weak or too short to exert a measurable influence on weathering intensity.

Keyword

volcanic component, weathering indices, Baltic Basin

[Keynote] Reconstructing a hyaloclastite complex: the Aci Castello hyaloclastite sequence

Andrea DI CAPUA[1]*, CNR - IGAG (andrea.dicapua@igag.cnr.it)
Federica Barilaro[2], CNR - IGAG
Young Kwan Sohn[3], Department of Geology, Gyeongsang National University
Gi-Bom Kim[4], Department of Geological Sciences, Pusan National University
Elena Zanella[5], University of Turin, Department of Earth Sciences
Gianluca Norini[6], CNR - IGAG
Roberto Sulpizio[7], University of Bari
Gianluca Groppelli[8], CNR - IGAG

Abstract

The present work investigates the intimate relationship existing between lava effusion rate, water-lava interaction and accumulation of hyaloclastites considering the Aci Castello hyaloclastite deposits of Mt. Etna. The emplacement of pyroclastic layers in various non-explosive volcanic settings is considered, in fact, primarily triggered by interactions between water and lava. Nevertheless, such interactions can occur at different level, depending on effusive rates, and control the generation of hyaloclastic deposits different in stratigraphic and microtextural characteristics. The present case study comprises an effusive facies, composed of pillow basalts, and an explosive facies in which of hyaloclastic beds includes basaltic fragments and muddy rip-up clasts within a reddish groundmass, emplaced in a submarine fan-like architecture. Therefore, the combination of fieldwork, petrographic analyses, paleomagnetic and 3D model rendering using GIS, allowed the three-dimensional reconstruction of the volcano-sedimentary architecture, investigating macro- and microscale properties of the entire body. Beyond the stratigraphic observations in the field, both facies have been analyzed in thin sections as well as at the XRD. Pillow basalts show a microcrystalline dark brown groundmass wrapping phenocrystals of plagioclase and pyroxene. Hyaloclastites are predominantly constituted of loose crystals and basaltic fragments in a yellow, glassy, vesiculated groundmass, indicating sintering processes soon after the hyaloclastite emplacement. Muddy rip-up clasts consist of quartz, calcite and clay minerals. Paleomagnetic analyses on feeder dykes indicate the original orientation of the architecture. 3D modelling allowed the reconstruction of the prograding fan-like body, where basaltic and hyaloclastic layers are interdigitated together, and the suggestion that alternations of basaltic and hyaloclastite emplacement seems to be controlled by effusive rates at which magmas reached the surface, beyond the magma-water interaction.
This work was supported in part by the Italian Ministry of Foreign Affairs and International Cooperation, grant number KR23GR08.

Keyword

submarine environment, water-lava interaction, 3D model

Influence of Volcanism on the Cretaceous Depositional Evolution of Alluvial Fans and Braided Rivers in the Western Qiantang Sag, East China Sea Shelf Basin

Kailong FENG[1]*, School of Ocean and Earth Science, Tongji University
(fengkailong@tongji.edu.cn)
Weilin Zhu[2], Center for Marine Resources, Tongji University
Xiaowei Fu[3], School of Ocean and Earth Science, Tongji University
Qiang Fu[4], School of Ocean and Earth Science, Tongji University
Kai Zhong[5], Center for Marine Resources, Tongji University
Shijie zhao[6], School of Ocean and Earth Science, Tongji University
Weizhen Chen[7], Key Laboratory of Deep-Time Geography and Environment Reconstruction and Applications of Ministry of Natural Resources, Chengdu University of Technology
Zengyuan Zhou[8], School of Ocean and Earth Science, Tongji University
Lichen Hu[9], School of Ocean and Earth Science, Tongji University

Abstract

The Qiantang Sag, located within the East China Sea Shelf Basin, harbors substantial Mesozoic strata, yet its sedimentary characteristics have remained underexplored, obscuring the full spectrum of the region's geological history and resource potential. This study hones in on the Cretaceous period of the Qiantang Sag, unveiling a nuanced multi-phase sedimentary model to chart the sag's depositional evolution influenced by volcanism. Employing an integrated analysis of drilling, core data, and seismic interpretations, we pinpoint a predominant development of alluvial fan and braided river deposits within an arid to semi-arid climate during the Cretaceous. Notably, detrital zircon U-Pb dating illuminates the Zhe-Min Uplift as a crucial provenance, offering insights into sedimentation timelines and source dynamics. By correlating vertical sedimentary sequences with provenance data, our research delineates sedimentary frameworks, paving the way for a reconstructed paleo-depositional narrative across diverse geological epochs. During the Early Cretaceous Yushan Period, the region was influenced by intense volcanic activity, while also developing alluvial fan deposits in an arid environment. The Late Cretaceous Minjiang Period was characterized by semi-arid alluvial fan and braided river deposits. In contrast, the subsequent Shimentan Period saw the development of similar deposits, with the possible addition of seasonal lake deposits. This study not only bridges critical gaps in our understanding of the Qiantang Sag's sedimentary processes but also amplifies the geological blueprint for resource exploration in the East China Sea Shelf Basin.

Keyword

Cretaceous, Alluvial fan deposit, Volcaniclastic rock, detrital zircon, East China Sea Shelf Basin

Whole-rock geochemistry and Sm-Nd-Sr isotopes of Phanerozoic shales and mudstones from the Parnaíba Basin, NE Brazil: Insights for provenance shifts in a cratonic basin, related to Mesozoic volcanism

Claudio de Morisson VALERIANO[1]*, Rio de Janeiro State University
(valeriano.claudio@gmail.com)
Luzia Antonioli[2], Rio de Janeiro State University
Miguel Tupinambá[3], Rio de Janeiro State University
Monica Heilbron[4], Rio de Janeiro State University
Miguel Mane[5], Rio de Janeiro State University
Julio Cesar Horta Almeida[6], Rio de Janeiro State University
Luiz Guilherme Eirado-Silva[7], Rio de Janeiro State University

Abstract

Whole-rock Samarium-Neodymium and Strontium isotope compositions of twenty four samples of fine-grained clastic rocks (shales, siltites, mudstones) from the eastern Parnaíba basin, Northeastern Brazil. Major and trace element compositions of nineteen of these samples are also presented. The studied samples were collected from outcrops of the Paleozoic Canindé (Pimenteiras, Longá and Poti) and Balsas (Piaui Formation) groups, and from the Jurassic Pastos Bons Formation. The latter unit is younger than the intraplate tholeiitic magmatism referred as CAMP – Central Atlantic Magmatic Province and locally as the Mosquito event. Discrimination diagrams based on more immobile trace elements such as Th, Sc, La and Zr indicate sedimentary provenance from predominantly felsic sources, with high degrees of crustal recycling. PAAS-normalized REE diagrams show that the Pimenteiras and Longá Formations display flat patterns with slight REE enrichment, and initial εNd and 87Sr/86Sr around the average composition of the upper continental crust, respectively between -8.9 and -14.6 and between 0.711 and 0.760, indicating provenance from old Precambrian basement. The Nd TDM model ages of the Pimenteiras between 1.32 Ga and 2.00 Ga indicate heterogeneity of source areas during the Devonian, and TDM ages around 1.6 Ga in the Longá Formation samples suggest intense recycling of older sediments. The Poti formation samples yield TDM ages of 2.30 Ga and 2.32 Ga, respectively, suggesting tectonic reactivation and new input from Archean-Paleoproterozoic basement complexes. The Pastos Bons Formation samples show lower Th-Sc ratios, light-REE depletion, and less negative initial εNd, indicating contribution from mafic rocks, probably from the underlying Mosquito Formation intraplate tholeiitic basalts and dolerites.

Keyword

Sedimentary provenance, intraplate magmatism, CAMP, Continental crust, Gondwana

Detection of Environmental Changes Post 2011 Puhyeue-Cordón Caulle Plinian Eruption Over 13 Years

Andrea DI CAPUA[1]*, CNR - IGAG (andrea.dicapua@igag.cnr.it)
Mohammed Hammouti[2], CNR - IGAG
Federica Barilaro[3], CNR - IGAG
Christian Natale Gencarelli[4], CNR - IGAG
Gianluca Norini[5], CNR - IGAG

Abstract

In the last three decades, the assessment volcanic impact on modern sedimentary systems and ancient sedimentary records has become of fundamental importance in the Earth Science community. Eruptions, in fact, are one of the few geological phenomena shaping the Earth observable on human time scale, and their impact on the environment can be directly investigated through time. Nevertheless, there is a paucity of data showing how major volcanic eruptions can impact the environments surrounding volcanic centres during time. With the aim of partially filling this gap, this work has been designed to highlight the environmental modifications occurred and still occurring on fluvio-lacustrine environments after the Plinian eruption of the the Puhyeue-Cordón Caulle (VEI 5). Through the analysis of satellite images in GEE (Google Earth Engine), the reconstruction of climatic series and the built of a GIS database for geostatistical analyses, it has been designed a workflow that quantifies the sedimentary modifications occurred and still occurring around the volcano under climatic control, with particular focus on fluvial drainage patterns (Golgol river) and lacustrine sediment repository (an area of about 26.0 km^2). Both on the southwestern and southeastern sides of the volcano, deltaic systems prograded since the eruption year, with a net increase in progradation rate since 2015. The Golgol river partially became a braided river due to the abrupt discharge of large volumes of tephras for around seven years, with an impacted area of about 1.0 km2. Lacustrine systems connected to hydrographic basins downwind with respect to the eruptive column in the southwestern part of the volcano experiences a net increase in the quantity of suspended sediments, which directly impacted the turbidity of the waters for a couple of years, as well as a net progradation of deltas and coastal deposits. All these findings better delineate in which way mid-latitude environments response to a Plinian eruptive event, with a particular focus on a time series of 13 years.

Keyword

Explosive volcanism, Drainage system, GIS

Petrological, Geochemical, and Depositional Characteristics of Early Proterozoic Tuffs of Gwalior Basin, Central India

SHIKHA DIXIT[1]*, CSIR-National Geophysical Research Institute (shikhadixit288@gmail.com)
Sreenivas Bulusu[2], CSIR-National Geophysical Research Institute
Teeda Vijaya Kumar[3], CSIR-National Geophysical Research Institute
Gugulothu Balu[4], CSIR-National Geophysical Research Institute

Abstract

The Gwalior Basin is one of the Paleoproterozoic basins in Central India, located in Madhya Pradesh in the northern part of the Bundelkhand craton. Many researchers worked out the details of lithostratigraphy. Among the litho units of the basin, the Morar Formation of the Paleoproterozoic Gwalior basin is of particular interest as it hosts numerous tuffaceous sequences that have not been the focus of research. Tuffaceous rocks (pyroclastic) represent a considerable thickness of 8 to 10m and are well-developed around the Birauli section. In addition, the Morar Formation has a carbonate-argillite sequence and well-developed BIF sequences. In this study, we report the petrographic and geochemical characteristics of the tuffaceous rocks from the Birauli section.

The petrographic studies of the tuffs indicate that the quartz grains are angular in shape, embayed quartz with uniform extinction, and crystal shards, pointing to possible volcanic origin. Further, accessories like minerals like pyrite, zircon, and anatase are identified.

The major element compositions of the Birauli tuffaceous rocks show that the ratio of SiO_2/Al_2O_3 ranges from 7.51 to 19.69 (average 14.02%), and the TiO_2/Al_2O_3 varies between 0.019 and 0.063 (average 0.035%), indicating that they have parentage of felsic magma.

The trace element analysis of these tuffaceous rocks shows that the total rare earth element (∑REE) concentrations range from 26.44 to 245.25 ppm (average 102.06 ppm). The chondrite normalized REE distribution of Birauli tuffs shows LREE fractionated with flat HREE patterns. The Eu anomalies range from 0.38 to 1.91 (average 1.20), suggesting a mild positive to negative Eu anomaly. Further, the tuffaceous rocks show positive anomalies in Rb, Nd, Ba, and Pb and negative anomalies in Nb, Sr on primitive mantle normalized trace elemental spider diagram. The geochemical compositions of the Birauli tuffs suggest that the parental magma from which these tuffs are derived is of rhyolitic composition. As no vent could be recognized within the basin around Birauli, it is suggested that the source could be extra-basinal and deposited as ash fall tuffs.

Keyword

Central India, Gwalior basin, Tuffs

Sedimentary processes around the volcanic U Island (Jeju Island, Republic of Korea)

Federica BARILARO[1]*, CNR-IGAG (federicabarilaro@gmail.com)
Andrea Di Capua[2], CNR – IGAG
Young Kwan Sohn[3], Department of Geology, Gyeongsang National University
Gi-Bom Kim[4], Department of Geological Sciences, Pusan National University
Gianluca Norini[5], CNR-IGAG
Roberto Sulpizio[6], Dipartimento di Scienze della Terra e Geoambientali, University of Bari
Gianluca Groppelli[7], CNR-IGAG

Abstract

This work investigates the composition of four beaches located around the Island of U (Jeju Island – Republic of Korea). Island sedimentary processes are strongly controlled by wind-driven waves, strong tidal currents, winter storms and seasonal typhoons. Field observations, sedimentological analyses, petrographic point-counts on thin sections and scanning electron microscope investigations were conducted in order to understand mechanisms leading to the generation of particles and their accumulation in tidal-dominated beaches under the aforementioned factors. Beaches located in the nearby of tuff cones are predominantly volcanic-derived, beaches laying on lava substratum or in flat areas are predominantly composed of carbonates. The volcanic epiclastic fraction of sands is predominantly composed of lithics and minorly of single minerals and derived from pyroclastic sequences forming the island tuff cones. In contrast, the bioclastic fraction is primarily composed of fragments of rhodolites and mollusks, followed by minor amounts of echinoderms, benthic foraminifera and bryozoan. In addition, some beaches are predominantly formed of pebble- to cobble-sized detritus of rhodolites. These rhodolites are mainly composed of aragonites and high-magnesium calcite, and often nucleated around volcanic particles. Preliminary results indicate that volcaniclastic sequences are more prone to disaggregation, generating the almost total volumes of volcanically-derived beach sand fraction. Nevertheless, such production of particles often becomes minor with the respect to bioclastic sand generation controlled by climatic and oceanic dynamics, resulting in the progradation of carbonate beaches on a volcanic substrate. Understanding generation and depositional processes of these beach sands provide valuable insight into the coastal evolution of U Island, and contributes to the comprehension of the relationship between volcanic and carbonate sediment production.
This work was supported in part by the Italian Ministry of Foreign Affairs and International Cooperation, grant number KR23GR08.

Keyword

coastal processes, volcanic epiclastic sedimentation, bioclastic sediments, rhodolites, Tuff cone

Chemofacies characterization of lacustrine shale based on machine learning classification: A case study from the Dongying Depression, Bohai Bay Basin, China

Guiang LI[1]*, +8617806242357 (1240003291@qq.com)
Chenyan Lin[2], +8615314318221
Pengjie Ma[3], 17561665156
Chunmei Dong[4], 159208965601
Yuqi Wu[5], 15314318221

Abstract

The rapid lithofacies transitions and compositional heterogeneities inherent in lacustrine shale posed significant challenges to accurately characterizing it, thus impeding the optimization of shale oil exploration and extraction. This study employed a multifaceted methodology to address these obstacles, integrating principal component analysis (PCA), K-means clustering, and geochemical trend analysis to precisely identify and characterize nine distinct chemofacies. A comprehensive analysis of petrological characteristics and depositional environments was accomplished by examining core samples, thin sections, scanning electron microscopy (SEM), mineralogical compositions, and total organic carbon (TOC) content. The identification of favorable locations was supported by meticulously considering variables, including TOC, porosity, permeability, and the mineral brittleness index (MBI). This investigation revealed the presence of nine distinct chemofacies within the targeted layer. Specifically, Chemofacies 5, characterized by calcite vein laminations, was identified within Unit 2 parasequence, and Chemofacies 6, enriched with feldspar-quartz mineral laminations, was located within Unit 4 parasequence. Both chemofacies exhibited elevated TOC, enhanced porosity and permeability, and favorable brittleness, qualifying them as ideal sweet spots for shale oil exploration. The insights from this study align with the characteristics of traditionally optimal reservoirs, validate the robustness of the employed methodologies, and carry significant implications for the accurate prediction of terrestrial shale oil sweet spots in future explorations.

Keyword

Chemofacies, Lacustrine shale, Machine learning, Sedimentary environment, Sweet spot

Diagenetic Evolution of Coal Beds in the Sabinas Basin, NE Mexico: Insights from Fluid Inclusions Geochemistry, and Stable Isotope (δ18O, δ13C, and δ34S) Analysis

SUMIT MISHRA[1]*, Instituto de Geociencias, Universidad Nacional Autónoma de México, México (smpsgeo@geociencias.unam.mx)
Eduardo González Partida[2], Centro de Geociencias, Universidad Nacional Autónoma de México, México
Joseph Madondo[3], Centro de Geociencias, Universidad Nacional Autónoma de México, México
Genesis Arelly Ramos Garcia[4], Centro de Geociencias, Universidad Nacional Autónoma de México, México

Abstract

The Sabinas coal region accounts for over 90% of Mexico's total coal production. The basin spans about 37,000 square kilometres, and its geological formation is linked to the formation of the Proto-Gulf of Mexico and its subsequent "tectonic closure" with the Laramide Orogeny. The basins are delimited by structural elevations such as the Coahuila Peninsula, the Burro-Peyotes platform, the Tamaulipas arc, and faults such as La Babia and San Marcos. The Olmos Formation also referred to as the "Coal Formation," was formed in a basin through two distinct periods. Firstly, there was a marsh environment with abundant flora, which led to the deposition of peat with varying thickness and quality. Secondly, there was a continental and transitional environment, including upper intertidal areas, marginal lagoons, swamps, and alluvial plains. The Upper Cretaceous deltaic system in question has been characterised as such through the use of palaeobotanical, pollen, and spore investigations. These studies have determined that the system existed in a subtropical climatic setting. We have found some new information about fluid inclusions in diagenetic calcites that are linked to coal. We also have found stable isotopes (18O, 13O, and 34S) in calcites, pyrites, and marcasites. The fluid inclusions exhibit homogenization temperatures ranging from +82 ºC to +143 ºC and final ice fusion temperatures ranging from -3.1 ºC to -1.1 ºC. These temperatures correspond to a salinity of 1.9% to 5.4% (mean of 2.2) in terms of the equivalent weight percent of NaCl. The sulphides have δ34S ‰ values ranging from +7.5 ‰ to +20.0 ‰. Calcite found in coal exhibits a carbon isotope composition (δ13CvPDB ‰) ranging from -7.87 ‰ to -11.11 ‰. The oxygen isotope composition (δ18OvPDB ‰) of the same calcite ranges from -5.01 ‰ to -11.80 ‰, whereas the oxygen isotope composition (δ18OvSMOW ‰) ranges from +18.75 ‰ to +25.74 ‰. The vitrinite reflectance values documented in the literature for coal expressed as a percentage of Ro, vary from 0.5 to 1.5. We found that the coal in the Sabinas Coal Basin matured in a temperature range that is within the catagenesis evolutionary zone. This was determined by analysing diagenetic calcites. The presence of mature organic material (such as upper plants and raw coal) can be inferred from the isotopic behaviour of sulphur dioxide and carbonate in a closed system. This system involves the circulation of deep meteoric water, which promotes the reduction of sulphates to sulphide. The

isotopic fractionation during this process is limited and can be classified as closed-basin diagenetic sulphides. The carbonate species observed are a byproduct of secondary organic matter, which underwent a final decarbonisation process at greater burial depths in the presence of CO2 derived from organic.

Keyword

Sabinas Basin, Olmos Formation, Fluid Inclusion, C-O-S Stable isotopes, Coal

Reservoir characteristics and formation mechanism of the Lower Cretaceous Laiyang Group deep-water tight sandstone in the Lingshan Island, Eastern China

Tongtong CHEN[1]*, School of Geosciences, China University of Petroleum (East China) (chenttupc@126.com)
Yaoqi ZHOU[2], School of Geosciences, China University of Petroleum (East China)
Hanqing LIU[3], School of Geosciences, China University of Petroleum (East China)
Ruiyang LIU[4], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University
Junru Gao[5], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Deep-water sandstone reservoirs of the Laiyang Group are developed in the Lingshan Island; however, due to the lack of in-depth understanding of microscopic characteristics and reservoir genesis, the exploration and development process of oil and gas resources in this area has been hindered. Combined with field outcrop observation and core data, the features of tight sandstone reservoir of the Laiyang Group were systematically characterized and controlling factors of reservoir development were discussed by means of casting thin sections, XRD analysis, scanning electron microscopy (SEM), physical property test and low-temperature nitrogen adsorption. The research results show that the tight sandstone is dominated by fine-grained lithic feldspar sandstone and feldspar lithic sandstone, with porosity ranging from 0.18% to 3.20%, and permeability ranging from 0.002 mD to 2.965 mD, which belongs to ultra-low porosity and ultra-low permeability reservoir. The reservoir space includes primary intergranular pores, secondary dissolution pores, intercrystalline pores and fractures. Within 100 nm range, the mesopores (2~50 nm) of sandstone samples, groove pores composed of flake particulate material, are relatively developed; the specific surface area of sandstone samples ranges from 0.360 m2/g to 2.772 m2/g, the total pore volume ranges from 0.001468 ml/g to 0.005878 ml/g, and the average pore diameter ranges from 8.483 nm to 18.672 nm. The reservoir quality is mainly controlled by sedimentation and diagenesis, that is, the deep-water low-energy sedimentary environment is critical for rocks with fine grain size, high matrix content and poor original physical properties. Strong compaction leads to the destruction of a large number of primary intergranular pores; the cementation of calcite, authigenic quartz, clay minerals, pyrite and albite eventually results in the densification of the rock. In particular, compaction and cementation of carbonate and clay minerals are the key to the tight reservoir in the study area.

Keyword

reservoir characteristics, reservoir formation mechanism, tight sandstone, Laiyang Group, Lingshan Island

The features and mechanisms of coral reef carbonate weathering since Miocene: evidence from Yongle Atoll in the South China Sea

Yang YANG[1]*, Guilin University of Technology (yangyang007@glut.edu.cn)
Kefu YU[2], Guangxi University
Xijun LIU[3], Guilin University of Technology

Abstract

Carbonate weathering is a crucial component of the global carbon cycle, however, the processes, influencing factors, and formation mechanisms remains unclear. Coral reef carbonate are ideal research materials due to their successive deposits, limited later reformation, susceptibility to weathering and ease of dating. Thus we focuses on a 928.75-m-long coral reef core (CK2) from Yongle Atoll in Xisha Islands, northern South China Sea, and study the features and mechanisms of coral reef carbonate weathering by petrological and geochemical methods. Compared with the white coral reef carbonate formed under normal environment, the weathered carbonate are usually yellow, brownish yellow and maroon red. In addition, voids and dissolution pores are abundant, the surface of these pores are mostly covered with calcareous crusts and clay mud-like materials, and some of the holes develop stalactite-shaped crystals. Besides, the weathered carbonate usually exhibit the following geochemical anomalies, with a sudden jump increase of 87Sr/86Sr, a simultaneous negative bias of δ13C and δ18O, an increase in content of Mn, Ti, Zr, Al, Si, K and Fe, and decrease in Sr. Based on the above consensus, 13 weathered coral reef carbonate strata are identified, and can be divided into three types according to their petrological and geochemical characteristics. The first type exhibits only a geochemical anomaly without any petrological anomaly. These strata mainly consist of rounded blocks and sand debris. We speculate that the coral reef stratum is composed of blocky reef-building organisms and filling sand in a grid structure. This structure collapses easily when the strata are exposed to suffer karstification, most of the sand and small blocks are washed away, while the remaining blocks are rounded by the waves. This type indicates that the species of reef-building organisms can influence the coral reef carbonate weathering by control the structure of the coral reef. In the second case, there is only a petrological anomaly without any geochemical anomaly. These strata usually appear for a short period and are thin. The coral reef carbonate in these strata is dense and mostly composed of massive corals. In this case, it is difficult to form a phreatic layer in the strata, which is necessary for the geochemical exchange between meteoric water and the surrounding coral reef carbonate. This type further confirms the influence of reef-building organisms on weathering.The third type exhibits both petrological and geochemical anomalies simultaneously. These strata are usually form in warm climates, and are the result of a combination of climate and hydrology. In comparison to previous studies on coral reef carbonate weathering, which mainly focused on the lateral and vertical control of hydrologic factors, this study places more emphasis on the influence of climate and species of reef-building organisms.

Keyword

Coral reef carbonate, weathering, biological effect, climate influence, South China Sea

LITHOLOGICAL PROCESSES ON THE EXAMPLE OF THE DONETSK COAL BASIN OF UKRAINE

Volodymyr Andriyovych BARANOV[1]*, M.S. Polyakov Institute of Geotechnical Mechanics of the National Academy of Sciences of Ukraine, Dnipro, Ukraine (andreevich7526@i.ua)

Abstract

In the north-east of Ukraine is the Donetsk coal basin (Donbass), which is part of the Dnieper-Donets Basin stretching from the Carpathian Mountains to the Caspian Sea. Donbass has been developed since the end of the 18th century. The uniqueness of this basin is that it contains deposits of all stages and substages of lithogenesis, except sedimentogenesis. It processes all grades of coal: from brown coal to anthracite. The rocks and processes occurring in this basin have been well studied. A large number of new phenomena and patterns have been described previously. The author of this work has been studying thermogasdynamic processes in the mines of this basin for more than 40 years. Some research results will be listed below.

At the end of the last century, a method of side illumination under an optical microscope was developed. Using this method, it is possible to study all microdeformations in rock-forming minerals. It is especially effective to use this method in the sandstones of Donbass, which consist of 50-60% transparent quartz. Using this method, all existing plastic microdeformations were described in detrital quartz grains of Carboniferous sandstones: Boehm stripes, plates and deformation belts, crumpled quartz, irrational twinning, blocking, granulation. Two new types of microdeformations were described: translational slip bands and “tabular” quartz. Studies of microdeformations made it possible to develop a plasticity coefficient - Kpl, mm-1 and a damage coefficient - Kd, %. These indicators make it possible to determine the relative degree of tectonic stress in the mountain range.

At the same time, the phenomenon of gas dissolution in minerals with increasing temperature and pressure was described; the appearance of inclusions with geometric shapes. These patterns made it possible to develop a method for determining paleotemperatures in sedimentary rocks without the use of coal. It was found that each grade of coal has its own paleotemperature of formation with a step of approximately 20 degrees of Celsius.

In 1984, the property of substances of different systems to form quasicrystals under the influence of changing thermodynamic, biochemical, physical-mechanical and other conditions was established. The study of this phenomenon made it possible to establish the reasons for the formation of suture and stylolite deformations in various rocks, which is very important when searching for oil and gas fields. Quasicrystals are considered as a transitional form of matter between its crystalline and amorphous states.

The study of thermogasdynamic processes in coal-bearing deposits of Donbass made it possible to describe the complete triune thermogasdynamic process: emission-explosion-ignition and truncated processes: explosion-ignition, emission-ignition. In the sediments of Donbass there are many emissions of coal and gas, as well as coal-hosting sandstones and gas. These problems are

also relevant in other countries with developed coal industries.

Keyword

lithogenesis, paleopressure, paleotemperature, quasicrystals, stylolites

Role of the initial texture of carbonates on dolomitization propagation from 4D Xray tomography

Nicolas E Beaudoin[1]*, Université de Pau et des Pays de l'Adour (nicolas.beaudoin@univ-pau.fr)
Kanchana Kularathne[2], UPPA
Benjamin Lefeuvre[3], UPPA
Fadi Nader[4], IFPEN
Souhail Youssef[5], IFPEN

Abstract

Dolomitization is a mineral replacement phenomenon that occurs in most carbonate platform and in foreland basins. In the latter context, the development of very large dolomite geobodies with a seemingly rather limited magnesium supply from hydrothermal fluids that migrate along and within faults during the orogenic contraction, is a long-term puzzle for the community: the so-called “dolomite problem”. One of the missing pieces of this puzzle is the lack of understanding of the kinetics of dolomitization, especially at low pressure and low temperature. On the experimental field, recent developments enabled the possibility of producing dolomitization from calcite in a controlled environment within a few days to a few weeks. This contribution presents a 4D evolution of the dolomitization fronts obtained from reacting carbonate calcium samples with different initial texture and porosity values. Carrara Marble, Oostones and Chalk were reacted at 200°C, 16 Bar with a Mg-rich, Zn-boosted brine in a closed environment, for 3 days to 3 weeks. The reaction was stopped at different times of the experiment by extracting and drying the sample, in order to scan it by the mean of 3D tomography, before reacting again for another period of time. Repetition of this protocol returns with an unprecedented 4D view of the propagation of the dolomitization front, in a volume where the porosity evolution can be monitored throughout the reaction. Results demonstrate that the initial texture has a primordial role on the replacement propagation speed, with a front penetrated much deeper at a given time in porous Oostones than in Chalk or in tight Marble. This impact is greater even than the availability of Mg in the system, as Mg-rich Calcite do not react faster than pure calcite. Our work validates that the role of chemical gradient is key to initiate and propagate the dolomitization in calcite, and provide new insights on how dolomite geobodies can be that voluminous in nature in spite of limited reactant supply.

Keyword

Dolomitization, fluid-rock interactions, texture, replacement, experiment

Cyclicity related to solar activity in lacustrine organic-rich shales and their significance to shale-oil reservoir formation

Miruo LIN[1]*, China University of Petroleum (East China) (upc_linmiruo@163.com)
Kelai Xi[2], China University of Petroleum (East China)
Yingchang Cao[3], China University of Petroleum (East China)

Abstract

The formation mechanism of micron- to centimeter-scale sedimentary cycles in lacustrine shales is a hot topic of research, because these small-scale sedimentary cycles significantly influence shale-oil distribution heterogeneity. High-frequency paleoenvironmental evolution is an important controlling factor for the formation of small-scale sedimentary cycles. However, the driving factors of high-frequency paleoenvironmental evolution and the formation process of sedimentary cycles under its constraint remain speculative. In this study, which focuses on lacustrine shales, we find that the alternating deposition of variable thickness of organic-rich lamina (ORL) and silty-grained felsic lamina (SSFL) form sedimentary cycles on the micron to centimeter scale in the Chang 73 sub-member of the Yanchang Formation in the Ordos Basin. Based on detailed petrographic characterization, in-situ geochemical parameter testing, and high-resolution cycle analysis, the formation process of cyclical sedimentary records and related paleoenvironmental evolution are investigated. Three solar activity cycles were identified from the shales, namely the 360–500 yr, 81–110 yr, and 30–57 yr cycles (cycles I, II, and III, respectively). High-frequency paleoenvironmental evolution caused by solar activity induced lake-level fluctuation, which further controlled silty-grained sediment deposition and organic matter preservation in deep lake areas. Cycle I controlled relatively long-term lake-level fluctuation, driving several pairs of SSFL and ORL deposition at the centimeter scale. Cycles II and III were short-term cycles and acted on the millimeter to micrometer scale, further complicating the sedimentary strata forming during the period of lake-level fall induced by cycle I. The cyclic deposition of SSFL and ORL correspond to cycle III. Lake-level fluctuation influenced by cycle II mainly caused SSFL thickness variation in each lamina couplet. During the period of lake-level rise induced by cycle I, periods of lake level rise during cycles II, and III show cyclic variation in reducibility, and are not thought to control the supply of coarse-grained sediments in to the deep lake areas. Frequent lake-level fluctuation promotes lamina couplet formation in thickly-bedded shales, which creates favorable conditions for shale-oil accumulation. Oil produced from ORL can migrate-locally into dissolved feldspar porosity in SSFL and therefore is able to accumulate in shales, which creates high potential for future oil exploration in thickly-bedded lacustrine shales.

Keyword

Triassic, lacustrine shales, solar activity, lake-level fluctuation, shale-oil exploration

Paleoenvironmental Conditions of the Huayacocotla Basin, Mexico, During the Late Jurassic: Implications for Mn accumulation

Joseph MADONDO[1]*, Universidad Nacional Autonoma de Mexico (joseph.madondo85@gmail.com)
Eduardo GONZALEZ-PARTIDA[2], Centro de Geociencias, Universidad Nacional Autonoma de Mexico
Carles Canet[3], Instituto de Geofisica, Universidad Nacional Autonoma de Mexico
Fernando Nuñez-Useche[4], Instituto de Geologia, Universidad Nacional Autonoma de Mexico
Augusto Antonio Rodriguez-Diaz[5], Instituto de Geofisica, Universidad Nacional Autonoma de Mexico
Teresa Pi[6], Instituto de Geofisica, Universidad Nacional Autonoma de Mexico
Sumit Mishra[7], Centro de Geociencias, Universidad Nacional Autonoma de Mexico
Genesis Arelly Ramos Garcia[8], Centro de Geociencias, Universidad Nacional Autonoma de Mexico

Abstract

The mechanism by which manganese accumulates in sedimentary Mn carbonate deposits remains debated. Mexico hosts some of the worlds largest black shale hosted Mn deposits in the Molango district of east central Mexico, providing an excellent opportunity to reassess the current models of their genesis. In order to explore the conditions of formation of the Molango manganese deposits, we present an integrated paleoenvironmental reconstruction of the deposits through redox proxies (U/Th and V/Cr) and redox sensitive trace elements (M, U and V), carbon and sulfur isotopes, and organic chemistry (TOC) of manganese carbonate beds of the host Chipoco formation and the underlying black shales of the Santiago Formation in the Huayacocotla Basin, east central Mexico. Our results indicate that Mn (II) was accumulated under anoxic (possibly euxinic) conditions in basin center settings. Euxinia resulted from the inflow of anoxic waters from the Gulf of Mexico and enhanced by restricted water circulation in the basin. Redox conditions as well as the Fe-Mn redox cycling were hydrologically controlled by the episodic ventilation of the bottom waters due to the inflow of seawater from the open ocean. Mn (II) was sourced from both continental and hydrothermal sources and concentrated in the bottom waters due to the operation of a Fe-Mn shuttle across a redox stratified water column. Organic matter degradation led to 12C-enriched dissolved inorganic carbon that was precipitated in Mn carbonates on the basin floor. Mn carbonated deposition occurred during diagenesis via the coupled oxidation of organic matter and reduction of Mn oxides during episodic ventilation of the bottom waters, similar to what occurs in the Baltic Sea. Manganese accumulation in the Huayacocotla Basin was significantly influenced by both local and global environmental factors.

Keyword

Paleoredox, paleohydrography, Euxinia, Mn carbonates, Trace elements

Selective Dolomitization and Its Influence on Reservoir Heterogeneity of the Lower Cambrian Longwangmiao Formation in Sichuan basin, South China

Xuefei YANG[1]*, Southwest Petroleum University (yangxf_swpu@163.com)
Hao TANG[2], Southwest Petroleum University
Chao CHEN[3], Southwest Petroleum University
Xingzhi WANG[4], Southwest Petroleum University

Abstract

Through field observation, thin section identification, cathodoluminescence, scanning electron microscopy observation (SEM observation), and geochemical characteristics analysis, we have conducted a comprehensive study on the selective dolomitization of the Lower Cambrian Longwangmiao Formation and its influence on reservoir heterogeneity in the northeast Sichuan Basin. Results indicate that the Longwangmiao Formation is composed of limestone, mottled dolomitic limestone, and dolomite from top to bottom. The mottled dolomitic limestone primarily consists of dolomicrite and powder crystal dolomite with anhedral to subeuhedral crystal shapes. Under cathodoluminescence (CL), these rocks exhibit dull red luminescence. In contrast, the limestone matrix is composed mainly of micritic limestone and micritic bioclastic limestone, which do not luminesce under CL. The dolomite mottle has a relatively high content of Na, K, and low Sr, Fe, Mn content compared to the limestone matrix. Notably, its Mg2+/Ca2+ ratio is lower, and MgO exhibits a negative correlation with CaO. The rare earth element (REE) characteristics of the dolomite mottle indicate the loss of light rare earth elements (LREEs) and the enrichment of heavy rare earth elements (HREEs), with an obvious negative Ce anomaly. The δ13C and δ18O values of the dolomite mottle are more positive than those of the limestone matrix and exceed the Early Cambrian normal seawater values. Combined with regional sedimentary background, petrology characteristics and geochemical analysis, it can be concluded that dolomitized fluids of mottled dolomitic limestone in Longwangmiao Formation originate from evaporated seawater with medium salinity. During the Late Longwangmiao period, as sea-levels continuously declined, seawater evaporated and concentrated to form medium salinity seawater, which caused the dolomitization during seepage reflux. Due to insufficient sources of dolomitized fluids, selective dolomitization preferentially occurred along biological burrows, leading to the formation of mottled dolomitic limestone. Intercrystalline pores and intercrystalline dissolved pores are developed in the dolomite mottle, leading to significantly higher reservoir porosity compared to dense limestone matrix, which results in enhanced reservoir heterogeneity. Distinct from mottled dolomitic limestone found in the northern Sichuan Basin, mottle dolomite reservoirs in the central Sichuan Basin have been completely dolomitized but exhibit strong reservoir heterogeneity caused by bioturbation. For the burrow, it contains numerous pore spaces that have been filled with bitumen and reflect as black mottle; however, for the dense matrix, there are fewer pores that reflect white mottle. The mottle shape and structure look similar to that of mottle dolomitic limestone found in the northern Sichuan Basin. Therefore, we believe that bioturbation is key to

forming the mottle structure in the Longwangmiao Formation within the Sichuan Basin and is also responsible for causing reservoir heterogeneity.

Keyword

Mottled dolomitic limestone, Selective dolomitization, Reservoir heterogeneity, Cambrian, China

The Main Controlling Factors on the Evolution of the Cambrian Carbonate Platform in the Tarim Basin and Its Implications for the Distribution of Ultra-Deep Dolomite Reservoirs

Kehui Zhang[1]*, China University of Geosciences,Beijing (xjuer@126.com)
Xuelian YOU[2], China University of Geosciences,Beijing
Yifen Wu[3], China University of Geosciences,Beijing
Yijing Zhao[4], China University of Geosciences,Beijing
Jia Wang[5], China University of Geosciences,Beijing

Abstract

Cambrian age strata are the critical development and research stratum series of oil and gas reserves in the Tarim Basin, which contains rich oil and gas resources. The restoration of the Cambrian carbonate platform conversion and the main control factors of development has significant implication for the distribution of ultra-deep dolomite reservoirs. Based on a large number of drilling and outcrop profile data, the micro geomorphic characteristics of carbonate platforms in different periods of the Cambrian period are reconstructed in the western Tarim area, and the basin filling and structure, paleoclimate, sea level change, and seawater redox conditions are combined to analyze the main controlling factors of platform development in different periods and establish the platform evolution model. The characteristics and evolution of the Cambrian Tarim prototype basin are mainly controlled by the break-up of the Rodinia supercontinent, and its tectonic sedimentary pattern has evolved from the north–south differentiation pattern at the end of the Ediacaran to the east-west differentiation pattern of the Cambrian. The sedimentary framework of the Terreneuvian was mainly controlled by the development of paleo-uplift caused by structure and the change of seawater properties caused by the sea level variation. In the Series2 carbonate platform with extensive development, the internal differentiation is controlled by the new paleogeographic pattern of “three uplifts and two depressions”, and reef beach facies belt and platform edge begin to develop due to the lowering of sea level. Under the combined action of rapid accumulation of carbonate rocks, gradual stabilization of global sea level, and the change of ancient climate from warm and humid to hot and dry, the platform environment in the west of the Tarim Basin changed from a restricted platform environment to an evaporation platform environment, and the evaporation lagoon area in Bachu was significantly expanded in the Miaolingian. During the Furongian, the basin ended the evaporation lagoon sedimentary environment mainly due to the rise of sea level and developed a restricted platform environment again.

Keyword

Cambrian, Tarim Basin, carbonate rock, paleogeomorphology, geochemistry

U-Pb geochronology, REE on detrital zircons and clast counting of the Gualanday Group and its tectonic implications for the Eocene - early Oligocene northern Andes paleogeography

María Daniela MUÑOZ-GRANADOS[1]*, Universidade de Coimbra (mdaniela.munozg@gmail.com)
Yamirka Rojas-Agramonte[2], Institut für Geowissenschaften, Christian-Albrechts-Universität zu Kiel, Ludewig-Meyn-Straße 10, Kiel, Germany
Camilo Montes[3], Departamento de Física y Geociencias Uninorte, Km 5 Vía Puerto Colombia, Barranquilla, Colombia.
Robinson Villamil[4], Universidad de Los Andes
Yue Heng Yang[5], Institute of Geology and Geophysics, Chinese Academy of Sciences, No. 19, Beitucheng Western Road, Chaoyang District, 100029, Beijing, P.R.China
Felipe Lamus-Ochoa[6], Departamento de Física y Geociencias Uninorte, Km 5 Vía Puerto Colombia, Barranquilla, Colombia.

Abstract

In the present contribution we report new data on U-Pb detrital zircon geochronology, REE in zircon and zircon typology from the Gualanday Group located in the Upper Magdalena Valley (UMV) intermontane basin. These syntectonic deposits records the unroofing of the Colombian Central Cordillera (CC) and the erosion of paleo-highs of the emerging Eastern Cordillera (EC) in the Eocene - early Oligocene as a result of the oblique collision of the Caribbean Large Igneous Province (CLIP) against the NW margin of South America. This event started in the Late Cretaceous - Paleocene and continued propagating northeast-wards to the middle Miocene.

Clast counting was performed on ten outcrops of the conglomeratic members of the Gualanday Group (Doima and Chicoral Fm.) showcasing a major chert component among all outcrops. This can be explained by the erosion of the paleo-highs in the deforming proto-EC marine sedimentary cover. The uppermost conglomeratic member (Doima Fm.) is the only one with igneous clasts, which highlights a stronger CC provenance, related to the subjacent conglomeratic member (Chicoral Fm). U-Pb detrital zircon Geochronology performed in the samples of the finer-grained conglomerate matrix, together with zircon typology characterization of cathodoluminescence images, suggest that the Precambrian zircons are re-deposited due to their rounded shape, while the other euhedral crystals comes from nearby magmatic sources. The age spectra of sample (810005) from the northernmost Chicoral Fm. indicates late Cretaceous/ late Jurassic provenance with minor Paleozoic components. Furthermore, sample 810004, collected ~60 km southwestwards has Early Cretaceous, late Jurassic and Permian igneous sources, lacking Late Cretaceous ages although it also corresponds to the Chicoral Fm. The southernmost sample (030447) from the Doima Fm. shows mostly early Jurassic and minor components of Late Cretaceous and Permian sources. The presence of Mesozoic and Paleozoic detrital ages suggests a CC provenance of the samples. However, the prevalence of certain peaks indicates an Eocene - early Oligocene proximity of the CC magmatic source, east from the drainage divide to the ancient

locations of the samples. For instance, the northernmost sample should have been closer to the Late Cretaceous source, with a depocenter somehow isolated from the sample located ~60 km southwestwards. Similarly, the southernmost sample had a major early Jurassic source closer that did not feed any of the northern samples.

The major late Cretaceous magmatic source in the CC is the Antioquia Batholith, which is nowadays located ~190 km NNW from the sample 810005 and bounded by dextral strike-slip faults. This might imply an Eocene - late Oligocene southward location of the tectonic blocks containing this pluton, which would have sourced the northern latitudes of the UMV. A paleogeographic model is proposed considering the results of this study and other published provenance work, which highlights mostly northward displacement of tectonic blocks along the SW margin of South America triggered by the continuous propagation of the collision towards higher latitudes.

Keyword

Detrital U-Pb Zircon Geochronology, Provenance analysis, Northern Andes, Caribbean Large Igneous Province (CLIP), Syntectonic deposits

Impact of Abnormal Pressure and Thermal fluid activity on Pore Evolution and Reservior Quality- A Case Study of Sandstone Reservoir from the Paleogene Shallow Marine Gravity flow, Yinggehai Basin, the South China Sea

Jinglan Lan LUO[1]*, Department of Geology, Northwest University, Xi'an, China (jlluo@nwu.edu.cn)
Cheng Zhang[2], Department of Geology, Northwest University, Xi'an, China
Caiwei Fan[3], Zhanjiang Branch of CNOOC Ltd, Zhanjiang, China
Jiangjun Cao[4], Department of Geology, Northwest University, Xi'an, China
Shijiu Wu[5], Zhanjiang Branch of CNOOC Ltd, Zhanjiang, China
Qianru Mao[6], Department of Geology, Northwest University, Xi'an, China

Abstract

Yinggehai Basin is a typical high temperature and high pressure basin in offshore China. In recent years, a series of large gas fields have been discovered in the shallow marine facies canyon channel and submarine fan in Dongfang district and Ledong 10 district, which demonstrate the broad prospect of deep water exploration in this basin.

A case study of normal pressure (pressure coefficient 1.05~1.20), overpressure (pressure coefficient 1.37~2.02) and thermal overpressure reservoir (pressure coefficient 1.74~2.30) of the Miocene Huangliu Formation in Ledong 10 area of Yinggehai Basin was conducted, impact of different pressure backgrounds and thermal fluid activities on reservoir diagenesis, pore evolution and reservoir quality are analyzed, based on identification of cast thin sections under microscope, scanning electron microscope, measurement of image pore throat, capillary pressure, porosity and permeability, inclusion homogenization temperature and analysis of XRD of clay minerals, combined with burial thermal evolution history. The research result shows that the normal pressure reservoir of Huangliu Formation is characterized by strong compaction and cementation, and weak dissolution, average pore loss by compaction and cementation is 22.8% and 9.5%, respectively, average pore increment by dissolution is 4.6%, resulted in the initial porosity of 34.9% to the present 7.2%. Affected mainly by overpressure and hydrocarbon fluids, the overpressure reservoir is of relatively weak compaction, weak dissolution and strong cementation, and experienced three stages of pore evolution. Average pore loss by compaction and cementation is 21.5% and 16.8%, respectively, and average pore increase by dissolution is 6.8%resulted in the initial porosity of 38.8% to the present 7.6%. The diagenetic stage reaches substage A2 of mesodiagenesis.

Deep-seated thermal fluid activity in the study area is dominated by CO2 with a small amount of H2S, mainly influenced the middle and lower parts below 3500m~3900m. Affected both by overpressure and thermal fluid, thermal overpressure reservoir is characterized by accelerated transformation rate of authigenic clay minerals, vitrinite reflectance mutation, reduced formation water salinity, the higher homogenization temperature of inclusions than the normal formation maximum temperature, and with development of hydrothermal mineral assemblage. This kind of reservoir is of relatively strong compaction, strong dissolution and weak cementation, and

experienced pore evolution of four stages. The diagenetic stage of the thermal overpressure reservoir reaches stage B of mesodiagenesis. Average pore loss by compaction and cementation is 23.0% and 13.8%, respectively, and average pore increment by dissolution is 7.7%resulted in the initial porosity of 38.1% to the present 9.2%. The diagenetic stage reaches substage B of mesodiagenesis.

Overpressure and thermal fluid activity have important effects on diagenetic pore evolution and favorable reservoir formation. High-quality reservoirs in the study area tend to develop in the thermal overpressure reservoir of the gravity channel and submarine fan sand body in the middle and lower part of Huangliu Formation.

Keyword

abnormal pressure and thermal fluid activity, diagenetic-pore evolution, reservoir qualit, shallow sea gravity flow sandstone, Yinggehai Basin

Origin of dolomite in the Middle Permian Maokou Formation in eastern Sichuan Basin under the coupling constraints of hydrothermal and karstification

Ling ZHOU[1]*, China University of Petroleum (East China) (jolene20@163.com)
Guangwei Wang[2], China University of Petroleum (East China)
Fang Hao[3], China University of Petroleum (East China)

Abstract

Dolomite reservoirs are significant for deep oil and gas, but the controversial origin of the Maokou dolomite under the complex geological setting restricts hydrocarbon exploration. It is difficult to identify the genesis of dolomite when the reservoir was subjected to multiple diagenetic or tectonic events. This study investigated the middle Permian Maokou Formation of the eastern Sichuan Basin, southwestern China, which has giant natural gas reserves. Petrological and geochemical analyses (e.g., trace elements, δ13C, δ18O, 87Sr/86Sr, and U-Pb dating) were performed on various carbonates to clarify the types of dolomites and their origin of the Maokou dolomites. In addition, combined with the special geological setting in this area affected by karstification and hydrothermal action, the source of dolomitizing fluids, dolomitization time, and the main controlling factors of dolomite distribution were clarified.

Five types of dolomites were found in the Mbr2 of the Maokou Formation in eastern Sichuan Basin, including micrite-crystalline dolomite (Dol-1), fine-crystalline dolomite (Dol-2), medium-crystalline dolomite (Dol-3), medium-coarse crystalline dolomite (Dol-4), and saddle dolomite (Dol-5). The dolomitizing fluids of Dol-1, Dol-2, Dol-3, and Dol-4 types derived from the seawater-like fluids. The Dol-5 type of cement in the fractures and vugs has obvious Eu anomaly, and is mostly associated with quartz and other hydrothermal minerals, indicating that it is hydrothermal-related cements. Dol-2 type is the most common type of dolomite in the study area, with red cathodoluminescence (CL). Dol-1 and Dol-2 types were formed in the dolomitization of seawater restricted by shoal bridges during the penecontemporaneous period. Dol-2 dolomite has lower δ18O values, and higher Mn/Sr ratios than that of Dol-1 dolomite, indicating the recrystallization of dolomite influenced by emeishan large igneous province. Dol-3 type was formed by metasomatism of the silicon-rich fluids replacing parts of dolomites. High ΣREE concentrations and high Mn but low Fe concentrations of Dol-4 type of cements suggest their karstification-related origin.

Dolostones stably distribute along the platform edge and are mainly controlled by sedimentary facies. The dolomitization occurred at the penecontemporaneous stage near the surface or shallow burial stage with ages of 263.1±9.5 Ma and 263.5±18.3 Ma, which is the earliest. Later, the silicon-rich fluids leached from the extrusive basalts by meteoric water replaced parts of dolomites along the contemporaneous faults. Then, the Maokou Formation suffered from widespread karstification at the end of the deposition, resulting in a large number of karst dissolution fractures and vugs, and the precipitation of some Dol-4 types with ages of 259.9±3.9 Ma and 260.5±2.8

Ma, which is consistent with the large-scale karstification at the end of the Maokou Formation. Finally, deep hydrothermal fluids migrated upward through the faults, leading to extended corrosion along the dominant karstification-related fractures and vugs, but also accompanied by the cementation of abundant Dol-5 types, blocky calcite, and quartz cements. The contribution of the tectonic-hydrothermal fluids to the reservoir space is not significant.

Keyword

dolomite, hydrothermal, karstification, Maokou Formation, eastern Sichuan Basin

Controlling factors of tight sandstone reservoirs: A case study of the He 8 reservoir in the Ordos Basin

gaixia xia CUI[1]*, School of Geosciences and Technology, China University of Petroleum (East China) (gaiixiacui95@163.com)
shou yu XU[2], 15253292259
Qin lian Wei[3], 15891449010

Abstract

Tight sandstone gas reservoirs, as a representative of unconventional gas reservoirs, possess significant reserves and abundant oil and gas resources. Consequently, they have become a crucial focus for governments and enterprises in terms of exploration and development. In the Longdong area located in the southwest of the Ordos Basin, a relatively complete set of dense, thick sandstones with multiple layers rich in oil and gas has been continuously deposited due to the sedimentary environment and structural factors. As exploration into tight sandstone oil and gas wells deepens, this area is gradually emerging as a new development replacement zone. This research area conducted experiments such as casting thin sections, scanning electron microscopy, high-pressure mercury injection tests, physical property analysis, etc., to study parameters including reservoir properties, lithology characteristics, and pore structure features. The results revealed that lithic quartz sandstone (61.6%) and lithic sandstone (15.06%) were the main rock types in the He 8 reservoir. The overall grain size was coarse with medium sorting, while intragranular dissolution pores dominated, followed by intergranular pores or crystallographic micro-pores. The thickness range of the storage layer exhibited significant variation along with strong heterogeneity in rock type distribution within it. Reservoir properties are jointly controlled by sedimentary facies and diagenesis processes, where sedimentary facies fundamentally determine reservoir property conditions. Sand body structure plays an important role in reservoir properties, where cutting-type single-sand-body storage exhibits better physical properties than spliced-sand-body storage, while isolated single-sand-body storage is inferior to both. Compaction is the primary reason for densification, whereby water mica serves as the primary factor causing cementation-induced densification, while low-degree dissolution has a limited effect on improving reservoir quality.

Keyword

Tight sandstone, Diagenesis, He 8 reservoir, Ordos Basin

Sedimentary Dynamics and Paleoenvironmental Signatures in the Witbank Coalfield, Main Karoo Basin of South Africa

Lindani Ncube[1]*, UNISA (lindyncube@yahoo.co.uk)
Sonwabile Kidwell Rasmeni[2], UNISA

Abstract

Situated in the northern sector of the Main Karoo Basin, the Witbank Coalfield displays a basin-like configuration extending from Brakpan in the West to Belfast in the East. The northern boundary interfaces with pre-Karoo basement rocks, mainly Waterberg sandstones, while the southern boundary highlights the notable pre-Karoo basement ridge known as the "Smithfield ridge." This basin formed in a shallow cratonic paralic environment, experiencing gradual subsidence during the late Carboniferous to early Permian period. The Main Karoo Basin is recognized as an asymmetric retro arc foreland, abundant in petroleum, originating from the Paleozoic to Early Mesozoic subduction of the Paleo-Pacific Plate beneath the Gondwana Plate. Sedimentary lithologies within the basin, part of the Karoo Supergroup, consist of sandstone sequences reflecting diverse depositional environments, including glacial, deep marine, fluviolacustrine, and aeolian settings. Our study focused on the sediments of the early to late Permian Vryheid Formation in the Ecca Group, a component of the Karoo Supergroup. Employing petrographic methods, we aimed to comprehend the factors influencing Permian sandstone reservoir quality to enhance predictions of porosity and permeability. Contemporary reservoir quality predictions now consider primary sediment supply, depositional environment, detrital bioclast fraction, and the influx of organically derived carbon dioxide. The Vryheid Formation's sedimentary profile comprises primarily arkose and sub-arkosic sandstone lithology. Early diagenesis processes, involving both mechanical and chemical compaction, were identified as pivotal in controlling porosity loss, indicating an incremental increase in compaction strength with burial depth. This is evident in the evolving grain contact manners, transitioning from point contact to long plane contact, concave-convex types, and sutured contacts among neighboring framework grains. Clay minerals like kaolinite, illite, and smectite act as cements or replacement minerals, particularly replacing feldspars. These clays form during early diagenesis, replacing quartz and feldspar through secondary replacement. Some sediments exhibit fine quartz cement and quartz overgrowths, indicating variable current strengths during sedimentation. Silica is locally supplied by pressure solution, dissolution of siliceous minerals, or siliceous skeleton grains. Additionally, silica may be imported from other areas of the basin during episodes of fluid flow related to deep basin mineral dehydration or tectonic activity. The Witbank Coalfield's depositional environment reflects marine influences, especially near the Dwyka continental glaciation, evidenced by marine indicators like tadpole-shaped pyrite. The unique paleoenvironmental context is supported by the nature of source rocks, predominantly granite with high proportions of alkali feldspar. The vertical succession in the Witbank Coalfield unveils stratigraphic complexity, featuring early diagenetic processes such as albitization, feldspar

dissolution, and kaolinite infill. Tectonic processes, including subsidence, faulting, and folding, have played a crucial role in shaping the basin's geometry.

Keyword

Main Karoo Basin, Sandstone, Depotional Environments, Diagenesis, Petrography

Diagenetic alterations induced by lamina-scale mass transfer and the impacts on shale oil reservoir formation in carbonate-rich shale of the Permian Lucaogou Formation, Jimusar Sag

Ke LI[1]*, State Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China) Qingdao (1293759824@qq.com)
Kelai Xi[2], Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China)
Yingchang CAO[3], Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China)
Miruo LIN[4], Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China)

Abstract

Diagenesis plays a crucial role in shale oil reservoir formation. However, complex organic-inorganic interactions result in pore system formation and heterogeneity changes at the centimeter, or even micrometer scale, which controls the evolution of shale oil reservoirs. In this paper, an integrated approach including core observation, thin section observation, cathodoluminescence thin section observation, scanning electron microscope, μ-XRF analysis, electron microprobe analysis, AMICS analysis, LA-ICP-MS analysis, and isotope analysis was used to clarify the laminae combination carbonate-rich shale, diagenetic alterations in different types of shale laminae and the controls on shale oil reservoir formation. According to the lamina combination, the carbonate-rich shale in the Permian Lucaogou Formation can be divided into three types. They are shale consists of dolomitic lamina and terrigenous felsic lamina (Type A shale), shale consists of calcite-rich tufaceous lamina and terrigenous felsic lamina (Type B shale) and shale consists of calcareous lamina and tufaceous lamina (Type C shale). Dolomite cementation is the major diagenesis in terrigenous felsic lamina of Type A shale. The dolomite can be identified as the early stage forming from recrystallization of micrite dolomite, and the late stage precipitate from adjacent dolomitic lamina. In the terrigenous felsic lamina of Type B shale, however, the calcite cementation is the dominated diagenesis, which was sourced from adjacent calcite-rich tufaceous lamina. Also, some feldspar dissolutions occurred in terrigenous felsic lamina during organic matter evolution. For the Type C shale, the main diagenetic alteration is micrite calcite recrystallization in calcareous lamina. The dissolution and precipitation of carbonate minerals between different laminae of carbonate-rich shale reveal that the organic matter evolution significantly influence the diagenetic alterations of inorganic minerals. Particularly, the diagenetic mass transfer and redistribution at the micro-scale in a relatively diagenetic system were confirmed by organic-inorganic interactions in laminated shale. In this process, dissolution pores and recrystallization pores have provided considerable reservoir pores for shale oil.

Keyword

Carbonate-rich shale, Diagenetic alteration, Diagenetic mass transfer, Shale oil reservoir, Jimusar Sag

Different Sedimentation, tectonism, diagenesis of ultra-deep tight sandstone reservoirs and its relationship with reservoir quality: a case study of Dabei Gas field in Kuqa Depression, Tarim Basin

Xiaotong XU[1]*, China University of Petroleum(Beijing) (1473078717@qq.com)
Lianbo Zeng[2], China University of Petroleum(Beijing)

Abstract

Sedimentation is the basis for the development of high-quality reservoir, and tectonism, diagenesis are the key to reforming reservoir quality. Ultra-deep tight sandstone reservoir exhibits extremely low matrix porosity and permeability, strong and complex diagenesis, fracture development, and strong heterogeneity. Under the background of overall densification, reservoirs with relatively good physical properties often develop. In order to understand control factors of reservoir quality and distribution law of high-quality reservoirs, this study focuses on the Lower Cretaceous Bashijiqike Formation in Dabei gas field, Kuqa Depression, Tarim Basin. Using cores, well logging, thin sections, scanning electron microscopy, cathodoluminescence, X-ray diffraction and physical properties, characteristics of petrology, diagenesis and fracture were studied. Then, effects of tectonism and diagenesis on different petrofacies were discussed. Finally, relationships between fracture, petrofacies and sedimentary microfacies were established. Sandstones are mainly lithic arkose. Authigenic minerals mainly include carbonates, anhydrite, authigenic clays, siliceous and albite. Natural fractures are mainly high angle and vertical shear fractures and are mainly filled with carbonates. The matrix is generally characterized by extremely low porosity and permeability and exhibits strong heterogeneity. Natural fractures can enhance matrix permeability by several orders of magnitude. Based on petrological fabric and degree of tectonism and diagenesis, sandstones are divided into ductile-rich sandstone, carbonate-cement sandstone and ductile-lean sandstone. Ductile-rich sandstone is characterized by strong compaction, weak cementation, weak dissolution. Carbonate-cement sandstone exhibits strong cementation, weak compaction, weak dissolution. Both are densification in early diagenetic stage. However, compaction and cementation are two main factors that control the brittleness of sandstones. Under the same differential stress, sandstones with high brittleness are susceptible to fracture. Therefore, ductile-rich sandstone and carbonate-cement sandstone are prone to fracture development, which greatly increases their permeability and becomes effective seepage channels. Ductile-lean sandstone is characterized by medium compaction, weak to medium cementation, strong dissolution. For low degree of compaction and cementation in early diagenesis stage, ductile-lean sandstone can not only preserve primary pores, but also be transformed by acidic fluids in late diagenesis stage. Distribution of different petrofacies is generally controlled by sedimentary microfacies. Ductile-lean sandstone with best physical properties is mainly distributed in the middle-lower part of distributary channel or the middle-upper part of mouth bar. This distribution law will provide guidance for the exploration of ultra-deep high-quality reservoirs.

Keyword

Sedimentary, tectonism, diagenesis, ultra-deep, high-quality reservoir

Differential precipitation mechanism and their effects on the reservoir quality of alkaline diagenetic environment in the tight Middle Jurassic sandstone in the Central Sichuan Basin, SW China

DONG PING TAN[1]*, Tan Dongping (1316212122@qq.com)
YING CHANG CAO[2], 13505325516
JIAN WANG[3], 18366201873

Abstract

The strong heterogeneity of continental tight sandstone reservoir was mainly determined by various types and strength of different cementation during burial process. However, Precipitation mechanism and its impact on reservoir quality of differential cement combination are rarely well understood. The Middle Jurassic Shaximiao Formation is one of the most important tight sandstone gas reservoirs in the Central Sichuan Basin, China. The reservoir heterogeneity of Shaximiao Formation sandstone, which was caused by the differential cement combination, is crucial to reservoir prediction in the Central Sichuan Basin. The diagenesis of these tight sandstones was examined using a variety of petrographic and geochemical techniques, including thin section description, X-ray diffraction (XRD), scanning electron microscopy (SEM), Cathodoluminescence (CL) imaging, electron probe analysis, fluid inclusions and isotopic analysis. Diagenetic minerals in the Shaximiao Formation (J2s) sandstone comprise calcite, laumontite, chlorite and dissolution. The pore space of J2s sandstone mainly comprises primary pores and secondary pores formed after mineral dissolution. The reservoir sandstones can be divided into six types according to different combinations of the laumontite, chlorite and calcite. Authigenic chlorite coating of J2s sandstones occurred via chloritization of smectite during eodiagenesis. Laumontite cements derived from transformation of volcanic rock fragments, were precipitated in a strong alkaline environment with high pH value (9.5–12) and abundant Ca2+, Si4+, Al3+ during eodiagenesis. The δ13C and δ18O isotopic values and petrological characteristics indicate that calcite cement was related to feldspar dissolution and decarboxylation of organic matter. The different cement combinations were determined mainly by the sedimentary facies and subsequent diagenetic environment evolution. Laumontite precipitation needs a stronger alkaline diagenetic environment than that for chlorite and calcite. The early chlorite coating provided sufficient remaining pore-space for pore-filling laumontite and calcite precipitation. The presence of pore-filling laumontite decreased space for calcite precipitation. However, laumontite is more readily soluble than calcite. The different cement combinations have distinct residual pore space combinations meaning that some intervals of rock have sufficient permeability to act as viable reservoir rock whilst other combinations do not.

Keyword

Tight sandstone, Differential cement combination, Differential precipitation mechanism,

Reservoir quality, Sichuan Basin

The coupling relationship between sandstone reservoir densification time and hydrocarbon charging time: A case study of the Yanchang Formation in South Ordos Basin, China

Zhen Wang[1]*, China University of Petroleum, Beijing (wangz_0205@163.com)
LIANBO ZENG[2], China University of Petroleum, Beijing
HONGHAN CHEN[3], China University of Geosciences, Wuhan

Abstract

As the second largest sedimentary basin in China, the Ordos Basin is rich in oil and gas resources. Conventional and unconventional tight oil reservoirs have been developed together, among which the Yanchang Formation of Mesozoic is rich in tight oil resources and has great exploration potential. However, the genesis of tight reservoirs in the Yanchang Formation in the Ordos Basin and its relationship with hydrocarbon charging remains controversial. Taking Chang 8 Members of Yanchang Formation in the south of Ordos Basin as the research object, this study investigated the reservoir diagenesis and accumulation process in the study area, to clarify the cause of reservoir densification and its relationship with the sequence of hydrocarbon charge events in this area. The reservoir diagenetic sequences were established by observing the thin sections with transmitted light, fluorescence, cathodoluminescence and stable oxygen and carbon isotope analysis. It is considered that compaction and carbonate cementation are the main reasons for the densification, porosity and permeability decline of the reservoir. By combing the relationship between reservoir porosity, calcite cement content, and buried depth, it is concluded that when calcite cement content is less than or equal to 7%, sandstone reservoir densification follows the rule of compaction. When the content of calcite cement is greater than 7%, it is considered that the reservoir densification follows the rule of cementation densification. However, due to the lack of valid dating methods, it is impossible to accurately obtain the compaction time. In this study, the coupling relationship between cementation densification time and hydrocarbon charging is mainly discussed. In the context of diagenetic sequences, the reservoir densification history was characterized by oxygen isotope calculation temperature-burial history projection method, laser in-situ U-Pb dating, and porosity evolution curve. The hydrocarbon charging history in the study area was established by using fluid inclusions and microscopic fluorescence spectrum combined with one-dimensional basin modelling. Finally, the Diagenesis-Accumulation-Pore evolution model is established for the Chang 8 Yanchang Formation in the Ordos Basin. The results show that the densification time of calcite cement determined by various methods is 167.4~118.3Ma. Three hydrocarbon charge events occurred in the study area, the first charge event occurred in the early of Early Cretaceous (136.1~124.0 Ma), the second charge event occurred in the middle of Early Cretaceous (121.1~114.0 Ma), and the third charge event occurred in the late of Early Cretaceous (111.8~95.9 Ma), among which the second and third stages are the main accumulation periods. In summary, the reservoir densification in the study area occurred from 167.4 to 118.3 Ma, oil charging began at 136.1 Ma, and the peak time of oil charging began at 121.1 Ma. The

results exhibit the reservoir densification before oil charging, with charging continuing after densification. It reveals, therefore, the coupling relationship between reservoir densification and hydrocarbon charging events, which has important implications for tight reservoir evaluation in the Ordos Basin.

Keyword

Tight sandstone, Diagenesis, Reservoir densification history, Hydrocarbon accumulation, Ordos Basin

Mineral dissolution-precipitation mechanism in ultra-deep clastic rock reservoirs: a case study under the temperature and pressure background of Bashijiqike Formation of Kuqa Depression, Tarim Basin, China

Bing WU[1]*, School of Geosciences, China University of Petroleum (East China)
(b21010048@s.upc.edu.cn)
Jian Wang[2], National Key Laboratory of Deep Oil and Gas
Yingchang Cao[3], National Key Laboratory of Deep Oil and Gas

Abstract

Deep ultra-deep reservoirs, as an important succeed field for future oil and gas resources, have very significant value of research, with 60% of recoverable reserves distributed in clastic rock reservoirs. The clastic rock reservoirs of the Bashjiqike Formation, developed in the Kuqa foreland basin, have experienced both gradually increasing formation temperature and pressure conditions and strong lateral compressive stress during geological history. Under such complex geological conditions, the dissolution-precipitation response of minerals has a significant impact on the quality of reservoir development. We studied the dissolution-precipitation reaction characteristics of quartz (Q2 type surface) under deep formation temperature, pressure, and lateral compressive stress conditions through molecular dynamics simulation experiments. The research results indicate that in alkaline fluid environments, compared to stressed-free condition, silica dissolved under compressive stress conditions can diffuse further in the solution, and after reaction, the amorphous layer formed on the surface of quartz is thicker. Within the amorphous layer, there are multiple quartz species, namely Q3, Q2, Q1, Q0, indicating the existence of a transition zone in the fluid mineral reaction process. It can be called an alteration layer or a transition layer. This layer is at the forefront of mineral dissolution reactions. In the simulated diagenetic environment, the dissolved silica ultimately undergoes re precipitation within the transformation layer. Our research indicates that on the one hand, compressive stress conditions promote the dissolution of quartz, and on the other hand, it indicates that the dissolution-precipitation reaction of quartz occurs within the alteration layer on its surface. The dissolution-precipitation reaction of minerals in deep formation has a significant impact on reservoir quality, and an open diagenetic environment is more conducive to the migration of dissolved substances.

Keyword

ultra-deep reservoirs, Mineral dissolution-precipitation, quartz dissolution, molecular dynamics simulation, lateral compressive stress

Diagenesis and reservoir quality prediction of Jurassic sandstones, central Junggar Basin, NW China

Penghui ZHANG[1]*, Hohai University (zph010@163.com)
Yong Il LEE[2], Seoul National University

Abstract

Recent hydrocarbon exploration realm has been expanded to deep tight oil and gas from the Lower Jurassic sandstone reservoirs in the central Junggar Basin, NW China. These deeply-buried sandstones are overall overpressured with hydrocarbon saturated or bearing, yet they have not been intensively investigated in terms of diagenesis and reservoir quality prediction. The Lower Jurassic sandstones primarily comprise feldspathic litharenites deposited in lacustrine-deltaic environments under warm, humid climatic conditions in a high-paleolatitude continental basin. Progressive burial, with minimal strata uplift, maintained a relatively stable burial-thermal regime, resulting in minor variations in diagenetic modifications such as compaction, cementation by carbonates, quartz and clay minerals, as well as partial dissolution of feldspars and rock fragments. Despite generally similar diagenetic histories, these tight sandstones exhibit considerable variations in pore system development, leading to heterogeneous reservoir quality. Porosity reduction was primarily due to the effect of compaction. In contrast, the development of overpressure, which occurred from the Early Cretaceous onwards, has been recognized to limit extensive chemical compaction and quartz cementation, and it would in turn potentially lead to porosity preservation. Additionally, the partial dissolution can generate secondary porosity as a non-negligible factor associated with porosity maintenance and is more likely concentrated in coarser-grained sandstone intervals. These findings suggest that an integrated consideration of the roles of depositional settings and diagenesis, when linked to burial-thermal history and overpressure evolution conditions, is essential for predicting reservoir quality.

Keyword

Reservoir quality, depositional setting, diagenesis, tight sandstones, Junggar Basin

The Characteristics and Genetic Mechanisms of the Lower Paleozoic Carbonate Reservoirs in South Yellow Sea Basin

Yu ZHENG[1]*, Research Institute of Bohai Oil Field, CNOOC (zhengyu3@cnooc.com.cn)
Bo Yang[2], Research Institute of Bohai Oil Field, CNOOC
Rucai Zhang[3], Research Institute of Bohai Oil Field, CNOOC
Zhen Huang[4], Research Institute of Bohai Oil Field, CNOOC
Xilong Gao[5], Research Institute of Bohai Oil Field, CNOOC

Abstract

Seismic data and drilling data show that carbonate reservoirs are developed in the Lower Paleozoic of the central uplift of the South Yellow Sea Basin. However, the reservoir genesis mechanism is unclear. In order to clarify the reservoir of oil and gas in this area, this study focuses on the reservoir characteristics and genesis.

The results of rock thin section and physical property analysis show that the carbonate reservoirs in the study area are mainly ultra-low pore and ultra-low permeability reservoirs.Among them, the limestone reservoir is mainly fracture type reservoir, and the dolomite reservoir is fracture-pore type reservoir with more developed dissolution pores and intercrystalline pores.On the whole, the physical properties of dolomite reservoirs are better than limestone, and some dolomite reservoirs can reach the II class reservoir evaluation standard.Sedimentary facies analysis shows that the limestone is mainly formed in the open platform sedimentary environment, and the sparry calcite cement is mainly formed between particles, which is the reason why the limestone reservoir is more dense.The dolomite is mainly formed in the evaporation platform sedimentary environment, and some dolomite is formed in the burial stage.The pore formation mechanism of evaporation dolomite is that the fine dolomite crystals form the pore framework, and the gypsum, high magnesium calcite and other soluble minerals formed in the early stage of the pores form mold pores after dissolution.The buried crystal dolomite pore space is mainly residual dissolution pores and intercrystalline pores, and the rapid filling of siliceous material destroys the pore space. The geochemical elements and inclusion analysis show that the siliceous filling mainly occurs in the late diagenetic stage. The homogenization temperature of the inclusions indicates that the formation temperature of the siliceous between the silica dolomite grains is low, and the source of the siliceous is mainly the rapid precipitation of the SiO2 in the formation fluid due to the decrease of the solubility.In addition, the atmospheric freshwater in the supergene stage plays a constructive role in the reconstruction of the reservoir, forming a large number of dissolution pores, and the carbon and oxygen isotope value is low and negative.

In summary, dolomite reservoirs are the main reservoirs in the study area. The uplift of the Indosinian tectonics makes the solubility of the SiO2 in the fluid of the dolomite formation decrease, and the rapid precipitation occurs in the pores, forming a large number of siliceous filling, making the pore space smaller. On the other hand, the dissolution of freshwater plays a constructive role in the reconstruction of the reservoir, forming a large number of dissolution pores, and expanding the pore space of the dolomite.

Keyword

carbonate reservoirs, evaporation dolomite, buried crystal dolomite, siliceous filling, mold pores

Origin of the carbonate cements in the upper Miocene Huangliu Formation in the Ledong Area, Yinggehai Basin, China

xuezhe LI[1]*, 18243502522 (1617568389@qq.com)
Yanzhong Wang[2], 18253266698
Fang Hao[3], 17685561729
Jinqiang Tian[4], 18953282068

Abstract

Carbonate cements are significant cause of porosity and permeability reduction in the clastic rock reseroirs in the Upper Miocene Huangliu Formation in the Ledong Area, Yinggehai Basin, China. We apply petrological, mineralogical and geochemical methods, combined with tectonic evolution, burial history and thermal history to elucidate different carbonate cements origin. The results show that the carbonate cements in the reservoirs of Huangliu Formation in Ledong Area originate from hydrothermal fluids and carbonate minerals of source rocks. And the diapir of Ledong area provides a transportation to the reservoirs, the rock composition of reservoirs makes the difference. In poorly sorted coarse clastic rocks such as coarse sandstone and pebbly sandstone, the reservoir is strongly cemented by calcite, with bright and dark calcite under cathodoluminescence. The carbon isotope of the bright calcite ranges from 2.45‰ to 4.8‰, the oxygen isotope ranges from -7.05‰ to -6.85‰, the fluid inclusions homogeneous temperatures ranges from 154.9 ℃ to 157.9 ℃, and 87Sr/86Sr ranges from 0.70881 to 0.70914. The carbon isotope of dark calcite ranges from 3.15‰ to 4.35‰, oxygen isotope ranges from -6.93‰ to -6.57‰, 87Sr/86Sr ranges from 0.70888 to 0.70912, and the fluid inclusions homogeneous temperature ranges from 139.5 ℃ to 148.1 ℃. Moreover, the two-phase calcite cements have LREE-rich patterns. And the Yb/Ca-Yb/La scatterplot shows two-phase calcite cements originate from hydrothermal fluids. From 9 Ma to 7.8 Ma before present, with the diapiric activity in Ledong Area, the hydrothermal fluid rich in carbon dioxide was formed by pyrolysis of carbonate minerals in the deep strata, mixed with some carbon dioxide from organic acid decarboxylation of source rocks of Meishan Formation and Sanya Formation migrate to reservoirs. The dark and bright calcite cements were successively precipitated in the coarse-clastic reservoirs. In well-sorted fine clastic rocks such as fine sandstone and medium sandstone, the reservoir is porous and develops dark calcite cements under cathodoluminescence and some ferroan calcite. The carbon isotope of dark calcite ranges from -1.71‰ to -0.37‰, the oxygen isotope ranges from -12.2‰ to -8.05‰, the 87Sr/86Sr ranges from 0.70902 to 0.70912, and the fluid inclusions homogeneous temperatures ranges from 151.8 to 169.7 ℃. The dark calcite cements have LREE-rich patterns. And the Yb/Ca-Yb/La scatterplot shows dark calcite cements originate from hydrothermal fluids. From 1.5 Ma to the present, with the reactivation of the diapir of Ledong Area, and the inorganic carbon dioxide produced by the decomposition of inorganic carbonate minerals in the source rocks of Meishan Formation and Sanya Formation was transported along the diapir to the reservoirs, and the dark calcite cements under cathodoluminescence precipitated in the fine-clastic reservoirs.

Keyword

Calcite cement, Origin, Huangliu Formation, Ledong area

Evidence of deep fluid activity in Jurassic tight sandstone reservoirs in the Northern Kuqa Depression

Yifan Zhang[1]*, China University of Petroleum (East China) (zhangyf0215@outlook.com)
Kelai Xi[2], China University of Petroleum (East China)
Yingchang Cao[3], China University of Petroleum (East China)

Abstract

Understanding diagenetic fluid types and their effects on diagenesis is important to identify the main control factors of reservoir characteristics and predict reservoir sweet spots. Reservoir space destruction caused by strong cementation, especially quartz overgrowth and calcite, is notable in the Lower Jurassic Ahe Formation (J1a) sandstones near the deep-rooted fault (Yiqikelike Fault) in the Kuqa depression. Different authigenic minerals and widely varying cementation contents indicate the complexity of diagenetic fluids. Therefore, we investigated strong cementation using petrographic and geochemical methods, including cathodoluminescence, scanning electron microscopy, laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS), and stable isotope analysis. The authigenic quartz cements were mainly in the form of quartz overgrowth, where its outer edge had a regular shape with thickness, and its color was non-luminescent under CL. The calcite was mainly cemented in the primary pores after quartz overgrowth cementation, which mainly exhibited dark orange luminescence under CL. The contents of authigenic quartz and calcite increased as they approached the deep-rooted fault, with maximum concentration of quartz and calcite of up to 8.73% and 8.92%, respectively. Abnormally high homogenization temperatures of the fluid inclusions were observed in the quartz overgrowth, one of which reached 156 ◦C. In calcite, the rare earth element Eu exhibited abnormal characteristics, and the carbon isotopes ranged from -8.00‰ to -2.00‰. Therefore, it is likely that deep fluids are involved in reservoir diagenesis near a deep-rooted fault. This study provides a good example of diagenetic evolution in deep sandstone reservoirs and the negative effects of the involvement of deep fluids in diagenetic processes.

Keyword

Deep fluid, Diagenesis, Authigenic quartz, Calcite, Ahe Formation

Diagenesis and Evolution of lacustrine carbonate reservoir in the Upper part of the Fourth Member of the Shahejie Formation in the Gentle Slope Belt of the Bonan Sub-sag, Jiyang Sub-basin

Jie Yu DU [1]*, 15192559010 (1464639543@qq.com)
Zhong Yan Wang[2], 18253266698
Chang Ying Cao[3], 17685561715
Yuan Kai Yu[4], 18243502469
Ping Shu Wang[5], 18366236887

Abstract

Diagenesis is significant to the research on oil and gas reservoirs. The lacustrine carbonate reservoir in the Upper Part of the Fourth Member of the Paleogene Shahejie Formation (Es4s) in the gentle slope belt of the Bonan Sub-sag in Jiyang Sub-basin has diverse rock types and reservoir spaces, which is one of the most important targets for oil and gas exploration. However, the complex diagenetic types and unclear diagenetic evolution have led to the strong heterogeneity in reservoir and so hard to predict the high-quality reservoir. Comprehensive analysis methods such as the observation of cores and thin sections, LA-ICP-MS, C-O isotope, homogeneous temperature of fluid inclusions were systematically used to investigate the diagenesis and diagenetic evolution of the lacustrine carbonate reservoir in the Es4s. The study area primarily developed granular dolomite, calcarenite, bioclastic limestone and argillaceous limestone. The particles were round to sub-round and the contact relationship between the particles was mainly point-line contact. The storage space were dominated by residual primary intergranular pores and a few intragranular dissolution pores. According to the differences in color under the cathodoluminescence (CL), three kinds of cements could be recognized: earthy yellow calcite cement, dark calcite cement and bright calcite cement, among which the bright one is less found. The earthy yellow calcite cement has obvious "abundant MREE" hat-shaped distribution characteristic and is mainly found in the dolarenite dolomite and algal bonded dolomite with darker color under plane-polarized light. At the same time two kinds of dolomite and the earthy yellow calcite cement have similar C positive feature, so the diagenetic fluid of earthy yellow one may be syn-depositional intergranular water. The C isotope of the dark calcite cement ranges from -0.41‰ to 1.88‰ and the value of bright one is -0.22‰, respectively, having obvious negative C compared with the earthy yellow calcite ranging from 0.28‰ to 2.77‰, indicating the source of C may be complicated and different. Meanwhile, considering the flat REE distribution patterns of two

cements, it's believed that the diagenetic fluid of dark and bright calcite cement is related to the mixture of organic acid and formation water. The positive Eu anomalies with Eu values of 1.32-1.88 *and all* $\delta^{18}O$ *datas range from* -13.98‰ *to* -17.07‰(*obviously small than* -10‰) *of the three stage calcite cements further indicate the influence of hydrothermal fluid. Combined with petrography, microscopic and geochemical characteristics of minerals developed in different diagenetic stages, it's suggested that the diagenetic evolution sequence of lacustrine carbonate reservoir in the* Es_4^s *in the gentle slope belt of the Bonan Sub-sag is as follows: early compaction and pressure dissolution → syngenetic-penecontemporaneous dissolution of particles → earthy yellow calcite cementation → dark calcite cementation → bright calcite cementation.*

Keyword

Diagenesis and Evolution, Lacustrine carbonate reservoir, Lacustrine carbonate reservoir

Origin Mechanism and Favorable Area Prediction of Scale-Type High-Quality Carbonate Reservoirs in the South Yellow Sea Marine Basin, China

Bo YANG[1], CNOOC China Limited,Tianjin Branch
Ying GUO[2]*, CNOOC China Limited,Tianjin Branch (350426124@qq.com)
Xilong GAO[3], CNOOC China Limited,Tianjin Branch
Yu ZHENG[4], CNOOC China Limited,Tianjin Branch
Xiaoling WANG[5], CNOOC China Limited,Tianjin Branch

Abstract

The exploration potential of the Paleozoic marine basin in the South Yellow Sea is enormous, but the origin mechanism of its carbonate reservoirs is complex, and the controlling factors are not yet clear, severely restricting the progress of oil and gas exploration in the region. In this study, based on drilling, field outcrop, petrological, rock geochemical, and seismic data, the origin mechanism of high-quality carbonate reservoirs in the study area was investigated. The results indicate: 1) Ancient climate and environment are the fundamental factors controlling the development of dominant lithology and lithofacies differentiation in the study area. From the late Sinian to the Cambrian, high ancient temperatures and salinity gradually decreased, controlling the development of early-stage dolomite in the Upper Sinian and Lower Cambrian. Additionally, due to higher ancient temperatures in the study area compared to the Upper Yangtze region, conducive to the abundant growth of algae, large-scale reef-flat facies reservoirs developed in both the Upper Sinian and Lower Cambrian, differing significantly from the Lower Cambrian grainy shoal facies reservoirs in the Upper Yangtze region. 2) Ancient sea level fluctuations are the basic conditions controlling the development of multi-level karst reservoirs. Multiple periods and levels of ancient erosion surfaces developed in the Paleozoic in the study area, serving as strong karstification zones. Moreover, a regional-scale regression occurred in the upper part of the Lower Cambrian, providing potential for the development of intra-fracture karst reservoirs. 3) Ancient tectonic activity is a key factor in forming late-stage high-angle effective fractures, thereby improving reservoir quality. Controlled by multiple tectonic movements, four stages of structural fractures developed in the carbonate reservoirs in the study area. Late-stage high-angle fractures formed under extensional stress during the Mid-Late Yanshan and Xishan periods are effective fractures, concentrated in extensional normal fault zones, playing a dominant role in reservoir improvement. Based on the above studies, it is pointed out that the southeastern part of the central uplift and the overlap area of developed extensional faults are favorable areas for high-quality reservoirs.

Keyword

South Yellow Sea, High-Quality Carbonate Reservoirs, Origin Mechanism, Favorable Area Prediction

Characteristics and origin of multistage chlorites in tight sandstone reservoirs of the Upper Jurassic Qigu Formation in Yongjin Area, Junggar Basin, China

Xinyuan HUANG[1]*, China University of Petroleum(East China) (2898306796@qq.com)
Yanzhong Wang[2], China University of Petroleum(East China)
Yingchang Cao[3], China University of Petroleum(East China)
Kai Sheng[4], China University of Petroleum(East China)

Abstract

Chlorite plays a crucial role in petroleum development, and is widely developed in tight sandstone reservoirs of the braided river delta front of the Upper Jurassic Qigu Formation in Yongjin Area, Junggar Basin, China. The chlorite has been analyzed using an integrated approach of petrographic observations and geochemical analyses to systematically study its type, distribution and origin in the study area. Three types of chlorites are developed in the study area: recrystallized chlorite, autogenic chlorite and grain replacive chlorite. Recrystallized chlorite is transformed from the precursor berthierine clay and maintains the characteristics of the precursor clay. It grows in the form of adherent petals parallel to the particle surface. The distribution of recrystallized chlorite is controlled by sediment transport and deposition processes. Following early compaction, alteration of abundant intermediate-basic volcanic rock fragments provided Fe2+ and Mg2+ for chlorite recrystallization. In areas with poorer sandstone sorting, there is a higher concentration of volcaniclastic debris, leading to increased development of recrystallized chlorite. In recrystallized chlorite, Fe=3.73-6.83, Mg=0.97-2.04 (based on 28 oxygen atoms). In comparison, authigenic chlorite has higher Fe and Mg (Fe=6-7.53, Mg=1.21-2.41). Authigenic chlorite is in the form of disorganized flakes with large, well-developed crystals and is often associated with authigenic quartz and analcite. Authigenic chlorite develops only in interdistributary bay adjacent to mudstone formations, with mudstone compaction water providing the source of its material. Mg-rich grain replacive chlorite grows in lithic grains and replaces darker minerals in the lithic grains. The work has shown that chlorite in the oil-wetted state often adsorbs bitumen, inhibiting oil recovery and reducing oil production. Systematic studies of the characteristics and genesis of chlorite can provide important insights into the chlorite research and are applicable to the exploration and development of chlorite-rich tight sandstone reservoirs at the front of the braided river delta.

Keyword

multistage chlorites, Junggar Basin, characteristics, origin

Dolostone Petrology: Unveiling the past through a multi-method thin-section observation

Jino PARK[1]*, Kangwon National University (jinopark@kangwon.ac.kr)
Jongsun HONG[2], Kangwon National University

Abstract

Dolostone (dolomite), comprising almost half of the world's carbonates, presents formidable challenges to geological investigation due to the obliteration of primary sedimentary structures, textures, and fossils during the recrystallization process. This study aims to assess the effectiveness of traditional petrological methods in extracting information from dolostones and advocates for a multi-method thin-section observation approach as the optimal strategy. The instigation focuses on 270 dolostone samples from the upper Cambrian Wagok Formation of Korea, primarily composed of massive dolostone with limited preservation of meso-scale sedimentary structures in the uppermost and lowermost intervals of the formation. Preliminary result on slab observations indicates that around 16% of samples exhibit patchy preservation of meso-scale sedimentary features, which discourages the undertaking of both qualitative and quantitative analyses of carbonate components. Polarized light microscopy reveals partial traces of sedimentary textures in about 13% of thin sections, predominantly showcasing highly crystalline dolomite fabrics. In contrast, visual examination of thin sections using fluorescent plates identifies meso-scale sedimentary structures, including Dunham's classification, in approximately 90% of samples. The 'white card' technique (Folk, 1987) proves valuable in detecting grain compositions and small-scale sedimentary features in about 60% of thin sections. However, this technique is only applied on xenotopic dolomite fabrics rather than idiotopic fabrics or scattered dolomite rhobms of less-dolomitized carbonates because outline of dolomite crystals is emphasized, preventing observation of the original textures. The study underscores the effectiveness of naked eye and 'white card' observations on thin-sections for petrological study of dolostones, emphasizing their complementary nature in elucidating sedimentary information across diverse scales. Consequently, integrating both observation methods maximizes information extraction from massive dolostones.

Keyword

Dolostone, Wagok Formation, Multi-method thin-section observation, Visual examination, White card technique

Stratigraphy and Carbonate Petrology of Permian Thitsipin Formation, Ywa-ngan Township, Myanmar: Implications for Depositional Environment

KYI KYI MAW[1]*, Maubin University (drkyikyimaw65@gmail.com)
KYI KYI MAW[2], Maubin University

Abstract

The research area is situated in Ywa-ngan Township, Shan State (South), eastern Myanmar bounded by 21° 10′ to 21° 15′ and 96° 25′ to 96° 35′. The research emphasizes on carbonate petrology and stratigraphy of Permian Limestone unit to rename formal stratigraphically. They are widely distributed in the eastern and western parts of the area. Petrographically, the rocks of Permian Limestone are classified as bioclastic grainstone, bioclastic wackestone packstone, bioclastic peloidal grainstone, peloidal bioclastic grainstone, bioclastic rudstone and dolomite. Megascopically, it mainly consists of bioclastic limestone, crystalline limestone, micritic limestone, cherty limestone and dolomitic limestone. From XRF analysis, the rocks fall in the fields of limestone, magnesium limestone and dolomitic limestone. Two columnar sections were measured in details. The first section, (Linwe section) is 306m thick, containing at least six microfacies, and second (Hsinsapya section) is 497m thick and consisting of four microfacies. They were grouped into three microfacies associations, representing subtidal, intertidal and supratidal environments. Corals (Ipciphyllum subelegans, Lophophyllidium sp., Pavastehphylum simplex, Pavastehphyllum spongifolium, Iranophyllum sp., Syringopora sp.), Fusulinids (Pseudo fusulina sp., Eoverbeekina sp., Nankinella sp., Rugososchwagerina sp.,? Pseudoschwagerina sp., Kahlerina sp.), Bryozoan (Fenestellina sp. Polypora sp.) and echinoderm indicate that it may be early to middle Permian. The petrographic study, XRF analysis and the stratigraphic criteria in a formal stratigraphic unit point out that the renamed Thitsipin Limestone (Early to Middle Permian) is more suitable than the Thitsipin Limestone Formation (Permian). It was possibly deposited in subtidal, intertidal and supratidal environment with low to high energy condition.

Keyword

Permian, Thitsipin Limestone, Limestone, Microfacies

The Miaolingian Series (Middle Cambrian) in Southern Sweden: Astronomical forcing, biostratigraphy, and carbon isotope geochemistry.

Valentin Jamart[1]*, Institute of Earth Sciences (ISTE), University of Lausanne, CH-1015 Lausanne, Switzerland (vjamart.phd@gmail.com)
Damien Pas[2], Institute of Earth Sciences (ISTE), University of Lausanne, CH-1015 Lausanne, Switzerland
Linda A. Hinnov[3], Atmospheric, Oceanic & Earth Sciences Department, George Mason University, 4400 University Drive Fairfax, Virginia (USA)
Jorge E. Spangenberg[4], Institute of Earth surface Dynamics (IDYST), University of Lausanne, CH-1015 Lausanne, Switzerland
Thierry Adatte[5], Institute of Earth Sciences (ISTE), University of Lausanne, CH-1015 Lausanne, Switzerland
Arne T. Nielsen[6], Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, DK 1350 Kbh K, Denmark
Niels H. Schovsbo[7], Geological Survey of Denmark and Greenland (GEUS), Øster Voldgade 10, DK-1350 Copenhagen K, Denmark
Nicolas R. Thibault[8], Department of Geosciences and Natural Resource Management, University of Copenhagen, Øster Voldgade 10, DK 1350 Kbh K, Denmark
Allison C. Daley[9], Institute of Earth Sciences (ISTE), University of Lausanne, CH-1015 Lausanne, Switzerland

Abstract

Among the fundamental turning points in the history of life, the Cambrian Explosion is of primary interest. Nevertheless, the lack of correlation between exposures, the scarcity of high-precision radioisotope ages, and a generalized endemism have hindered in-depth understanding of the mechanisms that triggered paleoceanographic changes associated with the evolutionary boosts. The Cambrian Explosion time scale can be greatly improved by the identification of Milankovitch-driven climate cycles through cyclostratigraphy.

High-resolution XRF core scanning data of the sedimentary series from the well-preserved Albjära-1 drill core from Scania, Southern Sweden reveals prominent cycles at wavelengths of 0.09, 0.15, 0.5 and 2 m. These wavelengths have similar ratios to the theoretical Cambrian Milankovitch periods and are attributed to the precession (18 kyr), the obliquity (31 kyr), and the short and long orbital eccentricity cycles (100 kyr, 405 kyr). In addition, a prominent cycle at 0.85 m is observed and interpreted as the 173 kyr obliquity modulation. Both the 173 and 405 kyr cycles can be used as “metronomes” (Laskar, 2020). The 173 kyr metronome was selected to build an astronomically calibrated time scale (ATS) for the Miaolingian series. The results allow to evaluate the duration of the trilobite zones Goniagnostus nathorsti (675 kyr), Ptychagnostus punctuosus (1.36 Myr), Ptychagnostus atavus (0.91 Myr), and Ptychagnostus gibbus (812 kyr), the Drumian Stage (2.95 Myr), and the Drumian Carbon Isotope Excursion (DICE) (0.99 to 1.55 Myr). To ensure stratigraphic continuity with Zhao et al.'s (2022) ATS, we incorporated the U-Pb numerical age anchor (486.78±0.53 Ma) below the Cambrian-Ordovician boundary in the

uppermost part of the core.

This updated biostratigraphic framework and δ13Corg profile place the DICE prior to the first appearance of the Wuliuan-Drumian boundary's index taxon P. atavus. This differs from the Wuliuan-Druminan GSSP where the DICE is located above the stage boundary. TOC and δ13Corg profiles combined with our improved biostratigraphy also enable the integration of this research into the Cambrian bio-geochemical framework, which can be used as a reference to calibrate other sections and events.

REFERENCES

Laskar, L. (2020). Chapter 4: Astrochronology, in Gradstein, F.M., Ogg, J.G., Schmitz, M., and Ogg, G., eds, The Geologic Time Scale 2020, Vol. 1, 139-158. https://doi.org/10.1016/B978-0-12-824360-2.00004-8

Zhao, Z., Thibault, N.R., Dahl, T.W., Schovsbo, N.H., Sørensen, A.L., Rasmussen, C.M.Ø., and Nielsen, A.T. (2022). Synchronizing rock clocks in the late Cambrian. Nature Communications, 13, 1-11. https://doi.org/10.1038/s41467-022-29651-4

Keyword

Astronomical cycles, Carbon isotope, Sedimentary geochemistry, Biostratigraphy, DICE

Paleoclimate, provenance and depositional environment of Permo-Triassic sediments of Satpura Gondwana Basin, Madhya Pradesh, India.

Ranjit G. Khangar[1]*, Geological Survey of India (ranjit.khangar@gsi.gov.in)
Manjusha Mahajan[2], Geological Survey of India
Savita Chaupagar[3], Geological Survey of India
Lalit Khasdeo[4], Geological Survey of India
Rashmi Rekha Naik[5], Geological Survey of India

Abstract

The comprehensive study involving Petrography, Grain Size Analysis, Geochemistry, Clay Mineralogy, and Palynology on a significant number of samples from the Permian to Cretaceous age sediments of the Talchir, Barakar, Motur, Bijori, Pachmari, Denwa, Bagra, and Jabalpur formations in the Satpura Gondwana Basin aims to unravel the paleoclimate, provenance, and depositional environment. This multifaceted investigation employs a detailed analysis of 90 samples each for Petrography and Grain Size, 150 samples for Geochemistry, 91 samples for Clay Mineralogy, and 144 samples for Palynology. QFR plot suggests that sediments of Jabalpur, Denwa and Pachmari deposited in hot, humid climates and Motur, Bijori and Barakar deposited in semi-arid to warm, humid climates. Bagra and Talchir deposited in semiarid to sub-humid climates. Weathering was intense during the deposition of Upper Gondwana as compared to Lower Gondwana sediments. Grain size analysis reveals that sediments of the western & eastern parts of the basin are medium-grained, moderately to poorly sorted, platykurtic to very leptokurtic nature except Jabalpur, Denwa and Talchir formations are fine-grained, well sorted. Chondrite normalized REE pattern of the majority of mudstone samples of all formations display a high LREE/HREE ratio and correlate with relatively felsic provenance of Upper continental crust and matches with granite gneisses supported by Th/U & Th/Co ratio. The high ratios of Th/Sc and Zr/Sc Indicate input of materials from recycled sedimentary provenance in some of the mudstone samples. The trivariate plots of La-Th-Sc, Th-Sc-Zr/10, and Th-Co-Zr/10 suggest passive & active continental margin tectonic settings. However, few samples are falling in the island arc setting. Total REE >210 for all formations of Satpura basin indicates Passive margin (PM) and Eu/Eu*= 0.64 to 0.69 suggests Aden-type continental margin (ATCM) as tectonic setting. The presence of illite and chlorite as inherited minerals from the Talchir Formation suggests a cold and dry climate, presence of Kaolinite suggests a warm and humid climate for Barakar Formation, a warm and humid climate with intermittent spells of arid climate during the deposition of the Motur Formation and a warm and humid as well as warm to arid climate during the deposition of the Bijori Formation. Pachmari Formation is deposited in warm and humid with few semiarid to arid intervals. Studies suggest warm and humid climates prevailed for the lower arenaceous part and hot, semiarid for the upper muddy part of the Denwa Formation. The warm and humid climate was prevalent with semiarid intervals during the sedimentation of the Bagra Formation, while Kaolinite as a major mineral strongly suggests warm and humid paleoclimate during the deposition of the Jabalpur Formation. The palynological study suggests that rich and diversified

vegetation during the deposition of the sediments and the Permo-Triassic boundary is straddling in between the Bijori and Pachmari formations in the area indicating a near correlation of lithostratigraphy and biostratigraphy of the basin with exception of Jabalpur formation due to insufficient palynological evidence. The recovery of glomus from all the formations indicates mainly freshwater input suggesting a riverine depositional environment for the Gondwana sediments.

Keyword

Premo- Triassic, Satpura basin, Gondwana sediments, Paleoclimate, Depositional environment

Detrital zircon geochronology of the basal Taebaek Group: Implications for regional scale provenance dynamics during the initial stage of the North China Platform

Donghyeok KANG[1]*, Seoul National University (aceray1248@snu.ac.kr)
Jusun Woo[2], Seoul National University

Abstract

High-frequency detrital zircon U-Pb data can provide detailed information on how sediment sources and dispersal systems evolved over the stages of the platform development. Regional scale provenance analysis is conducted from the basal Cambrian Taebaek Group, Taebaeksan Basin in the eastern margin of the North China Platform by revealing spatial and stratigraphic variability of the detrital zircon ages. Sediments forming basal coarse-grained units were largely fed from proximal basement rocks. However, as transgression proceeded, sediment sources for the basal units were submerged and buried, resulting in the upland shift of sediment provenance and the influx of sediments from the outboard arc complex. With the ensuing base-level rise, fine-grained sediments from the Gondwana mainland or elsewhere within the Sino-Korean Craton rapidly replaced in-situ sediments in the low gradient western/southern part of the basin resulting in abrupt change in detrital zircon patterns up the sequence. However, detrital zircon populations in the northern/eastern part of the basin, closer to the highland, exhibit consistent local basement signature, even in the fine-grained succession. The variations in detrital zircon patterns likely resulted from complex interplays of changes in topographic conditions and global marine transgression. These together with stratigraphic and sedimentological data, would likely lead to a better understanding of the early-stage basin-filling history of the Taebaeksan Basin and a more comprehensive reconstruction of the entire platform.

Keyword

Detrital zircon, Provenance, Cambrian transgression, Taebaek Group, North China Platform

Integrated Ichnological, Sedimentological and Geochemical Studies of the Cambrian Kunzam La Formation from Tidong Valley (Kinnaur), Himachal Himalaya: reconstructing the Northern Margin of the Indian Plate

Ranveer Singh Negi[1]*, Birbal Sahni Institute of Palaeosciences (negiranveer@bsip.res.in)

Abstract

The Northern margin of Eastern Gondwana, well-preserved in the sedimentary rocks of Tethyan Himalaya (TH) in North India, exhibits distinct signatures of sequential magmatic events and crustal growth history spanning Precambrian to Cambrian times. While extensive research has been conducted in the Zanskar-Spiti region regarding this time frame, the neighbouring Kinnaur-Kumaon region in the NW Tethyan Himalaya still needs to be explored, representing a significant missing link. Our study aims to address this gap by focusing on the Tidong Valley in Kinnaur. We investigate the Kunzam La Formation from the Cambrian period, employing an integrated approach combining ichnological, sedimentological, and geochemical analyses. Ichnological analyses reveal the presence of the *Psammichnites gigas gigas* ichnozone immediately beneath the Thango (Ordovician) sedimentary layers. Correlating these findings with the adjacent Zanskar-Spiti region suggests a tentative Cambrian Series 2, Stage 4 age for these deposits. The trace fossil assemblages include ichnospecies of *Bergaueria*, *Monocraterion*, and *Psammichnites*, alongside arthropod scratch marks. Notably, no body fossils have been recovered thus far. Sedimentological analysis identifies five distinct lithofacies within the studied area: (i) a prevalent low-angle trough cross-bedded facies with rip-up mud clasts, (ii) wavy (tabular) bedded sandstone facies, (iii) conglomerate facies, (iv) sandstone-siltstone-shale facies, and (v) bedded siltstone facies. Despite the absence of cyclic sedimentation, there is a discernible trend of shoaling upward across the lithofacies succession. Notably, facies commonly associated with offshore environments, such as hummocky cross-stratification and dark shale, which typically harbour abundant trilobite and brachiopod faunal elements in Zanskar-Spiti regions, are conspicuously lacking in the Tidong Valley. The geochemical composition including Rare Earth Elements (La, Ce, Pr, Nd, Sm, Eu, Gd, Tb, Dy, Ho, Er, Tm, Yb, Lu) and selected Trace Elements (Sc, V, Co, Ni, Cu, Zn, Ga, Rb, Sr, Y, Zr, Nb, Mo, Cs, Ba, Hf, Ta, Pb, Th, U), obtained from the Kunzam La clastic sediments, was analyzed using a range of analytical tools. These analyses suggest a mixed provenance of major felsic (UCC compositions) nature with minor contributions from basic sources (HFSE-depleted mantle) in continental island arc-type settings located south of the deposition site. Overall, the analyses corroborate each other, suggesting that the Kunzam La Formation in the Tidong Valley was deposited in a shallow-marine, nearshore to upper shoreface environment, proximal to the shoreline where a main river system met the northern margin of the Indian plate during the Cambrian period. The paleoredox condition was highly oxidizing, paleosalinity low, and paleoclimatic conditions were warm and humid during the sediment deposition.

Keyword

Cambrian, Himalaya, Trace Fossils, Kinnaur, Trace Elements & REE

Sedimentological and Geochemical Characterization of the Early Cambrian Eastern Yunnan, SW China

Xiaoxia PENG[1]*, Department of Geology, Northwest University, Xi'an, CHINA
(pengxiaoxia2019@126.com)
Xin Cheng[2], Department of Geology, Northwest University, Xi'an, CHINA
Zexing Fang[3], Department of Geology, Northwest University, Xi'an, CHINA

Abstract

Interpretation of bulk sediment geochemistry is one of several approaches for determining sediment provenance, depositional environment, and paleoclimate. This study investigates the value added by bulk sediment geochemical analysis and sedimentology characteristics in interpreting depositional environment in a passive margin clastic basin, the Lower Cambrian shallow shelf sediments of the Yangtze Basin, eastern Yunnan, SW China. The study utilized field outcrops, thin section analysis, major and trace element to investigate the sedimentary environment, provenance, paleoweathering and paleoclimate of the Lower Cambrian Hongjingshao (HJS) Formation (Cambrian Stage 3,~515Ma). The HJS sandstones is composed of 10 lithofacies, including massive and crudely bedded gravel supported by coarse sandstone (Gm), trough cross-bedded sandstone (St), planar cross-bedded sandstone (Sp), ripple cross laminated sandstone (Sr), horizontal bedded sandstone (Sh), scour-fill sandstone (Se), massive sandstone (Sm), fine to medium sandstone with thin bed muddy siltstone (Fl), muddy siltstone (Fsc), and mudstone (Fm). On the basis of these lithofacies, channel fill and over-bank deposits in delta and shallow shelf depositional environment is suggested for HJS Formation. The bivariate diagrams comparing Cr and V ratios with Y and Ni ratios, La and Yb ratios with total REE contents, and La and Th ratios with Hf suggest that the sandstones of the HJS Formation were derived from felsic source rocks in the study area. CIA, PIA and CIW values range from 71.29 to 93.72 indicating an intermediate to intense chemical weathering and a semiarid to humid climate conditions in Cambrian Stage 3.

Keyword

lithofacies, geochemistry, Paleoenvironments, Cambrian Stage 3, Yangtze Basin

Spatial variation in carbonate carbon isotopes during the Cambrian SPICE event across the eastern North China Platform

ZHAOPENG WANG[1]*, Shandong University of Science and Technology (zpwang@sdust.edu.cn)
CHEN JITAO[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The Cambrian SPICE (Steptoean Positive Carbon Isotope Excursion) event is widely reported from the late Miaolingian to the early Furongian, but recent studies imply that the synchroneity and magnitude of the SPICE may be controversial. In order to test the spatial variation of the SPICE, here we present 367 carbonate δ 13 C data from six outcrop sections across a ~700 km transect along the eastern North China Platform. The SPICE is present in all the studied sections, but showing different features regarding the duration and magnitude. An abrupt increase in δ 13 C from ~1.5‰ to 3.5‰ occurs in three Shandong sections, with maximum value present only in a thin (0.5–1.2 m thick) transgressive lag deposit (crudely wave stratified, bioclastic grainstone). In contrast, the δ 13 C record of the Baijiashan and Shashan sections in the Liaoning region displays a gradual increase (~20 m thick) from ~1.5‰ to the maximum value of 4.7‰. Both facies analysis and trilobite collections suggest that the spatial variation of the SPICE in the North China Platform most likely resulted from missing of sedimentary record (with high δ 13 C values) in the Shandong sections as a result of erosion and non-deposition during sea-level lowstand, a possible coeval hiatus prior to the Sauk III transgression in the Laurentian basins. Further high-resolution, integrated studies of sedimentology, biostratigraphy, and sedimentary geochemistry on the SPICE event are required to better understand its nature.

Keyword

SPICE, Miaolingian, Furongian, Transgressive lag deposits

A dendrolite reef in a Cambrian siliciclastic environment, Sesong Formation, Taebaeksan Basin

Jusun WOO[1]*, Seoul National University (jusunwoo@snu.ac.kr)
Sojeong Kim[2], Korea Institute of Ocean Science and Technology

Abstract

In the Korean Peninsula, microbialites, rocks formed by microbial organisms, occur in the sedimentary rocks age from the Neoproterozoic to the Cretaceous. The Joseon Supergroup in the Taebaeksan Basin is a early Paleozoic mixed siliciclastic-carbonate succession deposited in a shallow marine carbonate platform. Microbialites have reported from the carbonate succession of the Joseon Supergroup: the Myobong, Daegi, Hwajeol, Dumugol, Makgol, Duwibong formations.
The Sesong Formation is one of the siliciclastic succession comprising the Joseon Supergroup between the Daegi and Hwajeol formations. The formation has two lithologic divisions of shaley lower part (nodule bearing shale dominant) and sandy upper part (fine-to medium-grained sandstone dominant). The upper part can be subdivided into three intervals according to the grain size of the sandstone and bioturbation intensity. Interval 1, the lowermost interval, is composed mainly of fine grained sandstone with high bioturbation intensity (BI 2-5). Interval 2, is characterized by increased portion of medium grained sandstone and waning of bioturbation index (BI 1-3). The uppermost interval 3 consists of fine- to medium grained sandstone representing weak to moderate bioturbation (BI 1-4).
We report the discovery of dendrolite reef structures from the middle of the Sesong Formation. The outcrop is located on the road cut of road 31 near the Taebaeksan motel. The reef overlies the chaotic conglomerate with sandstone matrix and underlies moderately bioturbated fine- to medium grained sandstone. The exposed width and height of the reef structure are cm and cm, respectively. Continuity is poor and distribution of it is limited only in the limestone conglomerate that intercalates within the sandstone. The dendrolite reef is comprised of upward branching, downward tapering shaped dendroids and bioclastic limestone conglomerate matrices. Further studies, on the microscopic structures, comparison with other dendrolites, and paleogeographic occurrence, will improve not only the understanding about the depositional environment of the Sesong Formation, but also the origin and development of microbialites and their influence on the geological records at that time.

Keyword

Cambrian, dendrolite, Taebaeksan Basin, Sesong Formation, microbialites

Floating astronomical time scale from the Upper Yangtze Region of South China suggests rapid paleoevnironmental variations during the Hirnantian glaciation

Hanyu ZHU[1]*, Department of Geology, School of Earth and Space Sciences, Peking University (hyzhu@pku.edu.cn)
Mingsong Li[2], Key Laboratory of Orogenic Belts and Crustal Evolution, MOE, School of Earth and Space Sciences, Peking University
Junpeng Zhang[3], State Key Laboratory of Palaeobiology and Stratigraphy, Center for Excellence in Life and Paleoenvironment, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The Hirnantian glaciation during the transition from the Late Ordovician to the Early Silurian witnessed a set of critical paleoenvironmental events, especially the Late Ordovician Mass Extinction (LOME). Though the preliminary framework of the Hirnantian Age has been established, however, the detailed time scale of the Hirnantian Stage remained uncertain. The uncertainty of the chronostratigraphy was primarily attributed to the scarcity of precise radiometric dating results. A floating astronomical time scale (FATS) constructed using cyclostratigraphy can provide independent estimation on the time span of geological events. High-resolution abundance data from X-ray fluorescence core scanning (XRF-CS) of the specific drill cores recording the paleoenvironmental signals around the Hirnantian from the Yiwan-1 (YW-1) Well and Shuanghe-1 (SH-1) Well in the Upper Yangtze Region has been correlated to the current stratigraphic framework. We analyzed and processed the two data sets with modern methodologies. We identified the existence and stability of the 405,000 years (405 kyr) long eccentricity quasiperiodic cycles in multiple sedimentary signal channels of the two XRF-CS data sets through novel statistical testing methods. Besides, we built a regionally consensual FATS from the 405 kyr long eccentricity signal in the YW-1 drill cores with new tools including dynamic filtering and aligned tuning. Our new astrochronological estimation suggested a shorter duration for the Hirnantian glaciation and more rapid variations of the paleoenvironment processes. Our findings underscored the necessity to reevaluate the current chronostratigraphic framework of the Hirnantian Stage and the demand to examine the hypotheses on the mechanism of the paleoenvironmental changes during the Hirnantian glaciation.

Keyword

Hirnantian glaciation, cyclostratigraphy, floating astronomical time scale, astrochronology, Hirnantian Stage

Provenance changes of the lower–middle Cambrian successions in the Taebaek Group, Korea: Environmental controls on source rock changes

Hyojong LEE[1]*, Korea Institute of Geoscience and Mineral Resources (hyojonglee@kigam.re.kr)
Min-Kyu OH[2], Chungnam National University
Taejin CHOI[3], Korea National University of Education
Jeong-Hyun LEE[4], Chungnam National University

Abstract

The Myeonsan and Myobong formations (lower–middle Cambrian) from the eastern Sino-Korean Block were deposited in terrestrial–nearshore to tide-dominated marine environments during a second-order transgression. Analyses of detrital zircon (4 samples) and whole-rock geochemistry (25 samples) from these successions (ca 120 m thick) at the Sangdong section demonstrate the influence of depositional environments and sea-level changes over changes in provenance. Detrital zircon analyses reveal three major source rock ages: Cambrian (ca. 520 Ma), Meso–Neoproterozoic (ca. 600–1600 Ma), and Paleoproterozoic (ca. 1800–2600 Ma), which indicate a hypothetical syndepositional volcanic arc, Gondwana, and Sino-Korean sources respectively. Among the four samples collected from the bottom to the top of the succession, the lower two (at 1 and 23 m) are characterized by Cambrian and Paleoproterozoic ages, while the upper two (at 81 and 112 m) show dominant Meso–Neoproterozoic with subordinate Cambrian ages. Whole-rock geochemistry analyses show an abrupt transition from mafic to felsic composition at ca. 60 m above the basement. This provenance change can be correlated to changes in the depositional environment. The Myeonsan and lower Myobong formations were deposited in tidally influenced estuary and intertidal environments, where sediments would have been derived from the volcanic arc by tidal currents as well as by fluvial input from nearby basement rocks (Sino-Korean Block). The transition from mafic to felsic composition occurs in the middle of a thick shallow subtidal succession, coinciding with a supposed shift from deepening to shallowing. The sediments in the upper Myobong Formation (shallow subtidal to shoal) possibly reflect stronger effects of coastal currents and/or a shift in the sediment routing system in the source area, resulting in increased input from distant felsic rocks (Gondwana), supplemented by sediment input from the volcanic arc via tidal currents. The results of this study underscore the importance of depositional environments and sea-level changes in provenance studies, cautioning that careful interpretation is necessary to understand their paleogeographic implications.

Keyword

Provenance, Taebaek Group, Cambrian, Detrital zircon, Geochemistry

Recycling of the Appalachian Signature in DZ U-Pb Records of Phanerozoic North America and Barriers to Transcontinental Sediment Transfer

Isaac ALLRED[1]*, Brigham Young University-Idaho (allredi@byui.edu)

Abstract

The detrital zircon (DZ) U-Pb signature of the Appalachian-Ouachita orogenic system is dominated by Grenville (ca. 1250–950 Ma) and Appalachian (ca. 500–275 Ma) age groups and dominates the Phanerozoic record of North America. This study compares Pennsylvanian to modern DZ U-Pb data from across North America and demonstrates a persistent Appalachian signature, including a recycled Appalachian signature across western North America. Lower Pennsylvanian deposits proximal to the Appalachian orogen are 50–75 % Appalachian- and Grenville-age DZ, representing the key component in the primary Appalachian signature. It remains unclear how the Appalachian signal was propagated to the West, but Pennsylvanian Jackfork Group and other Ouachita Basin deposits represent a depositional sink and a barrier to transcontinental sediment transfer. Instead, Appalachian-age DZ in Carboniferous western Laurentian strata may have been derived from the northern Appalachians in the United States and Canada or the Ellesmerian orogen.

Triassic DZ samples document transcontinental fluvial systems with headwaters in the Ouachita-Marathon orogen that reached the western Laurentian margin. Subsequent Jurassic-Cretaceous samples, however, indicate drainage reversal due to the rise of the Mesozoic Western Cordillera. A persistent Appalachian signature exists in these western-sourced, eastward-flowing systems—a phenomenon that continues to the present. Samples are frequently composed of >40% Appalachian- and Grenville-age DZ. However, none of these systems are interpreted to be sourced by primary Appalachian or Grenville terranes, suggesting a recycled Appalachian signature. The persistent Appalachian signature, originally sourced by the linking of two orogenic terranes, continues to be the dominant contributor in the DZ record of North America.

Keyword

detrital zircon recycling, provenance analysis, North America, Late Paleozoic/Mesozoic, Appalachian signature

Depositional environments of the Dongjeom Formation (upper Cambrian to lower Ordovician) in the Taebaeksan Basin in North China Platform: spatial heterogeneity of facies in wave-dominated shallow marine environments

Seungbeom AHN[1]*, Seoul National University (sksm1357@snu.ac.kr)
Jusun Woo[2], Seoul National University

Abstract

The Dongjeom Formation is a thick sandstone unit intercalated within carbonate-dominated formations in the Taebaeksan Basin located in the easternmost part of the North China Platform. In order to understand stratigraphic and tectonic implications of the sandstone unit in between carbonate units, a detailed field mapping and sedimentologic investigation were conducted in seven sections which represent 30-km-wide exposure of the formation in the southern part. The Dongjeom Formation was deposited under wave-dominated shallow marine environments represented by four facies associations: FA1 (offshore transition zone), FA2 (lower shoreface), FA3 (middle to upper shoreface), and FA4 (mid ramp). FA1 is characterized by limestone and very fine sandstone couplet and laminated very fine sandstone with intercalating limestone conglomerate. FA2 comprises alternating bioturbated fine sandstone and low-angle cross-laminated fine sandstone. FA3 exhibits well-sorted and rounded massive medium sandstone or calcareous cross-bedded coarse sandstone. FA4 is composed of limestone shale couplet with intercalating limestone conglomerate. Two facies successions (FS1, FS2) are defined by those showing coarsening-upward trends with sharp upper boundary contact interpreted as each regressive deposition ended up by a transgression event. Facies associations in FS1 are spatially well correlated, but FA3 in the upper part varies in thickness in the sections and is not shown in the western part. Siliciclastic shelf facies are completely changed into carbonate ramp facies (FA4) at the uppermost part of FS2, except for a lens of sandy coarsening upward succession occurring in the eastern part. This discontinuous distribution of facies in shallow marine environments deviates from the standard linear facies belt of a wave-dominated environment. The heterogeneous facies development is inferred to be due to local differences in sedimentation rates. Understanding the origin of the coarse siliciclastic sediments is important for reconstructing paleogeography and tectonic settings.

Keyword

Heterogeneous facies development, Offshore transition zone, Lower shoreface, Middle to upper shoreface, Mid ramp

Preliminary study of spatiotemporal variability of sandstone compositions for early Paleozoic sandstones in the Bowers Terrane, northern Victoria Land, Antarctica

HONGWOO KIM[1]*, Seoul National University (asd1641@snu.ac.kr)
JUSUN WOO[2], Seoul National University

Abstract

The Bowers Terrane, located in northern Victoria Land, Antarctica, is represented by early Paleozoic sedimentary rocks, the Bowers Supergroup which consists of the Sledgers, the Mariner, and the Leap Year groups in ascending order. These successions record the depositional history of the eastern Gondwana margin in the early Paleozoic and serve as a significant puzzle piece in interpreting tectonic events in the Gondwana and surrounding landmasses. In this study, we analyzed the sandstone composition of the Bowers Supergroup using point-counting methods to visualize spatiotemporal variability on the QFL triangular diagrams. The Molar Formation (Sledgers Group) at Reilly Ridge, consistent with previous studies, shows a transitional continental to recycled orogenic composition. The Spurs Formation (Mariner Group) at Reilly Ridge and Eureka Spurs has a recycled orogenic to transitional arc composition. This is similar to the known composition of the Molar Formation, which means the source area didn't change dramatically. However, in Eureka Spurs, south of Reilly Ridge, a more mature composition is observed and leading up to Eureka Formation (Mariner Group). The South End Member (Mariner Group) overlying the Spurs Formation at Reilly Ridge represents recycled orogenic composition with higher matureness than the Spurs Formation at Reilly Ridge, but lower than the Spurs Formation at Eureka Spurs. The sandstone clast composition of this member interestingly resembles the sandstone clast of the Carryer Conglomerate (northern Victoria Land) and Lockett/Dead Goat Conglomerate (New Zealand), but differs from the sandstone clasts of the Douglas Conglomerate (central Transantarctic Mountains), all of which were considered to be located in the eastern margin of Gondwana during the early Paleozoic. The Reilly Conglomerate (Leap Year Group) at Reilly Ridge shows a recycled orogenic composition. Camp Ridge Quartzite (Leap Year Group) represents craton interior composition at Leitch Massif and recycled orogenic at Eureka Spurs. Considering good sorting and roundness of Camp Ridge Quartzite at Leitch Massif, the composition is thought that the influence of depositional mechanism played a significant role, such as differential reworking, rather than changes in the source province. Spatiotemporal variability of sandstone clast composition could provide a better understanding of the source area of the sandstone and deposition processes in the Bowers Terrane.

Keyword

Point-counting, Sandstone composition, Bowers Terrane

Provenance of Detrital Zircons in Zealandia: Implications of a Musgrave Province Source and Potential Link to the MAPCIS Impact"

Daniel Patrick CONNELLY[1]*, MAPCIS Research Project 4815 Covered Bridge Rd. Millville, NJ 08332 USA (danielconnelly@comcast.net)

Abstract

Detrital zircons offer insights into the geological history and tectonic evolution of sedimentary basins. This presentation reviews the detrital zircons from studies of Zealandia a submerged continental in the southwestern Pacific Ocean, with a focus on their suspected provenance from the Musgrave Province in central Australia. The results reveal a dominant population of detrital zircons with age peaks corresponding to the Mesoproterozoic and Neoproterozoic eras, characteristic of the Musgrave Province. These findings suggest a significant sediment input from the Musgrave region to Zealandia during the late Proterozoic to early Paleozoic. The findings also suggest a unique method of rapid long distance transport preserving many euhedral zircon crystals.

The MAPCIS impact, which stands for the Massive Australian Precambrian-Cambrian Impact Structure, refers to a large impact structure formed by an asteroid or comet at the end of the Neoproterozoic in the Musgrave Province of Central Australia during the time it was a shallow sea known as the Centralian Superbasin. Detrital zircons found in Zealandia with a Musgrave provenance could potentially be linked to the MAPCIS impact through the transport of zircon-bearing sediments. The impact event would have generated enormous amounts of energy, leading to the ejection and redistribution of material over vast distances. Zircon grains from the Musgrave Province could have been transported to Zealandia as part of the sedimentary fallout from the impact, thus providing a chronological link between the two regions.

Further research, including detailed sedimentological and geochemical analyses, would be needed to establish a more definitive connection between detrital zircons, the Musgrave Province, and the MAPCIS impact in the context of Zealandia's geological history.

Keyword

Impact, ejecta, zircon, Zealandia, Cambrian

Unveiling the geological significance of the Northern Gondwana glaciofluvial deposit: A geochemical approach by coupling rare-earth element and trace element geochemistry

Adhipa Herlambang Pamularso[1]*, KFUPM (adhipa.herlambang@kfupm.edu.sa)
Ardiansyah Ibnu Koeshidayatullah[2], KFUPM
Khalid Abdussamad Hassan Al-Ramadan[3], KFUPM

Abstract

The Sarah Formation represents a glaciofluvial sedimentary deposit formed during the end of the Ordovician ice age along the Gondwana Margin, and this period of glaciation initiated the carving of valleys and the formation of extensive paleo valleys. Stretching from westernmost North Africa to the Arabian Peninsula, the Sarah Formation is part of a discontinuous belt of outcrop deposits. Notably, it serves as a potential tight gas sandstone reservoir in the Rub' al Khali Basin and other basins in Saudi Arabia. However, despite its significance, global studies on the geochemical data, depositional settings, and spatial distribution of the Late Ordovician glaciofluvial sedimentary formation remain sparse. To address this gap, our study aims to unravel the provenance and tectonic settings of this formation using geochemical records. In this study, we conducted inductively coupled plasma mass spectrometry (ICP-MS) analysis on samples collected from six outcrops in two paleo valleys of the Sarah Formation in NW Saudi Arabia. By analyzing the composition of major, trace, and normalized rare earth elements (REEs) in conjunction with detailed stratigraphic measurements, we aimed to understand the provenance, paleoenvironment, and tectonic settings associated with the glacial events. Our results were compared with previous studies on Late Ordovician glaciofluvial sedimentary formations in various locations to enhance our understanding of sediment provenance and tectonic settings. The analysis revealed that Sarah sandstone is enriched in Ba, Zr, Sr, Zn, and Rb, with relatively high concentrations of V, Cu, B, Cr, and Pb. The total REE (ΣREE) content ranged from 24.7 to 215.9 ppm, showing enrichment in LREE and a slightly negative Eu anomaly. The high LREE/HREE ratios and Eu anomalies suggest that the sediment was mainly derived from felsic igneous rocks. Furthermore, the low (Gd/Yb)CN ratios indicate provenance from Post-Archean strata. In contrast, Ti/Zr and La/Sc ratios suggest deposition in a passive continental margin setting, consistent with the tectonic setting of North Gondwana during the Late Ordovician. On a broader scale, Late Ordovician glaciofluvial sediments from different locations share similar provenance but were deposited in slightly varied tectonic settings. This research highlights the usefulness of major, trace, and rare earth elements in understanding geological processes. It could aid in exploring and developing tight gas sandstone reservoirs within similar formations.

Keyword

Glaciofluvial, Rare Earth Elements, Provenance, Tectonic Settings, Geochemical

Late Sinian-Early Paleozoic Lithofacies Paleogeographic Characteristics and Exploration Significance of the South Yellow Sea Basin, China

Huiyong LI[1], CNOOC China Limited,Tianjin Branch
Ying GUO[2]*, CNOOC China Limited,Tianjin Branch (350426124@qq.com)
Qingxun WU[3], CNOOC China Limited,Tianjin Branch
Panpan SHI[4], CNOOC China Limited,Tianjin Branch
Zhiqiang LI[5], CNOOC China Limited,Tianjin Branch

Abstract

The South Yellow Sea Basin, located above the ancient land nucleus of the Lower Yangtze Platform in China, with thick Late Sinian to Early Paleozoic carbonate and clastic sedimentary layers, possesses excellent exploration potential. Lithofacies paleogeographic conditions play a significant control role in the development of source rocks, reservoirs, and hydrocarbon accumulation from the Upper Sinian to the Lower Paleozoic. In this study, drilling, field outcrop, seismic, and analytical data from the South Yellow Sea and the Lower Yangtze Land were systematically studied to understand the late Sinian to early Paleozoic lithofacies paleogeographic evolution and the geological significance of oil and gas. The research indicates that during the late Sinian to early Paleozoic, the study area experienced evolutionary stages of margin platform and foreland basin paleogeography. Late Sinian to Middle Ordovician, the study area was dominated by margin platform sedimentation, inheriting the global supercontinent rifting background, with rift basins and ancient uplifts distributed alternately, forming a pattern of dual basins and dual uplifts. Late Ordovician to Silurian, with the collision and amalgamation of the Yangtze Plate and the Huaxia Plate, the study area gradually transformed into a foreland basin paleogeographic pattern. The different paleogeographic patterns of basin-uplift and foreland basin control the development modes of two types of source rocks and reservoirs in the study area. The paleorift troughs and the post-uplift depression of foreland basin are concentrated areas of high-quality source rock development, with the Lower Cambrian and Upper Ordovician to Lower Silurian source rocks being the most enriched. The platform margin reef-flat facies on both sides of paleorift troughs are favorable areas for the development of high-quality dolomite reservoirs from the Upper Sinian to the Cambrian, forming a good reservoir-seal combination with Lower Cambrian and Silurian mudstones. The inherited ancient uplifts serve as advantageous directions for oil and gas migration in the study area, controlling the accumulation and reservoir formation of oil and gas from the Upper Sinian to the Lower Paleozoic, providing a favorable direction for oil and gas exploration in the study area.

Keyword

South Yellow Sea Basin, Late Sinian-Early Paleozoic, Lithofacies Paleogeographic Characteristics, Exploration Significance

The paleotectonic and paleogeography reconstructions of the Tarim basin during the Neoproterozoic

Bizhu HE[1]*, Chinese Academy of Geological Sciences (hebizhu@cags.ac.cn)
Cunli Jiao[2], Exploration and Production Research Institute of SINOPEC
Ruohan Liu[3], PetroChina Research Institute of Petroleum Exploration & Development
Zicheng Cao[4], Institute of Northwestern Petroleum Subsidiary of SINOPEC
Zhihui Cai[5], Chinese Academy of Geological Sciences
Xiaorui Yun[6], Exploration and Production Research Institute of SINOPEC

Abstract

The tectono-sedimentary development of the Neoproterozoic of the Tarim Basin is important for understanding the basin initiation process and for the regional ultra-deep/deep oil and gas exploration. Due to the deep burial and data scarcity, it is extremely difficult to research the deep buried areas of the basin, and data interpretation can be ambiguous. This study, based on comprehensive analyses of drilling data and newly reprocessed seismic reflection data collected across the basin, reveals that the Tarim Basin experienced at least three tectonic cycles during the Neoproterozoic and developed three super stratigraphic sequences and 7-9 stratigraphic sequences. The distribution of sedimentary facies of the Neoproterozoic in the basin and its margin vary greatly, constrained obviously by Neoproterozoic rift depressions. The basin developed shelf facies, glacier facies, basin facies, carbonate platform facies, tidal-flat facies, fan-delta facies, littoral and shallow sea facies, alluvial-fluvial facies, and igneous rock facies. Results on the structural architecture and spatial distribution of unconformities during the Cryogenian Early Cambrian reveal that the tectono-sedimentary frameworks of the basin margin and deep buried area are formed in an extensional environment. The main unconformity types include angular unconformity with low-angle and monocline structures, progressive syn-tectonic angular unconformity, fault-controlled unconformity, and para-conformity, and they are observed in every rift depression and at different locations. The paleotectonic and paleogeography of the basin before the deposition of the Ediacaran and the Cambrian are reconstructed based on sequence stratigraphy, Neoproterozoic fault activity, unconformity architecture, seismic stratigraphy, and wave impedance inversion property data, which show that the distribution of various sedimentary facies zones is related to the developments of rift depressions and subsidence centers and the differences of structural deformations. In response to the subduction-related outgrowth and the breakup of Rodinia, and the assembly of Gondwana, the Tarim Basin experienced three evolutionary cycles in the Neoproterozoic: initiation of deep rift depressions (900-760 Ma), development of deep rift depressions (~750-630 Ma), and rapid extensions and declining of rift depressions (630-520 Ma). Correspondingly, the Tarim block underwent subduction-related back-arc extension, continental rift, and passive continental margin transformations during the Neoproterozoic. The Ediacaran to Cambrian transition is an important period where the Tarim block transformed from continental-rift/rift-depression basins into a unified cratonic basin. This is evidenced by the unconformity between the Cambrian and the Ediacaran or pre-Ediacaran across

the basin and covered by the Lower Cambrian further.

Keyword

sequence stratigraphy, structural architectures of unconformities, seismic stratigraphic property, Neoproterozoic, Tarim basin

Sedimentation history and U-Pb detrital zircon age from Paleoproterozoic Mahakoshal back-rift basin developed during the evolution of Central Indian Tectonic Zone, India

ADITI SHARMA[1]*, Department of Geology, University of Delhi, Delhi, India (aditisharma.res@gmail.com)
PARTHA PRATIM CHAKRABORTY[2], Department of Geology, University of Delhi, Delhi, India; Hiroshima Institute of Plate Convergence Area Research, Hiroshima, Japan
KAUSHIK DAS[3], Department of Earth and Planetary Systems Science, Hiroshima University, Higashi-Hiroshima, 1-3-1 Kagamiyama, 739-8526; Hiroshima Institute of Plate Convergence Area Research, Hiroshima, Japan

Abstract

Sedimentation pattern in subduction-related rift basins, developed in Proterozoic orogenies, often not well understood due to modification of grain size and erasure of primary sedimentary structures due to subsequent deformation and metamorphic overprinting. The Parsoi Formation of the Paleoproterozoic Mahakoshal Group of Central Indian Tectonic Zone (CITZ), despite being metamorphosed in green schist facies grade, offers a reasonable scope to understand the typicality of sedimentation pattern in such a back-arc rift setting using process-based sedimentology aided by detrital zircon geochronology. In a west-east transect, the Parsoi Formation record i) poorly-sorted granular sandstone with trough cross-stratification, restricted in the north and north-western part of the basin (braided channel deposits), ii) polymictic conglomerates (mass flow-I/MF-I) and amalgamated/isolated massive to crudely normal-graded (meta) sandstone (mass flow-II/MF-II) in the north-west and their wedging towards east, iii) heterolithic (meta) sandstone-shale alternation with laterally extensive coarse/ medium-grained, massive/ normal-graded sandstone in the middle and eastern part, iv) thin-bedded fine sandstone of turbidite origin encased in shale (phyllite) in the east, (ii, iii, and iv are identified as deltaic mass flows of varied rheology in a proximal- distal relation) and v) medium-grained well-sorted sandstone with unequivocal wave signature at the southern margin of the basin (wave- and tide-dominated shoreface). Spatial facies distribution bear indication of sedimentation in a half-graben like basin setting where conglomerates, coarse sandstones define the footwall part and medium grained (meta) sandstones of shoreface origin record sedimentation history of hanging wall part.

Detrital zircon geochronology from Parsoi footwall and hanging wall sediments allowed validation of a riftogenic half-graben sedimentation model. Whereas fluvial sandstone clustered under three major modes viz 3.0 Ga-2.89 Ga, 2.1 Ga-1.9 Ga, and 1.85 Ga-1.71 Ga, MF-I shows peak of 3.3-3.1 Ga and 2.7-2.5 Ga and MF-II shows a major peak of 1.70 Ga with a number of moderate to subdued >2.50 Ga peaks. No grain with <2.50 Ga age from the MF-I, and absence of 2.0 Ga age grain in MF-II is noteworthy. Consideration of all geochronology data allowed understanding that i) maximum depositional age for the MF-I is ~2.5 Ga, that for the MF-II is ~1.7 Ga, hence, MF-I and MF-II are neither contemporaneous nor cogenetic, ii) absence of ~2.0 Ga zircon in MF-II despite the presence of these grains in fluvial deposits at this section suggest non-

reactivation of ~2.0 Ga provenance at the time of MF-II deposition. A comparison with geochronology ages described from Bundelkhand and Bastar cratons allowed zero down the delivery of detritus in the MF-I from the Bundelkhand craton, whereas in the footwall at the south-eastern part of the basin from the Bastar craton. The MF-II possibly records a mixing of detritus from both the craton. A clear asymmetry in facies association development pattern and detrital zircon geochronology is documented where wedge-shaped coarse-grained delta developed in fault-bound footwalls of rift in the north-northwest because of steep gradient and high bathymetric differential. Mass flow units in the delta (exposed at different studied sections) may be contemporaneous in a broad sense, but certainly not cogenetic.

Keyword

Paleoproterozoic, Back-arc rift, Central Indian Tectonic Zone (CITZ), Mahakoshal Basin, U–Pb detrital zircon

Tracking Middle and Late Jurassic environmental and sea-level changes in tropical Tethys Ocean

Antun HUSINEC[1]*, St. Lawrence University (ahusinec@stlawu.edu)

Abstract

The Middle and Late Jurassic was a prolonged period of warm greenhouse climate punctuated by cooler episodes, with long-term (2nd-order) sea-level highs at the Bathonian-Callovian, and Kimmeridgian-Oxfordian boundaries. The generally warm climate of the Tethyan tropics and subtropics was favorable for the growth of numerous carbonate platforms in the Tethyan Ocean, which acted as dip-sticks to sea-level oscillations while recording carbon-isotope fluctuations of the platform waters. Here we focus on the relatively continuous, ~1.9-km-thick, ~30 myr record of the Middle and Upper Jurassic Adriatic Carbonate Platform in southern Croatia. We logged in detail nine road-cut and mountain-side sections (~1,900 m total thickness), and sampled lime mudstone for C- and O-isotopes. The δ13C profiles were generated to help constrain the biostratigraphic ages, matching the excursions with those on published δ13C profiles. Identified excursions include the BjBaE (Bajocian-Bathonian), CaOxBE (Callovian-Oxfordian boundary), EOxE, and MOxE (Early and Middle Oxfordian). The similarity of the absolute δ13C and limited evidence of meteoric diagenesis below the unconformities, suggests that the studied carbonates likely preserved the original δ13C signature. The new continuous Adriatic Carbonate Platform δ13C curve may potentially serve as a standard for coeval Tethyan platforms and highlights the potential of thick platform successions as repositories of sea-level changes and carbon isotope fluctuations over long time intervals.

The succession preserves a ~ 30 myr record of carbon-isotope and sea-level fluctuations along the southern Tethyan margin. Three Jurassic 2nd-order sequences (Jurassic supersequences, JSS) can be recognized: JSS2 (Toarcian to basal Callovian), JSS3 (Callovian-Kimmeridgian), and JSS4 (Tithonian). They consist of cyclic subtidal interspersed with highly cyclic peritidal units. Poorly cyclic subtidal intervals commonly occur within the 2nd- and 3rd-order transgressive systems tracts: the upper Toarcian-lower Aalenian interval, a short interval just above the middle Bathonian and in the basal Callovian, the thick Oxfordian interval, much of the lower Kimmeridgian, and the lower Tithonian. Highly cyclic peritidal units are associated with long-term highstands in the upper Bajocian-lower Bathonian and short intervals in the upper Kimmeridgian, and with a long-term sea-level fall in the upper Tithonian. The integrated high-resolution sequence-stratigraphy tied to δ13C chemostratigraphy of the Adriatic Platform provides a framework that can help us better understand and track the environmental and sea-level changes in the tropical Tethys Ocean during the Middle and Late Jurassic.

Keyword

Middle and Late Jurassic, Sequence Stratigraphy, Chemostratigraphy, Sea-level change, Tethys

Petrographic and geochemical characteristics of Paleoproterozoic shales of the Limbunya Group: Implications on paleo-environment conditions.

Ananyaa Deepak[1]*, University of Adelaide (ananyaa.deepak@adelaide.edu.au)
Alan S Collins[2], University of Adelaide
Morgan L Blades[3], University of Adelaide
Darwinaji Subarkah[4], University of Adelaide

Abstract

The Proterozoic Birrindudu Basin was deposited across an expanse of 36000 km2 in the northwestern Northern Territory. Despite its size, it remains one of the least explored basins in the NT and lacks a robust chronostratigraphic framework. The Birrindudu Basin shares lithological and chronological similarities with the McArthur Basin and sedimentary successions of the Tomkinson Province. These three Paleo-Mesoproterozoic, intra-cratonic basins have been suggested to be interconnected at the time of deposition to form a superbasin system, informally named the greater McArthur Basin. To describe such regionally extensive multiphase systems, the sedimentary successions of these basins have been divided into five basin-scale, non-genetic depositional packages. In stratigraphic order, they are: - the Redbank, Goyder, Glyde, Favenc, and Wilton packages. The focus of this study is the Limbunya Group of the Birrindudu Basin which has been placed within the Glyde Package (ca. 1660–1610 Ma) based on geophysical and sedimentological correlations. It comprises a succession of cyclic carbonates and siliciclastic rocks, this study aims to reconstruct the sedimentary environment of the group using petrography and bulk geochemistry of the shales.

Considering the greater dominance of shales (clay mineral factories) in Earth's sedimentary record, using clay minerals as paleo-climate proxies becomes imperative. They have long been used as indicators of paleo-climatic conditions because of their chemical composition and structure that vary with their depositional environment. However, clay mineralogy fails to distinguish between the clays of different origins (continental-derived detrital, hydrothermal, burial, authigenic, etc.), which commonly show a distinctive particle morphology. In this study, we petrographically differentiate the various clay origins within the shales of the Limbunya Group and make use of textural evidence to draw paleo-environment inferences. Further, these interpretations are tested with independent geochemical indicators to track paleo-climate changes temporally. The shales are analysed for major and selected trace elements (V, Cr, Mo, Co, Ni, Cu, Th, U), including the REE to get insights regarding the source rock composition, weathering, and paleodepositional conditions.

The lower Limbunya Group rocks lack any reliable age constraints, through this study, we provide in situ Rb–Sr dating (LA-ICP-MS/MS) results of early diagenetic illites from lower Limbunya shales, recovered from the well, DD90VRB2 in the Birrindudu Basin. The obtained geochronological data help establish age correlation with the other Glyde Package sequences of

the greater McArthur Basin.

Keyword

Paleoproterozoic shales, greater McArthur Basin, Geochemistry, Rb–Sr dating, Petrography

Formation of diamictite by fault-controlled redeposition of concretions

Dmitrii ALEKSANDROV[1]*, IPGG SBRASS (lex_2706@mail.ru)

Abstract

Diamictites form by a variety of processes including, but not limited to glaciomarine deposition, tectonic activity, or sediment gravity flows. The term “diamictite” was introduced by Ramsay in 1855 for boulder deposits of the Permian age in England that were thought to be indicative of an as ice age, although there has been much controversy over their interpretation. Many formations which are, or have been, interpreted to have formed by glaciations are documented from the Archean, Proterozoic, and all periods of the Phanerozoic. Sometimes this information tempts researchers to interpret diamictites as glacial deposits influencing palaeoclimatological and palaeogeographical reconstructions. Frequently, mainly data supposed to be relevant for the current interpretation are reported. These biases have in some cases prevent alternative interpretations from being fully investigated. Therefore the features which are described in the literature often don’t give full view about formation than can mislead another researchers. Due to the growth of knowledge, observations made 30–50 years ago may now be of particular interest. Neoproterozoic diamictites from the south-western margin of the Siberian Craton are no exception to this. Late Neoproterozoic strata of presumed glaciogenic origin of the Marnya Formation, Oselok Group cropping out 2-km along the Uda River in the Eastern Sayan Ranges, south-western Siberia have received considerable attention due to the presence of at least three distinctive diamictite units. The lower diamictite unit (Karapchetui Member) is in subvertical contact (previously interpreted as a glacial valley) with stratigraphically older strata of the Tagul and Ipsit formations of the Karagas Group, and is represented by a wedge-shaped unit of breccia that hosts numerous ellipsoidal sandstone bodies (previously thought to be boulders). Based on detailed sedimentological observations, the boulders can be reinterpreted as early diagenetic sandstone concretions exhumed and redeposited from the Ipsit Formation when the latter was still uncemented and easily erodible. Tectonic compression, faulting and localised continuous syndepositional uplift led to exhumation of the concretions. In the process of redeposition, exfoliating concretions produced abundant debris that provided clasts for the breccia deposit. The Karapchetui diamictite, therefore, can serve as a sedimentary archive of a previously unrecognised episode of late Neoproterozoic tectonic activity at the south-western margin of the Siberian Craton. This research was supported by the Russian Science Foundation (project 23-17-00202).

Keyword

diamictites, exhumed concretions, Neoproterozoic, Siberia

Millennial scale marl-limestone rhythmites in the Middle Cambrian (500 My) Marjum Formation (Utah, USA) and their modulation by Milankovitch cycles

Damien PAS[1]*, University of Lausanne (damien.pas@unil.ch)
Maya Elrick[2], University of New Mexico
Anne-Christine Da Silva[3], University of Liege
Linda Hinnov[4], George Mason University

Abstract

Middle Cambrian offshore deposits of the Marjum Formation (Drumian; 504.5 Ma to 500.5 Ma; Peng et al., 2020) are characterized by four scales of superimposed cyclicity defined by variable abundances of fine siliciclastics versus limestone; these include the limestone-marl couplets (or rhythmites; 5-10 cm) which are bundled into parasequences (1-2 m), and small-scale (5-10 m) and large-scale (20-40 m) sequences. Time series analysis of SiO2 and lithologic rank stratigraphic series reveals cycles consistent with Milankovitch cycles with periods corresponding to Cambrian orbital eccentricity (20 m, 405 ky; 6 m, 110 ky), obliquity (1.8 m, 30 ky), and climatic precession (1.15 m, 18 ky). Astronomical calibration of the lithologic rank series indicates that the main sub-Milankovitch cycle at 0.065 m has a period of approximately 1 ky and corresponds to the basic rhythmite couplet. All scales of cyclicity are interpreted to be the result of wet vs. dry monsoonal climate oscillations controlling the abundance of fine terrigenous sediment influx to the basin. A plausible millennial-scale climate driver is solar activity. These results provide one of the oldest known geological candidates for solar-influenced climate change modulated by Milankovitch forcing.

Peng, S. C., Babcock, L. E., and Ahlberg, P., 2020, Chapter 19 - The Cambrian Period, in Gradstein, F. M., Ogg, J. G., Schmitz, M. D., and Ogg, G. M., eds., Geologic Time Scale 2020, Elsevier, p. 565-629.

Keyword

Cyclostratigraphy, Milankovitch cylces, Middle Cambrian, Drumian, Solar cycles

Microbial induced sedimentary structures (MISS) from the Paleoproterozoic Gwalior basin, Central India

PRITAM PARITOSH PAUL[1]*, Department of Geology, University of Delhi, Delhi, India-110007 (pritamgeo@gmail.com)
Partha Pratim Chakraborty[2], Department of Geology, University of Delhi, Delhi, India-110007
Arvind Kumar Singh[3], Precambrian Palaeobiology Laboratory, Birbal Sahni Institute of Palaeosciences, Lucknow, India-226007

Abstract

A Proterozoic sedimentary succession often offers a unique scope to study the nature of biosphere in the early Earth history and compare them with expected Martian analogs. The Precambrian biosphere was mostly occupied by algal and microbial life. The Paleoproterozoic Gwalior basin exposes such a sedimentary succession in peninsular India where the evidences of early life is preserved within the siliciclastic rocks in the form of microbial-induced features. The Gwalior Group is represented by ~1.8 km thick unmetamorphosed and undeformed lithopackage hosted in the North Indian shield. It is constituted of both clastic (Par Formation) and chemical (Morar Formation) sediment successions, in order of superposition. The Par Formation is arenaceous and broadly represented by conglomerate, coarse-grained granular sandstones, and sandstone-shale heterolithics, whereas the overlying Morar Formation is essentially chemogenic represented dominantly by Banded Iron Formation (BIF) and ferruginous shale with limestone in subordinate volume. The siliciclastic Par Formation is represented by an early retrogradational succession marked by successive superposition of continental alluvial fan/braided fluvial, fluvial-tidal, and tidal shelf facies succession. A late Progradation in the Par succession is documented in the inner shelf to wave-dominated middle/upper shoreface transition. Unique arrays of microbial-induced sedimentary structures (MISS) are documented from the siliciclastic inner shelf to middle/upper shoreface sandstone of the Par Formation. These structures include (a) Patchy ripple, (b) Keniya structure, (c) palimpsest ripples (d) Sand cracks, and (e) microbial chip on the surface of patchy ripple.

Keyword

Gwalior group, Microbially induced sedimentary structures, Paleoproterozoic, Siliciclastic rocks

Characterization and Development Patterns of Different Types of Karst Fracture-Cave Systems under Multi-Factor Controls: A Case Study of the Lungu 7 Area in the Tarim Basin.

Xiangbo ZHANG[1]*, China University of Petroleum (East China) (B23010041@s.upc.edu.cn)
Chengyan Lin[2], China University of Petroleum (East China)
Guoyin Zhang[3], China University of Petroleum (East China)
Lihua Ren[4], China University of Petroleum (East China)
Yanan Sun[5], China University of Petroleum (East China)
Chunmei Dong[6], China University of Petroleum (East China)

Abstract

The deep Ordovician carbonate reservoirs in the Lungu 7 area of the Tarim Basin exhibit a diverse array of genetic types and complex structural characteristics in karst fracture-cavity systems. Multiple regulating forces work together to cause superimposed development in karst fracture-cave systems, leading to ambiguous developmental patterns and difficult classification of different kinds of karst systems. Based on field geological outcrops, logging, seismic and other data, the Ordovician paleo-morphology, paleo-hydrology and paleo-structural conditions in the Lungu 7 area have been restored. The spatial distribution characteristics and main controlling factors of different types of karst fracture-cave systems have been described. The compositional units of karst fracture-cave systems have been identified, and the geological models of the development of different types of karstic fracture-cave systems have been established. Firstly, the paleo-morphology of the study area was restored by the "impression method". Based on modern karstic theory, the karstic geomorphic units and micro-geomorphic units were identified. Furthermore, 13 near-NS-direction surface water systems were interpreted based on the micro-morphology. Secondly, the characteristics of three types of faults in the study area, which are nearly NW-SE, nearly NE-SW and nearly EW, are described in detail using deep learning technology. Integrating the geological structural movements and seismic attribute responses within the study area, additional characteristics of the fractures were further elucidated. After comprehensively considering the distribution patterns of karst fissures and caves in the study area and the main controlling factors, the ancient karst system in the study area is divided into four types: paleo-karst, residual-hill karst, paleo-channel karst and faulted karst system. (1) The paleo-karst systems are mainly distributed in the epikarst zone, within 70m below the weathered crust of Ordovician, and are composed of waterfall holes, fault systems, corroded holes and caves. Karst water flows into the surface river along the surface cracks and in the direction of the unconformity slope. (2) The residual-hill karst system is mainly developed in the vadose karst zone, distributed in the high and thick-stratum residual hills. It is significantly affected by the ancient geomorphology. The fracture-cave body is communicated by faults, showing a nearly circular or elliptical shape. Karst water mostly corrodes along faults to water leakage. (3) The paleo-channel karst system zone at the runoff karstic near the karst slope is developed, which is controlled by the changes of water table and the distribution of faults. The river channels are distributed in a dendritic multi-layered

pattern along NE and NEE directions, and the conditions of water collection and discharge are complex. (4) The faulted karst system develops in regions with robust fault activity, exhibiting a planar strip-like distribution and potential vertical development within diverse karst belts. Karst water primarily dissolves along structural fractures on both sides of the fault, giving rise to a V-shaped characteristic in the karst system.

Keyword

Tarim Basin, Lungu oilfield, Ordovician system, The karst fracture-cave systems, Causes pattern

MODELING HYDROCARBON SYSTEMS USING AN EXAMPLE SOUTH TORGAY SEDIMENTARY BASIN (KAZAKHSTAN)

Araibek ZHIYENGALIYEV[1]*, Atyrau Oil and Gas University named after Safi Utebayev (zhiengaliev_2000@mail.ru)
Dulat Azhgaliev[2], Atyrau Oil and Gas University named after Safi Utebayev

Abstract

In modern understanding, the hydrocarbon system represents a set of concepts: the area of genesis and accumulation of primary hydrocarbons, migration channels, time of entry and localization of mobile hydrocarbon fluids into oil and gas traps. New data on the South Torgay sedimentary basin (STB) in recent years shows and confirms the rift genesis of large structures of the second order: grabens-synclines and horsts-anticlines. There are 3 structural-formational complexes (SFC) in the section. The material composition of the SFC allows us to distinguish 3 stages of rifting, each of which reflects the accumulation and main stages of development of the STB: pre-rift (Upper Paleozoic), rift (Lower - Middle Jurassic) and epirift (Upper Jurassic - Lower Cretaceous).

Systematic analysis of basin data expands understanding and improves understanding of the conditions for the formation of the region. Researchers receive valuable information that has practical application, and the efficiency of studying local objects and deposits during exploration and development of hydrocarbon deposits is significantly increased.

The degree of knowledge of promising complexes: Upper Paleozoic deposits - quasi-platform complex (QPC), Jurassic complex of rift filling, platform complex of Upper Jurassic - Lower Cretaceous, decreases with depth. It is possible that separate hydrocarbon systems could exist for each complex. However, this is not certain!

These studies are devoted to a more detailed examination of the Upper Paleozoic deposits, the least studied part of the section, which is of significant practical interest.

- QPC deposits are characterized by pronounced sedimentary genesis, can contain significant volumes of hydrocarbon reserves, and serve as a reserve for planning regional production according to STB.
- Ideas on the model of formation of deposits in the Upper Paleozoic cause wide discussion among many researchers in this region. An important conclusion of recent years is the division of basement and upper Paleozoic deposits into two different strata.
- Oil and gas localizing objects in the Paleozoic stratum are characterized by a peculiar structure and localization, often confined to the protrusions of the foundation. In the thickness of the foundation, researchers identify a separate type of HC accumulations, which belong to the upper decompressed part – the "*weathering crust*" of the foundation.

The “origin” of hydrocarbon deposits in the Paleozoic finds an analogy with examples of known deposits in the basins of foreign countries. These are large deposits: “*White Tiger*”, “*Rona Ridge*”, “*Bongor*”, etc. These objects are characterized by different geological structures, but they are united by the presence of the main productive strata associated with Upper Paleozoic

deposits and huge potential for the implementation of broad comprehensive scientific research. Modeling of hydrocarbon systems based on geological-geochemical, thermobaric and numerical methods substantiates new opportunities for effective forecasting and assessment of the resource potential of the South Basin, taking into account the increasing trend of decreasing overall production in the region and the late stage of development of most fields in the Jurassic and Lower Cretaceous complex.

Keyword

South Torgay basin, basin analysis, modeling, hydrocarbon system, Upper Paleozoic

RIVER SCALE AND CHANNEL PATTERNS IN THE ROCK RECORD

Cristiano GALEAZZI[1]*, Seoul National University (cpgaleazzi@snu.ac.kr)
Renato ALMEIDA[2], Universidade de Sao Paulo

Abstract

The recognition of river scale and channel patterns in the geological record are assumed gaps in fluvial sedimentology. They are of great importance for regional palaeohydraulic and palaeogeographical reconstructions. Rivers in general have been subject of research for more than a century but the link between proposed classifications and the rock record has been problematic, with a persistent lack of effective criteria to distinguish among channel patterns in fossil fluvial systems. A compilation of modern alluvial rivers with available water discharge data at a global scale was undertaken to to quantify the natural variability of channel patterns at the global scale, explore what controls may influence their development, and investigate whether channel pattern information is preserved in the alluvial plains in order to develop tools for recognizing them in the sedimentary record. By surveying 361 reaches, we present a quantitative channel pattern classification based on sinuosity and channel count index applicable to the recognition in the rock record. A continuum of channel patterns ranging from high-sinuosity single channel to low-sinuosity multichannels is documented, along with their alluvial plains and their conditions of occurrence. Preserved barforms in the alluvial plains of these rivers are used to infer and quantify paleoflow directions at the channel-belt scale and result in ranges of paleocurrent circular variance that may lead to channel pattern identification in the rock record. Channel scale was investigated by comparison of high-resolution multibeam echo-sounding imaging of two reaches in the large Amazonas River and small rivers.High-resolution bathymetric maps of the Solimões-Amazonas River are presentend, along with the quantification of dune data from their riverbeds and riverbed samples. Dune morphology, height and leeside angles, as well as grain size, are related to water depth and these relationships are used to make inferences about how to identify large river in the rock record and are compared with interpreted large river deposits. The recognition of channel patterns and river scale may be used to predict paleogeographic features such as the scale of drainage basin area and discharge, slope, and annual discharge regimes.

Keyword

Fluvial sedimentology, River to rock record, River scale, Channel pattern

Paleoweathering, Provenance and Tectonic Settings of Mesozoic Succession of Mundhan Dome (MD), Jhuran Formation, Kachchh, Western India: Insights from Petrography and Geochemistry

Poonam Rajeshbhai MANGTANI[1]*, Department of Geology, Faculty of Science, The M.S. University of Baroda, Vadodara, Gujarat, India (mangtanipoonam.geology@gmail.com)
Atul Vasant Joshi[2], Department of Geology, Faculty of Science, The M.S. University of Baroda, Vadodara, Gujarat, India

Abstract

The Mundhan dome (MD) in north western part of the Kachchh basin, Gujarat (GJ), comprises ~105 meters thick Upper Jurassic to Lower Cretaceous (Kimmeridgian to Hauterivian) siliciclastic succession belonging to middle, upper and Katesar members of Jhuran Formation. The middle member shows dominance of shales with subordinate siltstones, while the upper and Katesar members are marked by the presence of sandstones with varied primary sedimentary structures and fossil assemblages. In the present work, siliciclastic rocks of MD have been studied to understand their provenance and decipher the tectonic settings through petrography and geochemistry (major element oxides). The representative thin sections have been subjected to modal analysis carried out using Leica DM 2500 microscope. The framework grains show the dominance of quartz (monocrystalline, polycrystalline) with subordinate feldspars (orthoclase, microcline, plagioclase) and lithic fragments in a modal average ratio of Q83F12L5. The framework grains are embedded in siliceous matrix cemented by calcareous material and show tangential grain to grain contacts. As per Dott's classification, these sandstones have been classified as 'Quartz Arenites' and Sub-arkosic Arenites. High Qm /Qp ratio and dominance of K-feldspar over plagioclase feldspar indicate a stable cratonic source. The presence of orthoclase and microcline suggest plutonic igneous or metamorphic source. The preservation of fresh feldspar grains is due to quick burial and minimal transportation. The geochemical analysis carried out using Wavelength Dispersive – X-Ray Fluorescence (WD-XRF) at Sophisticated Instrumentation Centre for Applied Research and Testing, Anand, GJ, India-reflects high abundance of SiO2 and low abundance of Al2O3, Na2O, CaO and TiO2. The K2O/Na2O ratio > 1 as well as Al2O3/TiO2 ratio ~22, indicate deposition in passive margin setting and derivation from felsic rock source respectively. The deposition in a passive continental setting is substantiated by tectonic discriminant diagrams reflecting acidic igneous and metamorphic provenance. The average SiO2/ Al2O3 value > 5 is suggestive of the progressive maturity of sediments. The values of chemical index of alteration, chemical index of weathering and plagioclase index of alteration being suggest moderate to high chemical weathering and deposition in vicinity of source without extensive recycling. Thus, the research concludes that the rocks of Jhuran Formation are deposited in a marginal marine passive continental setting with acidic igneous and metamorphic provenance.

Keyword

Mundhan dome, Jhuran Formation, Petrography, Geochemistry, Provenance

Depositional characteristics of a braided river-type alluvial fan controlled by a small syndepositional fault

mingyue LI[1]*, China University of Petroleum (East China) (3176637243@qq.com)
xianguo Zhang[2], China University of Petroleum(East China)

Abstract

Syndepositional fault, Braided river, Alluvial fan, Huanghua Depression, Kongdian Formation
A great deal of understanding has been achieved on the influence of large syndepositional faults at the basin margins on the type and spread of sedimentary systems within the basin, while the influence of small syndepositional faults within the basin on the sedimentary characteristics of alluvial fans has been less studied. In this study, a typical braided-river-type alluvial fan stratigraphy of the Paleocene in the Huanghua Depression, Bohai Bay Basin, China, is selected to recognize the influence of small syndepositional faults on braided-river deposition in the fan.
The study area was frequently fractured during the period of the Paleocene Kongdian Formation, and later on, it was under the joint control of dextral strike-slip stress, forming several small-scale syn-sedimentary normal faults. The differences in sedimentary characteristics between the two sides of the faults are identified using cores and logging, the paleogeomorphology of the two sides of the syndepositional faults is recovered by well seismic combination, the relationship between the syndepositional faults and the location, scale, and lithological assemblage of the fan and the braided channel development is analyzed from the temporal and spatial dimensions. It is found that hanging wall of the syndepositional fault has a large volume of space, sufficient sediment supply, and the development of a thick sand body with multiple stacking phases, which is characterized by part of the near-source and rapid accumulation; in the footwall of the syndepositional fault, the thickness of the sand body is relatively thin due to the influence of the paleogeomorphology; and the change of the activity of the syndepositional fault along the strike affects the direction of the braided channel and the degree of the deformation of the strata, which has formed the special pattern of the river channel sand body spreading. Using the above results, the sedimentary phase model in the alluvial fan under the control of small syndepositional faults in the faulted lake basin in the study area was established.

Keyword

Syndepositional fault, Braided river, Alluvial fan, Huanghua Depression, Kongdian Formation

Paleoclimate evolution of the lower fourth sub-member of the Shahejie Formation in Niuzhuang Subsag during deposition

Rongkun LI[1]*, CHINA UNIVERSITY OF PETROLEUM (1308745376@qq.com)
Yingchang Cao[2], CHINA UNIVERSITY OF PETROLEUM
Yanzhong Wang[3], CHINA UNIVERSITY OF PETROLEUM

Abstract

Exploration practice has confirmed that the Paleogene red beds in Dongying Sag have great exploration potential. It is of great theoretical and practical significance to clarify the evolution of paleoclimate for revealing the control of extreme climate conditions on lake-basin sedimentary system and reconstructing paleogeography in this period.Several short-term thermal climate events such as PETM, ETM2, EECO and MECO occurred worldwide in the early Paleogene.Under the influence of thermal climate events, the red beds in the lower fourth sub-member of the Shahejie Formation of Niuzhuang Subsag developed and recorded the paleoclimate evolution process under the control of thermal climate events.In this paper, the red beds of the lower fourth sub-member of the Shahejie Formation in Niuzhuang Subsag are taken as the research object, and the paleoclimate evolution process is restored by statistics of natural gamma ray spectrometry data, analysis of climate information contained in tne analysis of fossil sporopollen assemblages and stratigraphic superimposition patterns.The results show that the climate of the lower fourth sub-member of the Shahejie Formation in Niuzhuang Subsag during the deposition period was characterized by overall drought, which can be divided into four stages. In the early stage, fluctuating humidity occurred, and then turned to dry and tended to be stable, and the temperature gradually decreased.

Keyword

Niuzhuang Subsag, red-bed, paleoclimate evolution, the lower fourth sub-member of the Shahejie Formation

Depositional characteristics of Cretaceous carbonate tidal channels in southern Iraq

Zihao LIU[1]*, Research insititute of Petroleum and Expoloration of PetroChina (278433581@qq.com)
Zhenyong Xu[2], Research Institute of Petroleum ExplorationDevelopment, PetroChina
Rui Guo[3], Research Institute of Petroleum ExplorationDevelopment, PetroChina
Fengfeng Li[4], Research Institute of Petroleum ExplorationDevelopment, PetroChina

Abstract

The Cretaceous Mishrif Formation carbonate reservoir in southern Iraq is one of the most important oil-producing layers in the world, in which carbonate tidal channel sediments serve to develop the best reservoirs. Clarifying their characteristics and distribution is crucial for reservoir prediction and further development. An integrated analysis of modern sedimentation, cores, thin sections and log data shows that the tidal channels are widely distributed in the lagoon environment and can be divided into 3 sedimentary facies as channel, inter-channel, and point shoals. Grainstone, bioclastic packstone, and wackestone are the main rock types in the research area with good sorting and rounding, a large number of intersecting bedding, and upward-fining successions. Rudists and bivalves with large diameters can be observed in grainstones, indicating a high energy environment, while benthonic foraminifera, bivalves, and echinoderm are always found in packstones and wackestones with a high content of micrite. On the plane, the tidal channel sedimentation is interlaced and banded, while the point shoal sedimentation is sporadically distributed between distributary channels. Vertically, the sedimentation can be generally divided into three stages, presenting the characteristics of multiple overlapping tidal channels. Three types of tidal channel contact relationships can be recognized as overlapping, cutting, and isolating, of which the connectivity of cutting is the best and that of isolating is the worst. Based on quantitative statistics and sea level changes, it can be concluded that as the sea level rises, the available space increases and the width of the tidal channel gradually increases, but the curvature decreases. The planar distribution range of point shoals also decreases, but their thickness changes little, indicating that their development is not related to tidal channel sedimentation. However, as the distribution range of tidal channel sedimentation expands, more point shoals are transformed. This study can enrich the study of carbonate tidal channel sedimentology, and also provide insights into reservoir prediction and efficient development in similar regions.

Keyword

Tidal channel, Carbonate reservoir, Sedimentary characteristics, Mishrif

Temporal and spatial variations in sediment provenance in the Gunsan Basin, Yellow Sea

JUNHYUK SEO[1]*, Department of Environment and Energy, Jeonbuk National University (signicher@naver.com)
HYOJONG LEE[2], Petroleum & Marine research division, Korea Institute of Geoscience and Mineral Resources (KIGAM)
SUNYOUNG PARK[3], Petroleum & Marine research division, Korea Institute of Geoscience and Mineral Resources (KIGAM)
INAH SEO[4], Department of Earth and Environmental Sciences, Jeonbuk National University

Abstract

The Gunsan Basin is part of the Northern South Yellow Sea Basin (NSYSB) and bordered by the Qianliyan Uplift and Shandong Peninsula to the northwest, the Central Uplift of NSYSB to the south, and the Korean Peninsula to the east. With its recognized potential as a reservoir for both hydrocarbon and carbon dioxide, the basin's internal structure has received extensive attention for several decades. Nevertheless, studies on the sedimentary provenance have not been attempted which play a critical role in evaluating reservoir quality and reconstructing the basin's developmental history. In this study, sediment provenance of the Gunsan Basin is examined based on the petrographic and mineralogic characteristics of five boreholes (KACHI-1, HAEMA-1, IIH-1XA, IIC-1X, and INGA-1) acquired from each sub-basin and uplift zone. Each borehole is subdivided into three seismic units (SU) in ascending stratigraphic order, namely SU-1, SU-2, SU-3, bounded by the widespread unconformities, ES-1 and ES-2, identified through previous seismic exploration of the basin. In each borehole, the lowermost SU-1 exhibits a notable contribution of plagioclase and lithic volcanic fragments in each borehole, while the specific types of lithic volcanics observed vary depending on the individual borehole. On the other hand, SU-2 and SU-3 show a similar composition across all boreholes, predominantly composed of quartz and K-feldspar, almost completely devoid of plagioclase. Such notable shift in sediment composition from SU-1 to SU-2 and SU-3 suggests a significant change in provenance across the ES-1. The spatially heterogeneous sediment composition of SU-1 suggests that the detritus comprising SU-1 were most likely sourced from the nearby geological features within the basin itself rather than being transported from large, external source. It is probable that the local highlands existed during the earliest stage of the basin opening, serving as the primary sources for the sedimentary materials of SU-1. In contrast, the regional-scale consistency in sediment provenance during the deposition of SU-2 and SU-3 is recognized, indicating a large external source. The petrography of SU-2 and SU-3 is similar to that of the Qianliyan Uplift among the geological highs surrounding the basin, making it the most probable source. Such large-scale coherence in sedimentary supply from a single source region was primarily resulted from the subsidence and flooding of the entire basin. The spatiotemporal changes in sediment provenance identified in the Gunsan Basin not only align well with the tectonic history proposed based on seismic exploration but also offer new insights into basin evolution.

Keyword

Gunsan Basin, Sediment petrography, Yellow Sea, Mineral composition, Sediment provenance

Campanian-Maastrichtian Paleoenvironmental and Sequence Stratigraphic Dynamics in the Southern Bida sub-basin, Nigeria: Insights from Sedimentology and Microfossils Studies.

Tope Shade ALEGE[1]*, Federal University Lokoja, Nigeria (tope.alege@fulokoja.edu.ng)
Kingsley Uchendu[2], Federal University Lokoja, Nigeria

Abstract

This study provides valuable insights into the paleoenvironmental dynamics and sequence stratigraphy of the Campanian-Maastrichtian period in the Southern Bida sub-basin through sedimentological and microfossil analyses. The research uses a combination of field mapping and laboratory analyses, including sedimentological facies analysis, petrography, and microfossil investigations. The study identifies three distinct facies: conglomerate, sandstone, and siltstone-claystone facies, indicating a range of environments from alluvial to braided stream, channel bars, and shallow marine settings. The facies association shows a basinward decrease in the energy of deposition. Textural analysis reveals coarse to medium-grained sediments with variations in sorting, skewness, and kurtosis. The pebble morphometric results suggest an angular to subangular with a maximum projection sphericity index (MPSI), considered dominantly fluvial. A statistical linear discriminate function scatter plot highlights a fluvial-deltaic system characterised by braided stream to alluvial fan deposits with a pronounced tidal influence. Heavy mineral analysis shows the presence of opaque and non-opaque mineral suites, suggesting a transportation pathway from upland areas of the Basement Complex to the basin. Calculated ZTR indices indicate compositionally immature to sub-mature sediments from a proximal provenance. The study also reveals that sediments within the Patti Formation exhibited Acritachs in an exclusively terrestrial palynomorph assemblage, indicative of a shoreface environment.

The Patti sediments yielded marine species of dinoflagellates cysts, palynomorphs, and foraminifera test lining, implying a shallow marine depositional setting. Vertical facies sequences within the Lokoja Formation revealed the lowstand and highstand system tracts (LST and HST), suggesting a progradational stacking pattern in response to sea-level fall. The sediments of the Patti Formation indicated a transgressive system tract (TST) terminating at the maximum flooding surface (MFS). The overall stratigraphic profile of the Bida sub-basin displayed a symmetrical log signature suggestive of tidal reversals during transgressive-regressive episodes. This integrated study significantly advances our understanding of the complex depositional processes and paleoenvironmental conditions during the Campanian-Maastrichtian period in the Southern Bida basin.

Keyword

Sedimentology, Microfossils, Petrography, Sequence stratigraphy, Bida Basin

Northward subduction-accretion of the Bangong-Nujiang Meso-Tethys Ocean, Tibetan Plateau

Yiming LIU[1]*, Institute of Geology, Chinese Academy of Geological Sciences (michael_yatmingliu@foxmail.com)
Qingguo Zhai[2], Institute of Geology, Chinese Academy of Geological Sciences
Yue Tang[3], Institute of Geology, Chinese Academy of Geological Sciences
Peiyuan Hu[4], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The subduction-accretion is widely recognized as a critical process associated with the evolution of the Meso-Tethys Ocean. The compositions, deformation and ages of accretionary complex that are preserved in mélange zone can reflect the nature of subduction. New petrologic, sediment composition, deformation and detrital zircon data from the Jurassic sedimentary units, as well as the geochronological and geochemical data of contemporary andesite and basalt interlayers reveal two magmatic arc systems of 196 Ma and 163-153 Ma. These sedimentary units constitute an Early Jurassic island arc and a Middle-Late Jurassic fore-arc trench-basin in response to the northward subduction of the Meso-Tethys Ocean. Detritus derivation from an Early Jurassic arc-ophiolite complex contains a 196 Ma intra-oceanic arc together with contributions from oceanic crust in early development of the basin. This is consistent with the basalts that derived from an enriched mantle source with negligible contribution from crust. In contrast, detritus derivation from a Middle-Late Jurassic arc-accretionary system reveals a mixed source of 163-153 Ma continental marginal arc, oceanic crust and north terranes. Furthermore, the 163-160 Ma high-Mg andesites originated from melting of sediments from a subducted slab, and the melts subsequently interacting with the overlying mantle wedge. The Late Jurassic high-Mg andesite interlayers in the accretionary complex, and the previous identified fore-arc basalt and boninite in the study area, are coincided with subduction initiation. They are obvious younger than the 196 Ma island arc, indicating a complex subduction evolution of the Meso-Tethys Ocean. Structural analysis shows that the Late Jurassic to Early Cretaceous deformation of the accretionary complex is dominated by north-dipping thrust faults and local tight folds. The deformation features combined with the magmatic arc and sedimentary units indicate a polarity of northward subduction. We infer that the accretionary complex may result from the southward transition of the northward subduction zone of the Bangong-Nujiang Meso-Tethyan Ocean.

Keyword

Gondwana, Tibetan Plateau, Meso-Tethys Ocean, Subduction accretion, Jurassic-Cretaceous

Deep marine siliciclastic sedimentation in a mélange zone: an example from the Late Cretaceous Fayah Formation in Batain Mélange, Northeastern Oman

IFTIKHAR AHMED ABBASI[1]*, Sultan Qaboos University (iftikhar@squ.edu.om)
Jenan Attar[2], Sultan Qaboos University
Mohamed A.K. El Ghali[3], Sultan Qaboos University
Abdulrahman Al Harthi[4], Petroleum Development of Oman

Abstract

Objective/Scope: This paper describes the depositional setting of a deep marine siliciclastic sequence in a mélange zone, commonly known as the Batain mélange formed during the Late Cretaceous along the northeastern part of the Oman Mountains. The Batain mélange is comprised of Permian to Late Cretaceous stratigraphy in a tectonically deformed area between Ra's Al-Hadd and Ra's Jibsch. The Batain mélange in its uppermost part comprises an early Maastrichtian siliciclastic sequence belonging to the Fayah Formation.

Methods: A complete section of the Fayah Formation at its type locality was measured and described to understand the constituent lithofacies across the formation and interpret its depositional setting.

Results & Conclusions: The Fayah Formation in Jabal Fayah area is over one thousand meters thick comprising five distinct facies associations; namely, i) interbedded claystone and sandstone, ii) debris and mass-flow, iii) graded sandstone, iv) Conglomerate, and v) calcarenite lithofacies. These lithofacies are repeated many times in the section. The interbedded claystone and sandstone lithofacies is grayish-green in colour, comprising thick monotonous clay and siltstone sequences occasionally interbedded with gray and green fine to medium-grained sandstone possibly deposited by settling of pelagic clays out of suspension in deep marine settings. This sequence constitutes the bulk of the formation. The debris-flow lithofacies association is matrix supported chaotic mixture of clay and boulders of granite, limestone, and volcanic rocks, some of which are a meter in diameter, possibly derived from the nearby Jabal Ja'alan basement rocks. These sediments were deposited along the slope due to submarine slumping and sliding. The sandstone lithofacies association exhibits a fining and coarsening upward trend making tens of meters thick sequences in various parts of the formation. The waterscape structures are common along with occasional sandstone dykes and convolute bedding reflecting syn-sedimentary deformation under fluidized conditions. The lithofacies was deposited by the channel-levee complexes. The conglomerate lithofacies association is comprised of a series of interbedded coarsening upward grit to pebble size conglomerates containing granite, volcanic, carbonate, and chert clasts of a few mm to cm in diameter. The conglomerate lithofacies was deposited by high-energy channelized flow in a sub-aqueous setting. The calcarenite lithofacies constitutes the uppermost part of the formation comprising brecciated limestone. The lithofacies is interbedded with green colour claystone and sandstone. The lithofacies was deposited along the shelf margin. Based on the above-described lithofacies associations, especially the dominance of debris-flow units and

turbidites, most parts of the Fayah Formation are interpreted to be deposited under a sub-marine fan setting. The submarine fan system was active during the last stages of Tethys Ocean closure at the onset of Batain nappe.
Novel Information: This study will help in understating the deep marine depositional setting, especially in isolated deep marine basins associated with the mélange zone.

Keyword

Batain Mélange, Fayah Formation, submarine fan, syn-sedimentary deformation, northeast Oman

Proposal of new gravel shape indicator by the 3D principal component analysis of fluvial gravels and assessment of its accuracies in detecting the fluvial geomorphology

Tomoo YOKOYAMA[1]*, Waseda University (tomoo.yy2014@gmail.com)
Tohru Ohta[2], Faculty of Education and Integrated Arts & Sciences, Waseda University

Abstract

The shape of sedimentary grains, i.e., roundness and surface smoothness were acquired by the transportation histories and depositional environment that grains underwent. Therefore, the shape of sedimentary grains might record an information to reconstruct the transportation histories and depositional environment that grains underwent. Therefore, numerous studies had been pursued to quantify the shape of sedimentary grains. Among them, Suzuki et al. (2015) proposed two shape parameters to quantitatively evaluate grain shapes by utilizing elliptic Fourier and principal component analyses (EF-PCA), which can quantify macroscopic circularity (REF1) and microscopic smoothness (SEF) of grains. Suzuki et al. (2015) furthermore revealed that on the REF1-SEF cross plot, sand grains derived from glacial, fluvial, foreshore, and aeolian environments form distinct clusters, and therefore the depositional environment can be predicted by the two indices. However, the limitations of Suzuki et al. (2015) is that it is only a 2-dimensional assessment of grain shape. Giving these limitations, we aim to expand the applications of REF1 and SEF to gravels and further propose a new 3D shape index. In this study, 242 gravels sampled from 8 locations along the Kuzuryu River (Fukui Prefecture, Japan) were investigated. Each gravel was photographed from three directions to investigate 3D gravel shape. The outline images of gravels were automatically extracted using Canny edge detection based on the method of Mukaizato and Ohta (2020).

The results showed that SEF (surface smoothness) revealed a statistically significant correlation with the fluvial transportation distance, however REF1 (2D elongation) did not showed a meaningful correlation. Therefore, we can conclude that SEF (surface smoothness) is an adequate index to determine grain shape but the REF1 index (2D elongation) has a room for improvement. We attempt to solve this problem by calculating REF1 from a-b, a-c and b-c plane images and conduct principal component analysis to extract 3D shape indices. As a result, the principal component 1 (PC1) was an indicator of cubic- to bladed-shape of gravels, and the principal component 2 (PC2) determined the rod- to disk-shape of gravels. Thereby, a 3-dimentional quantifications of gravels can be described mathematically as if the grain is cubic- bladed- rod- to disk-shaped.

In summary, the present result suggests that the convectional SEF index measured in 2D is still appropriate as a measure of the surface smoothness, but REF1 needs an improvement and this study succeeded to expand the REF1 into the 3-dimetional index to determine cubic- bladed- rod- to disk-shaped sedimentary particle morphologies.

Keyword

EF-PCA, SEF, REF1

Geochemical and statistical evaluation of Late Jurassic to early Cretaceous sandstones in the Bredasdrop sub-basin: Compositional signatures and provenance lithologies

Mogammad Yaaseen HENDRICKS[1]*, The University of the Western Cape
(myhendricks@uwc.ac.za)
Tapas Kumar Chatterjee[2], The University of the Western Cape

Abstract

Southern Offshore basins of South Africa are well known as potential provinces of hydrocarbon exploration and production. The complex syn-rift architecture of the Bredasdrop sub-basin developed during the break-up of West Gondwana can have adverse effects on the distribution of sediments, especially for the exploration of hydrocarbons. This study aims to classify rocks based on their geochemical signature and shed light on compositional variations within a spatial and temporal context. Over several decades, the geochemical classification of rocks has been met with scrutiny but have not been dealt with in the correct context.

Thirty samples have been selected for geochemical analysis and have been analysed through XRF and ICP-MS devices. Geochemical classification of the early Cretaceous sediments in the Bredasdorp Sub-basin revealed a feldspatho-quartzose and litho-quartzose nature. Major element ratios identified diagenetically altered samples (High ratios of P2O5/Al2O3, CaO/Al2O3 and Fe2O3/Al2O3), especially those affected by poikilotopic calcite micro-nodules that can have detrimental effects on the CaO content. Nevertheless, these samples were removed in calculations and further statistical transformations. The CIA values ranged from 48.56-71.04 (indicating incipient to moderate weathering intensities) with an average of 59.41. Calculations of Land surface temperatures (showing values of 12°C and 14°C for the V-BUSM and BUSM-1AT1 respectively), indicates an increase stratigraphically possibly confirming the transition from Humid to Arid during the Berriasian to Valanginian Stages. This change is also confirmed by different weathering trends between the two successions.

Compositional data analysis using Principal Component Analysis (PCA) and Discriminant Function Analysis (DFA) revealed a spatial change in provenance with the northern part of the studied section receiving sediments from a collisional terrain such as the Cape fold belt (including the Table Mountain Group and Bokkeveld Group) whereas the southern sections received more sediments from the basement highs (recycled Malmesbury Group (and Pre-Cape sediments) and Cape granite suite). The major element data showed a tectonic setting to be of a rifted margin whereas trace element data (concentrated by multiple cycles of depositional histories) showed ‘false’ tectonic settings. Therefore, the use of trace element data and to some extent major element data should be re-evaluated in rifted settings and hence should not be used casually in studies for tectonic settings. The geochemical footprint of diagenesis and depositional environments should always be considered as part of the context before it is used blindly in evaluating tectonic setting identification.

Keyword

Geochemical classification, Depositional environments, Bredasdorp Sub-basin, Late Jurassic to Early Cretaceous, Compositional data analysis

Detrital zircon U-Pb geochronology and geochemistry of Carboniferous sedimentary rocks from the Kharkhorin terrane, Central Mongolia

Erdenechimeg DAVAAJAV[1]*, 1. Institute of Geology, Mongolian Academy of Sciences 2. Department of Geology and Geophysics, School of Arts and Sciences, National University of Mongolia (erdenechimegd@mas.ac.mn)
Oyunchimeg TUMEN-ULZII[2], Institute of Geology, Mongolian Academy of Sciences
Sharav DAVAANYAM[3], Institute of Geology, Mongolian Academy of Sciences

Abstract

The Kharkhorin terrane is located in the central part of the Khangay-Khentey orogenic system, dominated by the Carboniferous sedimentary rocks. We have conducted U-Pb geochronology and geochemistry analyses to determine the provenance, weathering conditions, and tectonic settings of sedimentary rocks from the Cuugel formation within the Kharkhorin terrane. The Cuugel formation mainly comprises a flysch sedimentary sequence consisting of bluish-gray, dark-gray siltstone, bluish-gray sandstone, and less conglomerate.

According to the whole-rock geochemistry analyses, the sandstones of the Cuugel formation have high Al2O3/TiO2 ratios (25.1 – 38.4), LREE/HREE ratios (LaN/YbN = 6.58 – 10.45), and negative Eu anomalies (Eu/Eu* = 0.64 – 0.97), indicate the felsic igneous source and deposited an active continental margin. All sandstones have low values for CIA (51.5 – 57.3), PIA (51.9 – 59.9), and ICV (0.86 – 1.03), suggesting the sandstones have undergone relatively weak weathering and have an immature source.

Detrital zircons from the bluish-gray sandstone (sample Kh-22-213) of the Cuugel formation range in size from 70 to 130 μm. Most zircons are euhedral prismatic, exhibit clear oscillatory and sector zoning in cathodoluminescence (CL) images, and have Th/U ratios greater than 0.1 (ranging from 0.25 to 1.28), indicating a primary source dominated by igneous rocks. All zircons yielded highly concordant zircon 206Pb/238U ages ranging from 801±19 to 331±9 Ma with four age populations identified at 801 – 770 Ma, 449 – 418 Ma, 403 – 362 Ma, and 356 – 331 Ma. The youngest peak of detrital zircons indicates the maximum depositional age of sedimentary rocks. The eight youngest zircon grains in this sample have a weighted mean age of 338.6 ± 3.3 Ma (MSWD = 1.1), which suggests that the sample deposited later than the Early Carboniferous age.

The sample contains zircon from two origins, magmatic and hydrothermal, identified by the rare earth element composition. Most zircons exhibit high (Sm/La)N values ranging from 14 to 400, a steep slope from La to Lu, strong positive Ce anomalies (Ce/Ce* = 33 – 252), and slightly negative Eu (Eu/Eu*=0.11–0.56) anomalies, indicating unaltered magmatic zircons. Hydrothermal-altered zircons can be identified by higher REE abundance, flatter LREE pattern (Sm/La)N ranging from 0.14 to 6.05, and minor positive Ce (Ce/Ce* = 1.1 – 6.8) and slightly negative Eu (Eu/Eu* = 0.13 – 0.56) anomalies. We used the provenance diagrams of U – Y and Yb/Sm – Y and the tectonic environment diagram of Th/U – Nb/Hf, suggesting detrital zircons in the studied sample were mainly derived granite–granodiorite–tonalitic rocks formed in arc-related/orogenic settings.

Keyword

U-Pb geochronology, geochemistry, sedimentary rocks, Kharkhorin terrane

Preliminary study of the Jurassic Bansong Group in the Yeongwol area

Sang-eon PARK[1]*, Seoul National University (pse135@snu.ac.kr)
Jusun WOO[2], Seoul National University

Abstract

The Jurassic Bansong Group is an important key for understanding the tectonic regime of the Mesozoic Korean Peninsula. However, disagreement between biostratigraphic and U-Pb ages have caused confusion of interpreting time of deposition of the Bansong Group. To describe detailed lithofacies and interpret depositional environment, fieldwork to the group in the Yeongwol area has been conducted and resulted in two columnar sections from the Eorayeon and the Yeonhari sections. The Bansong Group in the study area can be roughly divided into lower conglomerate part and upper sandstone/siltstone alternation part. The lower part contains polymictic conglomerates which consist of well-rounded and poorly sorted pebble-to-boulder-grade clasts within the coarse-grained sand matrix, corresponding to the Sapyeongri Formation. Clast size decreases slightly upwards within succession, while ratio of the matrix increases. In the Jeongyang region, cataclastic conglomerate unconformably overlies the Joseon and Pyeongan supergroups. In the upper part, there is an alternation of fine to medium-grained gray sandstone and dark gray siltstone, which can be correlated to the Hyeoncheonri Formation, overlain by massive coarse sandstone, corresponding to the Deogcheonri Formation. In the Yeonhari section, erosional surfaces are observed at uppermost part of the Deogcheonri Formation. Ripples, cross bedding, and mud chips were identified in the sandstone layers, while leaf fossils and footprint-like structures were recognized in the bedding plane of siltstone layers. Cataclastic conglomerate in the Jeongyang section is estimated as the deformed lower part of the group. Polymictic conglomerates exhibiting wedge-shape bed and normal grading in the lower part can be interpreted as axial or hinterland fluvial system. Sandstone-black siltstone alternation with leaf fossils in the upper part may indicate lacustrine environment, and erosional surfaces can be an evidence for time of no deposition or erosion. Previous studies proposed the Bansong Group deposited in Early Jurassic syn-tectonic piggyback basin based on zircon age data and relationship with thrust fold. Distribution and lithology of the Bansong Group likely support this idea. Detailed facies analysis, together with our data, paleocurrents patterns and thin section petrography will provide to understand spatial distribution of the facies and integrated depositional history of the group.

Keyword

Bansong Group, cataclastic conglomerate, piggyback basin

Geochemistry and detrital zircon U-Pb geochronology of metasedimentary rocks of the Sergelen formation in Central Mongolia: Implications for their provenance and tectonic settings

Oyunchimeg TUMEN-ULZII[1]*, Institute of Geology, Mongolian Academy of Sciences (oyunchimegt@mas.ac.mn)
Erdenechimeg DAVAAJAV[2], 1. Institute of Geology, Mongolian Academy of Sciences 2. Department of Geology and Geophysics, School of Arts and Sciences, National University of Mongolia
Narantsetseg TSERENDASH[3], Institute of Geology, Mongolian Academy of Sciences

Abstract

This paper reports new results from U-Pb geochronological and whole-rock geochemical studies of metasedimentary rocks from the Sergelen formation in the Onon terrane, Khangay-Khentey Orogenic Belt, Central Mongolia, with the aim of constraining the depositional age, provenance, and the implication for tectonic setting. The Sergelen formation is mainly composed of quartz-sericite-feldspar schist, sericite-quartz schist, quartz-mica schist, black shale, and siliceous shale with minor amounts of quartzite, chert-quartzite, metavolcanic rocks, and limestone.

Totally, 136 detrital zircons from black shale (SKh-23-33) and siliceous shale (SKh-23-34) samples were subjected for U-Pb dating. The CL images show that detrital zircons from the two samples consist of euhedral to slightly subhedral, stubby to mid-long prismatic crystals (60-120 μm in length) with concentric oscillatory zoning and as well as with high Th/U ratios of 0.2 - 1.3, typically for igneous origin. Some of them are broken. Concordant analyses on the euhedral to subhedral zircon crystals from the black and siliceous shale samples give Early Neoproterozoic to Carboniferous 206Pb/238U ages between ~947 Ma and ~320 Ma and between ~654 Ma and ~315 Ma, respectively. However, their age clusters were similar, showing three major peaks at 428 Ma, 391 Ma, and 350 Ma. The weighted mean 206Pb/238U ages of the youngest detrital zircon population is 326.0 ± 3.1 Ma and 323.1 ± 2.6 Ma, respectively, for two samples, clearly indicating that their depositional age must be younger than Lower Carboniferous.

All metasedimentary rocks are classified as graywackes with minor lithic arenite. Geochemical features such as the ratios of SiO2/Al2O3 (3.22 – 8.15, av. 4.50), Al2O3/TiO2 (19.13 – 41.08, av. 25.01), LREE/HREE (4.84 – 14.77, av. 12.06), and Eu/Eu* (0.70 – 0.92, av. 0.82) values suggest that graywackes were mainly derived from the felsic igneous sources and fewer samples were sourced from intermediate igneous rocks. The meta-sedimentary rocks have a relatively low Chemical Index of Alteration (CIA; 49 to 61) and average Index of Compositional Variability (ICV) values of about 1.0, suggesting a mature source that has undergone weak chemical weathering.

Keyword

U-Pb geochronology, geochemistry, metasedimentary rocks, Sergelen formation, Onon terrane

STATE OF THE ART OF THE JUMA FORMATION, ALTO TAPAJÓS GROUP, AMAZONAS STATE, BRAZIL: STRATIGRAPHIC REMARKS AND ITS IMPACT ON THE STUDY OF THE ALTO TAPAJÓS BASIN

Pâmela Silveira Costa[1], University of Brasilia
João Gabriel Cavalcante Vieira[2], University of Brasília
Dermeval Aparecido Do Carmo[3], University of Brasília
Matheus Denezine[4], University of Brasília
Adriana Maria Coimbra Horbe[5], University of Brasília
Rodrigo Rodrigues ADORNO[6]*, Geological Survey of Brazil (rodrigo.adorno@sgb.gov.br)

Abstract

This study provides an overview of the stratigraphic understanding of the Alto Tapajós Group, with a specific focus on the Juma Formation, a lithostratigraphic unit of the Alto Tapajós basin. The Alto Tapajós basin is an intracratonic basin located in the Amazon area in Brazil, a globally significant biome for geodiversity. The Juma Formation, Alto Tapajós Group, has the potential to its stratigraphic record correlated with the Amazon basin due to its spatial proximity, but due to the scarcity of scientific studies, this correlation is merely suggested. In addition to its scientific significance, this lithostratigraphic unit holds economic importance as it yielded phosphate deposits, which are currently under exploration for their agromineral potential. Additionally, it presents an underexplored potential for hydrocarbons. In general, there is a notable scarcity of detailed geological studies on the Alto Tapajós basin, a gap that needs to be addressing to enhance the understanding its chrono-biostratigraphic evolution. Several proposals have been developed for the stratigraphy of the Alto Tapajós basin. However, the lack of detailed geological mapping in the region and the adjacent basement has has led to divergent interpretations regarding its chronostratigraphic scope. Six distinct stratigraphic frameworks have been published for this basin, and some of them with different designations for lithostratigraphic unities. This fact highlights the gaps in the stratigraphic knowledge of the Juma Formation, particularly in terms of biostratigraphy, with only one publication that assigns this unit to the Silurian-Devonian interval. Notably, the aforementioned publication assigned the studied section to a different stratigraphic unit, tentatively linking it to the Beneficente Group. Furthermore, considering the occurrences of Silurian-Devonian poorly preserved organic-walled microfossils, this interval was attributed to the Jatuarana Group and later to the Alto Tapajós Group. The present study opens a discussion about the stratigraphy of the Juma Formation conducted based on the study of three drill cores from the Alto Tapajós Group, situated on the right bank of the Jatuarana stream, Municipality of Apuí. This detailed analysis covers sedimentological, paleontological, and geochemical perspectives. Paleontological analyses of these three drill cores suggest a Precambrian chronostratigraphic interval, contrasting with previous suggestions of Silurian-Devonian. Therefore, the importance of revisiting the type-sections of all formations of Alto Tapajós Group is highlighted, providing precise geographical coordinates and detailed descriptions of its lithostratigraphic units. As final remarks, by comparing results from the studied areas with those from type-sections, a more

comprehensive scientific dataset will be used to correlate the Alto Tapajós basin with others, including the Amazonas basin, leading to a wider understanding of its geology and evolution.

Keyword

Alto Tapajós basin, Juma Formation, phosphate, Amazon, Precambrian/Silurian-Devonian

Mineralogy, and Trace and Rare Earth Element geochemistry of the Paleoproterozoic Karri Ironstone, Bijawar Basin, India: Implications for the genesis

Sushree Sangita Sangita PAL[1]*, 1. CSIR-National Geophysical Research Institute, Hyderabad - 500007 India 2. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad - 201002 India (sangita.ngri19a@acsir.res.in)
Sreenivas Bulusu[2], 1. CSIR-National Geophysical Research Institute, Hyderabad -500007 India 2. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad - 201002 India
Vijaya Kumar Teeda[3], 1. CSIR-National Geophysical Research Institute, Hyderabad -500007 India 2. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad - 201002 India
Balu Gugulothu[4], 1. CSIR-National Geophysical Research Institute, Hyderabad -500007 India
EVSSK Babu[5], 1. CSIR-National Geophysical Research Institute, Hyderabad -500007 India 2. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad - 201002 India
Andrey Bekker[6], Department of Earth and Planetary Sciences, University of California, Riverside, Riverside, CA 92521, USA

Abstract

Genesis of ironstone is still a matter of debate in terms of iron source. Hydrothermal, terrestrial, and diagenetic Fe sources have been suggested for Proterozoic and Phanerozoic ironstones. In this study, we have investigated the uppermost Karri Formation of the Gangau Subgroup of the Paleoproterozoic Bijawar basin developed on the Budelkhand craton in India - a thin uneconomic sedimentary succession hosting ironstone with iron-rich stromatolites in an iron-rich clay matrix. The whole-rock composition of the ironstones shows more than 85 % Fe2O3+SiO2 content. Microscopic and SEM-EDS analysis reveals that hematite is the prominent iron-bearing mineral in the samples; however, goethite is also present in some samples, likely due to recent weathering. Oolites account for 60 to 70 % by volume. The relative enrichment of Th, Al, and Zr indicates detrital contribution to the matrix. Post Archean Australian Shale (PAAS)-normalized REE patterns of the samples display almost flat patterns with LREE enrichment compared to HREE, small positive Eu (1.21 to 2.0), and negative La, Gd, and Y anomalies, consistent with a seawater signal influenced by high-temperature hydrothermal fluids. Geochemical data and sedimentary features point to a mixed terrestrial and hydrothermal sources for the Karri Formation ironstone. Trace element and REE data further suggest a suboxic to anoxic deep-water basin redox with deposition of the ironstone at the redoxcline.

Keyword

Bijawar Basin, Ironstone, Iron-rich stromatolite, Genesis, Trace and REE elements

Current-controlled sedimentation in the Charlie Gibbs Fracture Zone (North Atlantic)

Evgenia DOROKHOVA[1]*, Shirshov Institute of Oceanology, Russian Academy of Sciences, Russia (zhdorokhova@gmail.com)
Sergey Sokolov[2], Geological Institute, Russian Academy of Sciences
Ekaterina Ponomarenko[3], Shirshov Institute of Oceanology, Russian Academy of Sciences
Leyla Bashirova[4], Shirshov Institute of Oceanology, Russian Academy of Sciences
Tatiana Pugacheva[5], Shirshov Institute of Oceanology, Russian Academy of Sciences; Immanuel Kant Baltic Federal University
Daria Laskina[6], Shirshov Institute of Oceanology, Russian Academy of Sciences; Immanuel Kant Baltic Federal University
Kseniya Dobrolyubova[7], Geological Institute, Russian Academy of Sciences
Zarina Urazmuratova[8], Shirshov Institute of Oceanology, Russian Academy of Sciences

Abstract

The Charlie-Gibbs Fracture Zone (CGFZ) is the main transform system in the North Atlantic. It serves as a primary deep-water gateway for the current of the Iceland-Scotland Overflow Water (ISOW), which is part of the lower limb of the Atlantic Meridional Ocean Circulation that strongly modulates regional and global climate. The aim of this study is to determine the sedimentary processes in the area of a tectonically active deep-water gateway and to reconstruct the bottom current variability as reflected in the bottom sediments.

New geological and geophysical data were collected during the cruises of R/V Akademik Nikolaj Strakhov in 2020 and R/V Akademik Sergey Vavilov in 2021. The surveys included bathymetric studies using a deep-water multibeam sonar system, high-resolution subbottom profiling (2-6 kHz), and retrieval of two sediment cores using a gravity corer. Stratigraphic subdivision of the sediment cores is based on the micropaleontological analysis, ice-rafted debris (IRD) counts, calcium carbonate content and three radiometric 14C dates. Grain-size, bulk mineralogical, geochemical, and magnetic susceptibility analyses were used to distinguish lithological facies.

On the basis of the sub-bottom profiling, the current controlled sedimentation was inferred. Three types of local contourite drifts were identified in the valleys of the inactive fractures and the active transform: (1) channel-related drifts, (2) confined drifts, and (3) fault-controlled drifts. The ISOW current is the main agent controlling the drift formation in the northern valley. The influence of the Denmark Strait Overflow Water of northern origin and/or Low Deep Water of southern origin was also suggested for the southern valley. Tectonic deformations of the sedimentary strata have been detected within the valleys of the active and inactive transforms.

Studies of sediment cores have revealed of six sedimentary facies. During the Holocene, contourite sedimentation dominated with admixture of pelagic settling. The gradual increase of the ISOW current flow from the Late Pleistocene to the Middle Holocene was identified by the consistent disappearance of amphibole from the sediments. During the glacial intervals of the Late Pleistocene, the hemipelagic sedimentation with high input of ice-rafted debris prevailed in the fracture valleys. The acoustic stratification of the sediments is caused by the alternation of glacial

and interglacial intervals, at least in the upper part of the profiles. North Atlantic Ash Zone 1 layer, diatom ooze and turbidites were identified in the sediment cores, indicating short-term events.

Although the valleys of the CGFZ are well known as conduits for the ISOW flow, this is the first time that the contourite drifts have been revealed here. Therefore, our study highlights the importance of oceanic fracture zones in their role as deep-water gateways. They intensify the bottom currents that leave remarkable sedimentological imprints. Decoding these imprints helps to reconstruct the behaviour of the bottom current in the past and provides essential information for palaeoclimate reconstructions.

Study was carried out with the financial support of RSF, grant No. 22-17-00170, https://rscf.ru/project/22-17-00170/.

Keyword

deep-water gateway, contourites, Iceland-Scotland Overflow Water, subbottom profiling, sediment cores

Contourite drifts in the South-Eastern Baltic Sea

DMITRY DOROKHOV[1]*, Shirshov Institute of Oceanology, Russian Academy of Sciences (d_dorohov@mail.ru)
Evgenia Dorokhova[2], Shirshov Institute of Oceanology, Russian Academy of Sciences
Vadim Sivkov[3], Shirshov Institute of Oceanology, Russian Academy of Sciences
Ivan Dudkov[4], Shirshov Institute of Oceanology, Russian Academy of Sciences; Immanuel Kant Baltic federal university
Victoria Merkurieva[5], Shirshov Institute of Oceanology, Russian Academy of Sciences; Immanuel Kant Baltic federal university
Evgeniy Orlov[6], Shirshov Institute of Oceanology, Russian Academy of Sciences; Immanuel Kant Baltic federal university
Daria Laskina[7], Shirshov Institute of Oceanology, Russian Academy of Sciences; Immanuel Kant Baltic federal university

Abstract

Water exchange between the Baltic Sea (semi-enclosed brackish basin) and the North Sea began at about 8500 BP. Since that, dense (salty) North Sea water inflows spread in deep subbasins of the sea as contour currents and form contourite drifts. In a sense, these drifts are an accessible natural model of oceanic contourite drifts.

We identified and studied two drifts in the South-Eastern Baltic Sea, one in the Eastern Gotland Deep (“Gotland Drift”) and other in the Gdansk Deep (“Gdansk Drift”). For these purposes, a novel digital elevation model of the bottom relief and sub-bottom profiling data were used. Grain-size, organic matter and elements content were studied in sediment cores.

Complex Gotland Drift is located at the depth of 115-125 m and includes: channel-related contourite fan, elongated mounded detached drift, separated and sheeted drifts. The channel-related contourite fan originated first after start of North Sea waters inflow in the Baltic Sea (Littorina transgression). At the course of the weakening of the bottom currents the other types of drifts were forming. The numerous furrows (elongated pockmarks), originated from interaction of the gas seepages and bottom currents, complicate the surface of the Gotland Drift. The muddy contourites are laminated, sometimes micro-laminated, with high organic content and enrichment by hydrocarbon gases.

The Gdansk Drift is located at depths of 100-105 m, near the steep eastern slope of the Gdansk Deep, and consists of gentle mounded separated and sheeted parts. A 3-D geological model of the drift was constructed from subbottom profiling data. The model revealed structural depression in the Pre-Quaternary and overlaying limno-glacial sediments that conditioned location of the contourite channel. The drift, as well as Gotland Drift, was formed during the Littorina transgression.

Conturites indicate the shifts in the depositional environment of centennial time scales controlled by the North Sea water inflows and climate changes. Values of the ln (Zr/Rb) along the sedimentary sequences correlates well with the mean of organic-free sortable silt fraction ($\overline{(SS)}$), which is a well-known proxy for the bottom palaeocurrent velocity. Increased values of ln (Zr/Rb)

and $(SS)^{-}$ are inferred for the Holocene Climate Optimum, as well as a low content of organic matter in sediments. The weakening of the bottom currents began around 4000 BP, with marked decrease in velocity during the Little Ice Age.

Research was carried out with financial support from RSF, project No. 22-17-00170, https://rscf.ru/project/22-17-00170/.

Keyword

the Baltic Sea, contourite drifts, the North Sea water inflows, bottom palaeocurrents, Littorina transgression

Comparison of Middle Permian sedimentary characteristics and stratigraphy in the northern and southern typical sag areas of the East Junggar Basin,North China

Keting Fan[1]*, National Key Laboratory of Petroleum Resources and Engineering&China University of Petroleum (Beijing) (2022310030@student.cup.edu.cn)
Gang Gao[2], National Key Laboratory of Petroleum Resources and Engineering&China University of Petroleum Beijing
Jilun Kang[3], Research Institute of Exploration & Development, PetroChina Tuha Oilfield Company
Ziheng Zhang[4], National Key Laboratory of Petroleum Resources and Engineering&China University of Petroleum Beijing
Jie Li[5], National Key Laboratory of Petroleum Resources and Engineering&China University of Petroleum Beijing
Qiang Ma[6], Research Institute of Exploration & Development, PetroChina Tuha Oilfield Company
Wei Zhang[7], Research Institute of Exploration & Development, PetroChina Tuha Oilfield Company
Yan Zhang[8], National Key Laboratory of Petroleum Resources and Engineering&China University of Petroleum Beijing

Abstract

The Jimsar Depression and Shishugou Depression in the eastern part of the Junggar Basin are based on the Palaeozoic and have similar depositional setting. The main hydrocarbon layer of the Middle Permian in the southern Jimsar Depression, the Lucaogou Formation, is divided into the upper and lower members. The main hydrocarbon layer of the Middle Permian in the northern Shishugou Depression, the Pingdiquan Formation, is divided into the upper, middle, lower members. The depositional environments and stratigraphic correlations between the two formations are controversial, which significantly impacts the overall exploration deployment of the Junggar Basin, North China.

The rock exposure and drilling results of the Lucaogou Formation and the Pingdiquan Formation reveal that in the context of a salinized lake basin they are both grey black shale and dolomitic rocks deposited interactively, with overall similarity in the hydrocarbon source rocks and lithological sequences. It was found in the cores of the Lucaogou Formation and Pingdiquan Formation that the standard fossil Taoshuyuan Turfan Cod and fossilized sporoderm assemblages, and so on are basically the same. The stable presence of red beds in the overlying Triassic Leek Garden Formation. Combined, these studies consider the Lucaogou Formation is comparable to the Pingdiquan Formation.

Based on this, combined with seismic data, it was found that the Shaqi relief dividing the southern and northern depressions exists a part of underwater low relief. On this low relief, the Lucaogouo Formation in the south and the Pingdiquan Formation do not undergo a sedimentary break. Two exploratory wells were identified in the Jimsar Depression and the Shishugou Depression. After analyzing the characteristic biomarker compounds of the 206 sets of samples from the target layer

of the two wells and the 137 sets of XRD whole rock data, it was found that, the salinity of the water body in the Shishugou Depression in the north is lower than that in the Jimsar Depression in the south, but the fluctuations of salinity of the water body in both cases are similar to those in the palaeoenvironmental evolution. Based on the lithological sequence, flora and fauna community, seismic geological data, and parameters of characteristic biomarker compounds of the Lucaogou Formation and Pingdiquan Formation, the present study concludes that the lower and meddle members of the Pingdiquan Formation in the north and the Lucaogou Formation in the south belong to the same period of stabilization of undercompensated salinization lake basins. Although there are differences in paleo-salinity, and paleo-climate, they can be compared.

Keyword

The Junggar Basin, The Lucaoggou Formation, The Pingdiquan Formation, Stratigraphic correlation

Sedimentological characteristics and surface microtextures of quartz grains in modern sediments of the Hantan River, South Korea

Soyoung BAEK[1]*, Kangwon National University (bbackso1019@kangwon.ac.kr)
Kyoung-nam Jo[2], Kangwon National University

Abstract

Surface microtextures in quartz grains (SMQs) analysis on laboratory experiments or modern sediments can provide immediate insight on transport processes and signature imprinted textures of specific depositional environments. In this study, we conducted a detailed investigation of SMQs within modern fluvial environments, including both the mainstream and its tributaries, considering the geological and geomorphological characteristics of the Hantan River in central South Korea. The comprehensive SMQ results in the Hantan River showed a dominance of mechanical microtextures, including angular to sub-angular outlines, various-scaled conchoidal fractures, steps, flat cleavage, v-shaped percussion cracks, and upturned plated. These findings indicate characteristics similar to high-energy fluvial environments, as sediments in the Hantan River are transported under significant hydrological energy during the rainy season, influenced by the monsoon climate which brings concentrated summer rainfall. In a detailed comparison of SMQs between the mainstream and its tributaries, the mainstream was characterized by more sub-angular outlines, small conchoidal fractures, v-shaped percussion cracks, and medium to high relief. In contrast, the tributaries showed prominent angular outlines, flat cleavage surfaces, and low relief. These difference of the SMQ between the mainstream and tributaries suggest relative distances differences from their provenance. This observation is further supported by the mineralogical composition that tributaries contain minerals from nearby parent rocks, while the mainstream includes minerals not only upstream composition minerals but also those from the tributaries after their confluence. Thus, the sediments in mainstream are expected to contain materials transported from more distant sources, suggesting they potentially originate from further upstream areas. Although understanding their specific sources requires further detailed study, the SMQ of the mainstream reflect increased abrasion and impacts resulting from the longer transport distance of the sediments compared to those in the tributaries. These findings on modern sediments can be applied to other fluvial sediments similar to the Hantan River and help in understanding the processes related to individual SMQ formation.

Keyword

Surface microtextures of quartz grains (SMQs), Hantan River, Modern sediments, Scanning Electron Microscope (SEM)

Source rock determination of detrital quartz grains by utilizing the Voigt peak separation of cathodoluminescence spectrum and fabric textures.

Naoya Miyashiro[1]*, Waseda University (naoyanomori@icloud.com)
Tohru OHTA[2], Waseda University

Abstract

Cathodoluminescence (CL) is a luminescence phenomenon that occurs when a rock sample is irradiated with an electron beam and the luminescence intensity, and its spectrum can variate due to the lattice defect and the amount of the impurity elements inherited in crystals. Therefore, CL spectrum of quartz may variate depending on the rock type, and thus, many previous studies have utilized the CL characteristics of quartz grains in order to conduct provenance analyses (e.g., Zinkernagel, 1978). However, most of these studies are based on the overall color and the shape of the CL spectrum, and few conducted isolation and extraction of the luminescence centers individually. In this study, we measured CL spectrum of quartz grains obtained from various igneous and metamorphic rocks, and attempted to propose a quantitative source rock determination diagram by using peak separation.

Sixteen rock samples, including volcanic, plutonic, high-temperature metamorphic, and high-pressure metamorphic rocks, were analyzed. The analysis was conducted using the scanning electron microscope equipped with the diffraction grating spectrometer. Using this equipment, CL spectrum between the wavelength band of 250-945 nm, covering the visible light region, was measured at 5 nm intervals.

The CL spectrum of quartz grains obtained from volcanic and metamorphic rocks commonly emit a bimodal light in the red region (around 420 nm) and the blue region (around 620 nm). Generally, the volcanic rock samples showed a stronger emission in the blue region, while the metamorphic rock samples showed a stronger emission in the red region. To further analyze these differences quantitatively, the obtained spectrum was separated into five peaks by using the Voigt function. The five luminescence centers are 1.60 eV (770 nm), 1.95 eV (620 nm), 2.80 eV (450 nm), 2.95 eV (420 nm), and 3.30 eV (380 nm), which are mainly due to lattice defect and impurity elements in crystals.

Principal component analysis was performed and grouped the relative emission intensities into (a) 1.60 eV + 2.95 eV + 3.30 eV, (b) 2.80 eV, and (c) 1.95 eV are indicators reflecting the effects of impurity elements, heat exposure, and pressure, respectively. Taking these into account, a ternary diagram with these components organized in three apexes was created.

In this diagram, volcanic rocks with significant emission intensity in the blue region and high-pressure metamorphic rocks with significant intensity in the red region are clearly separated. The

CL spectrum of the plutonic and the high-temperature metamorphic rocks are similarly discriminated. However, the difference were insignificant and plot regions of plutonic and the high-temperature metamorphic rocks showed a partly overlapping pattern.

In conclusion, it was shown that newly proposed diagram can be used to determine the source rock by restoring the impurity elements, the degree of heat exposure, and the degree of pressure in quartz grains, although further improvements are still needed.

Keyword

cathodoluminescence, quartz, provenance analysis, source rock determination

Autogenic Oscillation of Grain-Size Transitions under Constant Sea-Level Rise-Flume experiment and Computational Modeling

Jaehyung LEE[1]*, Yonsei university (j_hyung_lee@yonsei.ac.kr)
Wonsuck Kim[2], Yonsei university

Abstract

The cause of formation in sedimentary structures can be broadly categorized into two processes: allogenic forcing and autogenic processes. Previous studies have often overlooked the influence of autogenic processes due to their small scale and randomness. However, recent studies (e.g., Kim et al., 2008) using flume experiments revealed that under calm environmental conditions, autogenic processes might cause cyclic signatures with measurable dimensions.

In this study, we analyze the periodic advancement and retreat of "grain-size transitions (GSTs)" under varying rates of sea-level rise. We conducted 33 experiments, with 11 different sea-level rise rates, repeated three times each. Under constant upper boundary conditions, the growth of the delta leads to the overall seaward advancement of the GST with occasional retreat. This repetitive advancement and retreat draw a zigzag-shaped trajectory, which can be quantified in two factors: the amplitude of GST movement and the frequency of retreat. Over 33 experiments, as the rate of sea-level rise increases, the amplitude of the trajectory decreases. However, the frequency of GST movement increases with a higher sea-level rise rate.

As sea level rises, more deposition occurs near the shoreline, leading to a decrease in the overall gradient of the delta surface. With the reduction in the overall gradient and the distance to the shoreline, the amount of sediment deposited on the delta surface decreases. As fluvial envelope (Powell et al., 2012) decreases, the storage and release of sediment, reflected by changes in gradient, occur more frequently for a given sediment supply rate. With the reduced amount of sediment stored during each storage phase, the amount of sediment to release decreases, resulting in shorter movement in GST.

To validate our experimental findings, we employed a simple one-dimensional delta model that incorporate the storage and release mechanism. The modeling results closely match the experimental results in the magnitude and frequency of GST movements. This study demonstrates the potential use of grain-size transition patterns driven by autogenic processes as a predictive tool for sea-level rise variations in limited and incomplete sedimentary records.

Keyword

Autogenic process, Grain-size transition, Sea-level rise

Geochemistry of Phosphatic Nodule within shale of Kopili Formation, Litang Valley, East Jaintia Hills, Meghalaya, India: Implications on Provenance

SHUBHAJIT KAR[1]*, GEOLOGICAL SURVEY OF INDIA (subhajit.kar@gsi.gov.in)
Rashmi Ranjan[2], GEOLOGICAL SURVEY OF INDIA
Dr. N Nandhagopal[3], GEOLOGICAL SURVEY OF INDIA

Abstract

An attempt is made to decipher the provenance of phosphatic nodule bearing shales of Kopili formations (Middle to Late Eocene) using geochemistry. The Kopili Formation comprises black splintery shales interbedded with marl and sandstone as its members, overlying the thick limestone unit of Upper Sylhet Limestone of Shella Formation, Jaintia Group, Litang Valley, Meghalaya, India. The area in and around Samasi-Pala-Larket-Akshe-Sherwang is found to have a concentration of phosphate nodules with varying size and shape within shale in lower part of the Kopili Formation. Phosphatic nodules ranging in size from a few mm to 10 cm have been observed within the lowermost shale unit occurring just above the contact zone, i.e. Marl of Kopili Formation and Upper Sylhet Limestone of the Shella Formation. The nodules are cherty and limonitic in nature. They are randomly scattered within the shale and have less concentration. The phosphate nodule bearing zone is discontinuous, and the nodules are sporadically distributed and confined to the lowermost shale horizon above the marl unit. These nodules vary from a few mm to 10 cm in size and are rounded, sub rounded, elongated, oval, or ellipsoidal in shape. The chemical composition of phosphate nodules (wt%): SiO_2 30.2 to 32.19%, Al_2O_3 10.33 to 11.3%, Fe_2O_3 14.9 to 17.04%, K_2O 1.1 to 1.3%, P_2O_5 varies from 5.23 to 19.18 % having an average phosphate concentration of 12.97 % in nodules only. The composition of shale varies from SiO_2 48.7 to 55.2%, Al_2O_3 19 to 20.84%, Fe_2O_3 7.75 to 14.33%, K_2O 2.11 to 2.88%. P_2O_5<1%. Using the Shapiro solution method, the presence of phosphate content is confirmed. The TiO_2/Zr ratio (avg. shale: 48.37; nodules: 44.86) represents that they have been derived from felsic, i.e. granitic to granodioritic sources. The phosphatic nodules are rich in La concentration. The average ratios Eu/Eu* (0.71) and Th/Sc (0.71) in shales also represent granitic to granodiorite sources. The lower to moderate ratio of Cr/V (avg. 0.61) & Y/Ni: 2.20 represents a probable derivation of source rocks from granitic terrain, but some amount of contribution from ultramafic sources can also be considered. The ratios of trace elements: Zr/Sc vs Th/Sc, represent two patterns regarding the source composition and effects on the source by sedimentation processes. The higher value of Zr in sediments is due to the association between detrital zircon and/or heavy minerals during sedimentation processes. The trace element variations such as La, Eu/Eu*, Th/Sc of shales and phosphate nodules also indicate that they were derived from the uplifted and eroded crystalline felsic terrain of granitic-granodioritic composition from the Himalayan ranges, with a likely contribution from the nearest orogeny such as Indo-Burmese and Naga hills. The REE patterns show the fractionated granitic rock at the source. The presence of phosphatic nodules reflects a warm climate to promote exuberant life, which is a pre-requisite for the accumulation of soluble

phosphate. It also indicates that the area was of shallow depth with slow accumulation, connectivity to the sea within the prevalence of stable paleogeographic conditions.

Keyword

Phosphatic nodule, geochemistry, provenance, Kopili Formation, shale

Geochemistry and petrography of Middle Jurassic Nariinsukhait sandstone: Implications for paleoclimate and provenance

Baigalmaa NOROV[1]*, National University of Mongolia (baigalmaa_n@num.edu.mn)
Erdenetsogt Bat-Orshikh[2], National University of Mongolia
Jargal Luvsanchultem[3], National University of Mongolia
Oyungerel Sodnom[4], National University of Mongolia

Abstract

The Nariinsukhait deposit, which has 1.2 billion tons of coal reserves, is situated in southern Mongolia. In 2020, more than 9 Mt coal was produced from the deposit. Middle and Upper Jurassic 34 sandstone core samples from exploration borehole were studied herein.

Petrographically, the sandstones are classified as fieldspatic litharenite and litharenite reflecting relatively weak weathering intensity in source area, probably due to arid or semiarid climate conditions. Provenance analysis indicates that the sandstones are sourced from transitional recycled orogen. Geochemistry of samples indicates that sandstones were derived from acidic and intermediate rocks and mixed with recycled older sedimentary rocks. Possible sources are volcanosedimentary rocks of Mississippian Tost Formation, granite and granodiorite of Early-Late Carboniferous Tavan-Uul complex and sedimentary rocks of Middle-Upper Triassic Noyon Formation. Paleoclimate indices (C-value, Rb/Sr, Sr/Ba, 1000xRb/K2O and CIA) reflect that coal seams were accumulated in warmer and more humid climate, when paleo-weathering was intense, whereas sandstones were deposited in relatively cold and arid climate. In Late Jurassic, it is more likely that paleoclimate became more arid and cold compared with Middle Jurassic, indicated by quite low CIA and Rb/Sr. Moreover, various discrimination diagrams suggested that Middle Jurassic coal-bearing sedimentary rocks were accumulated in foreland basin. It is consistent with previous interpretations of regional tectonic during Triassic and Jurassic time.

Keyword

sandstone, sedimentary rock, middle jurassic, Noyon Formation, foreland basin

Retreat of the fan margin in an alluvial fan

Haein Shin[1]*, Department of Earth System Sciences, Yonsei University (hishin@yonsei.ac.kr)
Wonsuck KIM[2], Department of Earth System Sciences, Yonsei University

Abstract

This study employs two-dimensional modeling of the fan margin in an alluvial fan, under the constant upstream boundary conditions of sediment supply and water discharge and a steady base-level. The findings reveal an inevitable retreat after a period of progradation, attributed to temporal change in groundwater infiltration during fan development. Seven flume experiments, varying sediment and water discharge rates, were conducted to further investigate the effect of infiltration on the alluvial fan evolution and thus the occurrence of fan-margin retreat. Fans typically exhibit continuous progradation, but a critical point is observed at which the surface runoff fails to reach the fan margin, leading to sediment transport only limited to the channel tips. Consequently, the margin of the active fan surface retreats landward. From the apex to the retreating margin, all runoff water was presumed to penetrate the deposit, passing through the substrate. It is observed that the infiltration rate increases as the fan deposit becomes thicker (larger storage potential of the deposit as shown in the Holtan Equation). Notably, the experiment runs with higher Qs/Qw ratios develop thicker, steep-sloped fans, reaching the faster critical point for channels to drain all surface water to groundwater. Thus, the specific deposit thickness, controlled by the upstream boundary condition, serves as a trigger for the retreat process. This research sheds light on the complexities underlying autogenic fan evolution and provides a potential mechanism for fan-margin retreat without changes in external controls, e.g., tectonic processes.

Keyword

alluvial fan, flume experiment, upstream boundary conditions, retreat, groundwater infiltration

Pelagic carbonate sections across the Faraoni Oceanic Anoxic Event in the Umbria-Marche Basin (Apennines, Italy)

Maryna Krochak[1], Institute of Natural Sciences, Geological Survey of Belgium
Mathieu Martinez[2], University of Rennes, France
Sophie Verheyden[3], Institute of Natural Sciences, Geological Survey of Belgium
Xavier DEVLEESCHOUWER[4]*, Institute of Natural Sciences, Geological Survey of Belgium
(xdevleeschouwer@naturalsciences.be)

Abstract

The Cretaceous sections of the Uppermost Hauterivian of the Umbria-Marche Basin (Italy Apennines) associated with the Faraoni Oceanic Anoxic Event (FOAE) were investigated. Deposits of this level in the region were first described by Cecca (Cecca et al., 1994).

In this study, a multi-methodological approach is undertaken combining microfacies, magnetic susceptibility and geochemichal techniques. Six sections were sampled for petrographic studies: Apecchiese road, Bosso, Burano, Frontone, Gorgo a Cerbara, Gubbio-Contessa. The aim of the study is to investigate the mineral and micropaleontological composition of the rocks, to identify microfacies that are the result of changing conditions of sedimentation before, during and after the FOAE. Samples were taken layer by layer at 5 cm intervals before, during and after the FOAE.

The rocks are represented by mudstones and wackestones. The bioclastic grains are mainly calcitized shells of radiolarians, less frequently foraminifers, ostracods, molluscans. Limestone textures are more often uniform indicating rather calm energetic conditions. Bioclastic lenses and or nodules could be the results of low-energy bottom-current and bioturbation features near the FOAE.

The percentage of radiolarians varies greatly throughout the analyzed stratigraphic interval and ranges from 1 to 12-15%. Based on the evaluation of the number of radiolarians, their size and diversity, as well as the presence of planktonic foraminifers, three microfacies are identified:

Microfacies 1 (MF1). Micritic mudstone with small, rare radiolarians, characteristic, as a rule, of remote deposits below and above the FOAE;

Microfacies 2 (MF2). Micritic mudstone to wackestone with rather large, diverse and frequent radiolarians, occurring near the FOAE at a distance of 50-60 cm before and after;

Microfacies 3 (MF3). Micritic wackestone with planktonic foraminifera associated with large and abundant radiolarians, characteristic of sediments inside the middle of the FOAE, as well as just before and after the FOAE at 5-10 cm.

The observed microfacies are consistent with published data, from studies of sections with the FOAE in the Apennines (Coccioni, 1998) and the Southern Alps (Cecca, 1996).

MF 2/3 are also characterized by the presence of detritus of thin-walled molluscan bivalves, single shells of small planktonic gastropods, ostracods, and fragments of ammonite shells (MF3), clumps of amorphous plant matter, palynofloras, scraps of plant detritus.

The general increase in bioproductivity, namely the abundance and flourishing of radiolarians, the appearance of heat-loving globigerina-like planktonic foraminifers identified as Gorbachikella

(Coccioni et al., 1998), the presence of other planktonic marine organisms and the terrestrial plant most likely indicate a rising surface water temperatures and increased influx of nutrients from eutrophic conditions established in the basin. Blooming of non-skeletal algae and oxygen depleted bottom-water conditions allowed the accumulation of enriched Corg black shales.
Correlating microfacies changes with fine detrital changes are planned with magnetic susceptibility data of the samples. MS variations associated with changes in the input of terrigenous clastic compounds from continental sources fluxes towards the marine area will confirm our assumptions about the increased flushing of organic matter from the land during the FOAE. Moreover, geochemical analyses are also planned to identify geochemical anomalies around the FOAE.

Keyword

Faraoni event, black shales, Italy, anoxia, pelagic carbonates

Temperature Effects on Ripple Migration and Bedload Transport Rates: Flume experiments

Sejin KIM[1]*, Yonsei University (mozaryong147@gmail.com)
Wonsuck KIM[2], Yonsei University
Yunhyeong LEE[3], Yonsei University

Abstract

In a fluvial environment, the complex interaction between fluid dynamics and sediment transport shapes the Earth's surface in response to sedimentary conditions e.g., climate. Particularly water temperature can affect depositional systems by changing the characteristics of fluid, such as viscosity. Even though water temperature affects not only the fluid itself, but also the interaction between fluid and sediment, which can lead significant morphological changes, there is limited knowledge in the temperature effects on morphodynamics. In this study we focus on the effect of water temperature on ripple migration rate and bedload transport rate. We use experimental data conducted under varying water temperature (between 10°C and 45°C) conditions. Using time-lapse images of the experiments and applying cross-correlation method to the topographic data, we could measure ripple migration rate. Ripple migration rates, coupled with different ripple heights under varying temperatures, enable the calculation of bedload transport rate. In the experiments, as water temperature increases, ripple migration rate increases, while ripple height decreases with increasing water temperature. Since the increase in the ripple migration rate has a more significant effect than the decrease in the ripple height with increasing water temperature, the bedload transport rate is expected to increase with increasing temperature.

This study contributes valuable insights into the intricate relationship between sediment transport through bedform migration and water temperature variation, and thus allows for better interpretation of paleo-climate in sedimentary records and prediction of landscape changes in different temperature regions.

Keyword

water temperature, ripple migration rate, bedload transport rate

Parvancorina :The anchor-shaped Ediacaran organism from Sonia Sandstone Formation of Marwar Supergroup, India

HUKMA RAM[1]*, Jai Narain Vyas University, Jodhpur, Rajasthan, India
(hukmaramchouhan@gmail.com)

Abstract

The present investigation documents and describes the anchor-shaped Ediacaran organisms assigned to *Parvancorina* on the sandstone bedding plane of Sonia Formation of Marwar Supergroup in India. This is the first report of *Parvancorina* organisms from India. Specimens are preserved as small, rounded to ovate, posterior shield-shaped impressions with an anterior-lateral widened portion and a posterior anchor-shaped structure. The Ediacaran period remains a captivating chapter in Earth's history, and within its fossil record lies the mysterious entity, *Parvancorina*. This abstract ventures into the depths of ancient oceans to illuminate the story of *Parvancorina*. This discovery adds a novel dimension to the understanding of *Parvancorina's* paleobiology and distribution, providing a crucial link to the broader Ediacaran biota in India and contributing valuable insights into the ecological dynamics of this enigmatic period in Earth's history. *P. minchami* shows both positive and negative relief preservation modes. In Sonia Formation, the recovered *P. minchami* specimens have been found in size ranges of 1.5 × 1.5 to 3.0 × 3.5 cm2 (length × width), suggesting preservation of adult and larger forms. The allure of *Parvancorina* lies not only in its peculiar morphology but also in the questions it raises about the evolutionary experimentation preceding the Cambrian explosion. Based on the *Parvancorina* and associated Ediacaran fossils assemblages, this study suggests in terrestrial to marginal marine habitats with moderate hydrodynamic forces.

Keyword

Parvancorina, Ediacaran Biota, Marwar Super Group, Rajasthan, India

Quantitative characterization of 3D pore structures and percolation characteristics in bioturbated reservoir media based on x-ray micro-CT: a case study of the neogene sanya formation in the Qiongdongnan basin, northern south China sea

Yongbin NIU[1]*, Henan Polytechnic University (niuyongbin@hpu.edu.cn)

Abstract

Organisms alter the primary texture of sediments, leading to alteration in petrophysical properties between the fills and host sediments, which affects reservoir properties and fluid flow characteristics . In this paper, the three plugs (S1, S2, and S3) selected were all derived from cores from the Sanya Formation in the Qiongdongnan Basin. The content of Ophiomorpha in the three selected plugs varied, with about 75% by volume of Ophiomorpha in the S1plug, about 60% by volume of Ophiomorpha in the S2 plug, and about 50% by volume of Ophiomorpha in the S3 plug. The 3D scanned data volume of the three selected plugs was obtained using the X-ray microscope (Zeiss Xradia 510 Versa) (XRM) to scan the rock plugs in the Key Laboratory of Paleomagnetic and Palaeotectonic Reconstruction, Institute of Geomechanics, Chinese Academy of Geological Sciences, and a 3D pore structure model was established. The geometric characteristics of the microscopic pore structure were quantitatively and visually characterized by a modified maximal ball algorithm, and connectivity analysis of the pore structure was carried out. Next, numerical simulations of the percolation characteristics of the analyzed bioturbated reservoir samples were performed using digital core software (Avizo) and multi-physics field simulation software (Comsol). The results show that: (i) 3D pore structures reveal that pore volume, pore area, pore equivalent radius, throat area, throat equivalent radius and throat length have a large distribution range; among them, the pore volume has the largest distribution range, which can vary by 6 orders of magnitude, indicating that the pore size distribution of the bioturbated reservoir is uneven and has strong heterogeneous characteristics; (ii) the connected pore structure is very complex , and as the equivalent radius of connected pore increases, the coordination number also gradually increases, the better the connectivity, Finally, numerical percolation simulation results also suggested that larger connected pore space plays a key role in the effective permeability of the reservoir. This study has important implications for analyzing the modification effect of bioturbation on oil and gas reservoirs and enhancing production and recovery in the study area.

Keyword

Bioturbation, Oil and gais Reservoirs, Pore structure, Percolation characteristic, Qiongdongnan Basin

Identification characteristics of barrier sandstones of Benxi Formation in Ganquan-Fuxian area in the Ordos Basin China

Renhai PU[1]*, Depart of GeologyNorthwest University (purenhai@nwu.edu.cn)
Xiangzheng MENG[2], Shaanxi Yanchang Petroleum (Group) Co., Ltd. Oil and Gas Exploration Company

Abstract

Barrier sandbar is the main reservoir microfacies of Benxi formation gas reservoir in Ganquan Fuxian area. However, due to the lack of exact insight into its diagnostic characteristics, the well location deployment lack of basis significantly. Based on logging, core and thin section data, the vertical and horizontal distribution, depositional cycle, logging facies analyzed for the barrier sandstones of Benxi Formation in Ganquan-Fuxian area. The results show that Benxi Formation in Ganquan-Fuxian developed two longshore barrier sandbars in NNW orientation, overlapping on the bilateral slopes of a paleomorgraphic highland. Barrier sandstones are beaded thickening, with maximum sandstone content up to about 50 %, and maximum single sandstone thickness 22m. The barrier is generally 3-10 km wide and more than 40 km long, simultaneously with the sedimentary characteristics of tidal channels and shoreface shoals. Sandbodies consist of pebbles and coarse to fine sandstone with herringbone cross bedding, tabular cross bedding, low angle cross bedding and subparallel bedding, graded bedding and biological disturbance. Two kinds of depositional cycles exist in the barrier depositions. One is an upward finning, the other is the upward coarsing. The former cycle is more common. There are four types of logging facies in barrier sandstone: box type, funnel type, bell type, and serrated type. The barrier sandstones are of high overall compositional maturity, medium textural maturity with locally lower or higher. The center of the barrier has good petrophysical properties for high-yield gas wells.

Keyword

Double barrier sandbars, Paleomorgraphy, Depositional cycles;, Textural maturity, Logging facies

Provenance and source area weathering of sandstones from the Tarkwaian group at the northeastern extent of the Paleoproterozoic Ashanti belt, Ghana: Constraints from petrography and geochemistry.

Victor SEDZIAFA[1]*, China University of Petroleum,East China (vsedziafa14@gmail.com)
Ying SONG[2], China University of Petroleum, Department of Geology, East China
Daniel Kwadjo ASIEDU[3], University of Ghana, Department of Earth Science, Legon-Accra
Chris Yao ANANI[4], University of Ghana, Department of Earth Science, Legon-Accra
Daniel KWAYISI[5], University of Johannesburg, Department of Geology, Auckland Park Kingsway Campus, South Africa
Emmanuel Daanoba SUNKARI[6], University of Mines and Technology, Faculty of Geosciences and Environmental studies, Department of Geological Engineering, P.O.Box 237,Tarkwa-Ghana

Abstract

Provenance and source area weathering of sandstones from the Tarkwaian group at the northeastern extent of the Paleoproterozoic Ashanti belt, Ghana:
Constraints from petrography and geochemistry.

1Victor Sedziafa, 1 Ying Song, 2,Daniel K. Asiedu, 2Cris Y. Anani, 3Daniel Kwayisi 4 Emmanuel Daanoba Sunkari
1China University of Petroleum, Department of Geology, East China
2University of Ghana, Department of Earth Science, Legon-Accra
3University of Johannesburg, Department of Geology, Auckland Park Kingsway Campus, South Africa.
4University of Mines and Technology, Faculty of Geosciences and Environmental Studies, Department of Geological Engineering, P.O. Box 237, Tarkwa-Ghana.

Abstract
This study investigated the origin, source area, and tectonic environments of sandstones of the Tarkwaian Group, which are part of the Paleoproterozoic formation situated in the northeastern region of the Ashanti Belt in Ghana.
An integrated approach involving petrography and geochemistry was used to achieve the research goal. A total of twenty-five (25) sandstone samples were carefully selected and their modal mineral composition was examined using the Leica DM750P polarizing microscope.
Additionally, geochemical analysis of major, trace, and rare earth elements was performed on all 25 sandstone samples using the ICP-AES and ICP-MS techniques. The observed minerals in the studied sandstones include quartz (monocrystalline and polycrystalline), muscovite, opaque minerals, possibly iron oxides, serecites, and plagioclase feldspars. Quartz was the most abundant component, constituting an average of 87.8% of the framework composition. Feldspars

(plagioclase) accounted for approximately 5.5% of the total framework grains, while sedimentary lithic fragments made up an average of 6.7% of the total framework grains. The average composition of the major oxides suggests that they are more enriched in SiO2 (84.9%), Al2O3 (8.3%), and Fe2O3 (2.7%) than other oxides. This indicates that the sandstones are predominantly composed of quartz and are thus, quartz arenites. Compared to the Post-Archean Australian Shale (PAAS) values, the sandstones exhibited a general depletion in major oxides, except for SiO2, Al2O3, and K2O, which were enriched relative to the PAAS. The high values of SiO2/Al2O3 (average: 12.74) and relatively moderate values of K2O/NaO (average: 1.42) suggest that the sediments are compositionally mature. The sandstones displayed a moderate concentration of Zr (average: 135.96 ppm), indicating zircon depletion and thus suggesting sedimentary sorting. The sandstones also showed moderate values of light rare earth elements (LREE) with an average LaN/SmN ratio of 1.38, and heavy rare earth elements (HREE) with an average LaN/YbN ratio of 6.97, as well as a negative Eu anomaly with an average Eu/Eu* ratio of 0.87. These findings are consistent with the Th/Sc against Zr/Sc plots. The high Chemical Index of Alteration (CIA) signature (average: 76.79 wt%), Plagioclase Index of Alteration (PIA) values (average: 90.13 wt%), and Index of Compositional Variability (ICV) (average: 0.61 wt%) suggest intense chemical weathering in the source area. Overall, the mineralogical and geochemical characteristics of the sandstones indicate that they were likely deposited in a passive continental domain or within intra-cratonic terranes.

Keywords: provenance; sandstone; Tarkwaian, Ashanti belt; tectonic setting

Keyword

provenance, sandstone, Tarkwaian, Ashanti belt, Tectonic settings

The Sedimentary Characteristics of the Braided River Delta of the Triassic Lower Oil Group in the Block 9 area of the Tahe Oilfield

zhao lei[1]*, sinopec (zhaolei.syky@sinopec.com)
Duan Tai Zhong[2], sinopec

Abstract

The understanding of the sedimentary environment in the Triassic Lower Oil Group of the No.9 area in Tahe Oilfield varies between scholars. By core observation, thin section identification, grain size analysis and log, the sedimentary facies is considered to be the braided river delta as a whole, and the main subfacies are braided river delta plain and braided river delta front. The lithology of the target layer is dominated by sandstone and from the bottom up the grain size becomes finer. The lower part is mainly coarse sandstone, medium sandstone, which is the braided river delta plain subfacies, including braided distributary channel, distributary interchannel and natural levee. The upper part is a large section of fine sandstone, siltstone, which is the braided river delta front subfacies, including underwater distributary channel, underwater distributary interchannel and mouth bar. The braided river delta sedimentary model in the study area is summarized. It is a regressive sedimentary process where the base level rises and the lake deepens. In the low water level period of the lake, the braided distributary channel sediments extend to the center of the basin, and the braided river delta plain is mainly developed, while the braided river delta river front is smaller in scale. When the lake level rises and transforms the low-level deposits, the braided river delta front is mainly developed, forming the braided river delta “small plain, large front” sedimentary characteristics. The property of sand is good, which forms a favorable place for oil and gas accumulation in the study area.

Keyword

braided delta, Sedimentary facies, Triassic, Sedimentary evolution

Three dimensional distribution characteristics of physical property with sedimentary depth in the Ulleung Basin of the East Sea: based on downhole logging data

Gil Young KIM[1]*, KIGAM (gykim@kigam.re.kr)
Kiju Park[2], KIGAM
Bo Yeon Yi[3], KIGAM
Dong Geon Yoo[4], KIGAM
Gwang Soo Lee[5], KIGAM

Abstract

The physical property data (downhole log data) were collected from logging-while-drilling (LWD) operations conducted in the Ulleung Basin of the East Sea, in 2007 and 2010. LWD was conducted using Schlumberger logging tools (GeoVision for resistivity, SonicVision for velocity, Telescope for data transmitting, and Ecoscope for porosity and density). Three-dimensional distributions of physical properties (density, porosity, velocity, electrical resistivity) for the sediments in the Ulleung Basin have been processed and displayed. The 3D distribution maps are categorized according to regular burial depth (from seafloor to10 m, 10-50 m, 50-100 m, 100-150 m, 150-200 m, 200-250 m below seafloor). Overall, the distribution characteristics of physical properties largely reflect the lithological features, incorporating various analyses from drilled core samples. Furthermore, density and velocity generally increase with sedimentary depth, while, porosity decreases. High resistivity values are observed within depth intervals of 50-100 m. Notably, intervals bearing gas hydrates, as identified through seismic data and drilling cores, exhibit elevated velocity and resistivity, significantly influencing the distribution characteristics of physical properties. This study provides vital insights into the physical properties concerning sedimentary depth in the Ulleung Basin, serving as essential information for future investigation in the area. The 3D distribution map of physical properties stands as a valuable resource for diverse prospective studies within the Ulleung Basin region.

Keyword

physical property, geoacoustic property, sedimentary geology, downhole logging data, Ulleung Basin sediment

Characteristics of Mesozoic Reservoirs in Gaoqing Region

Xiaolong CHEN[1]*, China University of PetroleumEast China (2697870403@qq.com)
Liqiang Zhang[2], 13280371131
Yiming Yan[3], 13280371131

Abstract

The truncation unconformity exists between the Mesozoic and the Paleoge-ne and the Guantao formation in Qingcheng uplift, and the denudation lines are distributed NW-EW. From the stratigraphic comparison diagram, the reservoirs are well developed, largely distributed in the plane, and overlapping vertically.

The strata in the south are thin and the thickness of the reservoirs is small. With the increase of the strata thickness to the north, the thickness of the reservoirs shows an increasing trend.

Based on the comprehensive analysis of previous studies, through core observation and thin section analysis, the use of pore structure analysis technology, petrological characteristics analysis technology, combined with geophysical data such as well logging and earthquake, the study of the characteristics of lithology, characteristics of diagenesis and reservoir space of the Mesozoic reservoirs in Gaoqing Region is carried out. The following conclusions are drawn:

(1)Reservoir lithology is sandstone, siltstone, pebbly sandstone and basalt; oil-bearing lithology is mainly siltstone, with a small amount of medium sandstone and fine sandstone and pebbly sandstone.

(2)Development of volcanic rocks in the Xiwa formation, with less stratum outcropping and sedimentation of sandstone and mudstone interbeds. The Mengyin formation is mainly sedimentary facies and delta facies, mainly massive thick sandstone mixed with mudstone. The Santai formation is mainly sedimentary facies and delta plain sediments, mainly purple-red mudstone in the upper and bottom, gray mudstone in the middle and lower parts, occasionally mixed with thin sandstone.

(3)After the Mesozoic deposition in Gaoqing Region, the Cenozoic did not experience deep burial(maximum buried depth<2500m),the buried depth is shallow, the compaction and pressure solution are weak, the degree of development of feldspar and siliceous cementation is not high, the carbonate cementation is mainly calcite cementation, a small amount of iron calcite, the dissolution of carbonate cement is strong.

(4)Pore types in Gaoqing Region are rich, the reservoir space is mainly primary pores, and intercrystalline pores and feldspar dissolved pores are also seen. The proportion of primary pores surface pore rate is greater than 60% under the microscope. The primary pores in medium and coarse sandstone are the best reservoir space, these pores generally have good connectivity, large pores, few impurity bases in the pores, and have good reservoir capacity; the reservoir space of medium and fine sandstone is mainly secondary pores, mainly for the dissolution of feldspar and debris, mainly caused by the dissolution of meteoric fresh water.

Keyword

Gaoqing, Mesozoic, reservoir characteristics, diagenesis

Sedimentary Characteristics and Controlling Factors of Biogenic Limestone in the Middle Part of the First Member of the Shahejie Formation, Shanghe area, Huimin Sag

Yu HU[1]*, National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China) (2410186320@qq.com)
Jian Wang[2], National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China)

Abstract

The middle part of the first member of the Shahejie formation (Es1z) in the Shanghe area of Huimin sag belongs to the low exploration layer. Currently, high-yield oil and gas have been encountered in the biogenic limestone of the first member of the Shahejie formation. However, the depositional model and distribution characteristics of biogenic limestone in this area are unclear, which restricts its oil and gas exploration. Based on the theories of sequence stratigraphy, seismic sedimentology, and modern sedimentology, combined with core, logging, and seismic data, this article establishes a sequence stratigraphic framework for the Shahejie formation in the Shanghe area, clarifies the sedimentary characteristics and controlling factors of biogenic limestone, and establishes a sedimentary model for biogenic limestone. Research suggests that the Es1z is a lacustrine intrusion system tract, which can be divided into five fifth order sequences; Vertically, biogenic limestone mainly develops at the top of the third fifth order sequence, and horizontally, it mainly develops in the underwater uplift area in the central northern part of the study area; The distribution of biogenic limestone is controlled by periodic lake level changes, volcanic activity, geomorphology, and hydrodynamic conditions; Based on control factors, a development model of biogenic limestone is established. As the water in the lake basin gradually deepens, the energy gradually weakens, creating a favorable environment for the survival of organisms in the middle stage of the lake intrusion system tract. Meanwhile, the low uplift formed by volcanic activity in the early stage of the first member of the Shahejie formation provides a large amount of nutrients, leading to the extensive development of biogenic limestone during this period.

Keyword

Biogenic limestone, Control factors, Depositional model, Es1z, Huimin Sag

Effect of floodplain morphodynamics on channel avulsion: Outcrop observations of the Cretaceous Tando and Namyang basins in the mid-western part of the Korean Peninsula

Kyungjin LEE[1]*, Kyungpook National University (kyungjin@knu.ac.kr)
Yong Sik Gihm[2], Kyungpook National University

Abstract

Channel avulsion controls the spatio-temporal variations of alluvial successions, and the combined effects of trunk channel-bed aggradation and contrasting sedimentation rates between the proximal and distal floodplains create the cross-floodplain topographic gradient, providing necessary conditions for channel avulsion. Well-exposed alluvial successions of the Tando and Namyang basins in the mid-western part of the Korean Peninsula were studied to unravel the effects of floodplain sedimentation on channel avulsion. These alluvial successions are classified into four facies associations (FA-1: gravel-bed stream, FA-2: floodplain fines, FA-3: crevasse channel, and FA-4: crevasse splay). Below the overlying, avulsed gravel-bed stream deposits (FA-1), the underlying overbank deposits (FA-2, FA-3, and FA-4) exhibit the following changes in depositional features. First, the stacked beds of overbank deposits show vertical facies variations from floodplain fines (FA-2) to compensational and/or progradational stacking crevasse channel (FA-3) and splay (FA-4) deposits. Second, the mean values of ten maximum clast size in crevasse channel deposits (FA-3) show coarsening-upward trends with systematic paleoflow directions identical to the overlying, avulsed gravel-bed stream deposits (FA-1). Deposition of crevasse channel and splay deposits rapidly filled with accommodation space close to the trunk channel, and these spatial changes in sedimentation rates created the cross-floodplain topographic gradient. The coarsening-upward trends with systematic paleoflow directions suggest that the increased gradient led the overbank floodwaters to advance toward the distal floodplains. As a result of the continuous sedimentation of the crevasse channel and splay deposits, the trunk channel bed was perched above the distal floodplains, and the associated gradient advantage provided favorable conditions for channel avulsion. Thus, the overbank sedimentation plays an important role in the floodplain morphodynamics, and thereby causes channel avulsion.

Keyword

overbank sedimentation, cross-floodplain topographic gradient, alluvial ridge growth, compensational stacking pattern, progradational stacking pattern

Characteristics of Mesozoic reservoir development in Gubei Sag

hongwei RANG[1]*, ranghongwei@outlook.com (ranghongwei@outlook.com)
Liqiang Zhang[2], 2556248893@qq.com
Yiming Yan[3], 2556248893@qq.com

Abstract

Gubei Sag is located in the north of the Gudao bulge in Zhanhua Sag, Jiyang Depression. The Xiwa, Mengyin, Santai and Fangzi formations developed in the Mesozoic in Gubei area. The Xiwa Formation is mainly interbedded with volcanic rocks, mudstone and siltstone, with poor clastic rock properties. Mengyin Formation sandstone reservoir is a relatively high quality reservoir in the study area. Taking Gubei 107 well as an example, it mainly develops interlayers of sandstone and mudstone, and the medium and fine sandstone reservoir with better oil content is Mengyin Formation. Sand-conglomerate and mudstone interlayers of varying thickness are mainly developed in Santai Formation and Fangzi Formation, and the reservoir quality is poor.

The clastic rocks in the study area develop facies types such as alluvial fan, braided river delta and shoreline shallow lake. Alluvial fan deposits mainly develop fan root subfacies and fan end subfacies. The braided river delta facies mainly develop delta plain subfacies and front subfacies. The main rock types of clastic rock reservoir in this area are lithic feldspar sandstone and feldspar lithic sandstone, followed by lithic sandstone and feldspar sandstone. The quartz content in sandstone is low, generally in 40%-60%. The average content of feldspar is between 10% and 25%, and the average content of cuttings is generally between 12% and 30%.

The reservoir space of sandstone reservoir in the study area can be divided into intergranular dissolved pores, intragranular dissolved pores, mold pores, authigenic mineral dissolved pores and various fractures. Intergranular pore is the main reservoir space of effective reservoir. The sand body of Mengyin Formation in the study area has strong compaction, mainly medium and strong compaction. Compaction and porosity reduction are the key factors for the densification of Mesozoic clastic rock reservoir in the study area. The cementation mainly occurred in the early and middle diagenetic stage, and carbonate and siliceous cementation reduced the pore space of the reservoir, which is an important factor for reservoir densification in the study area. The content of feldspar and soluble minerals in this area is high, and the distribution of solution pores is common, which is a favorable reservoir space for Mesozoic reservoirs in this area. The fractures produced by fracture include structural fractures, dissolution fractures, diagenetic contraction fractures, crushing fractures, etc.

On the whole, the clastic rocks of Xiwa Formation in Gubei area are mainly argillaceous sandstone with undeveloped pores. The reservoir space of the high-quality Mengyin Formation is mainly the medium and fine sandstone with little miscella, and the primary pores are the main reservoir space. The sandstone with high miscella content and poorly sorted pebbly sandstone of Mengyin Formation have few pores, and the reservoir space is mainly the secondary pores. The pebbly sandstones of Santai and Fangzi formations have high shaliness content, and the reservoir

space is not developed.

Keyword

Gubei Sag, Mesozoic, diagenesis, reservoir characteristics

EPHEMERAL DEPOSITIONAL SETTING OF THE RED SANDSTONE IN THE SONIA FORMATION OF MARWAR SUPERGROUP, INDIA

PRAKASH BABU LAL[1]*, Jai narain vyas university (psaran162@gmail.com)
PAWAN KUMAR[2], Jai Narain Vyas University
ANSHUL HARSH[3], Jai Narain Vyas University

Abstract

The ephemeral depositional setting of the red sandstone within the Sonia Sandstone of the Marwar Supergroup in India presents a significant geological context for understanding ancient terrestrial environments. This study investigates the sedimentological characteristics, paleoenvironmental indicators, and depositional processes of the red sandstone units to elucidate the paleoenvironmental conditions prevailing during their formation. Field observations coupled with petrographic analysis reveal distinct sedimentary features such as cross-bedding, ripple marks, and mudcracks, suggestive of deposition in an arid to semi-arid environment intermittently influenced by ephemeral fluvial processes. Previous geochemical analyses, including elemental composition and stable isotopic signatures, provide further insights into the provenance, weathering history, and diagenetic evolution of the red sandstone. The presence of iron oxides and clay minerals within the sedimentary matrix underscores episodes of oxidation and pedogenesis, indicating fluctuating moisture conditions and periodic exposure to subaerial environments. Additionally, the identification of evaporite minerals and desiccation cracks within certain horizons points towards episodic drying and evaporation events in shallow lacustrine or playa settings. Integration of sedimentological, petrographic, and geochemical data enables the reconstruction of the paleoenvironmental dynamics during the deposition of the Sonia Sandstone. The observed features suggest a dynamic landscape characterized by ephemeral fluvial channels, interdune lakes, and seasonal variations in water availability. These findings contribute to our understanding of paleoclimatic conditions, landscape evolution, and sedimentary processes operating in arid settings during the Neoproterozoic era, offering valuable insights into the depositional history of the Marwar Supergroup in India.

Keyword

Ephermal deposition, Sedimentary, Marwar Supergroup, Sonia sandstone

Provenance of sediments offshore northern Colombia as evidenced by detrital zircon U-Pb study of modern sediments (Magdalena River Delta and la Aguja Canyon)

Yamirka ROJAS-AGRAMONTE[1]*, Kiel University (yamirka.rojas@ifg.uni-kiel.de)
Daniel RINCÓN MARTÍNEZ[2], ICP-ECOPETROL, Colombia
Estefany Paola VILLANUEVA GARCIA[3], Universidad del Norte, Colombia
Julian Francisco NARANJO VESGA[4], ICP-ECOPETROL, Colombia
Delia RÖSEL [5], University of Gothenburg
Giuliana DIAZ-MENDOZA[6], Kiel University, Germany
José M. RIASCOS[7], Universidad de Antioquia, Colombia
Milena BENAVIDES[8], Universidad Nacional, colombia
Gitta Ann VON ROENN[9], University of Kiel, Germany
Kathrin GROSS[10], University of Kiel, Germany
Christian WINTER[11], University of Kiel, Germany

Abstract

The Magdalena River Delta (MRD) and the Aguja Canyon represent the most important geomorphological features offshore of northern Colombia in the Caribbean Sea. The Magdalena River, the largest river in Colombia, is considered the main source of fresh water and sediments into the Caribbean Sea. Thus, the sediment input directly influences the Magdalena Canyon architecture. The Aguja Canyon is a predominantly tectonic feature located north of the Sierra Nevada de Santa Marta which constitutes the highest coastal relief on Earth with an average elevation of ca. 4 km to an abyssal plain ca. 3.5 km deep in the Caribbean Sea.

No significant modern rivers flow into this canyon, which extends for ca. 115 km. Both complex canyon systems act as conduits, channeling sediments from the continent across the continental shelf into the abyssal plain.

Here, we report new data from both the offshore MRD and the Aguja canyon on detrital zircon U-Pb geochronology and trace elements from ten (out of 39) samples collected from box-cores near-shore to deep-water environments (~50 to ~4000 m deep). The sampling took place during a research expedition aboard the German Research Vessel Maria S. Merian (November 2022). Particle sediment size distributions of the box-cores show no significant sorting in distance to the coast, and turbidite depositional sequences suggest event-based downslope transport.

We analyzed 1100 detrital zircon grains by LA-ICP-MS for U-Pb ages and trace elements to constrain their provenance. In the MRD, the zircon grains yield concordant and nearly concordant U-Pb ages ranging from 0.1 to 2620 Ma, whereas in La Aguja Canyon, the ages range from 46 to 1798 Ma. The size of most zircon grains is larger than 100 μm in both the MRD and La Aguja Canyon, irrespective of the distance to the coast. Similarly, the morphology of the grains varied from equant and elongated grains to broken grains with rounded terminations. The zircon grains exhibit varied responses under CL (Cathodoluminescence), many show oscillatory or linear zoning typically of magmatic zircons, while others show core and rim features typical of metamorphic grains and another proportion of zircon grains do not show any response under CL.

The youngest age clusters in the MRD at about 0.1 to 8 Ma, 75 Ma, 155 Ma, and 275 Ma, denote provenance from the Central Cordillera of Colombia. The ages from 459-682 Ma suggest main provenance from the Santander Massif/San Lucas Range, while the age range from 916 to 2232 Ma (largest peak at 991 Ma) suggests provenance from the Eastern Cordillera. On the other hand, the youngest age peak in the Aguja Canyon (50 Ma) reflects provenance from the Santa Marta Batholith, a Paleogene intrusive suite of the Santa Marta massif. Additional significant age peaks at 186 and 265 Ma, denote provenance from the gneisses and meta-sediments intruded by the batholith. Older clusters in the range 434-534 Ma and 998 to 1765 Ma (main peak at 998 Ma) denote provenance from the Santa Marta and San Lorenzo Schist, both intruded by the Santa Marta Batholith.

Keyword

Detrital Zircon, Provenance, Magdalena River Delta, Aguja Canyon, Northern Andes

A high-resolution sequence stratigraphic framework of the Mississipian coastal system of the Poti Formation, Parnaíba basin, Brazil

Ricardo Guimarães PAIVA[1], Parnaiba Iron Consulting
Matheus DENEZINE[2]*, University of Brasília (matheusdenezine@gmail.com)
Carolina ZABINI[3], University of Campinas
Carlos Emanoel SOUZA CRUZ[4], University of Brasília

Abstract

This work studied the siliciclastic rocks of the upper portion of the Canindé Group, dated to the Mississippian by palynomorphs, represented by the Longá and Poti formations, as well as the lower portion of the Balsas Group from the Pennsylvanian Epoch, characterized by the Piauí Formation. The Parnaíba basin, located in the northeastern part of the South American platform, is intracratonic and developed within Western Gondwana, with a maximum thickness of 3500 m in its deepest sections, comprising Paleozoic to Mesozoic sedimentary and intrusive/extrusive igneous rocks. The focus of this study is on the Mississippian Poti Formation, representing a coastal system shaped by terrestrial, marine, and atmospheric processes, resulting in various depositional environments. Thirteen sedimentary facies within the upper Longá, Poti, and lower Piauí formations were identified and grouped into eight facies associations: Storm-dominated shallow-marine deposits offshore (FA1) and shoreface (FA2). Tidally-dominated coastal deposits, including tidal sand-ridges (FA3), protected tidal deltas (FA4), distributary estuarine channels (FA5), and tidal flats (FA6). Alluvial deposits, comprising fluvial channels (FA7) and overbanks (FA8). FA1-2 predominantly consist of fine to very fine sandstones with hummocky/swaley cross-stratification and grey bioturbated mudstones and shales, indicating shallow marine deposits. FA3-6 are characterized by medium to very fine sandstones with sigmoidal, trough, planar cross-stratifications, climbing ripples, mud couplets, interbedded with silty shales, representing coastal deltaic to estuarine tidally dominated deposits. FA7-8 are represented by conglomerates and sandstones with large planar to trough cross-stratifications, interpreted as alluvial deposits. Eight high-frequency sequences were established, including one in the gradual contact of Longá/Poti formations (LP), six within the Poti Formation (I to VI), and one in the basal portion of the Piauí Formation (Pi). LP sequence shows incomplete deposition with observed FA1 in the transgressive system tract (TST) and FA2 in the highstand system tract (HST). Poti's I to III sequences are characterized by lowstand systems tracts (LST) FA2 as incised shorefaces, TST retrograding offshore bars (FA1) and HST prograding shorefaces (FA2). In sequences IV to VI occurs the maximum development of a tidal dominated coastal system, were the LST is represented by FA7 as infills of incised valleys, with the TST represented by FA3, FA5 or FA6 and HST by FA2 and FA4 deposits. Pi sequence is incomplete, with an erosive sequence boundary and LST alluvial deposits (FA7 and FA8). This stratigraphic framework, were, a complex coastal system, tidally influenced, is developed in Poti Formation time, gives a high-resolution model that can be used to prospect economic resources, such reservoirs of natural gas as the incised valleys alluvial infills in

sequences IV to VI, or to coal prospect as the IV to VI TST tidal flats, were it should preserve better organic matter. Besides such applications this model invites the continuity of research such as high-resolution biostratigraphy, geochronology and allostratigraphy of the Paleozoic Parnaíba basin.

Keyword

Facies Analysis, High-frequency Sequence Stratigraphy, Coastal System, Parnaíba basin, Mississipian deposits

Distribution and environment changes of sand ridges on the southern shelf of Korea

Eun-Je JEONG[1]*, Korea Institute of Geoscience and Mineral resources (ejjeong513@kigam.re.kr)
Gwang-Soo LEE[2], Korea Institute of Geoscience and Mineral resources
Jong-Hwa CHUN[3], Korea Institute of Geoscience and Mineral resources
Jang-Jun BAHK[4], Chungnam National University

Abstract

The sand ridges on the southern shelf of Korea, parallel to the shoreline, are well preserved on the mid-shelf. The sediments of the sand ridges in the study area primarily originated from the paleo-Seomjin River and were redistributed during the post-glacial sea-level changes. Through analysis of sediment properties and vertical variation of sedimentary facies using deep core sediment from these sand ridges, we reveal the evolution of depositional environments on the southern mid-shelf of Korea during the post-glacial period. The core sediment data indicate the gradual transition of sand ridges from terrestrial to marine environments in response to the sea-level rise. The core sediments indicate interbedding of mud and sand facies with abundant shell fragments deposited during periods of lower sea-level, and the deposition of thick homogeneous sand facies since the rise in sea-level. These thick sand layers, exceeding 15 meters in thickness, observed in the upper core sediments, indicate that they were deposited under high-energy environments. This study demonstrates that the environmental changes and development of sand ridges on the southern shelf of Korea are closely associated with sediment supply, oceanographic regimes, and the post-glacial sea-level changes. Additionally, we used the seismic data to determine the distribution and thickness of sand ridges on the southern shelf of Korea.

Keyword

sedimentary facies, sand ridge, sea-level change

Stratigraphic and sedimentological study on the Pohang Basin, SE Korea

TAEYEON KIM[1]*, KIGAM (tykim@kigam.re.kr)
YOOJIN KWON[2], KIOST
SUJI CHOI[3], Samoo Architects & Engineers
GEESOO KONG[4], KIGAM
YIKYUN KWON[5], KONGJU NATIONAL UNIVERSITY

Abstract

The Pohang Basin emerged as a pull-apart basin resultant from crustal extension during the Early Oligocene, coinciding with the back-arc opening of the East Sea. This geological phenomenon influenced the eastern coast of the Korean Peninsula during the Late Oligocene. Diverging from the conventional characteristics of pull-apart basins, the Pohang Basin underwent diagonal extension during its inception, resulting in a distinctive fan-shaped evolution. Its sedimentary composition predominantly comprises nonmarine siliciclastic and deep-marine sediments, with terrestrial sediment influx originating from two distinct directions. During the initial phase of basin development in the early Miocene, sediment deposition primarily transpired from the southern periphery, subsequently transitioning towards the western sector. These shifts mirror regional tectonic dynamics that significantly shape the basin's evolution. Employing seismic and deep-drilled core data, this research endeavors to elucidate the basin's evolution and depositional chronology. Seismic analysis delineates the sedimentary succession into seven discernible units based on their acoustic properties. Complementary drilling core analysis identifies thirteen sedimentary facies, further categorized into five facies associations. Time structure and isopach maps prove instrumental in discerning sediment sources, revealing predominant sediment transport from the south and west. This study contributes to a more comprehensive comprehension of the Pohang Basin's evolutionary trajectory and sedimentary interpretation, thereby facilitating enhanced Neotectonic and stratigraphic investigations in the East Sea region.

Keyword

Pohang Basin, Fan-delta system, Sequence stratigraphy, Basin evolution, Miocene sedimentary basin

Building the GIS of International Quaternary Map of Europe and Adjacent Areas (IQUAME2500): Connecting and Harmonising the European Quaternary Geology without Political Boundaries

Kristine E.C. ASCH[1]*, Federal Institute for Geosciences and Natural Resources (BGR)
(Kristine.Asch@bgr.de)

Abstract

The project of the International Quaternary Map of Europe and Adjacent Areas (IQUAME 2500) is a multinational cross-boundary project and international collaboration with research organisations and national geological surveys in Europe is essential. Scientist from more than 40 countries are participating and a scientific board of Quaternary researchers ensures the scientific quality of the resulting GIS map layers.

The project is coordinated by the Federal Institute for Geosciences and Natural Resources (BGR) under the auspices of the CGMW (Commission of the Geological Map of the Word, Sub-Commission Europe) and with support of INQUA, the International Union for Quaternary Research.

The first edition of the map (BGR and UNESCO, 1967 – 1995) was published as paper map series in 14 map sheets, the new “map” edition is developed as a spatial data base within a geoinformation system and will be available on-line, in several layers, at the BGR Geoportal (https://geoportal.bgr.de)). It will represent the distribution of Quaternary deposits across the entire European continent, on-shore and off-shore. Within the IQUAME project BGR compiles centrally the spatial data information in cooperation with the project participants and uses actual publications, maps and additional, available project results.

The following features are being collected and compiled:
• lithology and geochronological age of Quaternary units,
• genetic descriptions of the units
• maximum extent of the ice sheets
• directions of ice movement
• extent of Arctic sea ice
• postglacial rebound
• off-shore Quaternary information (in cooperation with the EU EMODnet Geology project).
• active faults
• extent of permafrost,
• key localities (e.g. geologically and anthropologically interesting sites)

As multinational cross-boundary project, international collaboration with research organisations

and national geological surveys in Europe is essential. Scientists from more than 40 countries are participating and a scientific board of Quaternary researchers ensures the scientific quality of the resulting map layers.

The participation of numerous international partners presents a challenge and requires interoperability and data harmonization in respect to semantics, structure and geometry. To achieve this aim, common standards and guidelines needed to be developed and applied by all participants: structured vocabularies to describe the IQUAME's contents, a common topographic base, technical procedures to include the map data and technical guidelines to aid the partners to submit their data.

Apart from the participants' contributions, the IQUAME project includes results from actual publications, map and projects results, so that a synthesis of the current status of European Quaternary geological mapping and research will be created.

The presentation will show the background and process of building the GIS of the IQUAME, outline it's challenges and present the new status of the map layers.

Keyword

International, Quaternary, geology, vocabularies, harmonisation

Exploring Neotectonics and Seismicity during the late Quaternary in the vicinity of Gish fault in Darjeeling-Sikkim Himalaya through PGRS, MEQ, DGPS and OSL dating

RITU Pragya CHOURASIA[1]*, Geological Survey of India (ritu.chourasia@gsi.gov.in)
Anita Singh[2], Geological Survey of India
Deepanjan Ghose[3], Geological Survey of India
Anita Kumari[4], Geological Survey of India
Vishal C Kharkongar[5], Geological Survey of India
Niva Brahma[6], Geological Survey of India
Ashishit Lakra[7], Geological Survey of India
Imti kumzuk[8], Geological Survey of India
W S Rocky[9], Geological Survey of India
Mohammad Atif Raza[10], Geological Survey of India

Abstract

The Darjeeling-Sikkim Himalaya and its foredeep basin have active transverse faults linked to earthquakes, including the NE-SW trending Gish fault. Previous research lacked detailed knowledge of the Gish fault. Photo Geological and Remote Sensing (PGRS) studies, (Micro Earth Quake (MEQ), Differential Global Positioning System (DGPS) studies and Geological Mapping (GM) on a 1:25000 scale were conducted to explore its neotectonic, dynamics, dimensions, and seismicity.

PGRS studies revealed evidence of neotectonic in the Gish basin, supported by active morphometric indices. MEQ studies confirmed left-lateral strike-slip faulting with multiple reactivations. The fault delimited the eastern Siwalik Group extension, exposing Quaternary alluvial fan deposits. DGPS studies showed that maximum shear stress aligns parallel to the Gish Transverse Fault, shedding light on its behaviour and significant geological role in the region. GM unveils that the Gondwana rocks on the Gish fault's eastern side shifted northward, thrusting below Daling phyllites (MBT/Ramgarh thrust), suggesting a left-lateral disposition. Geomorphic evidence in the form of the sharp bend of Lethi River from the northwestward side towards the southeastward side with tilted terraces, entrenched river system, triangular facets and seismites in the form of convolute bedding, sand dykes, flame structure, sagged clay horizon and synthetic faults in Quaternary deposits are also observed in the area.

Optically Stimulated Luminescence (OSL) dating of the older T3 terrace of Baikunthapur Formation in Gish River shows aggradation in the valley since 38 ± 2 ka and shows intermittent reactivation. Whereas Soft Sediment Deformed (SSD) structures in the form of convolute bedding in cm scale yield a depositional age of 2.7 ± 0.2 ka which is underlain and overlain by the undeformed sand deposit of 4.0 ± 0.2 ka 2.4 ± 0.2 ka respectively indicate neotectonic activity or earthquake event around 2.7 ± 0.2 ka years ago. Moreover, the field evidence of the Gish fault suggests its extension from Mazing town to the Teesta lineament, trending NE-SW, perpendicular to the major thrust (MBT/Ramgarh thrust) in the Himalayas. It may function as a tear fault, bearing geological significance.

A comprehensive assessment of the Gish fault's potential for future seismic events is vital. However, implementing preparedness measures and raising public awareness about safe practices can enhance resilience and reduce seismic risks in the region.

Keyword

Himalaya, Neo-tectonics, Micro Earth Quake (MEQ), Optically Stimulated Luminescence (OSL), Seismic Hazards

Mapping the retreat of the Laurentide Ice Sheet in the western Gulf of St. Lawrence (Eastern Canada)

Patrick Lajeunesse[1]*, Département de Géographie, Université Laval, Québec, Québec, Canada (patrick.lajeunesse@ggr.ulaval.ca)
Jean-François Ghienne[2], Institut Terre Environnement de Strasbourg (ITES), UMR 7063, CNRS—Université de Strasbourg, Strasbourg, France
Alexis Belko[3], Département de Géographie, Université Laval, Québec, Québec, Canada
Pierre Dietrich[4], Géosciences Rennes, UMR6118, Université de Rennes 1, Rennes, France
Brouard Etienne[5], Geological Survey of Canada (Central), Natural Resources Canada, 601 Booth Street, Ottawa, Ontario, Canada
Charles Brionne[6], Institut Terre Environnement de Strasbourg (ITES), UMR 7063, CNRS—Université de Strasbourg, Strasbourg, France
Alexandre Normandeau[7], Geological Survey of Canada (Atlantic), Natural Resources Canada, Dartmouth, Nova Scotia, Canada

Abstract

During the retreat of the Laurentide lce Sheet (LIS) margin, the Gulf of St. Lawrence formed a large calving bay dominated by a high influx of glacial ice, meltwater and sediment through rapid ice flow. The retreat history of the LIS margin remains poorly documented in this region of northeastern North America, mostly because its morphosedimentary record lies on the seafloor. Recent mapping of glacial sediment-landform assemblages using swath bathymetry and terrestrial LiDAR reveal new information on the late-glacial and deglacial history of the LIS by the observation of (1) mega-scale glacial lineations (MSGLs) associated with the St. Lawrence lce Stream; and (2) series of grounding-zone wedges (GZWs), morainal banks and ice-contact submarine fans extending laterally along the shelf and the coastal zone. These ice marginal landforms and deposits record episodic phases of retreat of the marine-based LIS margin following its rapid retreat in the deeper waters of the Laurentian Channel –a deep submarine valley extending from the mouth of the Saguenay Fjord to the continental slope– after 14.8 cal ka BP. The occurrence of GZWs along distinct isobaths indicates that bathymetry exerted a strong control on ice stabilization during deglaciation by reducing the relative water depth at the ice margin and thereby the buoyancy and rate of iceberg calving, but ice-marginal re-advances over some GZWs suggest an additional response to climate-driven forcing. Following these events, the LIS margin retreated rapidly to the coastal zone slopes of the Québec-North-Shore, where a bedrock escarpment promoted a phase of very rapid ice flow that carved swarms of large glacial grooves distributed discontinuously over >500 km. As the LIS margin reached stages of stabilization further upslope during which it transited from a marine to a terrestrial base, submarine fans aggraded to form sandur-deltas by the delivery of large volumes of sediments and a rapid glacio-isostatically induced forced regression.

Keyword

Deglaciation, Glacial geomorphology, Seabed mapping, LiDAR, Laurentide Ice Sheet

Reconstructing the glacial lakes of northern Quebec and Labrador (Canada) through field-based mapping and GIS modeling

Martin ROY[1]*, University of Quebec at Montreal (roy.martin@uqam.ca)
Hugo Dubé-Loubert[2], Ministry of Natural Resources and Forestry, Quebec
Etienne Brouard[3], Geological Survey of Canada
Arianne Vallée[4], University of Quebec at Montreal
Joerg M. Schaefer[5], Lamont-Doherty Earth Observatory, Columbia University

Abstract

The retreat of the Laurentide ice sheet in northern Quebec and Labrador (Canada) was accompanied by the development of at least 8 large ice-dammed lakes that left a spectacular record of raised shorelines, deltas, and outburst flood deposits in extensive river valleys flowing into Ungava Bay. Although the Ungava glacial lakes drained into the nearby Labrador Sea – an important component of the Atlantic Meridional Overturning Circulation, assessing the impact of these meltwater discharges on the ocean-climate system is prevented by the lack of data on the configuration and volume of these ice-dammed lakes. This situation reflects sparse mapping coverage in the region and the concomitant lack of constraints on the evolution of the retreating ice margin that controlled lake development and drainage pathways. Here, we reconstruct the areal extent and history of the main glacial lakes in northern Quebec and Labrador through remote mapping of raised shorelines and deltas on high-resolution satellite imagery, combined with field investigations that allowed elevation measurements of key strandline sequences. The pattern of ice withdrawal was documented though systematic mapping of the main deglacial landforms (eskers, moraines, meltwater channels). The chronology of lake development and drainage was constrained through Terrestrial Cosmogenic Nuclide (10Be) dating of shorelines and outburst flood landforms. The different results were used to reconstruct the areal extent of the lakes and calculate their volumes through a GIS-based approach integrating the paleotopography (glacio-isostatic deformation) and available ice-margin chronologies. Results provide reliable estimates of the meltwater volumes and show that the largest meltwater discharges came from glacial Lake Naskapi and nearby ice-dammed lakes located southeast of Ungava Bay. The 10Be ages indicate that the Ungava glacial lakes formed and drained over a narrow time interval of the deglaciation, which suggests that these meltwater discharges likely contributed to the main freshwater forcing that caused the 8.2-ka cold event. This work refines the sources of meltwater discharges of the last deglaciation, while highlighting the importance of field-based mapping in detailing temporal changes in former continental ice cover and attendant glacial lakes. Overall, these reconstructions improve the accuracy of paleogeographic reconstructions, which provide critical constraints for several fundamental and applied fields of Quaternary science.

Keyword

Last deglaciation, Laurentide ice sheet, Meltwater discharges, Glacial geomorphology

A GIS Approach to Quaternary Glacial Geomorphology in Slovenia

Manja Žebre[1], Geological Survey of Slovenia
Petra Jamšek Rupnik[2], Geological Survey of Slovenia
Eva Mencin Gale[3], Geological Survey of Slovenia
Jernej Jež[4], Geological Survey of Slovenia
Uroš Stepišnik[5], Department of Geography, Faculty of Arts, University of Ljubljana
Jure Atanackov[6], Geological Survey of Slovenia
Miloš BAVEC[7]*, Geological Survey of Slovenia (milos.bavec@geo-zs.si)
Petra Gostinčar[8], Geological Survey of Slovenia

Abstract

Reliable reconstructions of former ice sheets depend on geomorphological evidence, chronological data and suitable ice sheet models. A great amount of glacial geomorphological evidence exists for the European Alps and Dinaric Mountains. For the area covered by Slovenia and its surroundings, however, there is a lack of a compilation of all previously published information and its comprehensive review. In addition, chronological information is scarce and scattered across many publications. In this study, we systematically compile the information published so far to provide a better basis for modelling ice masses and to enable a robust investigation for future studies on the European Alps and Dinaric Mountains. We have compiled an inventory of previously mapped glacial landforms and other glacially relevant data from the literature, which is available as a database and presented in a web map viewer. In addition, we have created a modified version of the dataset that includes both modified raw data and new data collected by the authors of this study. The main focus of the database/web map viewer is on the glacial landforms formed during the last glacial cycle and their sedimentological description, age and internal composition. The landforms included in the database are available in three types of layers (polygon, line and point), depending on the shape and extent of the feature and the way it is represented in the literature. Other layers in the database are outcrop (point), geochronology (point) and geophysics (line). The data stored in the GIS database is available in ESRI geodatabase and shapefile format. Both the GIS database and the web map viewer are freely accessible.

This work was funded by the Slovenian Research and Innovation Agency as part of the project J1-2479, “Past climate change and glaciation at the Alps-Dinarides junction project”.

Keyword

Glacial Geomorphology, Chronology, Quaternary, European Alps, Dinaric Mountains

[Keynote] Biostratigraphical data to unravel and map the early Middle Pleistocene

Thijs VAN KOLFSCHOTEN[1]*, Leiden University, Faculty of Archaeology
(t.van.kolfschoten@arch.leidenuniv.nl)

Abstract

The early Middle Pleistocene, spanning the period between the Brunhes-Matuyama boundary and the base of the Elsterian/Anglian/Oka/MIS 12, covers several glacial/interglacial cycles and is hence complex. The early Middle Pleistocene geological record in Western Europe is, however, fragmented and long sequences covering at least part of the early Middle Pleistocene are scarce. An exception is the exposure of a long sequence of Quaternary deposits at Kärlich (Neuwied Basin, Central Rhineland, Germany). The deposits yielded vertebrate remains as well as early Middle Pleistocene Palaeolithic artefacts. Several stratified faunas, within which the *Mimomys* – *Arvicola* transition occurs, have been collected from the Pleistocene sequence (Kärlich main section - Kä A - H) exposed in the Kärlich pit. The older faunas Kä C - E are characterised by the presence of two *Mimomys* species, *Mimomys savini* and the smaller *Mimomys* cf. *pusillus*, Kä F yielded only *Mimomys savini*. The oldest representatives of the water vole *Arvicola terrestris cantiana* are recovered in the extensive fauna Kä G. Based on palaeomagnetic data and the heavy mineral associations, it can be concluded that the Kärlich main section correlates with the late Early Pleistocene (Kä A and Kä Ba) and the early Middle Pleistocene (Kä Bb - Kä G). The stratigraphical position of Kä H is still unclear.
The fauna Kä C with e.g. *Microtus* (*Stenocranius*) *gregalis* indicates an open environment and continental climatic conditions. The composition of the Kä E faunal assemblages is characterized by the occurrence of *Dicrostonyx* sp. in Kä E, indicative for an open environment and cool, glacial climatic conditions, next to *Clethrionomys glareolus* and *Apodemus* sp, indicative for a more wooded environment and more temperate conditions. The presence of *Dicrostonyx* and *Spermophilus* in the fauna Kä F indicates an open environment; *Dicrostonyx* cold climatic conditions. *Clethrionomys* sp. points to the occurrence of at least locally forested areas. The composition of the Kä G assemblage indicates an environment with bodies of water, forested areas, most probably along the beds of the river and areas with steppe vegetation outside the river valley. The relatively high percentage of *Clethrionomys glareolus* and *Apodemus sylvaticus*/*Apodemus maastrichtiensis* and the occurrence of *Eliomys quercinus* point to interglacial, or at least interstadial, climatical conditions during deposition of Kärlich G. The faunal record from Kä H is relatively poor.

Keyword

Quaternary, Biostratigraphy, Small mammals, Kärlich

Evolution of Middle Ganga Alluvium In Parts of Ghaghara Sub- Basin, India Gajendra Nath Dwivedi* and Subodh Kr. Sharma**. Lucknow and Nagpur

Gajendra Nath Dwivedi[1]*, Geological survey of India (Retd.) (gajendragsi@gmail.com)
Subodh Kumar Sharma[2], Geological survey of India (Retd.)

Abstract

ABSTRACT
Evolution of Middle Ganga Alluvium In Parts of Ghaghara Sub- Basin, India
Gajendra Nath Dwivedi* and Subodh Kr. Sharma**.
Lucknow and Nagpur

Ganga alluvium is one of the largest alluvial plains of the world formed due to sediments deposited in a foredeep located to the South of rising Himalaya. Though the major part of this thick sedimentary sequence is concealed, it preserves all signatures of the Mid to late Pleistocene period encompassing to the Holocene episodes.

The upper few metres of the sequence available along the cliffs may be studied directly while the major chunk of this huge pile of riverine sediments can only be interpreted on the basis of data available through limited drill holes drilled for specific purposes other than for stratigraphic interest and by indirect geophysical studies in certain patches for sub-surface structures.

The study carried out in parts of Ghaghara sub- basin of Ganga basin situated in Middle Ganga Plains clearly suggests that the sequence is broadly divisible in two parts viz. Ganga older alluvium dated more than 11.5 ka and the Ganga newer alluvium dated less than 11.5 ka to present. The Ganga older alluvium situated on a higher elevation is a polycyclic sequence of oxidised, yellowish, sand, silt and clay with calcrete (kankar) concretions /nodules and horizons while the younger alluvium situated on the river floodplains consists of greyish sand, silt and clay characterised generally by absence of calcrete concretions. The calcrete horizons are of great significance for reconstructing the palaeo climate and palaeo -geography.

A detailed study of landforms, variation in the litho packages, tectonic and climatic changes clearly indicate weaker summer monsoon precipitation during glacial periods (marine isotope stages 2, 4, 6) and the high monsoon precipitation corresponding to interglacial periods (marine isotope stages 1, 3, 5).

An attempt has been made to summarise the evolution of the Ghaghara sub basin of Middle Ganga Alluvium.

*1/394, Sector B, Priyadarshni Colony, Sitapur Road, Lucknow, 226020. Uttar Pradesh.
** 403, Hibiscus, Shiv Elite Township, Shankarpur, Nagpur - 441108, Maharashtra.

Keyword

Ganga Alluvium, fore deep, riverine sediments, Pleistocene, Ganga older alluvium,, Ganga newer alluvium, calcrete,

The Geoscience of Wine: The influence of surficial geology on viticulture in Atlantic Canada

MITCH J MARACLE[1]*, Acadia University (mitchell.maracle@outlook.com)
IAN SPOONER[2], Acadia University
DENISE BRUSHETT[3], Nova Scotia Geological Survey

Abstract

Terroir encompasses the distinctive characteristics of a specific location that contributes a unique taste to wines. The Province of Nova Scotia is located on Canada's Atlantic coast, hosts an emergent cool climate wine grape growing region and is one of North America's fastest growing wine districts. This study which focuses on the Gaspereau Valley region of Nova Scotia, investigates the association between different surficial landscape features that host vineyards and the geochemistry of sediments in these landforms that is necessary for Vitis vinifera and hybrid varietal growth and vigor. Vitas vinifera requires specific metals (Ca, K, Mg, Cu, Fe, Mn, Zn, Mo) obtained from the subsurface to regulate growth and vigor, these metals also impart specific aesthetic qualities to wine and contribute to a wines sense of place and the regions terroir.

Atlantic Canada was subject to multiple ice advances during the last glacial period (late Wisconsinan) which produced distinct sediments and complex landforms that were resolved using LiDAR classification mapping. Field investigations guided by LiDAR were used to differentiate multiple stepped glaciofluvial terraces now occupied by vineyards that exist on the south side of the Gaspereau Valley. Further landforms delineated in the valley hosting vineyards include colluvium, till blanket (> 5 m sediment thickness), river terraces, and modern alluvium. In the Grand Pré region of Nova Scotia vineyards occupy drumlins in which multiple subglacial traction tills with distinct characteristics indicate locally dynamic ice flow directions and sediment sources. Soil samples were collected from the B and C soil horizons to a minimum depth of 0.6 m in four vineyards occurring on different landforms. Preliminary results of soil sample analyses indicate that the classified landforms have unique sedimentology and elemental concentrations. In particular, Cu is most prevalent in the glaciofluvial terraces and K is elevated in streamlined subglacial traction tills. This study contributes to an understanding of the relationship between glacial landforms that exhibit specific and desirable terroir characteristics and the geochemical benefits that each landform may provide. Understanding these relationships and characteristics will aid in identifying viable grape growing areas in glaciated terrains across the globe.

Keyword

Surficial, Geomorphology, Glaciated, Sedimentology, Geochemistry

Snapshots of glacial forefields: mapping modern-day processes in central Chilean Patagonia

Paulina MEJÍAS OSORIO[1]*, University of Vienna (paulina.mejias-osorio@univie.ac.at)
Daniel LE HERON[2], University of Vienna
Ricarda WOHLSCHLÄGL[3], University of Vienna
Bethan DAVIES[4], Newcastle University
Bernhard GRASEMANN[5], University of Vienna

Abstract

Glacier recession is a global occurrence and, as this is happening, landforms are being constantly revealed. They offer invaluable insights into processes related to transport of sediment and meltwater, as well as the behavior of the ice itself. In Patagonia, some of the glaciers in the area have been well studied in terms of paleoglacier extent and a few of them are continuously being monitored due to their importance in relation to possible hazardous events (for example, glacial lake outburst floods) or the local tourism industry. However, there are no detailed investigations regarding the current geomorphology that can be observed at their margins, where changes are rapidly occurring. Using uncrewed aerial vehicles (UAVs), it is possible to efficiently gather data in areas with difficult access, which can be used for creating high-resolution maps that show the present state of glacial margins. The unique characteristics of certain landforms translates into information about the behavior of the glacier responsible for creating them, but also pose questions on the exact nature of their formation. The results presented here are geomorphological maps generated with data from a UAV that show the landforms at sites in the Northern Patagonian Icefield and the neighboring Monte San Lorenzo massif to the east, specifically from the forefields of Calluqueo, Río Tranquilo, and El Cuarenta glaciers. Through these maps, we seek to characterize landsystems models and further understand the glacial processes that are taking place today at a local scale, but with the potential to compare them to other places in the world.

Keyword

glaciers, geomorphology, Quaternary, Patagonia, photogrammetry

The Quaternary geological map production in Korea

Jin Cheul KIM[1]*, Korea Institute of Geoscience and Mineral Resources (kjc76@kigam.re.kr)
Dong Yoon YANG[2], Korea Institute of Geoscience and Mineral Resources
Sei Sun HONG[3], Korea Institute of Geoscience and Mineral Resources
Sangheon YI[4], Korea Institute of Geoscience and Mineral Resources
Han Woo CHOI[5], Korea Institute of Geoscience and Mineral Resources
Wook Hyun NAHM[6], Korea Institute of Geoscience and Mineral Resources
Jin-Young LEE[7], Korea Institute of Geoscience and Mineral Resources
Jaesoo LIM[8], Korea Institute of Geoscience and Mineral Resources
Min HAN[9], Korea Institute of Geoscience and Mineral Resources
Ara JO[10], Korea Institute of Geoscience and Mineral Resources
Hyun Ho YOON[11], Korea Institute of Geoscience and Mineral Resources
Chang-Pyo JUN[12], Department of Earth Science Education, Chonnam National University

Abstract

The Quaternary is an important period in the geologic time due to extreme climate fluctuations and modern human occupations. The Quaternary map shows the spatio-temporal distribution of rocks and sediments deposited during the Quaternary period. The Quaternary geological maps have been produced mainly in the United States and European countries since the 1970s, which were digitalized with high resolution in the early 2000s. In Korea, the Quaternary geological map project based on the Quaternary age dating, sedimentary stratigraphy, and paleo-environments of Quaternary sediments began in the 2010s. The Quaternary geological map of the Korean Peninsula provides the basic Quaternary geological information for land utilization for the Quaternary distribution area and estimating past and present changes in the surface environment. The Quaternary geological map was produced with the concept of a Quaternary superficial geology map, which identifies the sedimentation environment at a depth of about 1 m above the surface and displays it on the map. For this purpose, the surface distribution characteristics of the unconsolidated sedimentary layers formed in the Quaternary were investigated, and the unconsolidated sedimentary layers were extensively drilled to analyze the subsurface sedimentary layers distributed above the bedrock. In addition, the depositional time of the sedimentary layer was measured using 14-carbon radiocarbon and OSL (optically stimulated luminescence) dating methods. Through this, the chronostratigraphy was provided, and the three-dimensional distribution status and deposition time of the Quaternary sedimentary layer distributed on the bedrock were distinguished. The investigation of the distribution range of the Quaternary boundary of the research area was made through the analysis of old historical maps, numerical topographic maps(digital maps), aerial photos, and drone images. The presence or absence of the Quaternary sedimentary layer confirmed through the image data was finally confirmed through a field excursion. The sedimentation environment of the surface layer was classified either by observing the sedimentary layer from the outcrop or by the trench survey and drilling. In the Quaternary distribution area, deep drilling was performed on the bedrock to collect the unconsolidated sedimentary layer, and a description of stratigraphic characteristics was performed

on the borehole. Also, proxy analyses and absolute age dating were performed. Based on these results, the chrono-stratigraphy was divided. In this study, the Busan Quaternary map was produced with a 1:250,000 scale. In this map, the study area was largely divided into the southeast, northeast, mid-east, mid-west, northeast and northwest, and the map guidebook was explained based on the 1:50,000 geological map.

Keyword

Korea, Quaternary, map, Busan, environment

On acquisition of natural remanent magnetizations in tidal depositional setting: insight from a Holocene tidal mud sediment in the southwestern coast of the Korean Peninsula

Hyeon-Seon AHN[1]*, Korea Institute of Geoscience and Mineral Resources
(hs.ahn.86@kigam.re.kr)
Sujeong Park[2], Korea Institute of Geoscience and Mineral Resources
Hyun Ho Yoon[3], Korea Institute of Geoscience and Mineral Resources
Jin-Young Lee[4], Korea Institute of Geoscience and Mineral Resources
Jaesoo Lim[5], Korea Institute of Geoscience and Mineral Resources

Abstract

Sedimentary magnetism on tidal flat sediments remains less studied so far. The presence of extensive tidal flat sediments of Pleistocene to the present ages in the western and southern parts of the Korean Peninsula allows us a good opportunity to study them. Here we focus on acquisition and preservation of natural remanent magnetizations (NRMs) to explore the usability of tidal flat (or 'tidal mud') sediment as a recorder of Holocene paleomagnetic secular variation (PSV). From a tidal sediment core (called QJS29) in the Dongjin River estuary, paleomagnetic and mineral magnetic analyses, combined with dry density and X-ray fluorescence data, exemplify robust evidence for primary NRM acquisition and preservation depending on depth and sample dry density in the 2–3.9 m depth interval with muddy tidal sediments. Major NRM carriers for the samples are suggested to be mixtures of low-coercivity ferrimagnetic minerals, probably detrital magnetite and greigite of diagenetic and biogenic origins. It represents gradual increases in NRM acquisition efficiency and remanence stability and decrease in sample dry density when increasing depth. Well-defined stable characteristic remanence (ChRM) components could yield in the tidal muds below 3.075 m depth but could not in the upper 1.075 m-thick tidal muds (above 3.075 m depth). Then we construct a depth-varying record in ChRM inclination and declination (relative) and relative paleointensity (RPI). The constructed record reflects the local PSV between ~2 and ~4 kyr BP from correlation to available local reference curves. Given the available age information about the sedimentation, this suggests a temporal lag of the remanence acquisition (or lock-in) from sedimentation; in other word, a need of compaction by mass accumulation in the remanence acquisition. Consequently, our results suggest that post-depositional remanence acquisition mechanism could dominate the PSV-related ChRMs, even though the remanence carriers are combinations of detrital, diagenetic and biogenic sources. This study thus contributes to improve the muddy tidal sediment usability as a PSV recorder.

Keyword

paleomagnetism, paleo-secular variation (PSV), post-depositional remanent magnetization (pDRM), tidal sediment, South Korea

Sea surface temperature variations at Shushi bay in Tsushima island over the last 3 ka

Sujeong PARK[1]*, Korea Institute of Geoscience and Mineral resources (sujeongp@kigam.re.kr)
Jaesoo Lim[2], Korea Institute of Geoscience and Mineral resources
Sujin Kang[3], Korea Institute of Ocean Science and Technology
Kyung-Hoon Shin[4], Hanyang University

Abstract

To reconstruct the change in sea surface temperature (SST) at Sushi bay, located on the northeastern coast of Tsushima island over the past 3 ka, we used Alkenone unsaturation index (Uk'37; Prahl et al., 1988) and radiocarbon age dating results from SS1C core sediments (34°37.358′N129°27.105′E; 2.8m in length; 21.2m of water depth). The reconstruction of past SSTs over the last 3 ka reveals an average value of 22°C. This is similar to the current average SST of 21.5°C during spring to autumn (March to October) in study area over the last 30 years. According to previous studies, SSTs derived from the core sediments also accurately reflect the SST during spring to autumn. The current SSTs along the southern coast of the Korean Peninsula show significant seasonal variations, largely related to changes in the Kuroshio Current and its extension area. To evaluate the relationship between the past SSTs in the study area and the Kuroshio Current, therefore, we compared with SST values obtained from MD-81 sediment cores, located at the starting point of the Kuroshio Current in the western Pacific. The results indicate that the general trend of variations, including centennial fluctuations over the past 1000 years, closely correlates with the spring-autumn SST changes in study area and the SST changes in the western Pacific during the last 3 ka. Furthermore, the decadal to centennial fluctuation trends during this period correspond with changes in Total Solar irradiance, suggesting the SST variations in northeastern part of Tsushima coast were directly influenced by solar activity. Therefore, we aim to continue our research to assess the factors influencing the SST fluctuations along the southern coast and their relationship with climate change in the Korean Peninsula.

Keyword

Sea surface temperature, Korea Strait, Kuroshio current, solar activity, Alkenone

The environmental dynamics studied in Boontsagaan lake, southwestern arid Mongolia: lake sedimentation and catchment erosion

Noriko HASEBE[1]*, Kanazawa University (hasebe@staff.kanazawa-u.ac.jp)
Shuukhaaz Gunbat[2], Kanazawa University
Zhe Shi[3], Kanazawa University
Uyangaa Udaanjargal[4], National University of Mongolia
Baasansuren Gankhurel[5], National University of Mongolia
Altansukh Nyamdorj[6], National University of Mongolia
Shinya Ochiai[7], Kanazawa University
Keisuke Fukushi[8], Kanazawa University
Davaadorj Davaasuren[9], National University of Mongolia

Abstract

Endorheic lake basins preserve great records of changes in regional hydrology and environmental conditions. In this study, we investigated sedimentation dynamics for the saline lakes in the arid region of Mongolia. Sediment core from the Boontsagaan lake, sediment traps samples from the lake and inflowing Baidrag river, and rocks from catchment mountain range were collected. Sediment characteristics, including organic matter (OM), carbonate (CaCO3), amorphous silica (A-Si), grain size, and mineral assemblages, were measured for both the sediment core and sediment trap samples. A chronology of the sediment core is given by the lead-210 measurement. The average sedimentation rate is 0.2g/cm^2/year. The comparison between climate factor and sediment characteristics indicates: (1) grain size is correlated to wind strength, (2) amount of sedimentation possibly correlated to precipitation, and (3) amount of carbonate increase in a dry climate inducing period. Sediment trap samples show authigenic carbonate in lake but not in river.

A catchment rock sample were analysed by the fission track method, the low temperature thermochronological technique, to estimate the average erosion rate in the catchment. A rock was crushed, served, then magnetic minerals were removed. By the heavy liquid separation, apatite was separated and dated. A sample from high elevation show younger ages than a sample from low elevation, probably indicating higher average erosion rate for high-elevation samples. The erosion was basically very slow (a few mm /100 yrs).

Keyword

Mongolia, saline lake, authigenic mineral

Reconstruction of Sedimentary Environment on the Western Shelf of the South China Sea since the last deglaciation

Yang LI[1]*, China University of Geosciences, Beijing (13102131738@163.com)
Yan LI[2], China University of Geosciences, Beijing
Yu long XUE[3], Marine Geological Survey Institute of Hainan Province
Mian jin CHEN[4], China University of Geosciences, Beijing
Chang liang TONG[5], Marine Geological Survey Institute of Hainan Province
Xue mu WANG[6], Marine Geological Survey Institute of Hainan Province

Abstract

Climate change has influenced the marine-terrestrial environmental evolution in the geological past. The climatologically driven sea-level rise resulted in transgression during the interglacial period. Meanwhile, the erosional and source-to-sink processes were also largely affected by precipitation, vegetation cover, fluvial discharge, etc., controlled by the climatological condition.

Paleogeographic condition and sedimentary environment have been changed significantly in the western shelf of the South China Sea (SCS) since the last deglacial period (~18 ka to present). In this study, the upper 20 m of a sediment core NH01 (-73.5 m bsl) collected from the eastern neritic area of the Hainan Island in the SCS was used for chronological and sedimentary environmental investigations. In total of seventeen samples were collected for OSL dating. Foraminifera collected from two layers were used for radiocarbon dating. Diatom analysis was conducted to explore evolution of the sedimentary environment since the last deglaciation.

The outcome showed that the sedimentary sequence of the core NH01 comprises terrigenous deposits and marine deposits since last deglaciation (18.3 ka). For testing the reliability of the optically stimulated luminescence (OSL) dating, the quartz (post-IR blue and post-IR pulsed) OSL, K-feldspar and polymineral post-IR IRSL signals were applied and compared with radiocarbon ages. The consistent between luminescence signal and radiocarbon ages shows that the luminescence chronology is reliable.

During the pre-Holocene (18.3-10.6 ka), the Sedimentation rate (SR) was 0.08 cm/yr, the west shelf of SCS was submerged by seawater after 15 ka. While the abundance of diatoms was extremely low, several marine diatom fragments were identified. During the early Holocene (10.6-9.2 ka), the SR was 0.5cm/yr. The sea level rose rapidly, and reached -28 m bsl from -48 m bsl. The abundance of diatoms suddenly increased, with the dominant species of *Paralia sulcata-Cyclotella striata*. During the 9.2-6.9 ka, the SR was 0.1 cm/yr, the sea level has reached current level, but no diatoms were found. As an important environmental indicator, the diatoms assemblages recorded the sedimentary environment evolution of the west shelf of SCS since the last deglaciation controlled by the East Asian summer monsoon, sea level changes and Paleogeomorphology.

Keyword

OSL, diatoms assemblages, sedimentary environment, the western shelf of the SCS

[Keynote] Exploring Desert Margins: Interdisciplinary Insights into Climate Dynamics, Human Migration, and Environmental Change

HEMA ACHYUTHAN[1]*, Centre for Environmental Studies, Anna University, Chennai 600025 (hachyuthan0@gmail.com)

Abstract

The desert margins are crucial hotspots, connecting between arid and humid ecosystems and exhibiting high sensitivity to climate changes. These regions have undergone significant environmental shifts during the late Quaternary period, making them susceptible to desertification and drought during prolonged arid conditions, resulting in temporary expansions and contractions of the desert margins. Many of these marginal areas preserve typical arid to semi-arid landforms, representing phases of drier and semi-humid late Quaternary climates. They have also served as corridors for human migration since MIS 5/6, with one notable example being the Thar Desert of Rajasthan, India. Given that drylands and desert margins are home to large populations, it is imperative to understand the geomorphic and anthropogenic processes responsible for climate shifts in these regions. These areas provide suitable sites where different paleoclimatic phases can be identified alongside human activities. Since the 1980s, numerous researchers have dated and excavated sites in these areas. Data from these sites have been instrumental in reconstructing paleoclimate shifts/events using fossil desert landforms, area reliefs, Quaternary sediment deposits, duricrusts, palaeosols, and archaeological evidence.

The application of OSL and 14C dating have facilitated correlations for the timing of aeolian deposition in deserts. Our data indicates that due to the onset of aridity, aeolian deposits began forming around 350 ka, followed by the formation of reddened paleosols. Between 200-150 ka, aridity intensified, accompanied by sporadic but intense aeolian deposition, river system drying, and declining groundwater levels. Aeolian phases occurred between 100 and 115 ka, 75 ka, 55 ka, 30 ka, and 25 ka with intermittent paleosol formations of varying thickness. During the LGM, the eastern margin of the Thar experienced intense aridity, although wind strength was insufficient for extensive aeolian accumulation. However, a climatic optimum period (7–6 ka) following the LGM witnessed a resurgence in aeolian activities. More recent phases of aeolian activity have been recorded between 5–3.5 ka and 2–0.8 ka. The lakes that are saline today were carrying fresh water and were probably interconnected, forming a major river system. Through this corridor, early humans likely migrated inland 'Out of Africa'. Based on Salt Lake studies, the lakes were hypersaline between 15 and 9 ka and relatively less saline or with fresh water between 7.5 and 6 ka. Most lakes dried up around 4 ka and became ephemeral after 1 ka. The lakes like Kanod and Bap-Malar remained saline from 9 to 6 ka while the Eastern margin lakes like Didwana, Tal Chapar, and Jhorda among others had fluctuating saline to fresh hydrology from 9 to 4 ka. Sites with microblade technology ranging in age from late-Pleistocene to mid-Holocene, as known from our studies at Sam (14 ka) and Jamba (7 ka), show human adaptation to arid, wet semiarid, and semiarid environments. Foraging communities had a symbiotic relationship with technologically

advanced food producing people in the eastern margin of the Thar Desert during the Medieval period.

Keyword

Desert margin, Aridity, Aeolian Deposition, Paleoclimate, Human Migration

Luminescence Dating Holocene Sediments from the Mongolian Forest Steppe

Manfred FRECHEN[1]*, LIAG (Manfred.Frechen@leibniz-liag.de)
Junjie Zhang[2], LIAG
Michael Klinge[3], University of Göttingen
Daniela Sauer[4], University of Göttingen

Abstract

The central-Asian forest-steppe forms the transition between the Gobi Desert in the south and the Siberian taiga in the north. In this sensitive landscape, even slight climatic shifts and minor human influence may lead to changes in vegetation patterns and geomorphological processes. Numerous alluvial and colluvial geoarchives, including successions of palaeosols and periglacial, aeolian, alluvial and colluvial sediments, indicate that diverse geomorphological processes have been active with varying intensity in different periods over the Holocene, shaping this landscape. Characteristic dark sediment layers with soil material, charcoal and plant remains are often intermingled within the sediment-palaeosol successions. They suggest that very often fires were the triggers that disturbed the vegetation cover and induced soil erosion. During the early Holocene, the region was widely covered by Siberian larch forests. A well-developed palaeosol is widely distributed giving evidence for a phase of relative geomorphological stability. Geomorphological processes substantially intensified around 4.5 ka, as evidenced by radiocarbon and luminescence age estimates. Although the climate became more humid, forest fires became more frequent than during previous warmer and drier periods. With the development of pastoralism since the early Bronze Age and associated population growth, the grazing pressure in the region increased.

Luminescence and radiocarbon dating methods are mandatory to set up reliable chronological frameworks for sedimentary systems to reconstruct climate and environmental changes quantitatively through time. Colluvial and alluvial sediments were sampled for luminescence and radiocarbon dating in detail. To some extend a discrepancy between radiocarbon and luminescence dating was found. Radiocarbon ages significantly underestimated the previous IRSL dating results. Therefore, quartz and feldspar minerals were investigated in detail to overcome the problem of insufficient bleaching and the problems encountered in the dim quartz OSL signals. We tested K-feldspar single aliquot (1 mm and 2.5 mm) for pIRIR dating to overcome the problem of the dim signal of quartz. Furthermore, single grain dating was also conducted to further address the problem of insufficient bleaching of the pIRIR signals, and OSL dating of quartz specimen was tested and found successful for a few samples. The preliminary established robust chronological framework indicates, in contrast to previous studies, an agreement between radiocarbon and luminescence dating. The robust data set and chronological framework will be presented in relation to the geomorphological processes.

Keyword

Luminescence dating, forest steppe, sediments, Holocene, Mongolia

Age dating of lava plateau and paleolake sediments formed by dammed lava plateau in Yeoncheon, the center of Korean Peninsula

JIEUN KWON[1]*, University of Science and Technology (kge3707@kigam.re.kr)
JIN CHEUL KIM[2], Korea Institute of Geoscience and Mineral Resources
MIN HAN[3], Korea Institute of Geoscience and Mineral Resources
YOUNGWOO KIL[4], Chonnam National University, Department of Energy and Resource Engineering
SEI SUN HONG[5], Korea Institute of Geoscience and Mineral Resources
HANWOO CHOI[6], Korea Institute of Geoscience and Mineral Resources

Abstract

In the Yeoncheon-Jeongok area of Gyeonggi-do in the center of the Korean Peninsula, Quaternary basaltic rocks occur as volcanic plateau and river cliff and representative Paleolithic sites of the Korean Peninsula are distributed. Though, Scientists have already reported for studies on several basalt outcrops, the results of dating vary depending on the region. In addition, it has been reported that paleolakes have been formed in the area by a lava dam formed by the flow of the Yeoncheon lava plateau. By dating the basalts of borehole inside the lava plateau and paleolake sediment core, this study aims to make a comprehensive interpretation of the formation period and distribution of the Yeoncheon lava plateau and to present the ages of the paleolake sediments for the first time. We obtained on total 63 Ar-Ar dating results for basalt outcrops and basalts at boreholes in this area and conducted OSL dating for sampling three or more materials at equal intervals of about 1 m each on 4-5 cores. As a result of Ar-Ar dating of basaltic rock, two different basalt were identified as distinctive periods. The weighted average age of each period is about 520 ka and about 170 ka. In the Jeongok-ri area of Yeoncheon-gun, old basalt rocks of about 520 ka form lava plateau at a position of 50 to 55 m above sea level. The basalt rocks of about 170 ka are distributed from Eundae-ri to Tonghyeon-ri in Yeoncheon-gun and were formed at an elevation of 65 to 70 m above sea level. Furthermore, to confirm the upper age limit, additional TT-OSL dating was performed on paleolake sediments and the age results of the existing OSL and TT-OSL were compared near Chatan river and downstream of Yeongpyeong river, respectively. As a result, paleolake sediments were mainly deposited during the Marine Isotope Stage(MIS 5: 130~80 ka), which corresponds to the last interglacial period. We date the uppermost paleolake sediments to 80 ka, suggesting a discontinuous boundary between the uppermost paleolake sediments and overlying fluvial sediments deposited by a fluvial environment after end of the lacustrine environment. It is interpreted that paleolake suddenly collapsed around 80 ka. Understanding the formation period and distribution of the Yeoncheon lava plateau and the age of paleolake sediments above it would provide interpretations of Yeoncheon's Quaternary formation and ancient river assumption, and provide clues to tracking the climate and ecological environment at the time human beings moved and settled.

Keyword

Quaternary, lava plateau, lake sediments, OSL dating, Ar-Ar dating

Exploring palynofacies and sediment texture dynamics in subtropical floodplains along the Gomati River, Lucknow, India: Transition from Suburban to Urban Environments

POOJA TIWARI[1]*, BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY LUCKNOW (pooja.tiwari@bsip.res.in)
BISWAJEET THAKUR[2], BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES LUCKNOW INDIA

Abstract

The study delves into the intricate interactions between hydro morphodynamics and vegetation, integral components of fluvial bio morphodynamics in actively meandering rivers. Focusing on the Gomati River in Lucknow District, Uttar Pradesh, India, the research examines spatial patterns of sedimentary organic matter (palynofacies) dynamics across a 38 km stretch, spanning from sub-urban to urban reaches within the river valley. Through analysis of palynofacies and grain size data from thirteen surface sediment samples, the fate of organic matter in this area is investigated, shedding light on its transportation, deposition, alteration, preservation, and degradation processes. The study delineates shifts in the composition of palynofacies associations—including phytoclasts, palynomorphs, and amorphous organic matter (AOM)—in conjunction with variations in grain size, providing insights into the depositional mechanisms at play. Utilizing CONISS cluster analysis, four distinct zones are identified, indicating differing degrees of palynofacies degradation and alteration, with urban areas exhibiting higher levels compared to sub-urban regions characterized by minimal interference with natural settings. Principal Component Analysis (PCA) is employed to elucidate the relationship between grain size and palynofacies, highlighting correlations within the meandering fluvial system of the Gomati River. By discerning the behavior of palynofacies within floodplain deposits, the study offers valuable insights into regional aspects of fluvial sediment disposition. Furthermore, the research endeavors to compare contemporary urban and sub-urban settlement patterns, providing a lens through which to understand the historical growth, dispersal, and decline of human settlements in the region. Overall, this study contributes to a deeper understanding of the complex dynamics shaping fluvial landscapes and human settlement patterns.

Keyword

Palynofacies, Grain size, Gomati River, Principal Component Analysis, Sub-urban settlement

[Keynote] Sahara's surface transformation forced an abrupt hydroclimate decline and Neolithic culture transition in northern China

Hao LONG[1]*, Nanjing Institute of Geography and Limnology, Chinese Academy of Sciences (NIGLAS) (longhao@niglas.ac.cn)

Abstract

The remote forcing from land surface changes in the Sahara is hypothesized to play a pivotal role in modulating the intensity of the East Asian summer monsoon (EASM) through ocean-atmospheric teleconnections. This modulation has far-reaching consequences, particularly in facilitating societal shifts documented in northern China. Here, we present a well-dated lake-level record from the Daihai Lake Basin in northern China, providing quantitative assessments of Holocene monsoonal precipitation and the consequent migrations of the northern boundary of the EASM. Our reconstruction, informed by a water-and-energy balance model, indicates that annual precipitation reached ~700 mm during 8-5 ka, followed by a rapid decline to 550 mm between 5 and 4 ka. This shift coherently aligns with a significant ~300 km northwestward movement of the EASM northern boundary during the Middle Holocene (MH), in contrast to its current position. Our findings underscore that these changes cannot be entirely attributed to orbital forcing, as corroborated by simulation tests. Climate model simulations deployed in our study suggest that the presence of the Green Sahara during the MH significantly strengthened the EASM and led to a northward shift of the monsoon rainfall belt. Conversely, the Sahara's reversion to a desert landscape in the late Holocene was accompanied by a corresponding southward retraction of monsoon influence. These dramatic hydroclimate changes during 5-4 ka likely triggered or at least contributed to a shift in Neolithic cultures and societal transformation in northern China. With decreasing agricultural productivity, communities transitioned from millet farming to a mixed rainfed agriculture and animal husbandry system. Thus, our findings elucidate not only the variability of the EASM but also the profound implications of a remote forcing, such as surface transformations of the Sahara, on climatic changes and cultural evolution in northern China.

Keyword

Green Sahara, Surface feedback, lake level, hydroclimate, northern China

Sr-Nd isotopic composition of the Quaternary brown clay-silt sequences in the Jeongok Paleolithic site, Korea: Implication for sediment provenance

Hawon YUN[1]*, Department of Environment and Energy, Jeonbuk National University (yunhawon@jbnu.ac.kr)
Inah SEO[2], Department of Earth and Environmental Sciences, Jeonbuk National University
Jin Cheul KIM[3], 3Climate Change Response Research Division, Korea Institute of Geoscience and Mineral Resources

Abstract

The origin of the Quaternary brown clay-silt (BCS) sequences at the archaeological site in Jeongok-ri, Yeoncheon-gun, Korea, has been debated regarding its relation to the timing of the Paleolithic artifacts. Proposed mechanisms, such as eolian and fluvial processes, each suggest distinct timelines and archaeological implications for the Korean Peninsula. The source-to-sink relationship between the BCS sequences and the potential source regions, such as the Chinese Loess Plateau (CLP) and local landmasses, is not straightforward because of the intense weathering and fine grain sizes, making it challenging to employ traditional provenance indicators. In this study, Sr and Nd isotope analyses are conducted on the 7.5 m-long sediment core (21JG-02) obtained from the E55S20IV pit of the Jeongok Paleolithic site to determine its provenance. The upper (0-3.6 m depth) section of the core, previously classified as a BCS sequence based on grain size, magnetic susceptibility, and geochemical properties, exhibits distinct 87Sr/86Sr and εNd(0) values compared to the lower section (>3.6 m depth), which was identified as a fluvial deposit. Notably, the εNd(0) values, minimally affected by grain size, in sediments from the upper section are similar to those of Yangtze and Yellow River sediments flowing through the CLP and surface sediments of the Yellow Sea basin. Conversely, sediments from the lower section exhibit similar 87Sr/86Sr and εNd(0) compositions to Korean river sediments and show down-core changes suggestive of a mixture with the detritus derived from the Jeongok Basalt, the bedrock. Combining these results with previously reported age dating results, the lower section originated from local sources in the Korean Peninsula through the fluvial process during marine isotope stages (MIS) 7, while the upper part, the BCS sequence, was derived from the CLP or Yellow Sea basin by the eolian process during MIS 6.

Keyword

Jeongok Paleolithic site, Korean Peninsula, brown clay-silt sequence, Sr-Nd isotopes, provenance

Taxonomic research on the Cenozoic gastropods from Qaidam Basin and their palaeoenvironmental significance

Tingting YU[1]*, Nanjing institute of geology and paleontology (ttyu@nigpas.ac.cn)

Abstract

Gastropoda belongs to the phylum Mollusca with a wide variety and is the second class of the animal kingdom. Gastropods are common fossils in the Cenozoic non-marine strata with great biostratigraphic and paleoenvironmental significance. The Cenozoic gastropods are abundant in the Qaidam Basin but have been little studied, resulting in the unclear appearance of the Cenozoic gastropod fauna in the basin, and reducing the effect of gastropods on biostratigraphic correlation and paleoenvironmental reconstruction. The palaeoenvironment reconstruction will be based on the facies analysis and compared to the paleoecology of the gastropod fauna as derived from the ecological characteristics of recent congeners. This project focuses on the Cenozoic gastropods in the Qaidam Basin to make the following studies by using multidisciplinary techniques: 1) make taxonomic study of these gastropods by adopting the latest cladistic systematics classification method, and using geometric morphometrics to distinguish the morphological differences between important genera and species; 2) recover the appearance of the Cenozoic gastropod fauna in the Qaidam Basin and conduct regional and intercontinental biostratigraphic correlations; 3) restore the paleoenvironment and paleoecology based on petrographic and taphthological analyses, combined with ecological attributes of gastropods and geometric morphologic data. This project aims to provide basic materials of gastropod biostratigraphy, taphonomy, biogeography and paleoecology for the research of Cenozoic Qaidam Basin.

Keyword

Gastropod fossils, palaeoenvironment, Qaidam Basin

The Geological Evolution and Palaeoclimatic Significance of the Temburong Peatland, Brunei Darussalam

Adlina MISLI[1]*, Universiti Brunei Darussalam (adlinamisli@gmail.com)
Basilios Tsikouras[2], Universiti Brunei Darussalam
Stavros Kalaitzidis[3], University of Patras
Elena Ifandi[4], Universiti Brunei Darussalam
Kimon Christanis[5], University of Patras

Abstract

Tropical peatlands are significant carbon sinks and freshwater stores and they comprise vital ecosystems governing the biodiversity. Furthermore, these peatlands serve as crucial palaeoclimatic and palaeoenvironmental archives, enriching our comprehension of sustainability and the dynamics of climate change. Peatlands worldwide face significant stress, yet Brunei Darussalam hosts some of the last remaining intact peatlands. These pristine ecosystems are invaluable for unravelling the geological evolution and the intricate conditions leading to peatland formation. Geological studies focusing on these last peatlands are limited, with particularly the Temburong region being understudied. This area is associated with a complex network of maeandering rivers and tributaries, which make up complex landforms and ecosystems. Peat formation in Temburong began approximately 2,500 years BP, during a Neoglacial cooling period, likely in an estuarine environment, representing a migrated palaeoshoreline. The Temburong peat, up to 130 cm thick, begun accumulating in a topogenous mire; it displays relatively low moisture, higher ash yield, and more acidic pH values, compared to the top 20-30 cm layer beneath the surface, which is accumulated in an ombrogenous mire. Peat accumulation rates are generally low, ranging between 0.4 mm/year to 0.5 mm/year, analogous to other synchronous, coastal peatlands of Southeast Asia. Variations in electric conductivity, coupled with lithological patterns, as well as proximate and ultimate analyses, are consistent with fluctuations in sea level and environmental changes during the peatland evolution. Literature data indicates climatic fluctuations during late Holocene with some Neoglacial cooling events that may have resulted in eustatic sea-level changes and therefore, have affected the evolution of the coastal Temburong peatland.

Keyword

Tropical peatlands, Palaeoenvironment, Southeast Asia, Topogenous, Ombrogenous

Insights into the Palaeoclimatic and Palaeoenvironmental Evolution of Brunei Darussalam through the Window of Tasek Merimbun Peatland

Basilios TSIKOURAS[1]*, Universiti Brunei Darussalam (basilios.tsikouras@ubd.edu.bn)
Muhammad Syazwan OMAR[2], Universiti Brunei Darussalam
Stavros KALAITZIDIS[3], University of Patras
Elena IFANDI[4], Universiti Brunei Darussalam
Kimon CHRISTANIS[5], University of Patras

Abstract

Tasek Merimbun Mire, situated in the central region of Brunei Darussalam, Borneo Island, occupies an area with altitudes ranging from approximately +3 to more than +18 metres. This peatland hosts an array of indigenous flora, including Shorea albida, Cyrrostachys renda, Pandace sp., Calamus rundentum, Areca nut, Lepironia articulata and subordinate Licuala spinosa. We performed four boreholes using a hand-driven peat sampler and the maximum observed thickness of the peatland is 10 metres. The collected cores show the predominance of peat overlying a clayey substrate with subordinate intercalations of peaty mud, mud, clay and clayey sand. Electrical conductivity values combined with B, Na and Mg contents, as well as the results of the proximate analysis, mainly S content, indicate a brackish-water influence in the lower peat strata, which subsequently changed to a freshwater system. This points to an initial accumulation of topogenous peat in a coastal lagoon or estuarine environment some 7,000 years ago, during the Holocene Climatic Optimum (HCO) period, followed by a rapid transition into a fluvial system and eventually to an ombrogenous peat. The accumulation rates are relatively fast during the early topogenous and the subsequent ombrogenous stages, up to approximately 3,400 years BP that is towards the end of the HCO, analogous to other peatlands of similar ages in the broad region of Southeast Asia. This period is followed by a significant deceleration of the peat accumulation until recent. X-Ray diffractograms reveal consistent influence of one or more rivers supplying mainly quartz, mixed clay layers, and chlorite. Signs of past (natural and/or anthropogenic) fire events manifest in charcoal remnants within peat layers. This study seeks to trigger further investigations into Tasek Merimbun's Lake formation, encouraging future research to incorporate palynological and petrographical studies for a more comprehensive understanding of this unique peatland ecosystem.

Keyword

Tropical Peatlands, Ombrogenous, Topogenous, Southeast Asia

Tracking the appearance of the first humans on the Jeongokri, Korea

Jin Cheul KIM[1]*, Korea Institute of Geoscience and Mineral Resources (kjc76@kigam.re.kr)
Jieun KWON[2], Korea Institute of Geoscience and Mineral Resources
Sei Sun HONG[3], Korea Institute of Geoscience and Mineral Resources
Ire CHOI[4], Korea Institute of Geoscience and Mineral Resources
Hoil LEE[5], Korea Institute of Geoscience and Mineral Resources
Tae Ho LEE[6], Korea Institute of Geoscience and Mineral Resources
Hyeon Seon AHN[7], Korea Institute of Geoscience and Mineral Resources
Jin-Young LEE[8], Korea Institute of Geoscience and Mineral Resources
Han Woo CHOI[9], Korea Institute of Geoscience and Mineral Resources
Seungwon SHIN[10], Daegu University

Abstract

The Acheulean-type hand axe, which was discovered only in Africa and Europe and never found in Asia, was discovered on the Korean Peninsula for the first time in East Asia in 1978 and attracted worldwide attention, but the debate surrounding the date of creation of the remains has continued in the archaeological community for 40 years. Although various absolute dating measurements have been conducted over the past 40 years since the Jeongok-ri relics were excavated and a lot of data has been calculated, the absolute chronology of the relics' formation has not yet been established.

The purpose of this study is to understand the geological distribution and formation of the Hantan-Imjingang River basin, identify the time of human emergence, and understand the characteristics of the climate and ecological environment at the time of human emergence to interpret interconnections. In this study, direct dating of the artefact-bearing layers was attempted by applying OSL techniques, which showed great potential for use in the accurate determination of the timing of deposition. To extend the age range of OSL dating, a thermally transferred optically stimulated luminescence (TT-OSL) signal and single-grain K-feldspars using the post-Infrared Infrared stimulated luminescence (pIR-IRSL) were also investigated. The Jeongok Basalts were directly analysed using the Ar-Ar method. 10Be dating from the unconsolidated gravel and sand layers underlying the Jeongok Basalt were dated for burial age. These results of multiple absolute dating methods allow the development of chronologies of the Jeongokri archaeological sites and constrain the timing of the earliest hominin occupation in South Korea.

Keyword

Jeongokri, OSL, IRSL, archaeological, Korea

Typhoon variability during the Holocene in East Asia and its linkage to ENSO activity

Jaesoo LIM[1]*, Korea Institute of Geoscience and Mineral Resources (limjs@kigam.re.kr)

Abstract

Understanding spatial-temporal variability in extreme hydrologic events driven by super typhoons over Asia is essential to test its controlling factors and predict its future change in anticipating global warming. Here we present a set of direct heavy-rainfall records for past 10,000 years recovered from wetland sediments of the two volcanic cones (Sara-oreum and Nongo-ak) in Jeju Island, where orographic amplification of precipitation is dominant and sensitive to typhoon influence. The reconstructed heavy rainfall index shows clear variability at decadal-centennial timescales and is similar to past records of coastal flooding events in the southern coast of Korea and typhoon-driven overwash events along the southwestern coast of Japan. These spatial similarities suggest that the reconstructed heavy rainfall index from the sediments of the volcanic cones can be used as an indicator for the past typhoon variability. Furthermore this typhoon index covering correlated well with past El Nin˜o/Southern Oscillation (ENSO) activity reconstructed from Ecuadorian high mountain area, confirming the existence of present linkage between more frequent typhoon occurrence and strong ENSO phases for the past 10,000 years at decadal to centennial time scales. This study demonstrates that the multi-decadal to centennial-scale typhoon variability in the western Pacific have been closely coupled to the eastern Pacific atmospheric-oceanic conditions than thought ever, needing better understanding of west-east Pacific teleconnection and its linkage to typhoon activity.

Keyword

Jeju Island, typhoon, Holocene, ENSO activity

Holocene landscape variations of a large shallow lake in East Asia: Interactions between climate, hydrology, and human beings

Yawen GE[1]*, Hebei Normal University (geyawen@hebtu.edu.cn)
Changhong Liu[2], Hebei Normal University
Yuecong Li[3], Hebei Normal University

Abstract

The lack of continuous Holocene sedimentary records in large shallow lakes with river inputs poses a significant challenge for gaining a detailed understanding of long-term correlations among climate, environment, and human activities in densely populated areas worldwide. In this study, we reconstruct the comprehensive evolutionary history of Baiyangdian Lake, a typical open lake in East Asia during the Holocene, using AMS-14C dating and multiple sedimentary proxies. Our findings suggest that Baiyangdian Lake has gradually expanded since 10,300 cal yr BP and subsequently entered into a slow paludification process after 4,500 cal yr BP, particularly influenced by the 4.2 ka event. The Holocene optimal period (especially 6,500–4,500 cal yr BP) greatly accelerated the emergence of agriculture through slash-and-burn cultivation practices while human activities and concurrent marine incursions significantly altered both mountainous and plain landscapes. Since 2,700 cal yr BP, intensified human activities and hydrological processes have progressively driven Baiyangdian Lake towards its modern landscape. The representation of the 4.2 ka event in the sedimentary record significantly diverged from that of 8.2 ka, 6.8 ka events due to alterations in geomorphology and sedimentary environment, alongside inherent differences between climatic events themselves. These results contribute to our understanding of interactions between climate changes, hydrology, and human beings in densely populated areas of East Asia since the Holocene.

Keyword

Vegetation succession, Climate changes, Sea level changes, Early agriculture, Holocene

Uplift of the northeastern Tibetan Plateau leads to the extreme desertification in East Asia around 0.9 Ma

Xinbo GAO[1]*, Institute of Geology, China Earthquake Administration (Xinbo-Gao@outlook.com)

Abstract

Climatic extremes have destructive impacts on human society and the natural environment. In the wind-blown dust deposits (loess) of the Chinese Loess Plateau (CLP), several loess layers are exceptionally coarse-grained, representing deposition under conditions of extreme aridification. Among these loess beds, the upper sandy loess layer L9, corresponding to marine isotope stages 22-24, has attracted much research attention. An important reason for this is the widely reported remagnetization of the coarsest part of L9 in loess sections in the eastern Loess Plateau. However, our present work found that for the coarsest part of L9 in the loess sections in the western Loess Plateau, the reported remagnetization is disappeared. This spatially inconsistent magnetization pattern originates mainly from the different magnetic carriers of the characteristic remanent magnetization, hematite in the western Loess Plateau and magnetite in the eastern Loess Plateau. We propose that the enhanced glacial grinding and the denudation of mountains caused by the uplift of the northeastern Tibetan Plateau led to the production of enormous quantities of fluvial and fluvioglacial materials rich in hematite, which were supplied specifically to the western CLP. This uplift also resulted in the occurrence of extreme aridification in the East Asian interior at ~900 ka.

Keyword

Loess, L9, Remagnetization, Hematite, Desertification

Limnological shift and droughts driven by monsoonal changes during the Holocene – insight from a diatom record from Biển Hồ maar lake, Central Highlands of Vietnam

Hoàn Đào-Trung[1]*, Center for Information, Archives and Museum of Geology, Vietnam Geological Department (dthoan@monre.gov.vn)
Yu Fukumoto[2], Estuary Research Center, Shimane University, Shimane 690-8504, Japan
Dương Nguyễn-Thùy[3], Faculty of Geology, University of Science, Vietnam National University, Hanoi, 334 Nguyễn Trãi Street, Thanh Xuân District, Hà Nội, Vietnam
Thành Đinh-Xuân[4], Faculty of Geology, University of Science, Vietnam National University, Hanoi, 334 Nguyễn Trãi Street, Thanh Xuân District, Hà Nội, Vietnam
Thái Nguyễn-Đình[5], Faculty of Geology, University of Science, Vietnam National University, Hanoi, 334 Nguyễn Trãi Street, Thanh Xuân District, Hà Nội, Vietnam
Ingmar Unkel[6], Institute of Geography, Heidelberg University, 69120 Heidelberg, Germany
Hướng Nguyễn-Văn[7], Faculty of Geology, University of Science, Vietnam National University, Hanoi, 334 Nguyễn Trãi Street, Thanh Xuân District, Hà Nội, Vietnam

Abstract

Extreme weather and climate events in the Central Highlands of Vietnam result from the complex interactions of the various monsoon systems across Southeast Asia, leaving numerous traces in the geological records such as lake sediments and speleothems. However, paleoenvironmental reconstructions require a stable, high-quality source of information that is detailed and continuous over time, which has been a significant challenge in Vietnam. Our ~530 cm sediment sequence collected from Biển Hồ maar lake (14°03′ N, 108°00′ E), near the centre of the transitional region, shows the evolution of the diatom community adapting to changes in climate and the local environment. The record is uninterrupted throughout the Holocene with a diatom-sampling resolution of approximately 180 years on average. A regime shift characterised by two identified diatom assemblages is recognised around 7,800 cal BP, close to the transition from the Early to the Mid- Holocene. During the Early Holocene, the change in the ratio of Aulacoseira veraluciae to Discostella stelligera indicates the intensities of two opposing mechanisms: water-mixing and thermal stratification in meso-eutrophic conditions. Meanwhile, the replacement of the previous main species by the prevalence of Aulacoseira granulata var. granulata during the Mid- to Late Holocene suggests intense eutrophication caused by year-round water destratification and mixing. The morphological variability of this taxon also serves as an indicator of the driest times in the Central Highlands associated with major droughts across Africa and Asia continents.

Keyword

diatoms, paleoenvironmental, seasonal, Holocene, maar lake

New data on the glacial history of the Southern Pamir

Mariia EFIMOVA[1]*, Institute of Water Problems, Hydropower and Ecology NAST (jakovlevamariya@gmail.com)
Natalia Taratunina[2], Department of Physics, Technical University of Denmark
Jan–Pieter Buylaert[3], Department of Physics, Technical University of Denmark
Andrew Murray[4], Nordic Laboratory for Luminescence Dating, DTU Physics and Department of Geoscience, Aarhus University
Redzhep Kurbanov[5], Institute of Water Problems, Hydropower and Ecology, NAST
Petr Sosin[6], Institute of Water Problems, Hydropower and Ecology, NAST
Evgeny Deev[7], Institute of Geography, National Academy of Sciences of Kazakhstan
Andrei Panin[8], Institute of Water Problems, Hydropower and Ecology, NAST
Mariya Lukyanycheva[9], Institute of Archaeology, Azerbaijan Academy of Sciences

Abstract

The Pamir Mountains are located in the northwestern region of High Mountain Asia (HMA), which is known as the Third Pole (TP), the third-largest cryosphere on Earth that has a crucial impact on the global water cycle and climate system. The Pamir glaciers serve as primary freshwater supplies for the main rivers in the region, including the Amudaria and Syrdaria. During the Quaternary, these rivers carried glacial, alluvial, and slope deposits from the Pamirs across long distances to the Aral and Caspian areas, resulting in the formation of the Karakum and Kyzylkum deserts. The glacial history of the Pamir mountains has been reconstructed using geological and geomorphological data, as well as CRN dating. Despite this, the number, extent, and timing of Pleistocene glaciations in the Pamir region are still debatable. A comprehensive study of the Pamir-Alai region identified three major stages of glacial advance in the Middle and Late Quaternary, with the local LGM appearing to be during the Middle Pleistocene. In the southeastern Pamirs, the most extensive glaciation occurred during the Middle Pleistocene, when a large part of the mountains was likely covered by an ice cap and filled the main valleys of the Shahdara, Gunt, and Panj rivers. This paper contributes to understanding the southern Pamir's glacial history and the evolution of glaciation by presenting new data on a series of moraine ridges on the southern slope of Shakhdara ridge in the main valley of the Panj River and a thick lacustrine sequence in the tributary of the Panj, the valley of the Sary-Shitharv River. Obtained ages describe the timing of the glacially-dammed lake at Sary-Shitharv valley to MIS 6, providing the nearly oldest dated glacial advance in the Pamir area. These results are essential for the study of the Pamirs' glacial chronology and provide further evidence supporting the hypothesis that during the Middle Pleistocene, the Panj River valley was occupied by a massive glacier that extended from the southeastern part of the Pamirs.

Keyword

Pamir Mountains, HMA, MIS 6, Luminescence dating, Glaciation

Paleoenvironment evolution in the Weihe basin and its impacts on drainage systems of middle Yellow River since late Pliocene

Jingyun XIAO[1]*, Institute of Earth Environment, Chinese Academy of Sciences
(xiaojingyun@ieecas.cn)
Yougui Song[2], Institute of Earth Environment, Chinese Academy of Sciences

Abstract

The Yellow River, the second longest river in China, its development and evolution is an important geological problem that comprehensively reflects the changes of tectonic landform and environment in East Asia. The Weihe Basin is an excellent research location for understanding the evolution history of regional tectonics, climate, and hydrologic environment due to the accumulation of extremely thick and continuous sedimentary strata since Cenozoic. To help decipher the history of the development of the middle reaches of the Yellow River since Pliocene, the accurate paleomagnetic dating and analysis of grain size and magnetic susceptibility of sedimentary records in Weihe Basin are carried out. Our results suggest that the Weihe basin changed from lacustrine to fluvial deposition at ~2.6 Ma, subsequently transformed into eolian deposition at 1.2Ma. We conclude that the modern pattern of drainage systems in the middle reaches of the Yellow River was basically established in 1.2Ma, and the tectonic far-field stress from the continuing Tibetan Plateau uplift and eastern expansion created differential uplift/subsidence pattern, as well as the continuing lowering of base-level since 2.6Ma driving this integration. More interestingly, the information of the evolution of the East Asian monsoon system can be perfectly recorded in our basin during the period of tectonic stability. It provides good sedimentary evidence for understanding the evolution history of the Yellow River and its driving mechanism.

Keyword

Sedimentary basin, Magnetostratigraphy, Tectonic, Climate change

Incised-valley filling Sedimentation in response to Holocene Sea Level rise, Yeongil Bay, Southeastern Korea

Hyun Ho YOON[1]*, Korea Institute of Geoscience and Mineral Resources (hhyoon@kigam.re.kr)
Jin-Young Lee[2], Korea Institute of Geoscience and Mineral Resources
Jin Cheul Kim[3], Korea Institute of Geoscience and Mineral Resources

Abstract

Incised valley infilling deposits are closely related to sea level changes and are one of the important issues in the late Quaternary sea-level history. In Asia, numerous large river basins receive a large amount of sediments from the land, and the study of infilling deposits of incised valley systems has been a major focus. Yeongil Bay is located on the southeastern coast of the Korean Peninsula, featuring a funnel-shaped bay indentation. The small Hyeongsan River flows into Yeongil Bay and exits to the East Sea. During the Last Glacial Maximum (LGM), when the sea level was more than 120-130m lower than today, incised valleys were formed due to erosion by inflowing rivers. In this study, the sedimentary patterns of incised valleys since the LGM were investigated by analyzing sedimentary facies, optically stimulated luminescence (OSL), and radiocarbon dating of three sediment cores obtained from Yeongil Bay. The sedimentation sequence consists of fluvial lag and meandering river deposits (>12 ka), estuarine deposits (12-7.8 ka), and delta deposits (7.8-0 ka) in ascending order. Shoreface systems appear only in cores obtained from the outer part of Yeongil Bay, indicating that estuarine and delta systems were formed in a wave-dominated environment. Shoreface systems emerged by eroding estuarine deposits around 8.5 ka. Millennial-scale isochrons based on OSL and radiocarbon dating show that after the LGM, meandering river and estuarine systems were deposited through retrogradation, and delta systems through progradation. The modern deltas in the large river basins of Asia started to form during the mid-Holocene when the rate of sea-level rise slowed down, considering this period is important for the study of relative sea level (RSL). This study emphasizes the importance of both sediment supply and the capacity of accommodation space as factors in the delta initiation. The results provide significant insights into incised valley infill deposits and past environmental conditions and may help to better understand how coastal environments have changed with sea level changes.

Keyword

SE Korea, Holocene sea-level rise, incised valley, maximum flooding surface, small river valley

Paleo-hydro environmental changes in Southeastern Mongolia from the Late Pleistocene to the Mid-Holocene: An analysis of lake sediment from Bayan Tohom Gobi

Sumin KANG[1]*, Kyung Hee University (sumin8185@khu.ac.kr)
Yukiya Tanaka[2], Kyung Hee University

Abstract

The Gobi Desert, located in southeastern Mongolia, is close to the limit of the EASM. Despite being extremely sensitive to climate change, only a few studies have been conducted on the paleoclimate in this region.

This study intends to provide a comprehensive analysis of the paleoenvironmental changes in southeastern Mongolia using lake sediments from paleolakes and classify the periods of dry and wet according to the effects of the EASM compared with the North Atlantic.

Lake sediments can provide proxy data and a continuous record of paleoclimate, and the analysis of the grain size and chemical properties of lake sediments and diatom can be used to reconstruct the environment around lakes.

The samples for analysis were obtained from Bayan Tohom Gobi, a depression in southeastern Mongolia. The grain sizes and geochemistry of the samples were analyzed to obtain proxy data. Furthermore, we carried out optically stimulated luminescence (OSL) and 14C dating of the sample sediments to investigate the paleoenvironmental changes in the region after the Late Pleistocene. We also use the diatom as an indicator of wet periods.

As a result, we obtained multi-proxy data from the Late Pleistocene to the Mid-Holocene by analyzing sediment core samples collected from three sampling sites in Paleolake Uidzen Nuur. The analysis results show that proxy data fluctuated wildly within the short period before 28 ka (OSL dating) and showed a huge decrease of around 10 ka. Fluctuation of proxy data means vegetation around the paleolake and precipitation. After comparing the results with previous data, the mean fluctuation of precipitation within a short period is associated with the D-O cycle in Hulu Cave (Northeastern China) and Ice core data (North Pacific). D-O cycle possibly affected the fluctuation of precipitation in southeastern Mongolia.

Thus, we provide evidence of a global-scale teleconnection by comparing these records with the paleo-hydrological records from the North Pacific region. This study will contribute to understanding global environmental changes during the Holocene and Late Pleistocene and highlight the interconnected nature of climatic processes across different areas.

Keyword

Mongolia, EASM, paleocliamte, proxy data, Diatom

Reconfirmation of the dating of Jeju Island's Suwolbong Tuff

youjin WOO[1]*, University of Science and Technology (youjin7308@kigam.re.kr)
Jincheul KIM[2], Korea Institute of Geoscience And Mineral Resources
Sei Sun HONG[3], Korea Institute of Geoscience And Mineral Resources
Jin-Young LEE[4], Korea Institute of Geoscience And Mineral Resources
Han Woo CHOI[5], Korea Institute of Geoscience And Mineral Resources

Abstract

Jeju Island is the Quaternary volcanic island located in Korea, and there are tuff called Oreum due to active eruptions of hydrovolcanic on the island. located in the southwest of Jeju Island Suwolbong Tuff is one of these tuff and is composed of pyroclastic materials. Suwolbong Tuff is created in as a mono-volcanic eruption, so there is no stratigraphic order.

According to previous studies, the formation age of Suwolbong Tuff is known to be about 18 ka when measured by Optically-Stimulated Luminescence (OSL) using quartz (Cheong et al., 2007). As per another previous study, the radiocarbon dating age of the unconsolidated sediments called the “Gosan Formation” under Suwolbong Tuff, is about 17 ka at the top (Lim et al., 2015). Therefore, the Suwolbong Tuff above the Gosan Formation was expected to be younger than 17 ka.

In this study, the depositional age was measured using single grain OSL dating, which determines the age by measuring 100 single quartz particles one by one. Then, the date is obtained through statistical processing. which was not preformed in previous studies. This study is conducted to re-evaluate previous OSL dating results of the Suwolbong Tuff. It is expected to find out the last hydrovolcanic activity on Jeju Island.

Keyword

Jeju Island, Single grain OSL, Quaternary, Suwolbong Tuff, Chronology

Electron Spin Resonance chronology and heavy minerals from the quaternary fluvial terraces of the Somme River (Northern France)

Rajib Kumar SAHA[1]*, Geological Survey of Bangladesh (rajibkumar.saha@gsb.gov.bd)
Pierre VOINCHET[2], Muséum national d'Histoire naturelle Département Homme et Environnement, UMR 7194 du CNRS
Pierre ANTOINE[3], Directeur de Recherche CNRS UMR 8591 CNRS-Univ. Paris I-UPEC Laboratoire de Géographie Physique, Environnements Quaternaires et actuels

Abstract

Chronological assessment is a fundamental requirement for comprehending the landscape's formation timing and reconstructing the connection between paleoenvironment and climate. With this goal samples from fluvial units of the Somme river stepped terrace system (Northern France) have been selected for a systematic application of a multi-center approach (Al, Ti-Li, and Ti-H) for Electron Spin Resonance (ESR) dating. This involves the examination of bleached quartz grains. Simultaneously, the sedimentary processes have been scrutinized through the identification of heavy minerals, achieved by both density separation and magnetic separation. The objective was to gather information on provenance and paleoenvironment, contributing to a comprehensive understanding of the archaeological context.

While the age estimates for the Amiens sites, "Rue du Manège" and "Ilôt des Bouchers," have associated uncertainties primarily stemming from challenges in long-term water content estimation, lithostratigraphy, and depth values, a Middle Pleistocene age has been assigned to these sites. This correlation is based on Marine Isotope Stages (MIS) and aligns with the Saalian Complex of Northwestern Europe chronosratigraphy. In contrast, the age estimation for Abbeville "Route de Paris," has been considered unreliable due to overestimation and non-repeatability with Al and Ti centers.

Most stable heavy mineral types are more prevalent in the 0.125 mm to 0.063 mm size fractions at the Somme River Valley sites sediments (the heavy mineral assemblages from the oldest part of the system are likely different from those of the Late Saalian terraces for instances, Ilôt des Bouchers). These minerals include garnet, epidote, green hornblende, augite, zircon, kyanite, staurolite, sphene, apatite, rutile, and tourmaline. Provenance tracks, primarily originating from sialic igneous rocks, have been defined based on granulometry, heavy mineral suites, and optical characteristics. The source rock has been identified as fluvioglacial Fenno-Scandinavian material derived from the Scandinavian Ice Sheets and the aeiolian transport of the minerals in loess sediments originated from the Eastern Channel area.

Keyword

Northern France, Somme River, ESR Multicenter, Heavy minerals, Fenno-Scandinavian

Fluvial dynamics and climate change in a tropical river throughout the Late Quaternary (Kampar River, Sumatra, Indonesia)

Yuniarti - YUSKAR[1]*, Institute of Earth Surface Dynamics, University of Lausanne (yuniarti.yuskar@unil.ch)
Davide - Mancini[2], Institute of Earth Surface Dynamics, University of Lausanne
Melanie - Bartz[3], Institute of Earth Surface Dynamics, University of Lausanne
Christoph - Schmidt[4], Institute of Earth Surface Dynamics, University of Lausanne
Tiggi - Choanji[5], Institute of Earth Science, University of Lausanne
Andrew Paul Nicholas[6], Faculty of Environment, Science and Economy, Geography, University of Exeter
Stuart Nicholas Lane[7], Institute of Earth Surface Dynamics, University of Lausanne
Georgina Elizabeth King[8], Institute of Earth Surface Dynamics, University of Lausanne

Abstract

Fluvial landforms and sediments with robust chrono-stratigraphy can be used to reconstruct paleoenvironments and link their relationships with paleoclimates. Quaternary landscape evolution in tropical river environments, such as Indonesia, remains poorly known, especially over Middle to Late Pleistocene time scales. The Kampar River is a meandering tropical river in Sumatra Island, Indonesia that has a gentle slope, sand-gravel beds and bends that migrated laterally due to bank erosion. This study provides a chrono-stratigraphic framework for the Late Quaternary period of the Kampar River to reconstruct long-term sedimentation events and investigate the drivers of morpho-dynamics, including climate change. Satellite images and drone imagery show the recent geometry of the river. Sedimentological analysis, utilizing X-ray diffraction and granulometry is used to investigate facies changes and paleoenvironments. A chrono-stratigraphy established with luminescence dating and fluvial modelling allows for a more precise reconstruction of alluvial history in response to environmental change. A simulation of fluvial dynamics was conducted using a numerical model of water flow and sediment transport, eRiDynas.

Results of sedimentological and luminescence dating analyses show that sedimentation of the Kampar River occurred in the Upper Middle Pleistocene with massive gravelly channel deposits. This happened in a period of high global glacier cover, cold conditions and low sea levels at Marine Isotope Stage (MIS) 6, possibly suggesting a significant increase in sediment supply and/or reduction in sediment transport capacity due to drier conditions. A hiatus in the sedimentary record suggests that sedimentation reduced substantially, and intensive erosion occurred during interglacial to glacial periods between MIS-5 and 4. In the Late Pleistocene, fining-upward sandy gravels were deposited at MIS-3, and the river became more associated with low amplitude point bars reflected in lateral accretion deposits. Overbank and chute bar formations were deposited and indicate the onset of large-scale flooding and more intensive bend-growth during the last glacial maximum (LGM). For the Kampar River, our results suggest that fluvial morpho-dynamics were primarily a consequence of climate-controlled sedimentation

processes rather than tectonic processes. These results are being combined to develop a model of fluvial dynamics to better understand the fluvial response to a changing climate. The model results are regarded as realistic based on the consistency of the simulated and actual mechanisms driving Kampar River’s evolution.

Keyword

Quaternary, fluvial dynamics, luminescence dating, tropical river, Indonesia

Dating the base of the Upper Pleistocene in Chinese and Tajik loess by OSL and its association with climatostratigraphy and chronostratigraphy

Liping ZHOU[1]*, Peking University (lpzhou@pku.edu.cn)
Jintang Qin[2], Peking University
Yuetian Li[3], Peking University

Abstract

One of the next priority tasks of the Quaternary stratigraphy community is to establish a Global boundary Stratotype Section and Point (GSSP) for the Upper Pleistocene Subseries, which was formalized with a provisional age of ~129 ka. To define its GSSP, a marine sediment record in Taranto, Italy and the EPICA Dome C ice core in Antarctic have been suggested as candidates. Once the boundary is ratified, it would not only serve as a chronostratigraphic marker but also carry specific regional climatic signatures reflecting a distinctive event of global significance. Loess-paleosol sequences in Eurasia have served as major climate archives on the continent. Their chronologic framework has been established by paleomagnetic reversals. The optically stimulated luminescence (OSL) method has been successfully employed to constrain the ages of the upper part of the sequences. Here we present results of OSL dating of four loess sections from northern China and southern Tajikistan. We show the effects of the choices of minerals and laboratory measurement conditions, and discuss their strengths and limitations. As the base of the Upper Pleistocene is associated with the onset of the Last Interglacial, a global warming event in the Earth system, the accuracy of the OSL ages of the Eurasian loess sequences is crucial for providing a basis for climatostratigraphic correlation. We evaluate the OSL age uncertainties and their chronostratigraphic implications with reference to the lithologic subdivisions of the loess and paleosols as well as to the other climate records on land and in the ocean.

Keyword

Loess, OSL dating, Upper Pleistocene

A ~426 ka Antarctic methane jump at the onset of MIS 11 could mark a prospective second stage for the Middle Pleistocene Subseries

Martin J. James Head[1]*, Brock University (mjhead@brocku.ca)

Abstract

The 'Mid-Brunhes Event' (MBE) in the late Middle Pleistocene represents an abrupt step-change to climate cycles of generally increased amplitude and warmer interglacials from Marine Isotope Stage (MIS) 11 onwards, as revealed by Antarctic ice core records, the LR04 benthic foraminiferal isotope stack, and a long alkenone paleotemperature record from the central Mediterranean Sea. Other long-term changes include an abrupt weakening of the East Asian Summer Monsoon, suggesting an increase in average Northern Hemisphere ice volume. The Middle Pleistocene Subseries, formalized in 2020 with the Chibanian as its only stage, is the second longest subseries of the Quaternary with a duration of 645 kyr. Defining a second stage with its base coincident with the MBE would subdivide the Middle Pleistocene at its mid-point utilizing a major climate transition (Head MJ 2021, Prog. Earth Planet. Sci. 8: 50). The MIS 12/11 boundary (Termination V) marks the highest-amplitude climate oscillation of the Quaternary and constitutes a logical base for this new stage. In addition to being recognised by rapid changes in the marine record, this level appears to align with the bases of the Holsteinian, Hoxnian, Likhvinian, and Zavadivian regional stages across northwestern and central Europe, the Russian Plain, and the Ukrainian Loess Plain; and can be traced across the Chinese Loess Plateau. In detail, MIS 12 represents possibly the largest ice-volume expansion in the Quaternary, and MIS 11 is one of the warmest interglacials, spanning two precession cycles in which full interglacial conditions persist for nearly 30 kyr despite only modest orbital forcing (reviewed by Tzedakis PC et al. 2022, Quat. Sci. Rev. 284 107493). The unusual characteristics and duration of MIS 11 have been attributed to a combination of extensive ice coverage during MIS 12 and weak boreal summer insolation forcing in MIS 11. Deglaciation at the end of MIS 12 began just before peak northern hemisphere insolation with a weakening of the Atlantic meridional overturning circulation leading to activation of the bipolar seesaw and Antarctic warming. This is reflected in the EPICA DOME C Antarctic ice core record by a simultaneous rise in atmospheric temperature over Antarctica and a rise in CO2 attributed to Southern Ocean degassing. A sharp rise in methane in the EPICA DOME C core at 426 ka appears to correlate with a similarly rapid and pronounced shift to more negative δ18O values in the Sanbao Cave speleothem of China, probably reflecting an expansion of tropical wetlands at this time. A particular challenge in searching for a globally isochronous base in the early part of MIS 11 in both marine and terrestrial deposits is the slow eustatic rise and prolonged ice sheet decay through the early part of MIS 11c. Nonetheless, the methane jump at 426 ka in the EPICA DOME C core, coinciding with the onset of MIS 11 and abrupt warming in the mid- to low latitude North Atlantic, might serve as the primary guide to the base of the proposed second stage for the Middle Pleistocene.

Keyword

New stage, Middle Pleistocene, Geological time scale

CENOZOIC STRATIGRAPHY OF SOUTH AFRICA: CHALLENGES AND POSSIBILITIES

Greg A. Botha[1]*, 35IGC Legacy Fund/ IGCC/ University of KwaZulu-Natal (bothag@ukzn.ac.za)

Abstract

The Cenozoic stratigraphy of South Africa evolved progressively during regional geological mapping over the past 168 years. The diverse Cenozoic regolith distributed across the wide range of bedrock types and terrain morphological contexts has not been classified consistently. Although geological mapping here utilizes lithostratigraphy to organise the Cenozoic deposits, some extensive surficial units are only characterised using lithological descriptors. No formal biostratigraphic units have been defined and the application of “Land Mammal Ages” compiled from fossil type sites is not incorporated on geological map legends. An analogous archaeological cultural-historical “Technocomplex” stratigraphy has been derived to subdivide the stone age cultural material. This system has commonly been used as a relative dating framework where artefacts are associated with Quaternary deposits. The current status of regolith lithostratigraphy and the geochronological framework relative to global chronostratigraphy is addressed.

It is proposed that Cenozoic regolith stratigraphic units are differentiated into the terrain morphologically defined Geomorphic Province context as a means of correlating similar deposits across the subcontinent. For mapping units based on lithological characteristics that have not been well researched, or when their geochronological position is uncertain, the use of lithodemic nomenclature to characterise units in each Geomorphic Province is proposed as a temporary measure. This will enhance inter-regional correlation and encourage further research that could lead to formal lithostratigraphic descriptions.

Keyword

lithostratigraphy, regolith, Cenozoic, chronostratigraphy, biostratigraphy

Date your late Cenozoic mud: New advances in applicability of the authigenic 10Be/9Be dating

Michal ŠUJAN[1]*, Laboratory of Quaternary Research, Nature Research Centre, Vilnius, Lithuania & Comenius University Bratislava, Slovakia (michal.sujan@uniba.sk)
Kishan Aherwar[2], Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia
Régis Braucher[3], CEREGE, Aix-Marseille Univ., Aix-en-Provence, France
Andrej Chyba[4], Institute of Chemistry, Slovak Academy of Sciences, Dúbravská cesta 9, Bratislava, Slovakia
Katarína Šarinová[5], Department of Mineralogy, Petrology and Economic Geology, Faculty of Natural Sciences, Comenius University Bratislava, Slovakia
Tomáš Vlček[6], Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia
Arjan de Leeuw[7], Institut des Sciences de la terre (ISTerre), University Grenoble Alps, CNRS, Grenoble, France
Anton Matoshko[8], Palaeomagnetic Laboratory 'Fort Hoofddijk', Department of Earth Sciences, Utrecht University, Netherlands
Alessandro Amorosi[9], Department of Biological, Geological and Environmental Sciences, University of Bologna, Italy
Bruno Campo[10], Department of Biological, Geological and Environmental Sciences, University of Bologna, Italy
Imre Magyar[11], ELKH-MTM-ELTE Research Group for Paleontology, Budapest, Hungary
Orsolya Sztanó[12], Department of Geology, Eötvös Loránd University, Pázmány Péter sétány 1/C, 1117 Budapest, Hungary
Krisztina Sebe[13], ELKH-MTM-ELTE Research Group for Paleontology, Budapest, Hungary
Bronislava Lalinská-Voleková[14], SNM-Natural History Museum, Bratislava, Slovakia
Anita Grizelj[15], Croatian Geological Survey, Zagreb, Croatia
Barbara Rózsová[16], Department of Mineralogy, Petrology and Economic Geology, Faculty of Natural Sciences, Comenius University Bratislava, Slovakia
Aster Team[17], CEREGE, Aix-Marseille Univ., Aix-en-Provence, France

Abstract

The method of authigenic 10Be/9Be dating, utilizing atmospheric cosmogenic 10Be and stable 9Be generated through rock weathering, holds promise for dating sediment deposition within the range of 0.2–14 Ma. Nonetheless, the disparate origins of these isotopes give rise to variations in initial 10Be/9Be ratios, influencing paleoenvironmental interpretations that have not been thoroughly investigated in previous studies. Our ongoing project is dedicated to empirically determining the variability in initial 10Be/9Be ratios within the depositional record across various sedimentological settings, encompassing Upper Miocene-Quaternary successions in the East Carpathian Foredeep and Pannonian Basin, as well as Holocene parasequences in the Po Plain. This overview outlines our current findings and provides recommendations for the method's application.

The sequence-stratigraphic framework relies on system tracts, which exhibit varying stacking patterns relative to changes in base level. The falling-stage and lowstand system tracts are

associated with decreases in base level and river incision in terrestrial environments, leading to the redeposition of older sediments. This can result in apparently older ages observed in alluvial successions. Changes in river networks during this process can significantly impact the delivery of 9Be due to changes in sediment provenance. As base level rises during the subsequent transgressive system tract, river delta retreat occurs, causing a noticeable decrease in 9Be delivery and variability of its spatial distribution. Furthermore, low rates of sedimentation can lead to post-depositional and diagenetic changes in the 10Be/9Be ratio. Hence, offshore muddy successions typically display considerable variability in initial 10Be/9Be. The highstand system tract is characterized by stable sediment supply under high accommodation rates and rapid burial of strata, thereby mitigating post-depositional processes. The stability of highstand settings results in low variation in initial 10Be/9Be ratios. n deep-water environments characterized by the dominance of turbidity currents, there may be instances of mud redeposition by hybrid event beds. These occurrences have been noted to result in apparently older ages, similar to the effects observed with incising rivers. Consequently, alluvial and deltaic deposits within the highstand system tract are deemed most suitable for dating using authigenic 10Be/9Be.

The study was caried out under the "New Generation Lithuania" plan (postdoctoral project CosmoLith, Nr. 10-036-T-0008) financed under the European Union economic recovery and resilience facility instrument NextGenerationEU, and by the Slovak Research and Development Agency contract No. APVV-20-0120.

Keyword

cosmogenic nuclide, authigenic 10Be/9Be, Neogene, Quaternary, geochronology

Unravelling the chronology of the infill of glacially overdeepened structures in the northern foreland of the European Alps.

Gustav FIRLA[1]*, University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology (gustav.firla@boku.ac.at)
Christopher Luethgens[2], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology
Clemens Schmalfuss[3], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology
Stephanie Neuhuber[4], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology
Markus Fiebig[5], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology

Abstract

The European Alps were influenced by repeated glaciations during the Pleistocene. Outcrops comprising sediments associated with glaciations prior to the last are comparatively rare. Glacially overdeepened valleys and basins are prominent subterranean structures eroded by glacial and/or glaciofluvial erosion below the regional fluvial base. Most of these structures were later filled with sediment sequences. Some of the sequences have resisted subsequent glacial, glaciofluvial and non-glacial erosion and can therefore be used as sedimentary archives of pre last glacial cycles. The multinational pan-alpine research project ICDP - DOVE (International Continental Scientific Drilling Program - Drilling Overdeepened Alpine Valleys) currently investigates overdeepened structures with drill-cores and geophysical surveys on the northern side of the European Alps and uses them to better understand the complex interplay of glacial dynamics, climate fluctuations, and sedimentary processes in the Alpine realm during the Pleistocene. Deciphering this valuable information requires a reliable numerical chronology, which in the ICDP - DOVE project is going to be achieved by implementing a combination of different dating methods, including luminescence dating approaches. Here luminescence dating results from four drill-cores (Ranging from 136 m to 252 m in depth) retrieved from complementary overdeepenings in the northern foreland of the European Alps are presented. All drill-cores showed generally a similar sedimentary succession, with coarser sediments at the top (diamicton and gravel dominated sections) and fine-grained sediments at the base (sand and silt dominated sections). Sampling was focused on the fine-grained basal sections to constrain the infilling onset of the investigated overdeepened structures. Luminescence dating results were obtained with a pIRIR SAR measurement protocol using single grains of potassium rich feldspar as dosimeters. Single grain measurement approaches overcome the challenges associated with luminescence dating of poorly bleached pre-last-glacial cycle sediments. Signal averaging, occurring when using multi-grain measurement techniques can be addressed and the signal population that represents the last depositional event can be differentiated from the poorly bleached population (partially in saturation). The results showed a similar depositional timeframe during the penultimate glaciation

throughout the investigated overdeepened structures. Furthermore, the sedimentation rate was shown to be high as within uncertainty no age difference in the luminescence ages within the fine-grained sections of each drill-core could be detected. Here we present new chronological data that improves our understanding of the timing of glacial activity in the European Alps during the penultimate glaciation and the accompanying landscape evolution. Moreover, this study adds to the broader discussion about the advantages and challenges of single grain luminescence dating methods applied to poorly bleached sediments.

Keyword

Luminescence dating, European Alps, Glacial basins, Penultimate glaciation, Scientific drilling

Inception of the European Ice Sheet revealed by cosmogenic nuclide dating in Lithuania: First results of the CosmoLith project

Michal ŠUJAN[1]*, Laboratory of Quaternary Research, Nature Research Centre, Vilnius, Lithuania & Comenius University Bratislava, Slovakia (michal.sujan@uniba.sk)
Albertas Bitinas[2], Laboratory of Quaternary Research, State Research Institute Nature Research Centre, Vilnius, Lithuania
Régis Braucher[3], CNRS-IRD-Collège de France-INRAE, CEREGE, Aix-Marseille Univ., Aix-en-Provence, France
Andrej Chyba[4], Institute of Chemistry, Slovak Academy of Sciences, Bratislava, Slovakia
Rouxian Pan[5], Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia
Vaida SEIRIENE[6], Laboratory of Quaternary Research, Nature Research Centre, Vilnius, Lithuania
Kishan Aherwar[7], Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia
Barbara Rózsová[8], Department of Geology and Paleontology, Faculty of Natural Sciences, Comenius University in Bratislava, Slovakia
Aster Team[9], CNRS-IRD-Collège de France-INRAE, CEREGE, Aix-Marseille Univ., Aix-en-Provence, France

Abstract

Comprehending the intricate interplay among the atmosphere, hydrosphere, and cryosphere hinges on a thorough understanding of past ice sheet dynamics, a pivotal aspect for precise climate modeling. Yet, the absence of precise chronologies regarding the inception of the European Ice Sheet Complex (EISC) in the Baltic region undermines the reliability of existing models. To tackle this issue, the 'CosmoLith' project endeavors to furnish conclusive evidence by dating sedimentary deposits linked to the ice sheet's emergence. While such sediments are scarce in northern Europe, they are remarkably well-preserved in the southeastern reaches of Lithuania within the Baltic Highlands.

The primary sampling endeavor prioritized horizons both preceding and succeeding the lowest and oldest moraine conserved in the stratigraphic archives. The most recent pre-glacial sequence comprises alteration of sandy channel fills and of proximal floodplain deposits including muddy intercalations. The Vetygala exposure along the Šventoji River valley was meticulously sampled for clay specimens intended for authigenic 10Be/9Be dating, alongside sand specimens earmarked for combined exposure-burial dating utilizing in situ 10Be and 26Al. Furthermore, a series of samples was extracted from borehole cores housed within the repository of the Lithuanian Geological Survey. These samples encompassed the youngest alluvial mud underlying the oldest moraine, as well as alluvial and lacustrine mud overlaying the earliest preserved moraine, procured specifically for authigenic 10Be/9Be dating. The latter stratum also provided sandy and gravelly samples for the purpose of simple 26Al/10Be burial dating. Initial determination of the authigenic 10Be/9Be ratio will be derived from contemporary floodplain muds sourced from the Šventoji River and from deltaic muds sourced from the Holocene Nemunas River delta. All

samples are meticulously prepared for analysis on AMS ASTER (CEREGE, France), with the preliminary dating outcomes awaiting revelation at the time of this abstract's compilation.
The study caried out under the "New Generation Lithuania" plan (postdoctoral project CosmoLith, Nr. 10-036-T-0008) financed under the European Union economic recovery and resilience facility instrument NextGenerationEU.

Keyword

cosmogenic nuclide, first glaciation, Pleistocene, Baltic region, authigenic 10Be/9Be

‘Nicola’ bed deposition at the onset of the Quaternary ~2.58 Ma, Monte San Nicola, southern Sicily – geological background

Wieslawa RADMACHER[1]*, Polsih Academy of Sciences (violakrol@gmail.com)
Martin J. Head[2], Brock University
Antonio Caruso[3], Università di Palermo

Abstract

The base of Quaternary System, Pleistocene Series, Lower Pleistocene Subseries, and Gelasian Stage (~2.58 Ma) is defined by the Global boundary Stratotype Section and Point (GSSP) at Monte San Nicola (MSN), near Gela, Sicily, Italy. In spite of the utilization of the Gelasian Stage GSSP, initially ratified in 1996, to define the base of the Quaternary (and redefine the Pleistocene) in 2009, little new research was undertaken on the type section following its initial ratification until recently. The boundary coincides with the end of deposition of the ~20 cm sapropelic, laminated ‘Nicola’ bed which is widely exposed in the ‘badlands’ of the MSN. Detailed study of this unique layer based on trace fossil analysis and X-ray computed tomography shows that it was deposited in anoxic to disoxic bottom-water conditions, with a progressive increase in oxygenation towards the top (Radmacher et al., 2023, Marine and Petroleum Geology 158: 106552). The Nicola bed has been assigned to Mediterranean Precession Related Cycle (MPRC) 250. Sedimentation rates for the Pliocene–Pleistocene transition at MSN based on astrochronology are reported to be ~6.1 cm/kyr, although higher rates of ~11.7 cm/kyr characterise the Punta Piccola section located ~80 km to the SW and represent shallower conditions within the same basin. The Punta Piccola section also contains a distinctive laminated bed assignable to MPRC 250. The more recent Mediterranean sapropel S5 deposited during the Last Interglacial has laminations that reflect seasonal variability and can therefore be used to establish precise sedimentation rates. Our microscopic analyses of the Nicola bed at MSN suggest that the relatively undisturbed lamination occurring within the lowest 15.6 cm represents annual deposition. We aim to determine sedimentation rates through much of the Nicola bed, and hence estimate the duration of anoxic bottom-water conditions at MSN just before the beginning of the Quaternary. Sapropel formation in the Mediterranean has been connected to increased seasonal contrast and higher summer temperatures due to precession cycle maxima (insolation maxima) that forced a more northerly African rain belt. This would have elevated river inflow during times of summer monsoon, increasing surface water buoyancy during autumn/winter cooling, and interrupting bottom-water ventilation. We address this issue by studying the marine dinoflagellate cysts as they are sensitive to environmental changes near the sea-surface. In general, sapropelic layers are enriched in smectite, illite and chlorite transported by rivers, with decreased abundance of palygorskite, kaolinite, dolomite, quartz and feldspar that are rather transported by winds from Africa. Intercalated marls in contrast yield opposite trends, corresponding to the interplay between fluvial and eolian input into the Mediterranean basin. We therefore use clay mineralogy to refine our understanding of Nicola bed deposition at the beginning of the Quaternary within the broader

context of Northern Hemisphere glaciation. This ongoing research is part of GELSTRAT, an international collaborative program to further our understanding of the Neogene/Quaternary boundary at the type locality and enhance its recognition on a global scale.

Keyword

'Nicola' bed, Gelasian Stage, sedimentation rate, GELSTRAT project

[Keynote] Paleoenvironmental changes across the Neogene–Quaternary boundary at the Monte San Nicola GSSP, near Gela, Sicily – an update of the international program GELSTRAT

Martin J. James Head[1]*, Brock University (mjhead@brocku.ca)
Marina Addante[2], Università di Bari Aldo Moro, Italy
Adele Bertini[3], Università di Firenze, Italy
Angela Girone[4], Università di Bari Aldo Moro, Italy
Timothy D Herbert[5], Brown University, Providence, RI, USA
Patrizia Maiorano[6], Università di Bari Aldo Moro, Italy
Maria Marino[7], Università di Bari Aldo Moro, Italy
Gabriele Niccolini[8], Università di Firenze, Italy
Wiesława Radmacher[9], Polish Academy of Sciences, Kraków
Andrew Roberts[10], Australian National University, Australia
Giovanna Scopelliti[11], Università di Palermo, Italy
Houssem Tabbabi[12], Università di Firenze, Italy
Alfred Uchman[13], Jagiellonian University, Poland
Antonio Caruso[14], Università di Palermo, Italy

Abstract

The Global boundary Stratotype Section and Point (GSSP) at Monte San Nicola, near Gela, Sicily, Italy, was proposed in 1996 to define the base of the Gelasian Stage, then the uppermost stage of the Pliocene Series, in recognition of the intensification of Northern Hemisphere glaciation. This GSSP became more important upon its approval in 2009 to define also the base of the Quaternary System and redefine the base of the Pleistocene Series. It is placed at the base of the marly layer immediately overlying the prominent, laminated, reddish, sapropelic Nicola bed, and has an astronomically tuned age of 2.58 Ma. The Nicola bed is assigned to Mediterranean Precession-Related Cycle 250 and aligns with an obliquity maximum representing Marine Isotope Stage 103, which, together with the Gauss–Matuyama paleomagnetic reversal, facilitates global correlation. Fine details of the stratigraphy nonetheless remain uncertain, including the precise position of the reversal relative to the GSSP at the type section. GELSTRAT is an international collaborative program inaugurated in September 2021 during an INQUA-SQS International Field Workshop focused on the reinvestigation and reanalysis of the Gelasian GSSP using modern methods and a broad range of proxies. Sampling across the boundary interval at the type section in September 2021 was supplemented by further fieldwork in April–May 2022 and resulted in the collection of 404 samples across a ~18 m stratigraphic interval spanning the GSSP and ranging from the top of bed A1 to ~10 m above the top of the Nicola bed (A5). Samples were collected at ~5 cm intervals. Approaches planned or in progress include: calcareous nannofossils, foraminifers, pollen, dinoflagellate cysts, macrofossils, ichnofossils, foraminiferal stable isotopes, organic geochemistry, clay mineralogy, magnetostratigraphy, and 10Be analysis. The first high-resolution planktonic oxygen and carbon isotope record has been obtained from the Gelasian type section, together with detailed marine and terrestrial biotic climate oscillations across the boundary. Our

dataset unravels the excellent climate signals recorded through the section and gives additional information on placement of the Gelasian GSSP within MIS 103 (e.g. Addante et al., 2024, Palaeogeog., Palaeoclim., Palaeoecol. 634, 111907). The Nicola bed is undergoing analysis at ultrafine stratigraphic detail employing many of the above approaches but also microstratigraphy, X-ray tomography, micro-XRF elemental analysis (ITRAX), micro-RAMAN spectroscopy, Fourier transform infrared spectroscopy (FTIR), and X-ray diffraction (XRD). Initial results show the rapid onset of anoxia at the base of the Nicola bed, followed by progressive dysoxia. The top of the Nicola bed is bioturbated over an interval of several centimeters. The overlying marl evidences a return to higher bottom water oxygen levels, although there appears to be a brief return to poor oxygenation (Radmacher et al., 2023, Mar. Petrol. Geol. 158, 106552). Refined characterization of the Gelasian GSSP will enhance its utility for precise recognition of the base of the Quaternary on a global scale, and our integrated paleoclimate reconstructions will illuminate a crucial phase of Earth history.

Keyword

GSSP, Gelasian, Plio-Pleistocene boundary, Quaternary

Vegetation dynamics and climate changes during the Onset of Northern Hemisphere Glaciation: Insights from the Monte San Nicola Section (central Mediterranean)

Adele BERTINI[1]*, Dipartimento di Scienze della Terra - Università degli Studi di Firenze (adele.bertini@unifi.it)
Gabriele Niccolini[2], Dipartimento di Scienze della Terra - Università degli Studi di Firenze
Houssem Tabbabi[3], Dipartimento di Scienze della Terra - Università degli Studi di Firenze

Abstract

The emergence of large ice caps in the Northern Hemisphere around 2.6 million years ago contributed to a significant shift in Earth's climate from a Cool- to an Icehouse climate state. Long-term changes in the Atlantic Meridional Overturning Circulation and the closure of the Central American Seaway have been proposed as primary factors driving this climate shift, clearly evident from Marine Isotopic Stage (MIS) 100 onwards along with the deposition of ice-rafted detritus in the North Atlantic. However, the specific mechanisms and regional responses to this transition in the Mediterranean area, particularly within the terrestrial ecosystems, remain subjects of debate. As part of the international GELSTRAT program, this research aims to investigate the flora composition, vegetation structure and the paleoclimatic changes in the central Mediterranean, at the Piacenzian-Gelasian transition as documented at Monte San Nicola (Sicily), GSSP section for the Gelasian Stage. 170 samples, collected across an 18-meter thick interval, encompassing the group of six precession-related darker beds A1, A2, A3, A4, A4/5 and A5 (Nicola bed), underwent chemical-physical processing at the Palynological Laboratory of the University of Firenze. Low to very low pollen concentrations characterized numerous samples particularly those from the base up to the top of A4 while samples from A4 are marked by higher concentrations. The high-resolution pollen analysis reveals distinct behavior of flora and vegetation according to a complex pattern of climate fluctuations on both Milankovitch and sub-Milankovitch timescales. Subtropical humid forest taxa are generally scarce, except for *Cathaya*. In contrast, deciduous temperate forest species, particularly deciduous *Quercus*, as well as altitudinal coniferous forest taxa such as *Picea* and *Abies*, along with open herbaceous vegetation, are abundant. They show distinct and significant expansions, indicating changes in temperature and humidity during successive glacial/interglacial phases. Above A5, there is a notable increasing trend in open vegetation and steppe taxa, exemplified by Amaranthaceae, *Artemisia*, and *Ephedra*, suggesting a significant expansion of dry conditions after 2.58 Ma. Conversely, just before this period, the increase in montane coniferous taxa, notably *Picea*, as observed in sapropel A4/5 (MIS 104), highlighted quite humid (and cold) phases. Comparing with other pollen records including those from Mediterranean sites along E-W and N-S transects contributes to a more comprehensive understanding of the Gelasian GSSP, enhancing its global correlation utility and facilitating accurate detection of the base of the Quaternary on a global scale.

Keyword

Lower Pleistocene GSSP, pollen, flora, vegetation, climate

Some problems of Pliocene – Pleistocene sediment studying at the East Siberian Sea according pollen data

Ekaterina NOSEVICH[1]*, Individual researcher (katenosevich@mail.ru)

Abstract

East Siberian Sea remains one of the most poorly studied area of Russian Arctic. New data on the geological sequence and genesis of Quaternary deposits were obtained during marine geological expeditions of carried out in 2018 and 2020. Six sediment cores were taken around New Siberian Islands archipelago. They were studied with grain-size, geochemical, diatom, palynological, and microfossil analyses and radiocarbon dating. The results of this research couldn't be properly interpreted due to controversy which was observed in the obtained data. Clay deposits of the underwater slopes of the New Siberia Island were dated 12040 – 12108 cal. BP (IGANams 8977), but their pollen spectra contained *Tsuga*, *Juglans*, *Corylus* and *Pterocarya* pollen, which are not characteristic of Upper Pleistocene deposits. Moreover, these spectra differed from each other and couldn't be correlated all together. These problems were previously described in the region (Biske, 1979; Trufanov et al., 1981), and pollen spectra could be attributed both Middle Pleistocene and Upper Pliocene or stay uncharacterized without any system.

In 2021 in frame of the deepwater drilling project, the new sediment sequence were taken. It comprise 40 m of Quaternary deposits and more than 100 m of Pre-Quaternary geological sequence. At the interval 69,5 – 98,0 m of the sequence sandy clay deposits were taken. They are also studied with grain-size, geochemical, isotope, mineralogical, diatom, palynological, and microfossil analyses. It was supposed that they belong to Eocene – Pliocene deposits according to their lithology and the depth of sampling. Their pollen spectra shows, that these sediments contain Quaternary pollen complex without species, specific to Pliocene. Results of our investigation of these sediments correlates with the previous research of the sedimentary sequence of East Siberian sea coastal margins and shelf (Gitterman, 1967; Bezrodnykh, 1981). This may prove the suggestion that in the deep cores Gelasian stage deposits may be found. At the covering Quaternary sedimentary sequence clay, silt and sand deposits were found. Our research is correlating with the investigations of Quaternary deposits of New Siberian Islands (Anisimov, 2002).

That allows us an assessment of Gelasian stage deposits mapping at the territory for the first time. Thus, it is now possible to describe main characteristics of Gelasian and Middle Pleistocene deposits of the territory and provide detailed description to distinguish them and to establish new characteristics for the local stratigraphy chart.

Keyword

Arctic, pollen analysis, marine deposits, Gelasian stage, stratigraphy

Hydrographic development of the northern South China Sea during the Pliocene–Pleistocene transition: The dinoflagellate cyst record of ODP Site 1148 – Preliminary results

Saif AL-SILWADI[1], University of Toronto
Martin J Head[2]*, Brock University, University of Toronto (mjhead@brocku.ca)

Abstract

The intensification of Northern Hemisphere glaciation that marks the Pliocene–Pleistocene transition is one of the most important climatic shifts in Earth's history. As a result of this shift, present day Quaternary climate patterns emerged and are characterised by high amplitude glacial–interglacial oscillations and climate cycle asymmetry. Although many mechanisms have been proposed for the intensification, including the onset of ocean stratification in the Northern Pacific at ~2.7 Ma and the closure of the Isthmus of Panama, the role and response of the Pacific Ocean remains poorly understood. The South China Sea is the largest marginal sea in the Western Pacific, and has frequently been used as a site for paleoclimatic reconstruction. This is due to its: high sedimentation rates that allow for fine-resolution reconstructions; semi-enclosed configuration that amplifies the impact of climatic changes; and geographic positioning that allows for influence from the evolving Tibetan Plateau, the Western Pacific Warm Pool and the East Asian Summer and Winter Monsoon systems. This makes it ideal for understanding the response of the Western Pacific across this interval of significant climatic transition. Dinoflagellate cysts, acritarchs and other palynomorphs are here used to assess the hydrographic evolution of Ocean Drilling Program (ODP) Site 1148, northern South China Sea, during the Pliocene–Pleistocene transition. This analysis covers approximately 111 samples from 2.85 Ma to 2.41 Ma with an average spacing of ~4 kyr, permiting a highly resolved paleoenvironmental reconstruction. An age model was developed using the oxygen isotope stratigraphy of Jian et al. (2003) that was tuned to the LR04 stack of Lisiecki & Raymo (2005). Preliminary results show over 50 marine palynomorph taxa, with fair to good preservation. Warm water dinoflagellate species (such as Polysphaeridium zoharyii) appear frequently throughout the section, along with Spiniferites bentorii and several Impagidinium species. This indicates a temperate to warm water, open ocean environment with a significant neritic component, and low temperature variation for most of the study interval. Fluctuations in the assemblages may be related to variations in salinity and nutrient levels. Salinity is also reflected in changes in the morphology of selected species, such as reduced process lengths of P. zoharyii and the cyst of Protoceratium reticulatum. Notable dinoflagellate cyst species include Atlanticodinium janduchenei, A. striaticonulum, Dapsilidinium pastielsii, Edwardsiella sexispinosa, Invertocysta tabulata, Operculodinium bahamense, and O. longispinigerum; and the acritarchs Cymatiosphaera? aegirii, C.? invaginata, C.? icenorum, C.? fensomei, and Nannobarbophora walldalei. Results from ODP 1148 will also be compared to dinoflagellate cyst analysis from International Ocean Drilling Project Site U1424 in the Sea of Japan and other sites in the North Pacific. This will facilitate a more detailed view of

paleoceanographic changes in the Pacific Ocean across the Pliocene–Pleistocene transition.

Keyword

Northern hemisphere glaciation, dinoflagellate cyst analysis, Pliocene-pleistocene

Climate variability and biotratigraphic constraints at the Neogene–Quaternary boundary at the Monte San Nicola type-section, Sicily

Marina Addante[1], Dipartimento di Scienze della Terra e Geoambientali - Università di Bari Aldo Moro
Adele BERTINI[2]*, Dipartimento di Scienze della Terra - Università degli Studi di Firenze (adele.bertini@unifi.it)
Angela Girone[3], Dipartimento di Scienze della Terra e Geoambientali - Università di Bari Aldo Moro
Patrizia Maiorano[4], Dipartimento di Scienze della Terra e Geoambientali - Università di Bari Aldo Moro
Maria Marino[5], Dipartimento di Scienze della Terra e Geoambientali - Università di Bari Aldo Moro
Gabriele Niccolini[6], Dipartimento di Scienze della Terra - Università degli Studi di Firenze
Giovanna Scopelliti[7], Dipartimento di Scienze della Terra e del Mare - Università di Palermo
Houssem Tabbabi[8], Dipartimento di Scienze della Terra - Università degli Studi di Firenze
Antonio Caruso[9], Dipartimento di Scienze e Tecnologie Biologiche, Chimiche e Farmaceutiche - Università di Palermo

Abstract

The Global boundary Stratotype Section and Point (GSSP) for the Gelasian Stage currently defines the beginning of the Quaternary System and of the Pleistocene Series. It falls within a critical climate transition, including the progressive intensification of the North Hemisphere Glaciation (iNHG). As part of the GELSTRAT project, we provide an updating on planktonic foraminiferal δ18O record and calcareous plankton assemblage in the Monte San Nicola type-section (MSNt-s), to unravel the climate-induced surface water changes and improve precision of bioevents across the GSSP. Improving the data set on such a relevant section we intend to strengthen the correlation potential of the MSNt-s and of the GSSP itself outside the type-area. Following the recent climate reconstruction obtained on the type-section across Marine Isotope Stage (MIS) G4-103 , we now focus on the interval encompassing MIS 104 and MIS 100, not yet studied in type-section with a high-resolution detail. Our results are based on high-resolution sampling (5 cm), which allows a sub-millennial scale resolution (~800 years). The acquired dataset gives clear documentation of both orbitally forced glacial-interglacial phases and suborbital cyclicity, as well as precise position of calcareous nannofossil biostratigraphic constraints close to the GSSP. We also provide a first correlation between marine proxies and terrestrial signals across the interval, to describe mode and time of iNHG as recorded in the Gelasian type-section. The correlation with coeval Mediterranean and Atlantic records informs on the overall excellent climatostratigraphic signals recorded in the type-section.

Keyword

Lower Pleistocene GSSP, stable oxygen isotope, calcareous plankton, pollen, paleoclimate and

biostratigraphy

Palynological implications for paleoenvironmental changes in the continental shelf, southeastern Korea, during the Plio-Pleistocene climate transition

Yongmi KIM[1]*, Korea Institute of Geoscience and Mineral Resources (kym1221@kigam.re.kr)
Sangheon Yi[2], Korea Institute of Geoscience and Mineral Resources
Dong-Geun Yoo[3], Korea Institute of Geoscience and Mineral Resources
Seok-Hwi Hong[4], Korea Institute of Geoscience and Mineral Resources
Gwang-Soo Lee[5], Korea Institute of Geoscience and Mineral Resources

Abstract

A palynofacies analysis was conducted using the core 19ESDP-104, obtained from the southeastern continental shelf of the Korean Peninsula, to reconstruct paleoenvironmental changes and estimated ages. The 19ESDP-104 core is mainly composed of silty clay, clayey silt, and sand, the present study focuses on the bottom 30 m of this core. Two palynomorph zones are established with a boundary 87 m depth based on pollen and dinoflagellate assemblages changes; P-I (87-100 m) and P-II (70-87 m). In the P-I zone, Quercus subgen. Cyclobalanopsis, Pinus-Diploxylon, relatively warm climate taxa, were abundant with a high proportion of amorphous organic matter (AOM). In addition, Polysphaeridium zoharyi, the warm water species, and the oceanic dinoflagellate species as Impagidinium spp. were observed in this zone. This result suggest relatively high sea level environment that was influenced by a relatively warm climate and warm water mass. On the other hands, in the P-II zone, Abies, Picea, and Pinus-Haploxylon, cold-dry conifer pollen assemblages were abundant. In addition, the prevalence of the xerophytic herb, Artemisia, Poaceae, Cyperaceae increases, and plant fragments smaller than 80 um is also observed in this zone. These results implying a colder climate and the discharging of large amounts of woody debris and herb pollen from the nearby exposed continental shelves by sea level decline. The last occurrence of pollen taxa from the Korean Peninsula and Japanese Archipelago in the Late Pliocene presented at 85 mbsf (top boundary of P-V zone). However, Impagidinium japonicum, extinct species at same era, is last occurred at 92 mbsf. The last occurrence depths of pollen and dinoflagellate age indicators are different. However, given the changes of lithofacies and palynofacies, our findings suggest that 85 mbsf (top boundary of P-V zone) is the Pliocene-Pleistocene boundary in core 19ESDP-104.

Keyword

Pliocene–Pleistocene boundary, Palynology, Paleoclimate, Paleoceanography, East Sea

Continuous measurements in north China and culture experiments reveal the potential of leaf n-alkane carbon isotopes in paleoclimate studies

Guoan WANG[1]*, China Agricultural University (gawang@cau.edu.cn)
Minrui Shi[2], China Agricultural University

Abstract

Interpreting the climate information recorded by leaf n-alkane carbon isotopes (δ13Calk) in geological sediments facilitates climate prediction. However, this interpretation relies on the calibration of modern plant δ13Calk responses to climate change. Here, we present the first continuous calibration at the same place next to a meteorological station, which excludes errors in the commonly used spatial calibrations along environmental gradients, resulting in robust calibrations. δ13Calk was negatively related to precipitation but not temperature. 13C29 was most related to precipitation, followed by δ13C27-33 (i.e., the mean δ13C from n-C27 to n-C33), δ13C27, δ13C31, and δ13C33. If δ13Calk was only corrected for changes in δ13C of atmospheric CO2 (δ13Catm), the coefficients of δ13Calk vs. annual precipitation were -0.0048‰/mm, -0.0035‰/mm, and -0.0033‰/mm for δ13C27, δ13C29, and δ13C27–33, respectively. If correcting for changes in both δ13Catm and atmospheric CO2 concentration to δ13Calk, the coefficients of δ13Calk vs. annual precipitation were -0.0038‰/mm, -0.0025‰/mm, and -0.0023‰/mm for δ13C27, δ13C29, and δ13C27–33, respectively. Furthermore, we provided evidence for this relationship using a greenhouse study wherein water availability explained 97% of δ13Calk variance. Therefore, δ13Calk is a good indicator of precipitation, especially δ13C29. Finally, we conducted a reconstruction of pCO2 levels during the late Paleocene (pCO2(initial)) and the height of the carbon isotope excursion (CIE) (pCO2(excursion)) at the Paleocene-Eocene Thermal Maximum (PETM) by coupling the coefficients with other geological indicators. In the scenario where methane hydrates might have been the primary carbon source responsible for PETM warming, the estimated pCO2(initial) and pCO2(excursion) were 201−275 ppm and 911−985 ppm, respectively; whereas, in the scenario where volcanic CO2 emissions were the primary carbon source, they were 398−505 ppm and 1708−1815 ppm, respectively.

Keyword

leaf n-alkane carbon isotopes, long-term investigation, coefficient of d13Calk vs. precipitation, paleoprecipitation reconstruction, reconstruction of pCO2 at PETM

Fire history of the Chinese Loess Plateau under extreme warming scenarios: a case study of the loess-paleosol sequence L5-S5

lian LIU[1]*, Chinese Academy of Geological Sciences (liulianen@163.com)
bin shuai yang[2], Institute of Geomechanics, Chinese Academy of Geological Sciences

Abstract

This study analyzed the carbon concentration and carbon isotope composition of black carbon within the loess-paleosol sequence of the Chinese Loess Plateau, in order to study the history of natural fires under warming scenarios and to evaluate the possible incidence of fires in the future. Notably, the interglacials in this East Asian monsoon region were abnormally warm. The results from the interval of L5-S5 of the studied Xifeng section suggest that the principal factors controlling natural fires in an interglacial period (S5) and a glacial period (L5) were fuel load and fuel moisture level, respectively. The difference between the carbon isotope composition of black carbon and soil organic carbon during S5LL1 (marine oxygen isotope stage (MIS) 14) was due to the fact that the former records the more positive carbon isotope values of C3 plants caused by drought and low temperatures in the fire season, while the latter records the carbon isotope of plants throughout the year. The optimum temperature and humidity conditions during S5SS1 (MIS 13) were the most conducive to fires during the interglacial period of S5. However, when the temperature and humidity decreased to a specific range (mean annual temperature 2-12ºC, mean annual precipitation 200-700 mm) during the glacial period of L5, the fire occurrence reached its highest level.

Keyword

Glacial-interglacial cycle, paleoclimate, paleovegetation, factors controlling fires

Carbon cycle and carbon isotope fractionation during the snail assimilation process

xuefen SHENG[1]*, Nanjing University (shenxuer@nju.edu.cn)
Haolin TAN[2], Nanjing University

Abstract

Reconstruction of paleoclimate across different time scales is a hot topic in global change research. From long-term cyclical changes (such as glacial-interglacial periods, the Younger Dryas, Heinrich events, and the Little Ice Age) to short-term ones like seasonal variations and extreme weather events, paleoclimate studies across various time scales provide a research foundation for understanding the patterns and dynamics of global monsoon change. It also offers theoretical basis for climate models and future climate changes forecasting. Most existed climate proxies can only provide information for specific time scale, making it difficult to directly compare reconstructions at different temporal resolutions. Therefore, finding the proxies providing climate information across multiple time scales is important. Numerous studies have shown the potential of snail shells for reconstructing ancient vegetation and hydrology across different time scales. The δ13C and δ18O in snail shells can indicate changes in vegetation composition (precipitation) and precipitation δ18O over longer (climate) and seasonal (weather) time scales. However, the accuracy of interpretations regarding the climatic significance of shell δ13C and δ18O remains controversial. Therefore, this study conducts a systematic δ13C analysis of snail shells, soft bodies, and the organs through laboratory culturing experiments. The carbon isotope fractionation during snails' food intake, assimilation, and metabolic excretion processes is investigated. The results show a significant positive correlation between the δ13C in snail excrement and the δ13C in food organic matter. The δ13C in excrement fed with C3 plants is heavier relative to that of the food, while it is lighter when fed with C4 plants. This suggests that selective assimilation or/and different biochemical mechanisms when snail intakes plants of different photosynthetic types (C3 and C4plants). Snail mainly ingests organic matter from mixed feed, which is leading to an increase in carbonate content in excrement, which means the contribution of carbonate from food to shell δ13C cannot be directly calculated based on the ratio in food. The δ13C of different snail organs is significantly correlated with the δ13C of food and carbonate content. Organic and inorganic carbons from food affect the δ13C values of organs through different pathways, while organic carbon is mainly absorbed through digestion, while inorganic carbon is due to internal arginine synthesis after being converted to CO2 and entering the bicarbonate pool through acidification. There are significant δ13C differences between different organs, with the hepatopancreas is about 2% lighter than that of the kidneys, and the δ13C in foot is closed to that of the mantle. These results indicate that different organs and tissues in snails have varying turnover rates during metabolism, and the δ13C of different organ is related to its turnover rate, leading to isotopic fractionation difference during cell differentiation.

Combining with previous studies, this study further proposes the new mechanism for carbon cycle and isotope fractionation processes in snails.

This work was funded by the National Natural Science Foundation of China42373062.

Keyword

snail shell, isotope fractionation, paleoclimatic reconstruction, global change, snail assimilation process

Late Pleistocene and Holocene Landscape Evolution in the White River Badlands, Great Plains, USA

patrick albert burkhart[1]*, Slippery Rock University of PA (patrick.burkhart@sru.edu)

Abstract

The landscape of the White River Badlands (WRB), Great Plains, USA reveals geomorphic forcing upon pediments and dune fields at several intervals of time during the Late Pleistocene and Holocene. Radiocarbon dating of humic fractions of paleosols buried in pediments show that a regional incision of streams has dissected the pediments into sod tables within the recent two millennia. Two climatic events, the Medieval Climate Anomaly and the Little Ice Age are each a candidate for triggering stream incision and dissection of the fans capping the pediments. While numerous climate proxies indicate that the interior of North America endured megadroughts during these climatic events, the WRB themselves contain few proxy records. Recognizing this geomorphic impact propelled further inquiry into the response of dune fields within the WRB. These dunes are important paleoclimatic indicators in an area of the Great Plains with few climate proxies. Detailed topographical mapping with drones has guided morphological study of the dunes, coupled to the use of Optically Stimulated Luminescence to identify intervals of aeolian activity. The results show three periods of dune activity: (1) ~ 21,000 to 12,000 years ago, (2) ~9 to 6 ka, and (3) post 700 a. This latest event appears synchronous with the fluvial incision that characterizes the formation of sod tables from dissected pediments across the region. Results suggest significant landscape resilience to wind erosion, which resulted in preservation of a mosaic of Early and Late Holocene parabolic dunes. In contrast, ongoing fluvial incision of the prairie exhibits rapid erosion – aggressive incision of channels coupled to lateral retreat of slopes eroding into poorly indurated silts.

Keyword

Badlands, Pediment, Dune, sod table, Holocene

Integrated multi-geochemical analysis for reliable 14C age of artificial carbonates

Zhanpeng Chen[1]*, Nanjing University (502022290025@smail.nju.edu.cn)
Xufen Sheng[2], Nanjing University
Junfeng Ji[3], Nanjing University

Abstract

Artificial carbonates (AC) are a type of non-natural carbonate commonly found in archaeological sites, originating from the alteration of natural materials through human production and living activities. The formation process of these carbonates is controlled by the environmental conditions, with atmospheric CO2 being directly absorbed by calcium hydroxide. Therefore, these carbonates may record environmental information and have a significant potential in offering an insight into the climate shifts during ancient civilizations. Establishing an accurate age framework of AC is crucial for paleoclimate research. However, the 14C dating results of AC often present significant uncertainties due to factors such as the old carbon effect, differences in carbonation process, and secondary effects. This study carefully analyzed the mineral constituents, trace element ratios, stable isotopic compositions, and mineral morphology of AC collected from the archaeological city-walls of the Song and Ming-Qing dynasties, and further discussed their potential for 14C dating.

Based on multi-proxy geochemical analysis, we developed a sample selection method for 14C dating of AC. Initially, through the selective leaching with dilute acid and trace element ratios, there is a significant positive correlation between ln(Sr/Ca) and ln(Mg/Ca) in AC, which is following the Rayleigh fractionation model. This indicates continuous formation of carbonates from initial paleo-solution, exhibiting authigenic secondary characteristics. Authigenic secondary carbonates usually contain small amounts of Mg and Mn, with the associated Mg and Mn mainly derived from primary carbonates, i.e., geogenic carbonates that have not been combusted sufficiently, which can lead to the dating results being erroneously older. However, under extreme Rayleigh fractionation and secondary calcite precipitation conditions, the Mg/Ca ratio in soil solutions may increase, leading to lower Mn/Ca in AC and a negative correlation between Mn/Ca and Mg/Ca. Secondly, by selecting samples predominantly consisting of authigenic secondary carbonates and utilizing stable isotope analysis, we found that only the targeted collection of AC exhibited a general positive correlation between δ18Ocalcite and δ13Ccalcite, showing a relationship of δ18Ocalcite = 0.59δ13Ccalcite - 1.18(VPDB) and consistent with kinetic fractionation. Controlling factors such as diagenesis and the mixing of primary calcite could cause remarkable deviations in isotopic compositions. Eventually, to evaluate the impact of varying degrees of isotopic deviation on chronology analysis, we selected samples located at different positions along the kinetic fractionation line for AMS 14C dating. Results show that AC close to the kinetic fractionation line or contain extremely negative δ18Ocalcite and δ13Ccalcite typically have lower Sr/Ca and Mg/Ca, with minimal interference from primary carbonates. The 14C

chronology results largely match our expectations. Thus, selecting AC based on geochemical data can improve the accuracy of 14C dating, having broad prospects for application and promotion.
This work was funded by the National Natural Science Foundation of China (42373062)

Keyword

artificial carbonates, 14C dating, multi-proxy geochemical analysis

A newly revised record of relative sea-level changes in western Philippines, Southeast Asia during the past 125 ka deduced from uplifted coral reef terraces

Kathrine MAXWELL[1]*, University of Bremen (katt.maxwell@gmail.com)
Hildegard Westphal[2], Leibniz Centre for Tropical Marine Research (ZMT), Bremen, Germany; University of Bremen, Department of Geosciences, Bremen, Germany
Alessio Rovere[3], Department of Environmental Sciences, Informatics and Statistics - Università Ca' Foscari, Venice, Italy
Kevin Garas[4], Department of Environment and Natural Resources–Mines and Geosciences Bureau (DENR-MGB), Quezon City, Philippines
Mirasol Guinto[5], Institute of Renewable Natural Resources, College of Forestry and Natural Resources, University of the Philippines, Los Baños, Laguna, Philippines
Denovan Chauveau[6], Department of Environmental Sciences, Informatics and Statistics - Università Ca' Foscari, Venice, Italy
Hsun-Ming Hu[7], High-Precision Mass Spectrometry and Environment Change Laboratory (HISPEC), Department of Geosciences, National Taiwan University, Taipei, 10617, Taiwan; Research Center for Future Earth, National Taiwan University, Taipei, 10617, Taiwan
Chuan-Chou Shen[8], High-Precision Mass Spectrometry and Environment Change Laboratory (HISPEC), Department of Geosciences, National Taiwan University, Taipei, 10617, Taiwan; Research Center for Future Earth, National Taiwan University, Taipei, 10617, Taiwan

Abstract

Coral reef terraces (CRTs), normally observed along coastal areas and are formed through repeated bioconstructional and erosional processes, are useful indicators of relative sea-level changes in the past. Often considered as a process analog for predicted future changes for a warmer world is the Last Interglacial (LIG, also Marine Isotope Stage 5e) and the analysis of sea-level indicators during this period can give us important insights about potential drivers of local, regional, and global sea-level changes in the past. We previously produced a standardized database of LIG sea-level indicators in Southeast Asia. Following this work, we revisited Cape Bolinao, a site in western Philippines where inferred Late Pleistocene CRTs were previously reported. We present a newly revised record of relative sea-level changes for the region based on detailed analysis of digital elevation models (DEMs) and satellite images, high-resolution topographic surveys, stratigraphic and geochronologic analyses, and reef modeling. We identified distinct levels of CRTs (Terrace I to Terrace IX) which may correspond to different Marine Isotope Stages with the highest terrace, TIX, (at 143 ± 12 m amsl) inferred to be MIS 5e. Terrace IX is characterized by the presence of diagenetically altered corals (e.g., Porites, Platygyra) within a skeletal packstone matrix. We designated the lowest elevation terrace, TI, (at 3-4 m amsl) to be mid-Holocene based on C14 ages (~5.8-5.4 ka cal BP) and Th230 ages (~6.4-5.7 ka BP) of in situ corals. Two Tridacna spp. shells collected at 3-8 m amsl elevation yielded C14 ages of ~44 ka cal BP, which may correspond to MIS 3. We were not able to find pristine fossil coral samples at elevations of 5 to 160 m amsl as most are already diagenetically altered. We also conducted reef modelling to simulate the formation of the different levels of terraces with respect to chosen global sea-level curves. We found that with a constant uplift rate of 1.17 mm/yr, we will be able to

produce the staircase morphology we observe today with the highest terrace being formed during MIS 5e. We also observed that multiple terraces can be formed during one Marine Isotope Stage. Interestingly, using the sea level curve of Waelbroeck and others (2002), we were able to observe an MIS 3 terrace at 20-30 m amsl (which coincides to Terrace IV). Based on this work, we have provided evidence of mid-Holocene and older than Holocene terraces in the region and with our reef model, we were able to simulate the formation of these terraces during the different Marine Isotope Stages. While the analysis of CRTs is important in understanding relative sea-level changes in a region, the difficulty of finding dateable materials makes our work more challenging. Despite this, we hope that our data will be useful in further understanding the different drivers of past sea-level changes in SE Asia providing necessary geologic baseline data for projections of sea-level change in the future.

Keyword

coral reef terraces, Last Interglacial, sea-level change, MIS 5e, Philippines

Hydroclimate changes during the Meghalayan Stage and its global teleconnection from Southern India

Upasana Swaroop BANERJI[1]*, Ministry of Earth Sciences (upasana.s.banerji@gmail.com)
Maya K[2], National Centre for Earth Sciences
D. Padmalal[3], National Centre for Earth Sciences
Kumar Batuk Joshi[4], National Centre for Earth Sciences
Ankur J Dabhi[5], Physical Research Laboratory
A.K. Sudheer[6], Physical Research Laboratory
Ravi Bhushan[7], Physical Research Laboratory

Abstract

The Meghalayan Stage (4.2 ka- Present), being the most recent interval of Earth's history provides an extensive amount of evidence for paleoclimate reconstruction and global climate teleconnection. Yet the significance of the Meghalayan Stage remains elusive due to limited investigation on latitudinal scale paleoclimate comparison and its association with global atmospheric circulation. The global atmospheric circulation has been the prime driving factor for the variability of the Indian Summer Monsoon (ISM) thereby impacting the climate and socioeconomic conditions of the Indian subcontinent. However, during the last few decades, the ambiguous changes in the ISM invoked the need to explore the centennial to millennial-scale past climate variability, especially during the Meghalayan stage, which has been observed as low-latitude aridification around 4.2 ka and resonated well with the archaeological evidence.

The ISM enters the Indian landmass through Kerala, southwestern India and gradually advances further causing rainfall throughout the country, thus, Kerala acts as a gateway for the ISM advancement thereby providing an ideal platform to investigate paleohydrological changes since the onset of the Meghalayan Stage. Considering the above, the present study aims to investigate the paleomonsoon variability during 3-5 ka demonstrating the onset of the Meghalayan Stage of the Holocene Epoch and addressing the linkage of ISM with the natural climate variables and forcings.

A sediment core of nearly 4 m in length raised from a Shasthamkotta freshwater lake was chronologically supported by six AMS radiocarbon dates studied using a multiproxy approach. The study demonstrated a dry climate (weak ISM) during 3.5-3.7 ka and 4.7-4.9 ka interrupted by a strong monsoon spell. Unlike the speleothem of Mawmluh Cave, Meghalaya (stratotype of Meghalayan Stage), the 4.2 ka severe arid event is merely observed in the present study, on the contrary, the monsoon intensification during 3.6-3.8 ka observed in the present study corroborated well with the speleothem of Mawmluh Cave.

The weak ISM periods (3.5-3.7 ka and 4.7-4.9 ka) resulted from low solar forcing while the 4.7-4.9 ka climate also witnessed enhanced El Nino events. An imperative role of Total Solar Irradiance (TSI) in controlling the ISM variability is envisaged with the possible occurrence of an El Nino event restricting ISM during 4.7-4.9 ka, and thereby triggering the 4.2 ka dry climate over the Indian subcontinent. However, the signals of 4.2 ka are seldom observed from the records of

the southern Indian lake. The study emphasises the association of ISM variability with the global forcing during the commencement of the Meghalayan Stage and invokes the need to identify the signals of 4.2 ka at different latitudinal scales.

Keyword

Meghalayan Stage, Kerala, solar forcing, radiocarbon, sediment geochemistry

EVIDENCES OF LATE-QUATERNARY SEA-LEVEL CHANGES IN CENTRAL KERALA, SOUTH INDIA

Shaima M M[1]*, Christ college(Autonomous), Irinjalakuda (shymamohan@gmail.com)
Linto Alappat[2], Department of Geology and Environmental Science, Christ College (Autonomous), Thrissur, Kerala, India, 680 125
Ravinesh R[3], Department of Aquatic Biology and Fisheries, University of Kerala, Thiruvananthapuram, Kerala, India, 695581
M.G. Yadava[4], Physical Research Laboratory, Ahmedabad, India, 380009
S. Tsukamoto[5], Leibniz Institute for Applied Geophysics (LIAG), Section S3: Geochronology, Stilleweg 2, 30655 Hannover, Germany
Manfred Frechen [6], Leibniz Institute for Applied Geophysics (LIAG), Section S3: Geochronology, Stilleweg 2, 30655 Hannover, Germany

Abstract

The coastal sediments in Kerala are preserved in two distinct geomorphological settings; in palaeo-mudflat/ coastal swamp deposits occurring inland, which are bordered by medium to fine sandy beach-ridge sequence, sub-parallel to the modern shore. While the palaeo-beach ridges generally devoid of shells, the equivalent ancient low energy tidal flats and coastal lagoon deposits show well preserved shells, mostly autochthonous. The study aims to understand the change in palaeo-environments using the abundance of species assemblage of shells in the sediments and radiocarbon and OSL dating to constrain the age of deposition. The samples were collected from five different locations of Thrissur district, Kerala, located 5-10 km inland from the present shoreline. The sections display lenticular bedding within the mudflat sediments and fossil shells where embedded in the grey sandy clay to clayey substratum at variable depth (between 2-10.5m). The taxonomic compilation of the shells shows that the specimens largely composed of bivalves and gastropods in the invertebrate macro-fauna with their characteristic environment of occurrence ranging between marine, marginal marine and estuarine conditions. Radiocarbon ages constrain the timing of distinct periods of shell accumulation during 6870±220, 7080±200, 3350 ±160 yrs. BP and >40 ka BP. The OSL dating of clastic sediments of younger beach ridge sequence bordering the lagoons/ mudflats largely show age of deposition between 0.5±0.1 ka and 4.0±0.1 ka. The sand units from the palaeo mudflat units at varying depth between 4.6m to 9.2m had shown age of deposition between 40.0±2.0 ka and 55.0±2.0 ka. The shell deposit displays an abundance of well-preserved Holocene shell specimens and slightly altered shells due to the effect of differential taphonomic conditions during late Pleistocene. The marine influence in the species assemblage and the formation of these landforms as a consequence of late-quaternary sea-level fluctuations at distinct time period and associated environmental response is deduced.

Keyword

Quaternary, Sea-level changes, Marine shells, Radiocarbon age, OSL dating

Variability of leaf wax n-alkanes across gradients of environment and plant functional type in China

Yutao ZHOU[1]*, China Agricultural University (zhouyt@cau.edu.cn)
Guoan Wang[2], China Agricultural University
Yaowen HAN[3], China Agricultural University

Abstract

The abundance and distribution of long-chain n-alkanes in sedimentary archives have been proposed as plant-derived paleoenvironmental proxies. The reliable application of these proxies hinges on comprehensive understandings drawn from investigations of living plants. However, previous studies have predominantly relied on a limited dataset sourced from local and regional sampling. As a result, our comprehension of how n-alkanes in living plants respond to climate factors on larger spatial scales remains unclear, especially across different Plant Functional Types (PFTs). In this study, we analyzed the abundance and distribution of n-alkanes in the leaves of 552 plants from diverse regions in China and explored the variability of leaf wax n-alkanes across gradients of climate and PFTs. We found that (i) the average chain length (ACL) and carbon preference index (CPI) exhibit statistically significant differences between various PFTs, although these differences may not be substantial enough to reliably distinguish between PFTs, (ii) the ratio of C33/(C31 +C33), C33/(C29+C31 +C33) or C33/ΣoddC27-33 exhibit considerable discrepancy between C3 herbs and C4 herbs, as well as C3 plants and C4 plants. (iii) the variance in n-alkane concentration (Σalk) is primarily controlled by precipitation, with a notable negative correlation between Σalk and mean annual precipitation (MAP) that is independent of PFTs, (iv) CPI demonstrates a weak correlation with climate factors, and (v) ACL shows a positive correlation with mean annual temperature (MAT) and a negative correlation with MAP. MAT appears to be a stronger driver of ACL for C4 herbs and woody plants, while MAP exerts a more pronounced influence on C3 herbs. These findings indicate that ACL and CPI are not effective in distinguishing between PFTs. However, the ratio of C33/(C31 +C33), C33/(C29+C31 +C33) or C33/ΣoddC27-33 hold the potential to distinguish between C3 and C4 vegetation types. Σalk is a good indicator of precipitation, while ACL can serve as an indicator of either precipitation or temperature, depending on the specific PFT. In contrast, CPI appears generally insensitive to climate, and great caution should be exercised in using CPI records in paleoclimate research.

Keyword

n-alkanes, Carbon preference index, Average chain length, Climate factors

Last and Holocene interglacial relative sea-level rises and coastal sedimentation in the Korean Peninsula

Woo Hun RYANG[1]*, Jeonbuk National University (ryang@jbnu.ac.kr)
Hyun Ho Yoon[2], Korea Institute of Geoscience and Mineral Resources (KIGAM)

Abstract

During the last interglacial (LIG), known as Marine Isotope Stage (MIS) 5e (about 130 to 115 ka), global sea level was 5~9 m higher than present sea level. However, the apparent magnitude of that highstand is expressed differently across the globe depending on local tectonics, glacial-isostatic adjustment processes, and sediment compaction. Like most of the world's coastlines, the Korean Peninsula experienced higher-than-present sea levels during LIG. The expression of that highstand in the geological record differs across the eastern and western Korean Peninsula. A total of 62 LIG constraining data points were compiled including 34 sea-level indicators, 22 marine limiting records, and 6 terrestrial limiting records. The ages from these data points are based on 61 optically stimulated luminescence (OSL) measurements and 1 paleomagnetic-based age. The tectonically active east coast of the Korean Peninsula is characterized by broad uplifted marine terraces, while the stable west coast is characterized by tidal flats and rias. Tectonic uplift likely has affected the elevations of the east coast LIG shorelines, while LIG sea-level records on the west coast of the Korean Peninsula are found at heights of between +3 and +6 m. In the macrotidal Gochang coasts of southwestern Korea, a transition from lower heterogeneous muddy tidal-flat deposits to upper sandy tidal-beach deposits occurred during the Holocene interglacial. The open-coast shelf experienced decreasing rates of Holocene sea-level rise, and 14 OSL ages from a single 32-m-long core track decreasing rates of the RSL rise during the Holocene. As the rate of sea-level rise decreased, a tide-dominated depositional process switched to a wave-dominated one during the late stage of transgression. Decreasing rates of RSL rise during the Holocene interglacial, accompanying changes in the underlying sea-floor bathymetry, can drive a switch from a tide-dominated tidal flat to an open-coast tidal flat and ultimately a wave-dominated tidal beach through time.

Acknowledgements: This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (NRF-2022R1F1A1063126).

Keyword

Last interglacial, Holocene, sea-level rise, tidal flat, tidal beach

New Geochronological Data on the Tatun Volcano Group in Northern Taiwan

Su-Chin CHANG[1]*, The University of Hong Kong (suchin@hku.hk)
Mei-Fei Chu[2], National Taiwan University

Abstract

The Tatun Volcano Group (TVG) is located at the northern end of Taiwan, adjacent to Taipei, a city of two million inhabitants and a metropolitan area of over seven million. This volcano group forms the core of the Yangmingshan National Park, one of Taiwan's most popular tourist destinations. Previous age studies proposed that the TVG eruptions with lava flows ceased at ~0.2 Ma, while emerging seismic and isotopic data indicated an active magma reservoir beneath. Over the past 20 years, vigorous debate has considered whether its eruption history based on old geochronologic data is accurate. In this study, we report novel 40Ar/39Ar ages for two andesite samples and one basalt sample from TVG outcrops. The sample collected from Chihsingshan, the highest mountain in the area, yielded a robust age of 81 ± 5 ka. Two samples yielded 0.28 ± 0.02 Ma for Tatunshan and 0.159 ± 0.017 Ma for Honglushan. Our new geochronological data update the previously proposed age model for the TVG, improving our understanding of the tectonic setting of the Northern Taiwan Volcanic Zone. Furthermore, our study suggests a mitigation plan must be developed to prevent the primary and cascading effects of volcanic hazards, as any future volcanic activity may impact Taiwan and the nearby areas.

Keyword

volcano, Ar/Ar dating, Taiwan orogeny, volcanic hazards, mitigation

A modern pollen-climate dataset from South Korea for palaeoclimate reconstruction

Jaeyoung LEE[1]*, Korea National University of Science and Technology
(jaeyounglee@kigam.re.kr)
Sangheon Yi[2], Korea National University of Science and Technology

Abstract

The occurrence of extreme weather events in response to climate change has become a global concern. To prepare for the intensifying climate crisis, it is imperative to comprehend past extreme climate fluctuations, control factors, and triggers. In this study, we conducted a pollen-based quantitative reconstruction of the Northeast Asia paleo-climate. We collected 387 surface soil samples from 89 mountains in South Korea to produce a modern pollen assemblage dataset. The dominant taxa were P. subgen. Diploxylon and Q. subgen. Lepidobalanopsis, which showed a tendency to increase and decrease in contrasting patterns. Abies, Betula, and Picea were mainly collected at high altitudes, and Tann was low while Pann and Psum were high. Quercus subgen. Cyclobalanopsis and Alnus were mainly found in the southern region or low-altitude mountainous regions. This finding was similar to vegetation patterns in South Korea and the Korean Peninsula's fossil pollen assemblage during the Holocene. NAP was rare compared to AP among our samples, and NAP showed weaker intercorrelations than AP with climate variables in South Korea. As the dataset indicated that pollen samples from South Korea reflected the regional vegetation well, we applied a weighted modern pollen analogue technique to quantitatively reconstruct the mean annual temperature (Tann), annual precipitation (Pann), and summer precipitation (Psum) in the Gwangyang area. The reconstructed Tann increased by ca. 4000 cal BP and gradually decreased thereafter. Long-term Tann trends in the Gwangyang area, along the East Asian continental and Northwestern Pacific margins, appear to have been influenced by oceanic climate conditions, particularly the Kuroshio Current, whereas short-term trends were significantly correlated with the continental climate, the East Asian winter monsoon, and Bond events. Pann and Psum have gradually decreased during the Holocene, which is consistent with the induction of the East Asian summer monsoon by a northward shift of the Intertropical Convergence Zone. After ca. 5000 cal yr BP, the decrease in Pann slowed in association with strong typhoon activity of the El Niño–Southern Oscillation. Analysis of hydroclimate proxy data from southern South Korea revealed wet events at ca. 8900, 7800, 5900, 4500, 3200, 1900, and 1300 cal yr BP, and dry events at ca. 9300, 8200, 6200, 5200, 2800, 2200, and 1400 cal yr BP. Notably, we also confirmed the occurrence of a flooding event in southern South Korea at ca. 8900 cal yr BP.

Keyword

Pollen, Korea, Holocene, Climate variation, MAT

Surface microtextures of quartz grains in soil of Chuncheon Basin

Eun-chae SHIN[1]*, Department of Geology, College of Natural Science, Kangwon National University (KNU) (eun@kangwon.ac.kr)
Kyoung-nam Jo[2], Department of Geology, College of Natural Science, Kangwon National University (KNU)

Abstract

Quartz is the most abundant mineral in the soil. Additionally, it exhibits strong resistance to chemical and mechanical weathering compared to other rock-forming minerals. However, traces of transportation and sedimentation processes leave microtextures on the surface of quartz grains. These characteristics serve as useful indicators of the environment. Furthermore, analyzing the surface of quartz grains using SEM is useful for understanding the formation of sediment and the contemporary weathering and sedimentation environment. In this study, the surface microtextures of quartz grains (SMQ) in soil originating from Chuncheon granite were investigated, considering the climate conditions of Chuncheon City, Gangwon-do, on the Korean Peninsula. Furthermore, a factor analysis was conducted to interpret how soilization and weathering processes influence the characteristics of SMQ. The overall properties of soil SMQ in the Chuncheon area include some predominant physical microtextures, such as angular outlines, large/medium/small conchoidal fractures, arcuate/straight steps, and upturned plates. Additionally, there are chemical microtextures resulting from dissolution/sedimentation within diagenetic alteration environments. One of the main characteristics of soil SMQ is the presence of physical microtextures well-known to be formed through freeze-thaw processes, such as breakage blocks and microsteps. Another characteristic of SMQ in the study area is that quartz grains with original crystal planes are more frequently observed in the outer basin soil than in the inner basin soil. This observation indicates the degree of weathering based on the distance from the center of the basin because the original crystal planes signify properties authigenically originating from the host rock. Another noteworthy point is that, in the same soil profile, SMQ of the B horizon shows a dominant frequency of silica globules, silica flowers, and silica pellicle than the A horizon. Through these results, the water content changes in accordance with the depth from the surface, playing an important role in the formation of surface microtextures due to precipitation on the surface of quartz grains. Factor analysis was conducted using SMQ results. Factor 1 represents the climate conditions of the study area, which have the most significant impact on the microtexture of quartz grain surfaces in the soil environment. Factor 2 represents the residence time of quartz grain. The results of this study may contribute to the systematization and further research using SMQ data for various environments in the Korean Peninsula.

Keyword

quartz, surface microtexture, weathering, chuncheon, soil

The preliminary study of reconstructing abrupt climate shift with speleothem in Korean Peninsula: a textural approach

Jungwon CHOI[1]*, Department of Geology, College of Natural Science, Kangwon National University (KNU) (eplchoi@kangwon.ac.kr)
Kyoung-nam Jo[2], Department of Geology, College of Natural Science, Kangwon National University (KNU)

Abstract

Abrupt climate transition is well documented in the Greenland ice core and other various archives. Several records from Chinese speleothem suggest that D-O events possibly affect on monsoon intensity and therefore climate conditions in the EASM area. In this study, age dating and textural analysis are performed on the lower part of JM2 stalagmite, which grew during the Pleistocene. This study aims to investigate possible textural responses to abrupt climate shifts.

16 points of 230Th age dating results suggest that the lower part of JM2 grew in Late Pleistocene, from 79,219±133 to 58,233±118 yr BP with an average error range of ±164.38. According to the age dating result, the growth period of JM2 includes the D-O 20, 19, 17, 16, 15 14, and MIS 4 to 5 boundaries. Therefore, it is possible that textural and geochemical evidence of each event can exist.

The textural analysis is divided into three processes. 1) Macro-scale observation, 2) Microscopic observation. Three significant tilting events in the growth axis are recognized and divided JM2 into three phases. Phase 1 can be described with Seven sub-phases with relatively stable growth axis. In contrast, phase 2 and 3 exhibit an abrupt tilt of the axis, result an unclear texture. At the distal texture of phase 3, a major hiatus was recognized with texture and age models. A microscopic investigation reveals that the fabrics of lower JM2 are showing compact and open calcite fabrics. The width of columnar calcite varies from narrow (90.72μm avg.) and thick (338.22 μm avg.).

Based on the age model and textural analysis, it appears that two condensed laminae coincide abrupt warming event, around the D-O 20 and 19. Laminae thickness measurement shows a similar trend with NGRIP and each interstadials.

This study provides insight of the paleoclimate in late Pleistocene. However, further detailed studies are required.

Keyword

Speleothem, Textural analysis, Growth laminae, Dansgaard-Oeschger

Where ice meets salt: A more than 800 m deep glacial basin in the European Eastern Alps (Salzkammergut region, Austria)

Clemens SCHMALFUSS[1]*, University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology (clemens.schmalfuss@boku.ac.at)
Gustav Firla[2], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology
Stephanie Neuhuber[3], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology
Christopher Lüthgens[4], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology
Thomas Burschil[5], Federal Institute for Geosciences and Natural Resources (BGR), Hannover, Germany
Fabian Dremel[6], Department of Environment and Biodiversity, Paris Lodron University Salzburg, Austria
Bernhard Salcher[7], Department of Environment and Biodiversity, Paris Lodron University Salzburg, Austria
Thomas Leitner[8], Salinen Austria AG, Altaussee, Austria
Petra Diendorfer[9], Salinen Austria AG, Altaussee, Austria
Markus Fiebig[10], University of Natural Resources and Life Sciences, Vienna - Institute of Applied Geology

Abstract

The sedimentary infill of glacially overdeepened valleys can serve as an excellent archive of the landscape evolution in formerly glaciated areas. The first phase of the ICDP (International Continental Scientific Drilling Program) project DOVE (Drilling Overdeepened Alpine Valleys) is investigating several drill-cores from overdeepened valleys along the northern side of the European Alps and their foreland. One of the investigated sites (ICDP-5068-5) is located in an inner-alpine setting near Bad Aussee (Austria), where a distinct gravity anomaly was initially interpreted to be caused by a large salt body. A subsequent drilling, which did not reach the bedrock, instead revealed an astonishing 880-m-long succession consisting of (glacio-)lacustrine and fluvial sediments under a thick cover of subglacial till. Results from luminescence dating show that the drilled sequence spans at least the last two glacial cycles. Petrographic and mineralogical analyses indicate highly variable sediment provenance, tentatively interpreted as a result of changes in the regional drainage network due to the effects of glacial landscape modification.

One of the major open questions concerns the effect of the regionally widespread evaporite rocks in the formation of this extraordinary overdeepened structure. As the drilled sediments are similar in density compared to salt, it is not possible to distinguish between these lithologies based on gravity data alone. Existing seismic data and the surrounding surface geology indicate the presence of evaporites in the close vicinity of the drill site. Through ongoing work combining gravimetry with electrical resistivity tomography and a high-resolution seismic survey, we aim to create a 3D geological model of the area to better understand the shape and internal architecture of

the overdeepening.
In this contribution, we give an outline of this multi-method approach and present preliminary results from the geophysical investigations. The results from sedimentological drill-core analyses enhance our understanding of Pleistocene landscape evolution in the Eastern Alps, where comparable records are scarce.

Keyword

European Alps, glacial erosion, salt, sedimentary archive, paleolake

Millennial to seasonal trace element variability within stalagmite fluorescence banding during the Last Interglacial

Jihye KIM[1]*, Kangwon National University (rlacl9243@kangwon.ac.kr)
Kyoung-Nam Jo[2], Kangwon National University

Abstract

Seasonally variable conditions, such as monsoon climate can affect the fluorescence signal and also geochemical concentration of cave drip water, which allow speleothems to record annual paleoclimate signatures for the cave site. It has been suggested that fluorescence properties in speleothems is influenced by the presence of soil-derived soluble organic matter in infiltrated water after heavy rainfall. However, the fluorescence properties of speleothems from Korean caves have not yet been examined in detail. In this study, we use the stalagmite (OG1) collected from a cave located in South Korea, which shows fast growth during the last interglacial. We investigate the relationship between fluorescence banding and trace element variations, in order to explore its fluorescence properties and paleoclimatic significance. Fluorescence imaging of the stalagmite was taken by Confocal Laser Scanning Microscope (CLSM) and trace element concentrations were measured using an inductively coupled plasma mass spectrometer combined with a laser ablation system (LA-ICP-MS).

The stalagmite OG1 exhibits distinct annual lamination consisting of a growth line and growth band. The upper and lower parts of OG1 have different fluorescence properties showing gradual change in middle part. Interestingly, in the middle of OG1, there is a very thin dark growth line in the center of the fluorescence banding. However, in the upper part, the dark growth line is not visible on both optical microscopy and CLSM due to the thinner growth line but instead appears as a thin fluorescence band. This means that there may be textural change or incorporation of non-luminescent matter into crystal lattice during the growth line formation. The element contents in OG1 show annual fluctuations in Sr, Mg, Y, P, and REE compositions, which are very strongly related to the fluorescence banding. P, Y, and La concentrations peaked simultaneously with the lowest values in Sr, Ba, and Mg on bright fluorescence in the upper part of OG1. This suggests that the annual fluorescence band may be caused by input of large amount of water discharge during the rainy season. These results will be compared to the fluorescence properties and trace element content in the lower part of OG1 which has a different pattern to confirm the longer-term change during the last interglacial maximum.

Keyword

stalagmite, fluorescence, trace element, seasonal variation, growth layer

Paleoenvironmental evolution since the late Quaternary from core YZ02 in the South Yellow Sea

XIA LIAO[1]*, Nanjing Normal University (liaoxia_2061@163.com)
PING WANG[2], Nanjing Normal University
YONG YIN[3], Nanjing University
LING ZHANG[4], Nanjing University
BO YANG[5], Nanjing University
Xiaoan LI[6], Nanjing University

Abstract

The South Yellow Sea (SYS) is a shallow (less than 100 m in water depth) epicontinental sea between the Korean peninsula and China. It underwent periodical subaerial exposure since the late Quaternary due to glacial-interglacial cycles, and was fully exposed during the LGM when the sea level was lowered by about 120 m below the present. Therefore, the sedimentary sequences of the SYS may provide significant records for paleoenvironment evolution during the late Quaternary in East Asia. Over the last two decades, numerous researches have been done in order to reveal the stratigraphic framework and paleoenvironmental evolution. However, there is still very few long sequences with reliable chronological frameworks from the offshore area. Here, we report new results of paleomagnetism, magnetic susceptibility and geochemical elements from a long-drilled core, YZ02, which is 80.1m in length with water depth of 56.8 m. Our magnetostratigraphic result reveals samples are all in Brunhes chrons, and indicates the age of the sediments no earlier than Marine Isotope Stage (MIS) 6. Based on sedimentary facies analysis, the core is generally dominated by fluvial deposition in MIS6 and MIS 2, shallow marine deposition in MIS5, MIS3 and MIS1 while no deposition during MIS4. The geochemical result shows that the ratios of Zr/Rb and Sr/Rb are relatively high while K/Ti is relatively low during MIS6 and MIS4. These element ratios reflect a cold and dry climate with less precipitation, indicating the strengthening of winter monsoon in the source region. Furthermore, the magnetic susceptibility shows a high value in the fluvial deposits of MIS 6 and an upward-decreasing trend, which may also reflect the large input of magnetic minerals for the source region during the dry climate.

Keyword

South Yellow Sea, Paleoenvironmental evolution, Magnetostratigraphy, Elemental analysis

Monsoon Mysteries Unveiled: Traversing Millennia Through Climate Reconstructions in Southern India

HEMA ACHYUTHAN[1]*, Centre for Environmental Studies, Anna University, Chennai 600025 (hachyuthan0@gmail.com)

Abstract

Reconstructing paleoclimates using current meteorological data is crucial for predicting future climate patterns and identifying any significant fluctuations. However, it is important to consider several caveats when utilizing proxy data generated through radiometric dating, tree-ring analysis, corals, cave deposits, soils, and lake and marine records for paleoclimate reconstructions. This study focuses on reconstructing Southwest Monsoon (SWM) variability employing lake sediments, cave stalactites, stalagmites, and 18O records from both Northern and Southern India. The findings illuminate climatic changes spanning millennia. Noteworthy is a substantial decline in monsoon strength around 1500 and 800-450 cal years BP, aligning with the transition from the Medieval Warm Period (MWP) to the Little Ice Age (LIA). From the LIA to the present, an uptick in droughts and floods is evident. Despite substantial variations in monsoon strength, no major shifts in its source, extent, and seasonality occurred before 2500 years BP. However, two brief arid phases occurred around 3500 and 2600 cal years BP, disrupting the otherwise stable SWM pattern. The Roman Warm Period (RWP) from 2100 to 1800 cal years BP witnessed a sharp monsoon decrease. In the Himalayan region, both dry and wet phases at the LIA's onset and end contribute regional nuances to broader monsoon variability. Corroborative evidence from lake and marine sediment cores in SWM-influenced regions, such as lakes Vellayani and Pookode in Kerala and from Landfall Island, Bay of Bengal, supports these findings. Radiocarbon dating of lake sediments spanning from 6240 to 565 14C BP reveals climatic shifts: drier conditions up to 3000 years BP and increased wetness around 1210 years BP. Lake sediment analyses, encompassing texture, Chemical Weathering Index values, phytolith and pollen assemblages, uncover warm and dry conditions during 6200–420 14C years BP (BC 4786–AD 1434 cal.). Intermittent wet phases around ∼3900–∼1900, ∼1400–∼760, and ∼420–∼140 14C years BP cause significant lake hydrological changes. Critical periods during the MWP and LIA witness a substantial shift in lake conditions. A decline in vegetation cover, evidenced by low phytolith morph types for 2300 years BP, is attributed to climate warming, weakened SWM, deforestation, and lake-margin reclamation for intensive agriculture. Strengthened SWM leads to short-wet events, elevating water levels and briefly expanding lake margins. Charcoal pieces post 3000 years BP indicate human impact. Marine sediment core, with radiocarbon ages from 6,078 to 1,658 years BP, display grain size variations reflecting cyclic wetter and drier conditions, aligning with SWM intensity shifts. Higher CaCO3 content, εNd, and 18O in Globigerinoides ruber affirm a long-term trend from cooler, wetter conditions to warmer, drier conditions. CWI reveals highly weathered sediment deposited around 4,000 years BP. Smectite and chlorite/illite (C/I) variations signifies an overall SWM weakening from 6,000 to 2,000 years BP, with an extremely reduced

SWM around 4,400 to 4,200 years BP. Oxygen isotope data on G. ruber indicate a major shift ~4,300 years BP, indicating a weakened SWM. Fluctuations in SWM intensity from the past 2,000 years to the present highlight the dynamic nature of monsoon patterns in the region.

Keyword

SWM variability, Paleoclimates, Radiocarbon dating, Proxy Data, RWP MWP and LIA

Reconstruction of Holocene Climatic Dynamics in the Western Himalaya: Speleothem Record

Jaishri Sanwal BHATT[1]*, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore (jaishrigeology@gmail.com)
Vinod Chandra Tewari[2], Formerly,Geology Department,Sikkim,Central University,Gangtok - 747201, Sikkim ,India

Abstract

The climate in the western Himalaya, shaped by the intricate dynamics of the Indian Summer Monsoon (ISM) and Western Disturbances (WDs), replenishes glaciers and plays a pivotal role in water security and agriculture. The geographical and physiographical distinctiveness of this region offers an excellent natural laboratory to reconstruct the dynamics of paleo-monsoon by using terrestrial proxies. This study reconstructs the climatic variations over ~4000 years using a U/Th-dated speleothem from Sweel Cave, Himachal Pradesh, Western Himalaya. We analyzed stable isotopes and trace elements distribution along the maximum growth axis of a speleothem that was actively growing during the collection in 2020. The variations in Mg/Ca and Sr/Ca ratios align with stable isotope records. Our results suggest substantial precipitation between ~4000 to ~3700 yr BP and ~3350 to ~3200 yr BP, evident by the gradual decrease in δ18O. Two phases of low precipitation are observed between ~3650 to ~3300 yr BP and ~3400 to ~3000 yr BP. A substantial increase in speleothem growth is seen after 3000 yr BP until ~2800 yr BP, followed by a brief drier phase. A fluctuating trend in δ18O suggests heavy rainfall after 2700 yr BP and a gradual decrease in precipitation between ~2400 to ~2100 yr BP. The increased precipitation, aligning with Mg2+ incorporation, δ13C, and δ18O values provide evidence of substantial climatic shifts ~1800 to ~1570 yr BP. Reduced precipitation between 1,445 to 1,411 yr BP with a declining trend of δ18O (-5.91‰ to -5.60‰) and δ13C (-7.10‰ to -6.83‰) coupled with an abrupt increase in Mg/Ca ratio and a decrease in Sr/Ca. A gradual decrease in Mg, corresponding to negative values of δ18O (-6.67‰ to -6.52‰) and δ13C (-8.22‰ to -7.33‰), provide strong evidence of substantial precipitation around the cave during ~1,319 to ~1,025 yr BP. The monsoonal behaviour over the last 1000 years portrays dramatic shifts characterized by recurrent natural disasters impacting human populations. The Medieval Warm Period (MWP) and the Little Ice Age (LIA), exhibit globally recognized weak and robust monsoon cycles. Our results show multi-decadal weak-monsoon periods between ~930 to ~850 and ~800 to ~570 yr BP. The strong ISM during the MWP correlates with the warm water circulation, generating a pressure gradient between the Indian Ocean and the Eurasian continent. Our study reveals intensified monsoons during the onset of the LIA between ~570 to ~290 and ~270 to ~130 yr BP. ISM intensity during the LIA exhibits significant heterogeneity, showcasing a low precipitation trend over peninsular India and increased monsoon precipitation in northern regions, which may be attributed to the 'break event" and winter westerlies. Simulation modelling suggests the migration of ITCZ from the Bay of Bengal to the Arabian Sea, influenced by solar insolation, impacting precipitation in

the monsoon zone and Himalaya during the mid-late Holocene. We noted a decreasing rainfall trend post-1880 CE, particularly pronounced from 1980 to 2019 CE. This aligns with cave drip water isotopic signatures in two ongoing monitored Himalayan caves in western (Sweel) and central (Sauli) Himalaya, signalling a recent decline in WDs.

Keyword

Holocene Climate, Stable Isotopes, Trace Elements, Speleothem, Indian Western Himalaya

[Keynote] Holocene Meghalayan Stage Speleothem (Stalagmite) carbonate petrography and paleoenvironmental significance from Meghalayan and Lesser Himalayan caves, India

VINOD CHANDRA TEWARI[1]*, Professor of Geology (Retd.), Sikkim University, Gangtok – 737102, Sikkim, India (Professorvct54@gmail.com)

Abstract

The latest Holocene Meghalayan Stage (4200 years) has been recently established from a well developed stalagmite from Mawmluh cave in Meghalaya, Shillong Plateau,NE India.There are several Holocene caves in other parts of the Meghalaya in northeast and northwestern regions of the Lesser Himalaya, India.The high resolution regional climate variation based on oxygen isotopic pattern from northwest to northeast needs further support from other physico-chemical,carbonate mineralogical and sedimentological proxies during the meteoric precipitation. Speleothems are continental cave deposits of carbonate minerals formed due to dissolution of the host rock, and its re-deposition in caves due to degassing of CO2.Speleothems are widely used as most reliable archives of continental palaeo- environment because of their depositional continuity, no diagenetic imprints,accurate chronology through U-Th disequilibrium series dating, high temporal resolution and wide spatial distribution.Stable isotopic changes from the speleothem carbonates of the Meghalayan and Lesser Himalayan caves of India reveal information about the meteoric precipitation during its formation and the regional climate conditions.Systematic petrographic studies of speleothem microcrystalline fabrics can explain the exact conditions of paleoenvironment during speleothem growth. Columnar calcite is usually common during wet conditions. In the present study, stalagmites from the Mawmluh, Meghalayan type area ,Mastos and Labit caves have been studied mineralogically, petrographically and geomicrobiologically.In addition to this, Sahastradhara, Prakateshwar and Chulerasim caves also situated in core Monsoon region in western Lesser Himalaya in Garhwal-Kumaon regions of Uttarakhand Lesser Himalaya have been investigated. Calcium carbonate speleothems dominate most of the caves globally.The petrographic studies show significant variations in calcite fabrics during wet and dry periods.Columnar crystals are observed in wet periods but other radiaxial ,dendritic and microstromatolitic micro fabrics were formed during different hydrological and paleoenvironmental conditions.The Mg rich radiaxial fabric of acicular crystals usually develop in drier conditions.Filamentous bacteria dominate cave microbial mats in Meghalaya.Bacterial association with carbonate minerals is quite significant in establishing the biomineralization process (interaction of microbes with calcite, aragonite and dolomite).Recent petrographic, Scanning Electron Microscopy , Cathodoluminescence and Laser Raman Spectroscopic studies of filamentous bacteria and microbially laminated structures (microstromatolites) from Meghalayan and Sahastradhara caves have confirmed the contribution of microbes to calcium carbonate precipitation in stalagmites.Geomicrobiology is an emerging field of research and grown over the last fifteen years research on speleothems from Indian caves and other parts of the world.`

The comparison and correlation between the petrographic microfacies changes, their relationship with stable isotopic data, major and trace element variation, and geomicrobiological evidences from these very significant speleothems (stalagmites) from Meghalaya and Lesser Himalaya situated in two different monsoon dominated regions of India has been discussed.Speleothems in Central Nepal Pokhara valley also shows regional Holocene Indian Summer Monsoon activity in South Asia between northern India and south of Himalaya.

Keyword

Speleothem, Holocene,, Meghalayan Stage,, Mawmluh, Himalaya,, palaeoenvironment

Comparison between a stalagmite record and a peat record over the past 14 Ka from NE China: To what extend the proxies in stalagmite and peat records to reflect climate changes

Hong-Chun Li[1]*, National Taiwan University (hcli1960@ntu.edu.tw)

Abstract

A 21.5-cm long stalagmite (20170710-4S) from Yunxia Cave in Tonghua City, Jilin Province was dated by 230Th/U and analyzed for d18O and d13C in 2500 subsamples. The high-resolution record exhibits detailed climate and vegetation variations from 11.7 Ka to the present. A 8.5-m long peat core (HNB) retrieved from Hani peatland in Jingyu County, Jilin Province was dated by 14C dating (a total of 105 14C ages) and measured for H2O%, dry bulk density (DBD), total organic carbon (TOC) and ash (%) on 850 subsamples. HNB contains the record from 14.1 Ka to the present. The two studied locations are about 80 km apart in the NE China where the climate is influenced by the east Asian summer monsoon as well as westerly, so that they should reflect the same climatic setting and allow us to compare the proxies in each records for climatic interpretations. The 4S d18O and d13C records exhibit centennial cycles superposed on multi-millennial trends. Between 8 and 3.5 Ka, both d18O and d13C were lighter than their averages, whereas between 3.5 Ka and the present the d18O and d13C were heavier than the averages. Before 8 Ka, the d18O and d13C were fluctuated around the averages. These multi-millennial trends of d18O and d13C during the middle and late Holocene may reflect long-term shift of moisture source and vegetation type related to summer monsoonal strength. Thus, it is necessary to make de-trend in the d18O and d13C records. The de-trended d18O and d13C provide centennial variations in terms of wetness, being the negative Dd18O and Dd13C values reflecting wet climatic condition, and vice versa. The peat record, on the other hand, showed stable high TOC and low recent carbon accumulation (RCA = TOC*DBD* SR (sedimentation rate)) during 3.5~8 Ka, but strongly centennial variations before and after this period. RCA is strongly positively correlated with SR (R2 = 0.85), but weakly related with TOC and DBD. The latter two have negatively correlation (R2 >0.6). The comparison of the stalagmite Dd18O and Dd13C with the peat TOC and RCA reveals that the negative Dd18O and Dd13C periods representing wet period generally corresponding to low RCA, and vice versa. This means that the peat development is better during relatively cold and dry conditions under weak summer monsoon. Two explanations may be considered: 1. Flooding and elevated water table under warm and wet conditions are not in favor of moss development in peatland. 2. Detritus input under warm and wet conditions could reduce SR and TOC. When DBS is greater than 0.25 g/cm3 and TOC is less than 20%, the RCA is strongly influenced by detritus and does not reflect peat development. Therefore, one should not depend on solely RCA or TOC of peat record for climatic interpretation. With the detailed stalagmite and peat records, we are able to interpret the monsoonal climates in the study area.

Keyword

Stalagmite, d18O and d13C, Peat record, NE China, Monsoonal climate

Signatures of trace element variations in the Indian speleothem from the core monsoon zone during the late Holocene

Naveen GANDHI[1]*, Indian Institute of Tropical Meteorology, Pune (naveen@tropmet.res.in)
Ipsita Roy[2], Indian Institute of Tropical Meteorology, Pune
Damodararao Karri[3], Indian Institute of Tropical Meteorology, Pune

Abstract

Speleothem trace elements serve as valuable proxies for investigating past precipitation changes in tropical areas at an annual to decadal time resolution. While elemental variations in biogenic carbonates have been extensively studied, speleothems have received less attention in this regard. The core monsoon zone of the Indian subcontinent is crucial for analyzing past fluctuations in the Indian summer monsoon. A speleothem from the Gupteswar cave in Odisha, India, collected and dated using the 230Th/234U method, covers the last 3000 years. Trace elements, including Mg, Ba, Sr, Mn, U, and Rb were analyzed to understand regional and local climate variability induced by the Indian Summer Monsoon. This cave lies in the core monsoon zone of the Indian subcontinent and receives approximately 1,500 mm of rainfall annually. Over the past 3000 years, warm and moist climates were documented during the Roman Warm Period and the Medieval Warm Period, while relatively dry conditions were experienced globally around 2.8 ka and during the Little Ice Age. Overall, trace element behavior in speleothems is influenced by regional climate, seepage pathway, bedrock chemistry, and vegetation cover above the cave. A shift in Mg, Ba, U, and/or Ba to Sr ratios indicates a change in the intensity of regional precipitation or local moisture availability. The Mn concentration correlates with the contribution of the element from surrounding vegetation. Additionally, the Rb to Sr ratio is postulated to represent the depositional behavior of sediments at the study site. Trace element variations in the speleothem capture short-lived and abrupt climatic events. The trace elemental variations driven by climatic events and the possible driving mechanisms will be presented at the conference.

Keyword

Monsoon core zone, Indian summer monsoon, 2.8 ka, Roman Warm Period, Little Ice Age

Meghalayan Stage Stalagmites , Indian Summer Monsoon and Paleoclimate records from Northeast India

POOJA BHARALI[1]*, Msc student(passed) from Sikkim University (pooja.bharali07@gmail.com)
VINOD CHANDRA TEWARI[2], Professor of Geology (Retd.), Sikkim University, Gangtok – 737102, Sikkim, India

Abstract

Pooja Bharali *and V.C.Tewari**
*Formerly Student, Geology Department, Sikkim University, Gangtok, India
Present Address: Purabi Nagar, Changsari, Kamrup - 781101, Assam, India (email: pooja.bharali07@gmail.com)
** Professor of Geology (Retd.), Sikkim University, Gangtok – 737102, Sikkim, India (email : professorvct54@gmail.com)
Present Address: Himalaya, 203, South Vanasthali, Mandir Lane, Ballupur ,Dehradun- 248001, Uttarakhand, India

Abstract:
The Indian Subcontinent in South Asia has a history of civilization that can be traced back to 5000 years from present and boasts a geological history of 3.5 billion years and also recently established the youngest Holocene age of Earth history from the isotopic dating of speleothem (4200 years old stalagmite) from limestone cave of Meghalaya given the name Meghalayan Stage. The Indian Summer Monsoon (ISM) is a very significant phenomenon throughout Asia and the Indian subcontinent. The livelihood of the billions of people living in this region primarily depends on agriculture and consequently on ISM. ISM controls the climate of the South Asian region and has affected the civilization due to severe drought conditions in the past that is why ISM's precipitation patterns are being reconstructed using speleothems (mineral deposits in cave formed by the calcium carbonate precipitation due to dripping groundwater) to study those past events. The detailed study of the speleothems mainly stalagmites is quite significant in dating and establishing the intensity and abrupt change in the monsoonal conditions by measuring the oxygen isotope ratios of the stalagmites. The recently established “Meghalayan Stage” of Holocene epoch has been dated 4200 years from a stalagmite of the Mawmluh cave in Shillong Plateau, Meghalaya, Northeast India. There are hundreds of caves very well preserved and found extremely useful in the study of paleoclimate, paleomonsoon and historical events associated with abrupt change in societal conditions due to climate change. In northeast India, the largest caves are developed in Meghalaya around the town of Cherrapunji (Sohra,Mawsmai, Mawsynram,Mawmluh and Mustos caves) where the heaviest monsoon rainfall in the world is recorded. The stalagmites from these caves have given important traces about the intensity of the ISM in the past, abrupt change in monsoon conditions since pre historic time and now they are well dated by the uranium series technique and oxygen stable isotope variation since stalagmite

records have the ability to predict future changes in the ISM as well. The tremendous progress gained in this area recently suggests global research opportunities in the future for young researchers. The evidences of paleoclimatic glacial event of Little Ice Age (LIA), intensity of ISM establishedby oxygen isotope ratios from stalagmites from Meghalayan Stage (Mawmluh and other caves) has been discussed.

Keyword

The Indian Summer Monsoon (ISM), Speleothems, Meghalayan Stage, Paleoclimate, Paleomonsoon

Seismic Impact on Speleothems and Cave Structures: Evidence for Major Earthquakes in the Central Himalaya

Jaishri Sanwal BHATT[1]*, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore (jaishrigeology@gmail.com)
Rajendran CP[2], National Institute of Advanced Studies, Bangalore

Abstract

The investigation of structural damage and growth anomalies in speleothems in the Central Himalaya holds the potential for accurately dating the earthquake-induced impacts in and around the caves. These formations, which include stalagmites, stalactites, and soda straws that exhibit breakage in alignment with the cave roof, provide valuable insights into seismic events. This work delves into active fault structures and geomorphic features in and around caves, providing chronological constraints linked to earthquakes. Using six deformed stalagmites from four limestone caverns - Sweel, Bhuligao, Dharamjali, and Hathikhal caves in the central Himalaya, we aim to establish timings associated with paleo-earthquakes affecting the caves and the surrounding area. These caves are situated within the seismically active region between the Main Central Thrust (MCT) and the Main Boundary Thrust (MBT), struck by medium to large earthquakes in the past. The study contributes to understanding seismic activities linked to hinterland structures, such as the MCT, MBT, or other minor thrusts, in contrast to great décollement earthquakes impacting the Himalayan Frontal Thrust (HFT).

During our exploration of these caves, numerous displaced and broken speleothems were observed, accompanied by the subsequent growth of second-generation stalagmites on these formations. Additionally, the caves displayed fallen ceilings and ~60 cm to 2m thick speleothem debris, containing broken soda straws, small stalactites, and chunks of fallen ceilings. Growth perturbations in stalagmites encompass sudden tilting, rotation, termination, and faulting within laminas, providing a detailed record of past seismic activities. Detailed petrographic analysis of twenty thin sections from stalagmites unveiled distorted microstructures and fragments of broken soda straws. The broken calcite crystals and aragonite needles are evident in a few slides under Scanning electron microscope (SEM) analysis. Advanced analytical analysis, including Raman spectroscopy and Laser-Induced Breakdown Spectroscopy (LIBS) of five distorted speleothems, provided insights into mineralogical and trace element composition changes. In some samples, the inclusion of silica and aluminum-rich detrital sediment was identified within the growth anomalies. Notably, stable isotopic records did not indicate signatures of floods or droughts. Utilizing U-Th age data from six specimens, we pinpoint intervals for these growth anomalies, dating them at 4273±410 years BP (2673–1853 BCE), 2782±79 years BP (851–693 BCE), 2498±117 years BP (605–371 BCE), 1503±245 years BP (262–752 CE), 1346±101 years BP (563–765 CE), and 687±147 years BP (1176–1470 CE). These chronologies potentially align with major seismic events, with the most recent event (1176–1470 AD) corresponding chronologically to a documented great medieval earthquake (1050–1250 and 1259–1433 AD) observed in trench

excavations along the Himalayan Frontal Thrust." This alignment underscores the potential link between these growth anomalies and significant seismic activities in the region during different historical periods.

Keyword

Speleothems, Speleoseismology, Medieval Earthquakes, Central Indian Himalaya, Seismic Gap

Small mammal fossils from cave sediments and their use for palaeoenvironmental reconstructions. Potential and limitation

Lutz Christian MAUL[1]*, Senckenberg Research Station of Quaternary Palaeontology (lmaul@senckenberg.de)
Jaishri Sanwal[2], Geosciences Unit, Jawaharlal Nehru Centre for Advanced Scientific Research, Bangalore 560064, India
Chris Baumann[3], Department of Geoscience, University of Tübingen, Hölderlinstrasse 12, 72074 Tübingen, Germany

Abstract

Palaeontological data provide important contributions to palaeoenvironmental reconstructions. At terrestrial sites, this is particularly true for small mammals (insectivores, bats, rodents and lagomorphs). They are very informative because of their usually rich fossil record, their wide geographical distribution, their biostratigraphic importance and their often very close adaptation to certain habitats. For such reconstructions, the nearest living relatives (NRLs) of the fossil taxa are usually used, either in the form of ecological groups for open land, forest, aquatic habitats, etc., or attempts are made to quantify them, usually via recent ranges and the ecological or climatic parameters that can be derived from them. If the site consists of only one fossil layer, an ecological snapshot can be derived; if it consists of several layers, an ecological sequence can be derived. Among the various types of fossil sites, caves are among the most important archives.

Results and problems of palaeoecological reconstruction are discussed for three Quaternary cave faunas from Central Europe. (1) The cave profile from Koněprusy C718 (Czech Republic) shows a sequence of the relative abundance of different fossil vole taxa from the early Middle Pleistocene (early Cromer complex). Although none of the fossil species can be fully shown to be ecologically comparable to their recent relatives, the sequence shows a clear picture of the succession from a forested, warmer environment to an open, colder one: some taxa with presumed similarities in ecological adaptation (dry, cold vs. wetter, temperate affinities) change in parallel - some in opposite directions. Others, however, are changing without any discernible pattern. (2) Small mammals in the sequence of Hunas Cave (Germany) reflect different phases of the late Middle to Late Pleistocene. A cold phase in the upper part, characterised by Lemmus lemmus, Microtus oeconomus and M. gregalis, a continental phase in the middle part, defined by Ochotona, Cricetus, Phodopus, Spermophilus and Marmota, and a warm phase in the lower part of the profile, reflected by the occurrence of Muscardinus and Microtus subterraneus. (3) The Pisede burrow complex (Germany), which was created by badgers and inhabited for several centuries, contained extensive micro faunal material dating from the terminal Pleistocene to the early Holocene. During use, the structure was extended, and older areas were reworked several times. This generally resulted in a horizontal stratigraphy with massive faunal assemblages.

The three examples show that palaeoecological reconstructions based on small mammals are mostly conclusive, although uncertainties remain. Despite the risk of misidentification and the inherent differences between fossil and modern species, leading to uncertain ecological

conditions, ongoing research efforts are aimed at refining this understanding. It's worth noting that older faunas present greater challenges in this regard. In addition, the mixing of faunas, possibly due to bioturbation, can complicate the accurate stratigraphic placement of different units. Taphonomic filters, influenced by cave dwellers or the prey spectrum of accumulating raptors, especially owls, also contribute to this complexity. To increase the robustness of the results, consistent cross-checking with palaeoenvironmental reconstructions derived from other methods, such as palaeobotanical or geochemical data, is encouraged.

Keyword

small mammals, Quaternary, cave sites, palaeoenvironment

Past-WDs modeling using CMIP6 Paleoclimate Modeling Intercomparison Project (PMIP4) Experiments and Speleothems Over Hindukush Himalaya.

Pramod KUMAR[1]*, Banaras Hindu University, Varanasi, India (promnagar1@gmail.com)
Om Kumar[2], Miranda House, University of Delhi, New Delhi, India, 110007

Abstract

Western Disturbances (WDs) have a very crucial role in snowfall/rainfall over the Western Himalayas. Subsequently, WDs are a major contributor to water resources over Hindukush Himalaya (HKH) through rainfall, snowfall, and other forms of precipitation. The Himalayas are one of the freshwater reservoirs that contain glaciers, rivers, springs, and lakes, which nourish various communities in HKH. However, utilizing CMIP6 model PMIP4 paleo-experiments and speleothems (proxies), it can be better understood the past contribution made by WD precipitation. The subtropical westerly jet is captured in synoptic-scale systems, termed WDs. The western Himalayas receive greater precipitation due to extensive orographic interaction. However, the winter monsoon (WM) refers to the precipitation caused by WDs and other factors. Paleoclimatology of HKH using δ13C and δ18O can give the actual climatic scenario and weather pattern. The study evaluates the fingerprints of oxygen isotopes in model simulations and speleothem records. The model generates a higher level of δ18O variations than what is observed in speleothem archives. Although interpreting speleothem data might be difficult, it has the potential to aid in climate reconstruction. It should be considered to use a multi-model technique when evaluating modelled and proxy data. More detailed modelling requires an understanding of the underlying mechanics of karst and caves in HKH.

Keyword

WDs, HKH, CMIP6, PMIP4, Speleothems

Evidence from southern India suggests that the Little Ice Age was not uniformly cold and dry across the globe.

ISHFAQ AHMAD MIR[1]*, Geological Survey of India (geoishfaq@gmail.com)
Jooly Jaiswal[2], Geological Survey of India
Anindya Bhattacharya[3], Geological Survey of India

Abstract

A radiocarbon-dated sediment core from Honnamankere Lake in southern India's Western Ghats is being examined to learn more about the area's paleoclimate between CE 1219 and 1942. The current study aims to better comprehend evolving continental weathering regimes in peninsular India over the last 753 years, including the medieval warming period (MWP: CE 1219-1374), little ice age (LIA: CE 1374-1671), and modern global warming (MGW: CE 1671-1942). The chemical weathering and erosion proxies in the catchment region have low values during MWP and MGW, indicating a drop in rainfall, but high values during LIA, indicating an increase in rainfall. The downward trend in the sediment core shows that a warm and humid environment governs both physical erosion and chemical weathering. Higher latitudes had less physical erosion and chemical weathering during the LIA. The LIA in the research area was warm and moister, rather than cold and dry. The LIA, a global climatic phenomena characterized by significant diversity in rainfall patterns, calls into question the widely held idea of a continuously cold and dry climate with reduced monsoon rainfall throughout the LIA. This study underlines the importance of looking at alternative high resolution paleoclimate archives in the region, including as speleothems and tree rings, in order to better explain LIA oscillations between lower and higher latitudes. The high resolution multi-proxy and multi-archive paleoclimate records could help to improve climate models for future forecasts. Accurate climate models will aid in strong scientific policy planning, both of which will be extremely beneficial to the world's most populous country, India, where agriculture makes for a sizable portion of its GDP. Human-induced climate change demands extensive modelling studies for accurate projections, and our data, together with future studies in the region on speleothems, tree rings, and corals, can make a significant contribution.

Keyword

Tropical India, Monsoon, Paleoclimate, Chemical Weathering, Little Ice Age

[Keynote] New Palaeolithic Explorations in Eastern Asia

Shixia YANG[1]*, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (yangshixia@ivpp.ac.cn)

Abstract

The evolutionary history of humans and our closely related early ancestors is one of the most important scientific endeavors. Current knowledge about human evolution is mainly based on the fossil and archaeological record in Africa and Europe. Yet, Eastern Asia is known for its long sequences of Quaternary terrestrial deposits, which have supplied detailed information about changes in environments and the history of hominin occupations. However, few systematic and coordinated research efforts have been conducted in Eastern Asia to bridge its climatic history with its rich paleoanthropological records.

This talk will introduce a series of new scientific studies focused on the evolutionary history of hominins in Eastern Asia. These studies, covering the entire length of the Paleolithic, are altering our views about the evolution of hominins in Eastern Asia. In contrast to traditional arguments for a homogeneous and continuous record of the Paleolithic in Eastern Asia, the new findings demonstrate the potential complexity of early human adaptions in Eastern Asia, and the close relationship between early human behavior and climatic events. With respect to behavioral adaptions of modern humans in Eastern Asia, recent studies suggest that we should pay close attention to a mosaic of behavioral adaptations and innovations occurring during the worldwide dispersal of our species, rather than simple diffusion and replacement.

Keyword

Eastern Asia, Evolutionary history, Paleolithic archaeology

Early Holocene human in the Tengger Desert, northern China

xuefeng SUN[1]*, Nanjing University (xuefeng@nju.edu.cn)

Abstract

By the onset of the Holocene, the ability to exploit new territory of hunting and gathering people have been significantly improved in the worldwide. But one area that remained largely unidentified was the desert regions in northwest China. Since 1989 a small number of surface prehistoric remains were discovered in the Tengger Desert Region (TDR) northern China. However, until now, we have never known when humans occupied the TDR, when they left, and where they went in the end. Between 2020 and 2023, we found 60 stone artifact sites (TGL4-TGL63) including a human bone site (TGL43) in the Tengger Desert Region (TDR), northern China. The Tengger Desert lithic assemblage is core-flake-retouched flake tools industry and microlithic industry. Three AMS 14C samples dating showed TGL43 human bones is 7560-7267 yr BP. Then 79 OSL samples dating in 9 burial sites and 23 surfaces sites suggested the initial occupation before 9 ka, activities between 9 ka and 6 ka by, and extinction or migration after 6 ka by the hunting and gathering people around several hundred square kilometers in the TDR northern China. An ancient genome from the TGL43 human showed a lonely and isolated human population, and Tengger human seem to have disappeared. However, it shed light on the genetic origin of Yangshao farmer's related ancestry.

Keyword

Desert, Stone artifact, Luminescence dating

New OSL dating reveals interactive migrations of Western and indigenous populations in north China corresponding to monsoonal fluctuations during the past 70-10 ka

JUNYI GE[1]*, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (gejunyi@ivpp.ac.cn)
Chunxue Wang[2], Jilin University
Yan Li[3], University of the Chinese Academy of Sciences
Xiaoling Zhang[4], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Shixia Yang[5], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
John W. Olsen[6], School of Anthropology, University of Arizona
Xing Gao[7], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Chenglong Deng[8], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The timing and mechanism of modern Human's dispersal and occupation into North China, especially cultural interactions between exogenous Paleolithic populations and those indigenous to East Asia during the Late Pleistocene are of great interest.

Homo sapiens dispersed eastward into Siberia and Northeast Asia after ~45 ka. When anatomically modern humans crossed the Mongolian steppe/desert and dispersed further across East Asia, encounters between allochthonous modern humans and indigenous hunter-gatherers inevitably occurred, possibly leading to population replacement and geographical shifts. How they colonized and interacted with autochthonous Paleolithic populations in East Asia remains ambiguous.

In this study, two Paleolithic sites (YZXS and TZL) located in the southern piedmont highland of the Yanshan Mountains, with artifacts typified by simple core and flake technology associated with foraging populations, have been dated to ~39-29 ka and ~53-47 ka respectively, using Optically Stimulated Luminescence (OSL). Our results suggest that North China south to the Yanshan Mountains was occupied mainly by autochthonous East Asian Paleolithic populations using a core-flake technology, although during this period Initial Upper Paleolithic (IUP) modern human populations have been present in Western Europe and dispersed into Asia. By synthesizing and integrating the ages of Northeast Asian Paleolithic sequences during the last glacial period (ca. 70-10 ka), we analyzed spatio-temporal variations in Late Pleistocene human populations during relatively cold stadial events (MISs 4 & 2) and warmer interstadials (e.g., MIS 3), revealing an "ebb and flow" pattern for migrations of the Western IUP "blade" populations and indigenous "core-flake" populations in East Asia corresponding to the advance and retreatment of the East Asian monsoon belt around the Greater Khingan and Yanshan mountain ranges. During relatively cold MIS 4, only a few small indigenous human populations remained in the Qinling

Mountains and along the North Chinese coastline. During subsequent MIS 3, a warm climate both facilitated expansion of the autochthonous “core-flake” population size and the dispersal of populations whose lithic technology focused on the production of blades. However, the subsequent extremely cold climate phase engendered a major population shift during the Last Glacial Maximum (LGM; ca. 26.5-19 ka), which drove the recession of both these Paleolithic populations, but afterward facilitated the emergence and rapid dispersal of microblade populations in Northeast Asia, including North China. These populations associated with microblade technologies achieved their maximum extent during the warm Bølling-Allerød interstadial event (ca. 14.7-12.9 ka) and then gradually decreased, perhaps due to the development of agriculture after ~13 ka.

Keyword

Late Pleistocene hunter-gathers, IUP population changes, Core and flake technology, Microlithic technology, East Asian monsoon

Discovery and research at Xuetangliangzi in the Yunxian hominin site, central China

Chengqiu LU[1]*, Hubei Provincial Institute of Cultural Relics and Archaeology (5457167@qq.com)

Abstract

The Xuetangliangzi site is located in Yunyang District, Shiyan City, Hubei Province, in the central part of China. It is renowned for the discovery of Yunxian hominin crania and is also known as the Yunxian Man Site. The site is situated on the left bank of the upper reaches of the Han River, west of the Quyuan River estuary. It is an important Paleolithic site that contains a combination of hominin fossils, mammal fossils, and stone artifacts. The site covers an area of over 1.9 million square meters and has an average thickness of Quaternary deposits reaching 8 meters, preserving stratigraphic deposits from different periods spanning over one million years. In the archaeological survey of 1989, the Yunxian Man No. 1 cranium was discovered. During the first excavation in 1990, the Yunxian Man No. 2 cranium was unearthed. In the seventh excavation in 2022, the even better-preserved Yunxian Man No. 3 cranium, along with a large number of mammal fossils and stone artifacts, was discovered. Compared to the severely deformed yet relatively complete Yunxian Man No. 1 and 2 crania, the newly found Yunxian No. 3 cranium shows no apparent deformation. It is the most well-preserved hominin cranium of the same age ever discovered in the Eurasian mainland. All three crania were found in the same stratigraphic layer, and dating methods, such as electron spin resonance, uranium series, and paleomagnetism, indicate an approximate age of one million years.

Keyword

Paleolithic, Hominin cranium, Yunxian Man

A tale of two widespread Proterozoic fossils: Chuaria and Tawuia assemblage from ~1.0 Ga rocks in North China

Ke PANG[1]*, State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China (kepang@nigpas.ac.cn)
Changtai NIU[2], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Guangjin LI[3], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Qing TANG[4], School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, China
Xiaopeng WANG[5], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Rui HUANG[6], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Hanzhi QU[7], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Mingyang QIU[8], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Bin WAN[9], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Zhe CHEN[10], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Chuanming ZHOU[11], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Xunlai YUAN[12], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

Abstract

The Proterozoic witnessed the emergence and rise of early eukaryotes, which have played an important part in improving the habitability of the early Earth. Proterozoic carbonaceous compression macrofossils can provide important clues to our understanding of the ecological expansion of early eukaryotes as well as their role in the evolution of habitability of the early Earth. Among them, the discoidal to elliptical form chuarid, represented by *Chuaria*, and the elongate to tomaculate form tawuid, represented by *Tawuia*, are among the most common fossil forms in Proterozoic successions, which often co-occur in the same bedding layer and both have extremely long temporal and broad geographical distributions. However, the phylogenetic interpretations of chuarids and tawuids and the relationship between them have been debated for decades, due to their simple morphologies lacking phylogenetically diagnostic features.

To resolve the taxonomic chaos and explore the potential biological relationship of chuarids and tawuids, we used an integrated application of reflected and transmitted light microscopy, scanning electron microscopy, biometric analysis, and Raman spectroscopy to characterize well-preserved carbonaceous compression macrofossils of *Chuaria* and *Tawuia* from the Tonian Liulaobei

Formation (~1.0 Ga) in Huainan region, North China. The fossils are abundantly preserved in a ca. 10–20 mm thick homogeneous mudstone layer and can be considered to be closer to an ecological community than fossils from multiple different layers or localities. The comprehensive analysis shows that even *Chuaria* vesicles from the same layer may have a polyphyletic origin and several groups of *Chuaria* vesicles have been identified. Among them, a group of small *Chuaria* vesicles with minimum diameter <1.2 mm can be related to the sphaeromorphic acritarch *Leiosphaeridia*. In contrast, a group of large *Chuaria* vesicles with minimum diameter ≥1.2 mm are more comparable to the type material of *Chuaria circularis* from the Chuar Group and more closely related, either phylogenetically or ontogenetically, to *Tawuia* vesicles.

The seemingly simple chuarids and tawuids from other Proterozoic successions may also have multiple sources, particularly for *Chuaria*, and their morphological simplicity may be resulted from the convergent evolution of different but morphologically similar organisms. Therefore, the species diversity and maybe also the geobiological role of Proterozoic *Chuaria-Tawuia* assemblages and sole *Chuaria* assemblages might have been underestimated. This study takes a step on the path to solving the mystery of the most common and widely distributed Proterozoic macrofossil assemblage, and urges thorough and systematic evaluations to be taken on the possibility of polyphyletic origins for *Chuaria-Tawuia* assemblages or sole *Chuaria* assemblages in other Proterozoic localities.

Keyword

North China, Liulaobei Formation, Proterozoic, *Chuaria, Tawuia*

Discs from Tonian rocks in North China: Relating discoidal fossils with a central opening to worm-like annulated tubular fossils and their paleoecological and evolutionary implications

Guangjin LI[1]*, State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China (gjli@nigpas.ac.cn)
Ke Pang[2], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Qing Tang[3], School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, China
Chengxu Wu[4], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Rui Huang[5], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Bin Wan[6], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Chuanming Zhou[7], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Xunlai Yuan[8], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

Abstract

The Tonian Period represents a critical transition from a prokaryote-dominated biosphere to a eukaryote-dominated biosphere in the early Earth. However, our understanding of the Tonian benthic eukaryotes and their role in improving the habitability of the substrate of benthic ecosystem is quite limited. Discoidal fossils (e.g., *Chuaria* and abundant unnamed discs) and tubular fossils (e.g., *Tawuia* and the worm-like annulated taxa *Protoarenicola*, *Pararenicola*, and *Sinosabellidites*), dominate most Tonian macrofossil assemblages. Previous work on Proterozoic materials indicated that some discoidal fossils could be detached holdfasts of co-occurring erect benthic organisms, but little attempt has been made to quantify the potential relationship between the discoidal fossils and the discoidal holdfasts of tubular fossils from Tonian successions. Recently, we have confirmed biometric and chemospatial links between discoidal fossils with a central opening and worm-like annulated tubular fossils from the Tonian Jiuliqiao Formation (~950–720 Ma) in Huainan region, northern Anhui province, North China, which supports the notion that the discoidal fossils with central opening represent detached holdfasts of tubular fossils and that tubular fossils with or without a holdfast share a potential biological or ontogenic relationship. Meanwhile, the clustered discoidal fossils with central openings were interpreted as holdfast coalescence (physical contact and fusion of two or more adjacent holdfasts) for Pre-Cryogenian benthic algae, which is supported by the clustered holdfasts of Protoarenicola specimens. Holdfast coalescence may have become a common strategy for Tonian algae in benthic ecosystems as an ecological response to relatively strong hydrodynamic forces. Detached holdfasts and holdfast coalescence may be more common than we

have thought in the Pre-Cryogenian, and the paleoecological and geobiological role of benthic algae and their holdfasts during this period is probably underestimated. Our study also highlights the adaptation of holdfast morphology to Precambrian mat-ground substrate, and provides evidence for the co-evolution of substrate and benthic organismic morphology during this period.

Keyword

North China, Tonian, Holdfast, Discoidal fossil

Symbiotic fossils from the early Ediacaran in South China and their implication for lichenization and bio-weathering

Hanzhi Qu[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (hzqu@nigpas.ac.cn)
Ke Pang[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Tian Gan[3], State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences
Qing Ouyang[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Xunlai Yuan[5], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Shuhai Xiao[6], Department of Geosciences and Global Change Center, Virginia Tech

Abstract

Lichens are symbiotic associations of fungi (mycobionts) and cyanobacteria/algae (photobionts). They are of pivotal importance in continental weathering and landform evolution. However, the scarcity of lichen fossils, particularly in the Precambrian, hampers our ability to reconstruct the tempo and mode of lichen-like symbiosis and to assess the impact of lichen-like organisms on continental weathering. In this study, we systematically re-describe previously reported lichen-like fossils from the early Ediacaran Weng'an biota (~600 Ma) in South China. These fossils are characterized by a non-stratified thallus consisting of filamentous mycobionts and coccoidal photobionts, the latter ensheathed by a translucent envelope. The mycobionts are composed of uniseriate, sometimes dichotomously branching, hyphae and terminal, occasionally intercalary, vesicles interpreted as spores. They share some similarity with Glomeromycetes, most of whose extant representatives (i.e., arbuscular mycorrhizal fungi) develop a symbiotic relationship with vascular plants. The photobionts are preserved with different stages of cell division, the most common of which is the tetrad stage, and can be compared with lichen photobionts from the Early Devonian Rhynie chert. Confocal Laser Scanning Microscopy (CLSM) reveals some possible interactions between the mycobionts and photobionts, including encirclement where the photobionts are partially surrounded by curved hyphae. These interactions imply that the Weng'an lichen-like fossils are protothalli with some symbiotic features yet rather primitive relative to extant lichens. For comparison, we also carried out detailed observations on the possible symbiotic association of filamentous and spheroidal fossils from the basal Ediacaran cap dolostone of the Doushantuo Formation (~635 Ma) in the Weng'an area, South China. Symbiotic association in the basal Ediacaran fossils, probably in a prethallus stage, is still more primitive. Overall, our study of early Ediacaran symbiotic fossils indicates that the origin of lichenization and therefore its impact on the Earth-life system may have a deeper root than previously thought.

Keyword

early Ediacaran, South China, Weng'an Biota, lichen-like fossils, symbiosis

Stromatolites improved the habitability of Precambrian seafloor: Evidence from the molar-tooth structure in the Tonian Jiudingshan Fm., North China

Xubin WANG[1]*, Peking University (xubinwang@pku.edu.cn)
Lin Dong[2], Peking University

Abstract

The oxygenation of Earth's surface environment, primarily the atmosphere and the ocean, is the key to the habitability for metazoans. The Great Oxygenation Event (GOE) and Neoproterozoic Oxygenation Event (NOE) represent permanent rises of atmospheric oxygen levels, representing crucial environmental evolutions during the Precambrian. However, the oxygen level hardly changed between GOE and NOE, a period often referred to as the 'Boring Billion' (~1.8 Ga to ~0.8 Ga). At the end of Boring Billion, The Tonian Period marks a critical node in biological evolution, evidenced by the origin of metazoans from molecular clock dating, phosphatic biomineralization in microfossils, and active predation documented from organic-walled microorganisms. Despite likely sufficient nutrient levels in seawater, including both phosphorus and nitrogen, widespread shallow-water anoxia prevailed in the Tonian oceans. These findings lead to a knowledge gap between the environmental and biological evolutions: how early metazoans can originate, survive, and possibly be diverse in the face of low atmospheric-oceanic oxygen levels. Here, we investigate the petrological features of the Jiudingshan Formation in the Huaibei Group, North China. Abundant and diverse molar-tooth structures (MTs) are found in the Jiudingshan carbonate depositions, which exhibit large divergence in morphology, size, and mineralogy. The sparry matrix could recrystallize around the MTs, suggesting that the matrix is more unstable. MTs only exist in the basal succession, with no evidence of their occurrence in the overlying stromatolite layers. Besides, sedimentary pyrite is observed only at the top of the MTs-bearing succession, suggesting a transition in the marine sulfate pool. The presence of stromatolites overlying MTs probably indicates an environmental shift associated with an increase in sulfate concentration. To sum up, the Jiudingshan Fm. may represent an oxygenation event in the Tonian oceans, likely facilitated by stromatolites, and holds the potential to restrict evolutions within the marine sulfate pool.

Keyword

Molar-tooth structure, Tonian, Stromatolite, Metazoan, Early habitability

Large magnitude sulfur isotope mass independent fractionation indicating subaerial volcanism in 3.8 Ga

Ruimin WANG[1]*, Peking University (ruiminwang@pku.edu.cn)
Bing Shen[2], Peking University
Dominic Papineau[3], University College London
Wei Yang[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Mang Lin[5], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Abstract

The continental crust, mostly above sea level, has been playing key roles in maintaining Earth's long-term habitability. Continental weathering consumes CO2 in the atmosphere, affecting the global temperatures, and supplies nutrients for the surface ocean primary productivity and redox-sensitive components. Thus, understanding when and how continental crust formed is pivotal in unraveling the evolutionary history of habitability. However, evidence for the earliest continental crust formation is limited from both geological and geochemical perspectives. Here, we apply mass-independent fractionation of sulfur isotope (S-MIF) signal of sulfides (e.g., sedimentary pyrites and pyrrhotites) to constrain subaerial volcanic eruptions. We report sulfur isotopes of pyrites and pyrrhotites from 3.8 Ga banded iron formation (BIF) in the Nuvvuagittuq Supracrustal Belt. Nano-SIMS analyses of sulfide crystals reveal limited variations in δ34S but large magnitude S-MIF signals (Δ33S) ranging from -2 to +11‰. The nearly invariant δ34S may indicate absence of dissimilatory sulfate reduction (DSR) or quantitative reduction of sulfate, while the large magnitude S-MIF may imply a large flux of S8 from the atmosphere and mixing with negligible terrestrial H2S. This observation could be interpreted as indicative of extensive subaerial volcanism characterized by high SO2/H2S ratios, suggesting the presence of landmass above sea level. The presence of topographically elevated land mass at 3.8 Ga might have profound impacts on the habitability of the early Earth.

Keyword

mass-independent fractionation of sulfur isotope, sedimentary pyrite, banded iron formation, early Earth, subaerial volcanism

[Keynote] The expansion of marine eukaryotes in the early Neoproterozoic Era

Shuhai Xiao[1]*, Department of Geosciences, Virginia Tech, Blacksburg, VA 24061, USA (xiao@vt.edu)
Junyao Kang[2], Department of Geosciences, Virginia Tech, Blacksburg, VA 24061, USA
Qing Tang[3], School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, China

Abstract

Molecular clocks and paleontological data indicate that the Eukarya diverged from the Archaea no later than the Paleoproterozoic Era (2,500–1,600 Ma). However, the taxonomic diversity, morphological disparity, and ecological importance of marine eukaryotes remained relatively low until the Tonian Period (1,000–720 Ma) of the Neoproterozoic Era. The drivers of taxonomic diversification, morphological expansion, and ecological rise of Tonian marine eukaryotes are poorly understood. In this presentation, we review currently available paleontological and geochemical data to assess various hypotheses about the drivers, including a Tonian intensification of ecological interactions (e.g., predation, symbiosis) and a Tonian increase in the availability of marine macronutrients (particularly phosphate and nitrate) and bio-essential metals. Together, these factors may have enabled the taxonomic, morphological, and ecological rise of photosynthetic eukaryotes in the Tonian Period, which, in turn, opened ecological opportunities for the diversification of eukaryotes overall, resulting in the transition from a prokaryote-dominated to a eukaryote-dominated marine ecosystem. Ultimately, this transition may have led to fundamental changes in export bioproduction, global carbon cycles, nutrient recycling, and marine redox structures. These changes may have had profound impact on the Earth system and in the long run may have contributed to snowball Earth glaciations in the following Cryogenian Period (720–635 Ma).

Keyword

Tonian Period, eukaryotes, phosphate, nitrate, ecological interactions

Unique Archean phosphorous cycle linked to submarine hydrothermal and biological activities

Takeshi KAKEGAWA[1]*, Tohoku University (kakegawa@tohoku.ac.jp)

Abstract

Archean phosphorous cycles have been debated in last decades. On the other hand, the source and speciation of phosphorous in the Archean oceans were still uncertain. Geochemical and mineralogical studies were performed on Archean submarine volcanic rocks and banded iron formations from Pilbara (3.4 Ga), Barberton (3.2 Ga) and Abitibi and Wawa (2.7 Ga). The examined basalts and rhyolites were suffered from submarine hydrothermal alteration and seafloor CO2 metasomatism. They contained various secondary apatite and monazite. This observation and thermodynamic calculations indicate that phosphate was a dominant specie in the migrating fluids, rather than reduced phosphorous species. Altered volcanic rocks are in general depleted in phosphorous concentrations. These findings suggest that Archean oceanic crusts behaved as the source of phosphorous in the global phosphorous cycle. This suggestion is contradicting to the modern phosphorous cycle.

A part of examined BIFs (3.2 Ga and 2.7 Ga) were found to be rich in phosphate (up to 0.8 wt%). In addition, apatite grains are spatially associated with organic matter in the examined samples. This further indicates the phosphate accumulation in BIFs through sedimentary organic matter, not by Fe-(hydro) oxide adsorption. Those results indicate that phosphate concentrations were rather high in the Archean oceans and microbial sink of phosphate were significant in Archean oceans.

Keyword

phosphate, Archean, oceanic crust

Abiotic Sulfur Cycling Model Across Deep Time

Javed Akhter MONDAL[1]*, Deep Space Exploration Laboratory/CAS Key Laboratory of Crust-Mantle Materials and Environments, University of Science and Technology of China, Hefei 230026, China (javed1996@mail.ustc.edu.cn)
Rafael Rianço-Silva[2], Departamento de Física, Faculdade de Ciências, Universidade de Lisboa, 1749-016 Lisboa, Portugal
Henry Jurney[3], Blue Marble Space Institute of Science, Seattle, USA
Marcos Jusino-Maldonado[4], Planetary Habitability Laboratory, University of Puerto Rico at Arecibo
Henderson James Cleaves II[5], Department of Chemistry, Howard University, Washington DC

Abstract

Sulfur is a redox active element that may have helped mediate the electron flow which kickstarted life, and is a bioessential element for all life on Earth. Despite current uncertainties in global sulfur fluxes, modeling sulfur's abiotic cycling through Earth's deep history is important for understanding the impact of a planet-wide biosphere on sulfur's geochemical cycling and availability and vice versa. We present here an open-source, dynamical box model for estimating global sulfur fluxes and concentrations among surface and deep Earth reservoirs over Earth history, allowing tracking and estimation of the sulfur distribution in planetary reservoirs over deep time in the absence of life. While the main model presented here does not take into account the abrupt evolution of redox-shunting biosynthetic pathways such as oxygenic photosynthesis, we also modeled the abiotic sulfur cycle before and after the Great Oxidation Event (GOE) on Earth-like planets. Our results suggest a considerably distinct chemical makeup of sulfur content in marine sediments in the absence of life on an Earth-like planet, leading to a marine sediment sulfate content four orders of magnitude larger than on present-day Earth, attributable to the lack of microbial sulfate reduction. This model could be useful for understanding sulfur cycling on potentially habitable exoplanets.

Keyword

Sulfur, Habitable, Abiotic, Great Oxidation Event, Exoplanets

What happened in Mesoarchean during earth history? Evidence from western Dharwar craton, southern India

Yan ZHAO[1]*, Department of Geology, Northwest University, Xi'an, China (zhaoyan9917@126.com)
Wenhao AO[2], Chang'an University, Xi'an, China
Chengli ZHANG[3], Department of Geology, Northwest University, Xi'an 710069, China
Mingguo ZHAI[4], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
Longlong GOU[5], Department of Geology, Northwest University, Xi'an 710069, China
Junsheng LU[6], Department of Geology, Northwest University, Xi'an 710069, China
Paul Mathews GEORGE[7], School of Mining and Geosciences, Nazarbayev University, Qabanbay Batyr Ave 53 Astana, KAZAKHSTAN- 010000

Abstract

Several special geological phenomena during Mesoarchean have been discovered: (1) significant increase in crustal thickness at ~3.0 Ga; (2) high-K granites widely developed in several cratons at ~3.1-3.0 Ga; (3) all the cratons in the same region of Pangea became stable at – 3.0 Ga. All these evidences suggest that a great geological event happened during Mesoarchean. To plumb what happened in Mesoarchean during earth history, metamorphic rocks metamorphosed at ~3.0 Ga and magmatic rocks formed between ~3.2-3.0 Ga in the western Dharwar craton, southern India were investigated. Metamorphic chronological data of pre-Neoarchean are important but relatively sparse. Mesoarchean (ca. 3.0 Ga) metamorphic rocks, including metamafic and metapelitic rocks, outcrop in the Banavara area, western Dharwar Craton, southern India. They provide a critical example to understand the tectonic evolution of the Dharwar Craton. The main mineral assemblage of metamafic rocks is composed of garnet, amphibole, plagioclase, quartz and partial retrogressive epidote, while main mineral assemblage of metapelitic rocks consists of coarse-grained garnet, quartz, muscovite, biotite, sillimanite and retrogressive chlorite. Metamorphic zircon U-Pb dating of two meta-mafic rock samples yield metamorphic ages of 2967±18 Ma and 2976±14 Ma, respectively. Zircons of two meta-pelitic rock samples yield metamorphic ages of 2959±8 Ma and 2960±9 Ma, respectively, and inherited detrital zircon age of 3202±33 Ma. These metamafic and metapelitic rocks were previously considered as Paleoarchean-Mesoarchean (ca. 3.4-3.1 Ga) rock unit of the Sargur greenstone belt, and underwent amphibolite-granulite facies metamorphism in Neoarchean. This study further confirms that the metamorphism of the Sargur greenstone belt occur in Mesoarchean (ca. 3.0-2.95 Ga). The Mesoarchean magmatic rocks including TTGs and basic intrusive rocks mainly formed at ~3.38-3.21 Ga, and the high-K granites mainly formed at ~3.15-2.96 Ga in the western Dharwar craton. The TTGs and basic intrusive rocks mostly have depleted zircon Hf and whole-rock Nd compositions, while the high-K granites mostly have enriched zircon Hf and whole-rock Nd compositions. These data indicate crustal growth event at ~3.4-3.2 Ga, and crustal reworking event at ~3.1-3.0 Ga in the western Dharwar craton. Combined with the occurrence of the ca. 3.2-3.1 Ga crustal rocks expose in the

eastern Dharwar Craton, it could be speculated that the western Dharwar Craton and the eastern Dharwar Craton might have been a united block before ca. 3.0 Ga. The similar geological events related to Mesoarchean magmatic and/or metamorphic were also discovered in the Kaapvaal craton, Singhbhum craton, Pilbara craton and Gawler craton. Accordingly, we infer that a global-scale crust-mantle interaction may have possibly occurred in Mesoarchean at ~3.2-3.0 Ga.

Keyword

Dharwar craton, Mesoarchean, TTG-greenstone, High-K granite, Metamorphic rock

Molybdenum isotope and oceanic redox evolution during the Cryogenian non-glacial period

Jin LI[1]*, Institute of Geology, Chinese Academy of Geological Sciences (lijin80119@hotmail.com)
Xiang-kun Zhu[2], Institute of Geology, Chinese Academy of Geological Sciences
Fred T. Bowyer[3], School of GeoSciences, University of Edinburgh
Simon W. Poulton[4], School of Earth and Environment, University of Leeds

Abstract

The Datangpo Fm and correlative Xiangmeng Fm record continuous siliciclastic deposition in the Nanhua Basin, South China, during the Cryogenian non-glacial interval (Zhang et al., 2015; Bao et al., 2018; Peng et al., 2019). The formations are sandwiched between two major glacial diamictites, the older Tiesi'ao Fm (Gucheng Fm in western Hunan Province) and the younger Nantuo Fm (Zhang et al., 2008; Peng et al., 2019). Previous δ98Mo studies of organic-rich black shales from the Datangpo Fm (e.g., Chen et al., 2015; Cheng et al., 2018) relied upon extrapolating seawater δ98Mo for the entire Cryogenian non-glacial interval from black shales of the lower Datangpo Fm only, which constitute a small fraction of the total thickness of Cryogenian non-glacial deposits.

Here, we investigate local and global palaeoredox dynamics using integrated Fe-speciation and redox-sensitive trace element (RSE) systematics, in addition to δ98Mo, from drill core Xiangtan (core ZK3603), for which the detailed lithostratigraphy has been described by Peng et al. (2019). We critically assess existing δ98Mo datasets from globally distributed Cryogenian non-glacial successions and use our best estimate of seawater δ98Mo and Mo concentration ([Mo]) to calibrate a single reservoir model in an attempt to better constrain the link between Sturtian deglaciation and global ocean palaeoredox.

The δ98Mo compositions of black shales from the Xiangtan section range from −1.07 to +1.28‰ (mean = +0.66‰). In the Xiangtan section, FeHR/FeT >0.38 demonstrates significant enrichments in highly reactive iron, coupled with high Fepy/FeHR ratios (0.49 to 0.88), including 15 samples >0.6 that have the potential to capture seawater δ98Mo composition. These data suggest that black shales of the Xiangtan section likely accumulated under dominantly sulfidic/euxinic conditions. Samples with FeHR/FeT >0.38 and Fepy/FeHR >0.70 can be subdivided into a lower interval (570 – 510.5 m), where values of δ98Mo remain relatively invariant in the range +0.75 to +0.81‰, and an upper interval (508.5 – 482 m), where δ98Mo has greater variability, in the range +0.27 to +1.28‰.

Integrating published data from the Arena Formation of Greenland with new and published data from the Datangpo and Xiangmeng formations may therefore yield a continuous record of δ98Mo throughout the non-glacial interval. Within this framework, seawater δ98Mo may have approached +1.47‰ in the immediate aftermath of the Sturtian deglaciation, decreased to +0.81‰ during MnOx deposition, and recovered to +1.28‰ in the latter half of the Cryogenian non-glacial.

Keyword

Cryogenian, Mo isotopes, Nanhua Basin, paleoredox, non-glacial

New discovery of rare 3.8 Ga crust in Labashan, eastern China: Petrogenesis and significance

Chunyan DONG[1]*, Institute of Geology, Chinese Academy of Geological Sciences (dongchunyan@sina.com)
Hangqiang Xie[2], Institute of Geology, Chinese Academy of Geological Sciences
Allen P. Nutman[3], School of Earth, Atmosphere and Life Sciences, University of Wollongong, Wollongong, NSW 2522, Australia
Yusheng Wan[4], Institute of Geology, Chinese Academy of Geological Sciences, Beijing

Abstract

Eoarchean rocks are scarce worldwide, limiting our understanding of the Earth's early history. We carried out integrated field and petrographic work, whole rock geochemistry and zircon U-Pb-Hf-O analyses on Eoarchean granitoid rocks, including 3838–3754 trondhjemitic gneisses, 3786–3773 Ma granodioritic gneisses, 3775 Ma quartz monzonite gneiss and 3786–3640 Ma potassic granite gneisses, newly-discovered in the Labashan area, eastern Hebei, North China Craton. The granitoids are identified in a tract 1 km long. They are in tectonic contact with 3.4–3.1 Ga supracrustal rocks, with both occurring as enclaves in 2.5 Ga potassic granite. The trondhjemitic gneisses show low (La/Yb)n values (23.4–56.8) and insignificant Eu anomalies (Eu/Eu* = 0.86–1.24). Compared with the trondhjemitic gneisses, the granodioritic gneisses and quartz monzonite gneiss have lower (La/Yb)n ratios (9.2–11.3) and lower Eu/Eu* values (0.62–0.79). The potassic granites have (La/Yb)n ratios of 20.65–55.23 and insignificant and Eu/Eu* values of 0.75–1.84). Zircon saturation temperatures of the granitoids range from 667 to 878 ℃. They have whole-rock εNd(t) of -4.6 to 1.0 and tCHUR(Nd) of 4.3 to 3.6 Ga, and zircon εHf(t) values of -6.9 to 0.4 and tCHUR(Hf) ages of 4.1 to 3.5 Ga (mainly 4.1 to 3.8 Ga) and δ18O of 4.6 to 7.5 ‰. It is speculated that the granitoids are derived from a mixture of mafic and earliest (>3.8 Ga) tonalitic sources, with the granites representing ‘pure’ melts of older continental crust. The rock types and compositional features show diversity at 3.8 Ga, indicating that by then the local continental crust had reached a high degree of evolution. Two possible models, magma underplating and plate subduction, are explored for the tectonic regime forming the Eoarchean granitoids.

Keyword

Eoarchean, granotiods, Nd-Hf-O isotopes, eastern Hebei, North China Craton

Preservation of early life molecular signatures in a ~2.5 Ga banded iron formation, North China

Jingbo NAN[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (Jingbo.nan@icloud.com)
Zidong PENG[2], Institute of Mineral Resources, Chinese Academy of Geological Sciences
Zongjun YIN[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

Biological organic molecules preserved within Precambrian banded iron formations (BIFs) can provide valuable information about the origin and evolution of life. Metamorphism leads to the alteration of organic molecules associated with traces of early life in BIFs, where certain minerals can serve as protective armors, shielding these organics from decomposition. Despite this, identifying and preserving early life traces in BIFs faces significant challenges. The degree to which remnants of biological organics are preserved, along with the protective capabilities of various minerals during metamorphism, still need to be fully understood. Here, we present petrographic observations and Time-of-Flight Secondary Ion Mass Spectrometry (TOF-SIMS) analyses on the organic matter (OM) in a ~2.5 Ga BIF from North China, which has undergone lower amphibolite-facies prograde metamorphism. The OM is in paragenetic equilibrium with prograde mineral phases and is often associated with apatite that occurs in Fe-rich bands parallel to layering. Raman spectroscopy reveals that the maximum metamorphic crystallization temperature is consistent with the metamorphic peak conditions of the host BIF. The BIF possesses average bulk 13Corganic values of −20.0‰ and δ13Ccarbonate values of −12.9‰, indicating biomass remineralization during prograde metamorphism. TOF-SIMS analyses show the presence of biological molecular remnants, including H-bearing aromatic compounds and N-bearing aliphatic compounds, within the OM. This further supports the hypothesis that the OM likely originates from biomass deposited contemporaneously with the BIF. Notably, the spatial distribution of these molecular remnants exhibits a strong correlation with mineralogy, suggesting that different minerals may offer varying levels of protection to organic molecules during the process of metamorphism. Our findings highlight the importance of understanding how minerals influence the preservation of molecular information related to early life. This understanding is essential for deciphering the complex abiotic interactions between geological processes and the biosignatures on Earth and other rocky planets.

Keyword

early life, banded iron formation, biosignatures, metamorphism

Redox-stratified seawater during the GOE: Evidences from rare earth elemental and C-O isotopic compositions of Paleoproterozoic BIFs and carbonate rocks from the Taihua Group, North China Craton

Cai Yun LAN[1]*, Northwest University (lancaiyun@nwu.edu.cn)
Xiao Ping Long[2], Northwest University

Abstract

The Paleoproterozoic Great Oxidation Event (GOE) is known for the dramatic change in atmospheric composition that led to oxygen becoming a persistent component of global surface processes. Drastic environmental changes greatly affected ocean and atmosphere chemistry. However, the distribution of dissolved oxygen in the ocean during the GOE is still unclear as rare contemporary sediment-records have been found. In order to identify the redox state of both shallow and deep water, and reveal the ocean redox structure during this time, we present new major and trace elemental and C-O isotopic data of bulk samples of the banded iron formation (BIF), dolomitic marble, and graphite-bearing marble of the early Paleoproterozoic upper Taihua Group in the Lushan area, southern margin of the North China Craton (NCC). The BIF samples exhibit typical major and trace element characteristics akin to very pure marine chemical sediments, such as the shale-normalized positive La, Ga, and Y anomalies, indicative of a marine depositional setting. In these BIF samples, both negative Ce anomalies and the lack of Ce anomalies reflect the presence of both oxic and suboxic/anoxic water in the ocean. Samples of the dolomitic marble are characterized by extremely low amounts of crustal material (such as Al, Ti, Zr, Hf) and high Y/Ho ratios (46-66), also implying a pure marine chemical origin. Excluding some contaminated samples, the rest of the graphite-bearing marble samples display similar features of the dolomitic marble. Significant positive Ce anomalies and high light to heavy REE (Pr/Yb(SN)) ratios in both dolomitic marble and graphite-bearing marble are essentially consistent with the 2.2-2.1 Ga carbonates from the Guanmenshan Formation of the Liaohe Group in the NE Sino-Korean Craton. Combined with the Ce anomalies in the BIF samples, we consider that the seawater when the upper Taihua Group deposited was redox-stratified from oxic shallow water to deeper anoxic water. Besides, the graphite-bearing marble record coeval surface water in the column that was enriched in nutritive materials and beneficial to microbiology and high productivity. Moreover, the early Paleoproterozoic IFs in the Songshan Group and the Lüliang Group in the NCC also exhibit significant both positive and negative Ce anomalies and enrichment of redox sensitive elements. These evidences, therefore, suggest that redox-stratified seawater occurred extensively during the GOE.

Keyword

North China Craton, Great Oxidation Event, C-O isotopes, Rare earth elements, Redox

Preliminary observations of fulgurites: prebiotic sources of reduced phosphorus on early Earth

DongJun KIM[1]*, Metropolitan Seoul Center, Korea Basic Science institute/ Kangwon National University (donzon94@kbsi.re.kr)
Sae Jung Chang [2], Metropolitan Seoul Center, Korea Basic Science institute
Kideok Kwon [3], Department of Geology, Kangwon National University
Ruth E. Blake[4], Department of Earth and Planetary Sciences, Yale University
Matthew A. Pasek [5], School of Geosciences, University of South Florida

Abstract

Phosphorus (P) occurs on Earth primarily in fully-oxidized form as phosphate (HPO_4^{2-} at pH 8, represented here by PO_4 to encompass the range of protonation states and ion pairs) with a valence of 5+ and is conventionally thought of as having no significant redox chemistry. However, recent discoveries have shown that phosphorus (P), not as phosphate (PO_4 with P^{5+}) but as phosphite (PO_3 with P^{3+}), could have been a major source of phosphorus for pre-biotic synthesis and major nutrient in early pre-oxygenated oceans (Pasek, 2008).

The highly energetic nature of lightning causes the abiotic reduction of phosphate and provides reduced P-compounds to modern near-surface earth environments. Pasek and Block (2009) proposed cloud-to-ground high energy lightning strikes as an important source of reduced-P (both phosphide/Fe_3P and phosphite). Fulgurites, commonly composed of glass and fractured minerals, are the product of cloud-to-ground lightning strikes. Fulgurites could have been a significant source of prebiotic and bioavailable phosphorus instead of apatite, known as the most common form of phosphate minerals on Earth surface environment (Hess et al., 2021).

The goal of this study is to determine oxygen isotope systematics of phosphorus redox chemistry. Here, we will present preliminary mineralogical and chemical compositions of fulgurites (Type III) from La Paz County and Yuma County, Arizona, in addition to their oxygen isotopic composition of natural phosphite (PO_3) from fulgurites to evaluate initial prebiotic oxygen isotope signatures of phosphite (PO_3) as well as co-evolution of these prebiotic oxygen isotope signatures and life.

Keyword

Fulgurite, phosphite, phosphate, oxygen isotope

The coming and going of banded iron formation

Bing SHEN[1]*, Peking University (bingshen@pku.edu.cn)
Ruimin Wang[2], Peking University

Abstract

Banded iron formations (BIFs), featured by rhythmic Fe-rich and Si-rich mm- to cm-thick laminae, is the Archean and Paleoproterozoic landmark, and did not show up in the rest of Earth's history except for a brief reprise in the Cryogenian global glaciations (~0.7 Ga, billion years ago). The up and down of BIFs have been attributed to the wax and wane of marine Fe2+ inventory, while Si precipitation, as a background, was decoupled with the Fe cycle. However, the mid-Proterozoic ocean was predominantly ferruginous (Fe2+ rich), and non-BIFs iron formations (IFs) are not uncommon, casting doubts on the Fe-depletion as the primary reason for the shutdown of BIFs factory. Here, we show genetic relationships between Fe, Si, and P mineral phases, suggesting the coupled Fe-Si-P cycles in the BIF formation. We propose that rhythmic depositions of Fe-rich and Si-rich laminae may reflect cyclic fluctuations of Fe redox cycles, consisting of Fe2+ oxidation in seawater and microbial FeOOH reduction in sediments. FeOOH shuttled seawater Si and P into sediments, and a large Si flux that is required for BIFs only occurred in Si-rich oceans. The disappearance of BIFs in mid-Proterozoic might result from declines of seawater Si content due to the evolution of eukaryotes and mild oxygenation of the atmosphere, enhancing Fe redox cycles in globe. Reoccurrence of BIFs might result from a sluggish Fe redox cycle, allowing accumulations of Fe and Si, in anoxic and organic-lean Snowball Earth oceans. The post-glacial oxygenation restricted the Fe redox cycle predominantly within sediments, and the epoch of BIFs eventually and ultimately ended. This model highlights the essential role of microbial activities in BIFs formation, implying BIFs as a biosignature for life in early Earth and other planets.

Keyword

Banded iron formations, Fe biogeochemical cycle, Precambrian, Biosignature

Overlooked role of dissolved ferrous iron in the adsorption of phosphate by clay minerals: Implications for phosphorus cycling on the early Earth

Xing CUI[1]*, The University of Hong Kong (cxing1124@163.com)
Zongbin Zhang[2], University of Science and Technology of China
Jihua Hao[3], University of Science and Technology of China
Guochun Zhao[4], The University of Hong Kong
Min Sun[5], The University of Hong Kong

Abstract

Phosphorus is an essential nutrient element for life and its availability is one of the limiting factors for primary productivity. Recent studies have highlighted the roles of clay minerals in delivering phosphorus by surface adsorption to the early ocean under the anoxic and ferruginous conditions of early Earth. One critical finding from the adsorption experiment is that a large amount of phosphorus adsorbed by clay minerals could be back released when transitioning from acidic and diluted river water to more alkaline and saline seawater, which could greatly promote early biological productivity. However, these adsorption experiments do not consider the potential influence of high contents of dissolved ferrous iron (Fe2+) in early anoxic waters on the adsorption. In this study, we conducted batch adsorption experiments under anoxic conditions to simulate the adsorption of phosphate by kaolinite in Archean marine and river water, emphasizing the effect of dissolved Fe2+. Our preliminary results show that the adsorption of phosphate onto kaolinite was greatly promoted in the presence of moderate levels of dissolved Fe2+ relevant to the early seawater, thus challenging the previously proposed “kaolinite shuttle” hypothesis that emphasizes the role of clay minerals as carriers for transporting phosphorus from river to seawater on early Earth. This work was financially supported by Internal Grants for HKU Faculty Start-up Fund (000250348).

Keyword

phosphorus cycling, early Earth, clay minerals

Cr-Cd isotopes track redox and nutrient conditions during the rise of biomineralizing organisms: The Ediacaran Taguatiya Guazú Fm., Paraguay

Fabricio CAXITO[1]*, Universidade Federal de Minas Gerais (facaxito@gmail.com)
Robert Frei[2], University of Copenhagen
Gabriel Antunes[3], UNESP
Lucas Warren[4], UNESP
Juliana Okubo[5], UNESP
Gabriel Uhlein[6], Universidade Federal de Minas Gerais
Jesper Allan Frederiksen[7], University of Copenhagen

Abstract

The Ediacaran-Cambrian transition is a key interval of Earth's history, when some of the most important biological, tectonic, climatic and geochemical shifts changed the surface of the planet unidirectionally and set the stage for the Phanerozoic. To test how interlinked the variations in one of those spheres were connected to the others, proxy tools that can be used to identify the possibly changes in key variables such as nutrients and oxygen availability need to be applied on fossil-bearing successions. This approach has proven to be the most appropriate permitting to infer the possible influence of paleoenvironmental factors on the development and diversification of early complex life. The Ediacaran mixed siliciclastic carbonate Tagatiya Guazú Formation, Itapucumi Group, covers the southern part of the Rio Apa block in northeastern Paraguay and is interpreted as deposited in a shallow rimmed ramp bordering southwestern Gondwana. Due to the presence of an abundant and diverse late Ediacaran fossil assemblage and a robust stratigraphic sedimentological and isotopic background, this unit is an ideal basin to test the hypothesis of nutrient and redox control on such biological communities, as it contains microbialites with in-situ Cloudina and Corumbella remnants, locally associated with ichnofossils such as Archaeonassa. We apply two carbonate-based modern isotopic techniques to track, respectively, redox and nutrient conditions during deposition of the Taguatiya Guazú Formation: Cr and Cd isotopes, along with novel trace elements and Sr isotope data, in two different sections (PLI and PLIII). The carbonate samples show slightly MREE(Middle Rare Earth Element)-enriched patterns and Y/Ho ratios around 26-32. Cr isotopes are fractionated throughout the two studied sections, with authigenic delta53Cr values ca. 0 to 0.5‰. The levels containing trace fossils are especially enriched, reaching as high as ca. 1‰, indicating important oxidative weathering in the source areas. Conversely, Ce anomalies are muted throughout most of the two sections (Ce/Ce* around 0.9), but in the levels containing trace fossils they plunge down to ca. 0.67, indicating important Ce cycling and manganese oxide precipitation. Authigenic Cd isotopes show variable fractionation, reaching delta114Cd values as high as 5.57‰; in the trace-fossil bearing levels, delta114Cd is around 4‰. These values indicate increased uptake of Cd, among other nutrients, into phototrophic plankton, supporting high levels of primary productivity. Finally, 87Sr/86Sr is homogeneous around 0.7086 for section PLI and around 0.7090 for section PLIII, indicating typical late Ediacaran seawater signatures. Our results shed light into the biogeochemical cycles

during the rise of metazoans, and suggest that the first complex organisms thrived in shallow oxygenated seas under favorable nutrient conditions that fueled trophic chains during the final amalgamation of Gondwana. This work is supported by Instituto Serrapilheira through Project “MOBILE: Mountain Belts and the Inception of Complex Life on Earth (geolifemobile.com)” (Serra-1912-31510) and by CNPq-Brazil through grants nb. 408815/2021-3 and 304509/2021-3.

Keyword

isotope stratigraphy, Gondwana, Ediacaran, oxygenation, redox

Ediacaran diamictites and glaciation in North China

Yongqing LIU[1]*, Institute of Geology, CAGS (liu_cags@126.com)
Hongwei Kuang[2], Institute of Geology, CAGS
Xiaoshuai Chen[3], Institute of Geology, CAGS
Yuchong Wang[4], Institute of Geology, CAGS

Abstract

The Ediacaran glacial deposits are developed in the North China Craton, Tarim Craton and the microblocks among them, where they can extend for 3000 km from east to west. However, the chronology, scale of glaciation, paleogeographic reconstruction and tectonic setting are still controversial. Based on the spatial distribution, stratigraphy and sedimentary sequence, sedimentary environment and sedimentary facies of the Ediacaran diamictites in northern China, combined with previous literatures at home and abroad, the above issues related to Ediacaran glaciations are systematically analyzed. This paper revealed that during the Ediacaran, there should have been a glaciation of younger than 580 Ma (Gaskiers) all over the world. The age constraints of the Ediacaran glaciations in northern China were placed between 583 and 551 Ma, and the subglacial, periglacial, and proglacial sedimentary facies can be identified; these form the diamictite from subglacial to proglacial, followed by normal marine sedimentary sequences vertically (in ascending order), in line with the sedimentary response pattern of continental glacier (ice sheet). The Ediacaran diamictites and glacial erosional forms are widespread distributed globally, and the cap dolostones can be developed above the diamictites, exhibiting sedimentary structures similar to the Cryogenian cap dolostones, but the carbon isotope characteristics of them are not the same. This paper speculates that the Proto-Tethys Ocean and its surrounding continents may have developed continental ice sheets during the Ediacaran, but there was no affinity between the Asian blocks and the Gondwana supercontinent. The results provide geological evidences for the global paleogeographic reconstruction and tectonic setting restore of the Ediacaran period.
It is co-funded by the National Natural Science Foundation of China (No. 42072135), the National Key Research and Development Program (No. 2022YFF08003021), the project of China Geological Survey (No. DD20221649) and the International Innovation Resources Cooperation Project of the Beijing Science and Technology Commission (No Z201100008320007).

Keyword

Ediacaran, North China, Glacial diamictites, Continental ice-sheet, Global

Was there a palaeo-ocean in South China during the late Tonian to Cambrian? – Evidence from provenance variation across the Xiang-Gui-Yue Basin

Yang TIAN[1]*, Wuhan Center, China Geological Survey (Geosciences Innovation Center of Central South China), China (41834572@qq.com)
Zhijun NIU[2], Wuhan Center, China Geological Survey (Geosciences Innovation Center of Central South China), China
Wei WANG[3], School of Earth Sciences, State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, China

Abstract

The South China Block was formed by the amalgamation between the Yangtze and Cathaysia blocks, after the closure of the South China Ocean. However, the closure time of this ocean is still controversial with ages proposed ranging from Neoproterozoic to early Paleozoic. Provenance analysis of siliciclastic rocks outcropped at the Xiang-Gui-Yue (XGY) Basin across the potential suture zone between the Yangtze and Cathaysia blocks, was used to reveal whether the two blocks were separated by a palaeo-ocean during late Tonian to Cambrian. An obviously provenance transition from the Yangtze-derived (dominated by ~0.8 Ga zircons) to the Cathaysian-derived (dominated by ~0.98 Ga zircons) detritus was founded in the whole XGY Basin, while this transition happened gradually changed at Cryogenian, Ediacaran and Cambrian respectively, from the southeast to northwest parts of the XGY Basin. Cathaysian-type detritus continued to transport towards northwestward as probably caused by uplift of the Cathaysia Block. Collectively, the XGY Basin was mainly fed by Yangtze-derived detritus during late Tonian, while the Cathaysia-derived sediments became prevail since then. In details, the Cathaysian-derived detritus arrived at the southeastern, central, northeastern part of the XGY Basin at Cryogenian, Cambrian, and Ordovicain respectively. This provenance change argues against the existence of a broad palaeo-ocean during the late Tonian to Cambrian in the South China. Combined with sedimentary sequence and associated volcanism, the XGY Basin was a rift basin until ca. 660 Ma, following by the development of a passive margin basin during Ediacaran-early Cambrian and a foreland basin after the middle-late Cambrian.

Keyword

Detrital Provenance, Siliciclastic migration, South China, Late Tonian to Cambrian

Ediacaran-Cambrian transition events in the peninsular India: Insights from isotope stratigraphy and geochronology of Bilara carbonates, Marwar Supergroup

Bivin Geo GEORGE[1]*, Indian Institute of Technology Bombay (bivingeo@gmail.com)
Jyotiranjan RAY[2], Physical Research Laboratory

Abstract

Peninsular India hosts a number of Proterozoic sedimentary successions; of which some continue well into the Cambrian. These successions contain largely undeformed and unmetamorphosed marine carbonate units which are believed to have recorded physical and/or chemical evidence for the important global events of the Proterozoic and early Paleozoic such as 'snowball Earth' glaciations, Shuram δ13C excursion, terminal Ediacaran and early Cambrian extinctions. However, the attempts to unravel such information from these rocks have been limited. In search of chemical and physical evidence of some of these events, we studied Bilara Group, the carbonate unit of late Neoproterozoic – early Paleozoic Marwar Supergroup.

87Sr/86Sr of the limestone formation of the Bilara Group shows variation from 0.70810 to 0.70916 indicating an early Cambrian (520 - 539 Ma) depositional age for the Group. The 207Pb/204Pb-206Pb/204Pb isochron of the same limestone formation yielded an age of 537 ± 19 (2σ) Ma further confirming the age estimate suggested by 87Sr/86Sr-stratigraphy. δ13C stratigraphy of the Bilara Group revealed negative excursions of magnitudes ~6‰ and ~7‰, respectively, in the middle and lower parts of the Bilara Group, respectively. Since these δ13C anomalies are observed through-out the Marwar Basin that was connected to global oceans, it is likely that they represent temporal changes in the seawater chemistry. Using the principles of δ13C stratigraphy and the available geochronological information, we correlate the middle Bilara anomaly to Shiyantou carbon isotope excursion (SHICE) and the lower one as basal Cambrian carbon isotope excursion (BACE). δ13C and 87Sr/86Sr stratigraphic records along with Pb-Pb age suggests that the Ediacaran-Cambrian transition in the Marwar Supergroup is likely contained within the Bilara Group, and it is the first such report from the peninsular India.

Keyword

Neoproterozoic, Cambrian, Chemostratigraphy, Pb-Pb dating, India

Discussion on a lectostratotype proposal for the Ediacaran Sete Lagoas Formation, Bambuí Group, Brazil

Matheus DENEZINE[1]*, University of Brasília (matheusdenezine@gmail.com)
Lucas BITTENCOURT[2], University of Brasília
Dermeval Aparecido DO CARMO[3], University of Brasília
Martino GIORGIONI[4], University of Brasíllia
Marcos Cistovão BAPTISTA[5], Geological Survey of Brazil
Rodrigo Rodrigues ADÔRNO[6], Geological Survey of Brazil
Edi Mendes GUIMARÃES[7], University of Brasília
Lucieth Cruz VIEIRA[8], University of Brasília

Abstract

The Neoproterozoic deposits in the western portion of the São Francisco basin, which was contiguous with the Congo craton, are represented by the Jequitaí Formation and the Bambuí Group. The Sete Lagoas Formation represents the basal unit of the Bambuí Group and consists of a sequence of carbonate-dominated sediments in the São Francisco basin. Even though five formations have been formalized within the Bambuí Group, the type sections of these lithostratigraphic units were never formally described. The International Stratigraphic Guide establishes that a formal lithostratigraphic unit must have a type locality and a stratotype section with a clear characterization. As a stratotype was never described for the Sete Lagoas Formation, a proposal of a lectostratotype is highly recommended. Additionally, the designation of a lectostratotype section is a possibility to complement the definition of a lithostratigraphic unit. Due to the lack of a formal proposal for a stratotype section for the Sete Lagoas Formation, the Rei do Mato cave section is discussed as a potential candidate for a lectostratotype designation. This section is located inside the borders of the Gruta Rei do Mato Conservation Unit, Sete Lagoas County, Minas Gerais State, southeastern Brazil, Datum WGS84, 23K, 575103 mE, 7844059 mN (UTM). This section is 125 meters thick, and the upper boundary with the Serra de Santa Helena Formation outcrops. However, the basal boundary of the Sete Lagoas Formation with the underlying lithostratigraphic unit is not exposed in this area, and the rocks of the Sete Lagoas Formation rest on top of a Paleoproterozoic gneiss–migmatite basement. The section consists predominantly of limestones, with little or no contribution of siliciclastics. The main lithologies are pure calcarenites, light to dark gray, with variable grain size, and presenting a high diagenetic grade. In the basal and intermediate portion of the section, sedimentary structures such as hummocky and swaley cross-bedding, soft-sediment deformation comprising synforms, and convoluted bedding occur. This lithofacies association indicates deposition below the fair-weather wave base, in a transitional environment influenced by storms, and associated with a sloped carbonate ramp with a high accumulation rate. In the upper portion of the section, the lithofacies display a greater amount of low-angle, tabular cross-lamination, climbing ripples, herringbone cross-stratification, and the occurrence of bifurcated columnar stromatolites. Such morphotype of microbialites was classified as possibly belonging to the Genus *Gymnosolen* Steinmann, 1911.

The distribution of these stromatolites varies laterally, depending on the paleoecological conditions, possibly representing a stromatolitic internal carbonate ramp, influenced by waves or tides. The interval above the stromatolites presents a more significant contribution of siliciclastic material, consisting of marls overlain by massive laminated siltstones, representing the transition to the Serra de Santa Helena Formation. This boundary can represent a major marine transgression associated with paleoenvironmental changes, in which the platform becomes influenced by siliciclastic materials from the craton.

Keyword

Sete Lagoas Formation, Bambuí Group, Lectostratotype

Orbitally-paced carbon-isotope excursion and sedimentary rate during the middle-late Cambrian

Jixuan WANG[1]*, China University of Petroleum (East China) (1079299440@qq.com)
Guanghui YUAN[2], China University of Petroleum (East China)
Zhonggui HU[3], Yangtze University
Shilin Li[4], Chongqing Gas Mine, PetroChina Southwest Oil and Gas Field Company, Chongqing 402160, China
Yulai Pang[5], Chongqing Gas Mine, PetroChina Southwest Oil and Gas Field Company, Chongqing 402160, China

Abstract

Important events occurred during the Cambrian, including extinction events, biotic turnover, eustatic sea-level events, carbon isotope excursion, and climatic perturbations. Due to the lack of data from the Cambrian, a valid temporal framework for the Cambrian and major events cannot be constrained, and the key forcings of sea-level change on the million-year (Myr) scale remains controversial. Here, the high-resolution gamma-ray logs (GR) and carbon isotope of a Well LT are utilized to conduct cyclostratigraphic analysis of the middle-late Cambrian Drumian -Stage10 Xixiangchi Formation of the Well LT in South China. A ~17.992 Myr-long high-resolution astronomical time scale across Drumian -Stage10 is developed by astronomical tuning of gamma-ray logs to the stable 405-kyr long orbital eccentricity cycles. The Myr-scale sea-level fluctuations in the middle-late Cambrian are reconstructed through the sedimentary noise modeling of the 405-tuned GR series. The correlation of filtered ~2.2 Myr cycles of sedimentary noise curves with the filtered ~2.2 Myr long orbital eccentricity modulation cycles of carbon isotope excursion demonstrates that the sea-level variations of ~2.2 Myr long orbital eccentricity modulation cycles may be a primary driver for carbon isotope excursion during the middle-late Cambrian period, further contributing to the late Cambrian SPICE (Steptoean Positive Isotopic Carbon Excursion). Sedimentation rate evolution in carbonates of the 405-kyr long orbital eccentricity cycle time model for the middle-late Cambrian may be related to mineral content, sea-level variations, and carbon isotope excursion. Our results enhance knowledge of the connection between Myr-scale sea-level variations and carbon isotope excursion and provide new empirical constraints on the deep-time evolution of sedimentation rates.

Keyword

Drumian -Stage10, cyclostratigraphy, sedimentary noise modeling, carbon isotope excursion, sedimentary rate

Multiple glacio-eustatic cycles through the Hirnantian (Late Ordovician) in South China: correlations between the nearshore and offshore outcrops

Chao LI[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (chaoli@nigpas.ac.cn)
Junpeng Zhang[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Wenjie Li[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Qing Chen[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Yuandong Zhang[5], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Junxuan Fan[6], School of Earth Sciences and Engineering, Nanjing University

Abstract

The end–Ordovician Glaciation (also known as Hirnantian Glaciation) was one of the three major glacial events in the Phanerozoic. Although this glaciation lasted for a short time, it had a significant impact on Earth's environment. This glaciation triggered the dramatic fluctuations of isotopic composition of ocean water and the redox state of the seafloor, along with the end-Ordovician Mass Extinction. To figure out how the glaciation affected the biological evolution processes and the changes in seawater chemical condition, it is necessary to explore the development processes of glaciation and the glacio–eustatic cycles. Over the past decades, it has been recognized that the end-Ordovician Glaciation consisted of multiple ice sheet expansions and retreats.

Four sections of scientific drill cores, the Wells HY–1, HG–1, SH–1 and YW–1 in South China are selected as the main material for the present study. These wells are close to four classic outcrop sections of near-shore to offshore facies on the Yangtze Platform, i.e., the Honghuayuan, Huanggexi, Shuanghe, and Wangjiawan sections, which provides a precise correlation between the wells and the outcrop sections. Continuous, non-destructive, high-resolution core scanning (34770 data points) of element concentration, measurements of major and trace element concentration (268 samples), and analyses of organic carbon isotopic composition and TOC (333 samples), as well as sedimentary facies analyses (67 thin sections), were carried out for a total length of 34.77-meter fresh drill cores with depositional age ranging from the Katian (Ordovician) to the Rhuddanian (Silurian).

The results of microfacies analyses, and the chemical index of alteration (CIA), silicon-aluminum ratio (Si/Al), zirconium-aluminum ratio (Zr/Al) and sum of aluminum-potassium-titanium (Al+K+Ti), show that the end Ordovician Glaciation began at the end of Katian (the upper Paraorthograptus pacificus Biozone) and terminated in the late Hirnantian (the lower-middle part of the Metabolograptus persculptus Biozone), represented by a large glacio–eustatic cycle. The results also show that the glaciation consists of three secondary glacio–eustatic subcycles as recorded in South China, the first occurred at the Katian–Hirnantian transition (the topmost Paraorthograptus pacificus Biozone to the basal Metabolograptus extraordinarius Biozone), the second in early Hirnantian (the upper part of the Metabolograptus extraordinarius Biozone to the basal Kuanyinchiao Bed), and the third in late Hirnantian (the upper part of the Kuanyinchiao Bed

to the lower Metabolograptus persculptus Biozone), which likely represents the glacial maximum . The glacio–eustatic cycles in South China during the end-Ordovician Glaciation are consistent with those cycles recognized by tillite depositions and the glacio–eustatic cycles identified elsewhere.

Keyword

end–Ordovician Glaciation, core element scanning, South China Block, glacio–eustatic cycle, bio–environmental co–evolution

The sedimentary characteristics and stratigraphic framework of the Cryogenian in the northwestern Yangtze Craton

Xiaoshuai CHEN[1]*, Insititute of Geology, CAGS (chenxiaoshuai34@126.com)
Hongwei Kuang[2], Institute of Geology, CAGS
Yongqing Liu[3], Institute of Geology, CAGS
Yuchong Wang[4], Institute of Geology, CAGS
Nan Peng[5], Institute of Geology, CAGS
Kening Qi[6], Institute of Geology, CAGS
Yi Zhang[7], State Key Laboratory of Coal Mine Disaster Dynamics and Control, School of Resources and 9 Safety Engineering, Chongqing University

Abstract

There are relatively few sedimentological studies on the Cryogenian in the northwestern Yangtze Craton, especially in the Chengkou area of Dabashan Mountain, and whether the Cryogenian Muzuo/Mingyue and Dai'anhe formations have glacial sedimentary characteristics is also lack of detailed sedimentological interpretation, which restricts the understanding of sedimentary evolution process of the Cryogenian in the Yangtze Craton, and is not conducive to the determination of the sedimentary stratigraphic framework and regional correlation of the Cryogenian. In this paper, four typical Cryogenian sections in the Chengkou area are selected to carry out a detailed stratigraphic and sedimentological study, and the glacial sedimentary marks such as the gravels with glacial striae, dropstone, and subglacial soft sedimentary deformation are identified to prove the glacial genesis of the Dai'anhe and Muzuo/Mingyue formations. The facies of continental, periglacial and marine glacial are also discerned. On this basis, according to the rock assemblages, sedimentary characteristics, structure of stratigraphic succession, geochemical indexes (such as chemical index of alteration) and detrital zircon U-Pb age, the Dai'anhe Formation is divided into two members. The first member is correlated with the Gucheng Formation, the second member is correlated with the Datangpo Formation, and the Muzuo/Mingyue Formation is correlated with the Nantuo Formation. Further, through regional correlation, the stratigraphic framework of the Cryogenian in the northwestern Yangtze Craton is re-determined, and can be correlated with that of in the adjacent Shennongjia area and southeastern Yangtze Craton. The sedimentary co-evolution process of the Cryogenian in the Chengkou-Shennongjia areas is: during the Stuartian glacial period, the glacial transgressive-regressive cycle from the glaciomarine to the land and then to the glaciomarine developed, and then the extensive transgression of the interglacial period formed a lagoon environment represented by carbonaceous silty mudstone. With the global temperature falling again, the Marinoan glacial period was triggered, which was reflected in the multiple glacial dynamic evolution from the glaciomarine ice-proximal to the ice-distal environment, and accompanied by the opening of the ice sheet and finally to the end of the Cryogenian. The research has determined the correlation and subdivision of the Cryogenian in the northwestern Yangtze Craton, providing new basic data and important basis for the correlation of the Cryogenian in the Yangtze Craton.

It is co-funded by the the National Natural Science Foundation of China (No. 42072135, 42302123), National Key Research and Development Program (No. 2022YFF0800302, 2016YFC0601001), the project of China Geological Survey (No. DD20221649) and the International Innovation Resources Cooperation Project of the Beijing Science and Technology Commission (No Z201100008320007).

Keyword

northwestern Yangtze Craton, Cryogenian, stratigraphic framework, glacial sedimentology, sedimentary co-evolution

Sedimentology and timing of the Klipheuwel Group, South Africa – anatomy of a Cambrian-Ordovician failed rift in southwest Gondwana

Ruan Francois RAATH[1]*, Stellenbosch University (18971601@sun.ac.za)
Cameron PENN-CLARKE[2], University of the Witwatersrand
Clarisa VORSTER[3], University of Johannesburg
Alexander F.M. KISTERS[4], Stellenbosch University

Abstract

Detrital geochronology of 700 zircon grains and in-depth sedimentological characterisation of the upper Cambrian, coarse clastic deposits of the Klipheuwel Group provide new evidence for the onset of rift-type tectonics shortly after Gondwana amalgamation. Isolated Klipheuwel exposures in southern South Africa reveal the presence of at least two distinct depocentres (informally: “northern”- and “southern” Klipheuwel depocentres), highlighting independent sedimentation controls responsible for the deposition of the Klipheuwel Group in an extensional setting.

Deposits in the northern depocentre are characterised as “braided sheets” with lithologically lateral continuous beds reaching maximum thicknesses of 400 m that onlap the Pan-African basement. Here, palaeo-flow vectors suggest southeastern palaeocurrent indicating a north-northwestern source of detritus. Detrital zircon geochronology shows distinctly bimodal distribution with peaks at ca. 540 Ma and 1050 Ma. Older zircon populations (ca. 1050 Ma) indicate the influence and detrital input from the Namaqua-Natal Metamorphic Belt (1200 – 950 Ma) to the immediate north, whilst the younger detrital population (ca. 540 Ma) is likely derived from the local Cape Granite Suite (555 – 515 Ma) and/or South American granites from the Pampean Belt (580 – 510 Ma).

Deposits in the southern depocentre are characterised as “braided channels” with rapid facies changes over short distances. These deposits are fault-bounded and preserved in half-graben structures, likely reutilizing, and reactivating older Pan-African basement shear zones. In contrast to the northern depocentre, deposits in the southern depocentre are thicker (> 2000 m) with a northwestern palaeocurrent indicating a south-southeastern source of detritus. Here, detrital geochronology shows distinctly unimodal signature with a population peak at ca. 530 Ma, which likely reflects local derivation of the directly underlying Cape Granite Suite (555 – 515 Ma). The source of six younger zircons, ca. 510 – 488 Ma, from the southern depocentre, is enigmatic in origin when considering only local source terranes but may have potential ties to middle- and late-Cambrian granitoids on neighbouring continental fragments (i.e. North Patagonian Massif and Deseado Massif).

The maximum depositional age of ca. 488 Ma, for the Klipheuwel Group, straddles the Cambrian-Ordovician transitional boundary and notably coincides with the late-Cambrian, early-Ordovician emplacement of coast-parallel mafic dykes in Namaqualand to the immediate north that are tentatively related to mafic, magmatic underplating and a possible mantle plume. Other Cambrian-Ordovician deposits from South America, (Nahuel Niyeu and the Olta Formations) display similar geochronological zircon populations and similar lithological characteristics, which could be

considered as regional, rift-related depositional equivalents, although linkages remain tenuous. This points to continental scale extensional tectonics immediately following Gondwana amalgamation, conducive to subsequent deposition of the far more extensive Cape Supergroup in South Africa.
This study of the Klipheuwel Group interprets numerous new detrital zircon ages and reevaluates the sedimentology of these enigmatic depocentres, both locally and regionally, in a post-Gondwana, pre-Cape setting. Partly fault-controlled rift-type sedimentation, coinciding with rift-parallel dyke formation and mafic underplating as well as correlations with sequences in South America around the Cambrian-Ordovician boundary, implies that the Klipheuwel Group likely represents depositional relics of the regional Cambrian-Ordovician failed rift.

Keyword

Gondwana, Failed rift, Cambrian-Ordovician sedimentation

Application of the Wavelet Transform coupled with Fischer plots and INPEFA in Sequence Stratigraphy

Yu ZHANG[1]*, School of Geosciences, China University of Petroleum (East China), Qingdao, 266582, ShandongPR China (zhangyu136097@163.com)
Taixun Liu[2], School of Geosciences, China University of Petroleum (East China), Qingdao, 266582, ShandongPR China
Jie Wen[3], School of Geosciences, China University of Petroleum (East China), Qingdao, 266582, ShandongPR China

Abstract

In recent years, the exploration and development of deep-water petroleum resources in the South China Sea region has shown significant potential for increasing reserves and production. In offshore areas with few wells, the limited availability of paleontological fossils and rock data makes it challenging to accurately classify stratigraphic sequences using traditional methods. This difficulty hinders the exploration and development of oil and gas reservoirs. To accurately characterize the transverse distribution of sand bodies and improve the prediction accuracy of sand bodies, the second-order sequence La was divided by sequence stratigraphy in this study. Based on traditional stratigraphic division methods research, such as seismic interpretation, stratigraphic correlation, and core observation, INPEFA and wavelet transform can be utilized to analyze the gamma ray (GR) curve. This process can enhance the inflection points and changing trends of the curve while minimizing human intervention. A method combining the Continuous Wavelet Transform (CWT) and Fischer plots is proposed to identify sequence boundaries and achieve high-resolution stratigraphic correlation. In this study, the Morlet wavelet was selected as the optimal wavelet mother function due to its excellent periodicity and significant variability. Based on the modulus average value of the GR of the Morlet wavelet at various scales, it is compared with core and well-logging data. The optimal scale factors are determined to be 40,20, and 10, corresponding to the long-term cycle, the medium-term cycle, and the short-term cycle, respectively. By analyzing the sequence characteristics of a large number of core segments and the corresponding CWT results (wavelet coefficient curve and time-frequency energy spectrum), three main types of sequence cycles (progradational, accretive, and regressive) are identified and applied to the entire well section in the study area. Based on the division of the short-term cycle and the identification of the medium-term cycle, the Fischer plot is used to determine the long-term cycle and validate the results using the CWT. Finally, comparing the application range and effectiveness of INPEFA and wavelet transform.

The results show that La can be divided into 5 long-term cycles,13 medium-term cycles, and 38 short-term cycles using maximum entropy spectral analysis and wavelet transform. The high-resolution sequence stratigraphy, which is based on the combination of the Continuous Wavelet Transform and Fischer plots, demonstrates agreeable practicality. It can intuitively identify the relative changes in sea level position and is consistent with the results of sea level analysis obtained from core samples and well-logging curves. The inflection point and the trend change of

the INPEFA curve are more pronounced at the sequence boundary with a larger span, making it suitable for determining third- and fourth-order sequences. The wavelet transform can adjust the scale factor to recognize the internal cyclicity of logging curves, making it more suitable for identifying fourth- or fifth-order sequences. This method can effectively establish the isochronous stratigraphic framework of the clastic rock reservoir, similar to the approach used in this study. It has significant promotional value for identifying sequences in similar oil fields and can also improve the efficiency of geological research processes.

Keyword

wavelet transform, high frequency sequence, INPEFA, Fischer plots

Geochronological constraints of high-grade metasedimentary rocks of the Italva and Costeiro basins: Reconstructing the Outer Magmatic Arc System of the ribeira belt, SE Brazil

Caroline de Araujo PEIXOTO[1]*, UERJ (caprdj@gmail.com)
Marcela Lobato[2], UERJ
Natalia Cota[3], UERJ
Monica Heilbron[4], UERJ
Ivo Dussin[5], UERJ
Elton Dantas[6], UNB

Abstract

U-Pb provenance studies of the magmatic arc-related basins of the Ribeira Orogen are essential to unravel the depositional history and the paleogeography prior to the diachronic collision that has resulted in Neoproterozoic to Cambrian Western Gondwana assembly. This work brings new geology and LA-ICPMS data from metasedimentary units and felsic to mafic magmatic rocks that compose the Outer Magmatic Arc System (OMAS) in the Ribeira segment of the Araçuaí-Ribeira Orogenic system (AROS), contributing to unravel the construction of the West-Gondwana supercontinent. The OMAS evolution started in Tonian time (860–790 Ma) as the juvenile intraoceanic Serra da Prata arc and evolved into the immature continental Rio Negro arc during the CryogenianEdiacaran times (650–620 Ma). The long-term subduction revealed the coeval stages development of arcrelated basins. In the first Tonian stage, basin development is associated with the Italva group, divided into two sequences representing both fore and back-arc settings. The forearc sequence (Euclidelandia unit) comprises meta-psammitic sedimentary rocks with a single provenance source from the SP arc (peaks at 812 Ma and 828 Ma). The back-arc sequence (Sao Joaquim unit) consists of marbles with MORB-like interlayered amphibolites (ca. 831 Ma) bracketing the maximum age of carbonatic platform deposition. On the other hand, the younger Cryogenian to Early Ediacaran Costeiro back-arc basin is represented by three units of the S˜ ao Fid´elis group. The proximal Macuco unit, comprising meta psammitic rocks with marble, yielded a bimodal provenance distribution (852–815 Ma; 643–634 Ma), which reflects only the SP and RN magmatic arcs sources. The pelitic distal Upper and Lower units point out multimodal sources, coming from the SP-RN arc-rocks (ca 950–734 Ma; ca. 693–621 Ma) and Archean to Mesoproterozoic sources (ca. 3.12–3.0 Ga; 2.98–2.49 Ga; 2.29–1.50 Ga; 1.49–1.01 Ga), derived from ancient cratonic blocks located eastern wards, in African side. All units of the OMAS recorded two metamorphic episodes, with the oldest M1 (ca. 600–590 Ma) related to the collision of the OMAS against the Inner Magmatic Arc System (IMAS) and the younger M2 (ca. 545–533 Ma) that resulted from the final docking of the Cabo Frio terrane (Angola block) and finally closed the OMAS back-arc basin. Data obtained reinforces the long-term E-verging subduction that built the OMAS.

Keyword

Fore-arc and back-arc metasedimentary sequences, Tonian arc-basin, Ediacaran-Cryogenian arc-basin, Neoproterozoic arc-system, Central Ribeira Orogen

The selection of the Global boundary Stratotype and section (GSSP) for the Carboniferous Moscovian Stage

Keyi HU[1]*, Nanjing University (kyhu@nju.edu.cn)
Xiangdong Wang[2], Nanjing University

Abstract

The Carboniferous System includes seven stages, namely the Tournaisian, Visean, Serpukhovian, Bashkirian, Moscovian, Kasimovian, and Gzhelian stages. Except for the Tournaisian, Visean, and Bashkirian stages, the Global boundary Stratotypes and sections (GSSPs) of the remaining four stages have not been established. The Moscovian Stage was originally named in the Moscow Basin, Russia in 1890, and was selected as an official Carboniferous stage for the International Chronostratigraphic Chart at the beginning of this century. However, the boundary marker or the index fossil for the base Moscovian has not been selected yet although the Task Group has studied many potential boundary markers across different regions during the past two decades. Currently, conodonts Diplognathodus ellesmerensis Bender and Declinognathodus donetzianus Nemirovskaya are considered to have a higher potential for recognition of the Bashkirian-Moscovian boundary and international correlation. The Naqing section, South China, and the Basu section, South Urals, Russia are candidate sections for the GSSP of the Moscovian Stage. Here, we evaluate many aspects of the two potential boundary markers, e.g., species concept, evolutionary pathway, geographic distribution, First Appearance Datum (FAD), and auxiliary markers to determine which has a higher potential for marking the global Bashkirian-Moscovian boundary. The FAD of Diplognathodus ellesmerensis is close to the traditional BMB in its type area. If it is used to mark the base of the global Moscovian Stage, Diplognathodus ellesmerensis would maintain the traditional concept of the Bashkirian-Moscovian boundary. Diplognathodus ellesmerensis has been found worldwide, and its lineage is well documented. Therefore, Diplognathodus ellesmerensis meets the requirements for a boundary marker in a part of the geological column where international correlation is very difficult.

Keyword

Carboniferous, Moscovian, Global boundary Stratotype and section, correlation

The Middle-Late Pennsylvanian Event: timing and mechanism

Yixin WANG[1]*, Nanjing University (211830014@smail.nju.edu.cn)
Keyi HU[2], Nanjing University
Xiangdong WANG[3], Nanjing University

Abstract

Driven by the Late Palaeozoic Ice Age (LPIA) and climate dynamics, drastic biotic changes have been recorded in both marine and non-marine realms during the Middle-Late Pennsylvanian, i.e., Moscovian-Kasimovian (ca. 307-303.7 Ma). However, the timing, mechanism, and amplitude of these events are not well understood due to rare records of the Pennsylvanian rock successions, and difficult international correlations caused by frequent glacio-eustatic transgressions and regressions during the LPIA. This study focuses on the late Desmoinesian extinction Event and the conodont biodiversification Event in the marine realm. Both happened close to the Middle-Late Pennsylvanian boundary interval and are referred to as the Middle-Late Pennsylvanian Event. In southern Guizhou, South China, carbonate successions containing abundant conodonts were deposited at the slope to basinal environments during the Pennsylvanian, providing great opportunities to study those events. Focused on the Middle-Upper Pennsylvanian boundary interval, the Naqing, Shanglong, and Narao sections are studied here. We present an integrated stratigraphic framework including conodont biostratigraphy, strontium and oxygen isotope of conodont apatite, and carbon isotope of bulk rock across the Middle-Upper Pennsylvanian boundary interval. A total of 11 conodont zones, namely the late Moscovian Idiognathodus podolskensis and Swadelina sp. A zones, the Kasimovian Sw. subexcelsa, Sw. makhlinae, I. heckeli, I. turbatus, I. magnificus, I. guizhouensis, Heckelina eudoraensis, and I. naraoensis zones, and the Gzhelian H. simulator Zone, are recognized. Notably, the bases of the Sw. subexcelsa and I. heckeli zones mark the traditional and the alternative Moscovian-Kasimovian boundaries, respectively, while the base of the H. simulator Zone marks the Kasimovian-Gzhelian boundary. δ13C and 87Sr/86Sr curves in the Naqing, Narao and Shanglong sections are consistent, showing three phases of environmental change during the late Desmoinesian extinction Event and the conodont biodiversification event. During the first phase, a negative shift of δ13C is recorded in the Swadelina sp. A Zone, while no significant change was documented in 87Sr/86Sr. In the second phase, a negative shift of δ13C in the Swadelina subexcelsa Zone was well recorded, in which 87Sr/86Sr dropped by ~0.0001. In the last phase, positive excursion of δ13C is correlated with a rise in 87Sr/86Sr. The first phase is well correlated with the biomes change in rainforest, which reduced plant productivity but had no significance in weathering probably attributed to vegetation cover being unchanged. In the second phase, increasing climate aridification caused changes in rainforest, which led to productivity reduced again. Furthermore, the negative shift in 87Sr/86Sr indicates continental weathering weakened during this phase, which may be attributed to the desertification in the equatorial region by the aridification. In this case, nutrient input from rivers was reduced, which may affect the shallow-water environments and partly contribute to the

late Desmoinesian extinction Event. In the last phase, δ18O values start to drop, which means temperature started to return to normal level. The productivity and coverage of vegetation recovered, which both led to the positive shifts in δ13C and 87Sr/86Sr curves. Regained continental weathering and river runoff increased nutrient input into the ocean, which could contribute to the conodont biodiversification.

Keyword

Late Palaeozoic Ice Age, Middle-Late Pennsylvanian Event, Isotopes, Conodont, South China

Phylogeny and paleobiogeography of the Carboniferous conodont genus *Gnathodus*

Wenqi WANG[1]*, Nanjing University (wqwang@smail.nju.edu.cn)
Keyi HU[2], Nanjing University
Xiangdong WANG[3], Nanjing University

Abstract

Conodonts are regarded as an important biostratigraphic tool for the subdivision and correlation of global marine strata deposited during the Paleozoic and Triassic. For the Carboniferous, various conodont zonations have been established in different regions due to palaeobiogeography. The conodont genus *Gnathodus* arose in late Early Mississippian and disappeared in early Early Pennsylvanian, and is one of the most important taxa for Carboniferous biostratigraphy. Nearly half of the Mississippian conodont zones are defined by the first appearances of certain *Gnathodus* species/subspecies. The genus *Gnathodus* contains numerous species, which generally can be divided into three earlier groups, the *G. delicatus*, *G. typicus*, and *G. punctatus* groups, and two later groups, the *G. bilineatus*, and *G. girtyi* groups. Currently, the evolutionary relationships between these groups and the morphological changes during the evolutionary process are not fully understood, which sometimes leads to inaccurate correlations when using *Gnathodus*-based zonation. Therefore, an intragenus phylogenetic framework of *Gnathodus* is needed.

Numerous *Gnathodus* specimens were recovered from South China carbonate sections, e.g., the Naqing section of Guizhou, the Yudong section of Yunnan, and the Yajiao section of Guangxi. By incorporating published data elsewhere, we compiled a detailed matrix of morphological characters of the genus *Gnathodus*. Additionally, information on two species of *Protognathodus* that was generally considered as the ancestor of *Gnathodus* were also included in this matrix. Followed by cladistic analysis using TNT and R, the phylogenetic relationship based on the P1 elements of all *Gnathodus* species/subspecies is reconstructed. Furthermore, the Dispersion-Vicariance Analysis is also applied in this work to profile the paleobiogeographic immigration and dynamic variations of *Gnathodus* during the Mississippian and Early Pennsylvanian. Our results reveal a temporal and spatial evolutionary model for the conodont genus *Gnathodus*, which provides a meaningful reference for the taxonomic and biostratigraphic application of the genus *Gnathodus*, as well as that of other related Carboniferous taxa. Future discoveries of multielement apparatuses will serve as a test and facilitate a comprehensive revision of the phylogenetic relationship of *Gnathodus* proposed in this work.

Keyword

Carboniferous, conodonts, *Gnathodus, phylogeny, paleobiogeography*

Farfield effects of the Hercynian orogeny on the sedimentary succession of the Arabian Plate

Michael H Stephenson[1]*, Stephenson Geoscience Consulting Ltd (mikepalyno@me.com)

Abstract

The Hercynian orogeny was a period of tectonism during the Carboniferous, due to collision of Gondwana and Laurasia forming Pangea, and causing severe tectonic and orogenic effects in western Europe, northwest Africa, and eastern North America. The farfield effects of the orogeny are however less well known. High precision palynological analysis across the entirety of the Arabian Plate has identified a sedimentary hiatus (the Hercynian unconformity), and faulting, associated with the Hercynian orogeny, which can be traced from Israel and Jordan in the north through western Iraq, Saudi Arabia, the Gulf States, and Oman, showing that the hiatus ranges from the Proterozoic to the Mid-Permian in the Levant, and Ordovician to Mid-Permian in northern Oman, to much smaller durations corresponding to part of the Carboniferous in the Nafud-Ma'aniya and Faydah-Jafurah basins. The form of the Hercynian unconformity is complicated by contemporaneous salt dissolution and withdrawal, and deposition on erosional features caused by the Permo-Carboniferous glaciation with which it is party co-eval. The Hercynian unconformity and associated faulting are the most important stratigraphic controls on the Palaeozoic of the Middle East, affecting the geographic and stratigraphic distribution of sedimentary rocks that have value for groundwater and carbon storage, as well as being oil and gas source and reservoir rocks. This palynological survey allows unique insights into the farfield 'ripples' of a major orogenic event, the origin and character of the unconformity, and the interplay between Palaeozoic tectonic and glacial controls on erosion and deposition.

Keyword

palynology, Hercynian, orogeny, Permo-Carboniferous, Arabia

Revision of Idiognathodus sagittalis (Conodonta, Pennsylvanian): 2D- and 3D-based morphometrics

Yingjun PENG[1]*, Nanjing University (211840284@smail.nju.edu.cn)
Keyi Hu[2], Nanjing University

Abstract

Conodonts are one of the major fossil groups for stratigraphic subdivision and correlation in the Paleozoic and Triassic. Conodonts Swadelina subexcelsa, Idiognathodus heckeli, I. turbatus and I. sagittalis have been proposed for the Global Moscovian-Kasimovian stage boundary. Among them, I. sagittalis was named earliest and plays a crucial role in recognizing the alternative Moscovian-Kasimovian boundary in the Russian Platform. The evolution pattern of I. swadei-I. heckeli-I. turbatus is better understood based on conodont data from North American Midcontinent and South China, while the ancestor and evolutionary pathway of I. sagittalis are poorly known. In the 3D morphology of P1 elements, I. sagittalis is primarily distinguished by its lobes that turn lower than the upper surface of other parts of the platform. Beyond that, elements of I. sagittalis reported from the Russian Platform and South China resemble those of I. swadei-I. heckeli-I. turbatus lineage in their 2D morphology as they share a wide rostral lobe shifting dorsally, longitudinal alignment of the rostral ridge, carina, and caudal ridge, and the flaring, high-elevation caudal adcarinal ridge. Here, 2D- and 3D-based morphometrics analyses are applied to distinguish I. sagittalis from the elements within the I. swadei-I. heckeli-I. turbatus lineage. In this study, we compile a dataset that includes conodonts I. sagittalis and other similar forms from South China and published data elsewhere followed by the Bi-lobed Landmark Analysis (BLA), Principal Component Analysis (PCA), and Canonical Variate Analysis (CVA) of 2D-based morphometrics analyses, and various 3D-based indexes (e.g., RFI, Slope). The PCA shows that I. sagittalis has several morphotypes that fit into the groups of I. heckeli or even I. swadei. In the CVA scatterplot, I. sagittalis, I. heckeli, and I. turbatus are separated well. However, the holotype of I. sagittalis is completely mixed with the I. turbatus cloud because of its highly similar morphology with I. turbatus, e.g., the medial nodosity. Additionally, topographic indices show that I. swadei, I. heckeli, I. turbatus, and I. sagittalis share a similar sloped rostral lobe angled from 20°-40°, distinguished from that of I. sulciferus and I. harkeyi angled from 0°-20°. Combining with 2D and 3D analyses, We conclude that 1) I. swadei, I. heckeli, I. turbatus, and I. sagittalis are a distinctive group differing from other Idiognathodus species; 2) the P1 element of typical I. sagittalis should be diagnosed by its medial nodosity and inclined rostral lobe angled 20°-40°, 3) I. heckeli has a complete eccentric groove and maybe the sloped rostral lobe; 4) the species name I. turbatus may not be valid due to that the I. sagittalis was named earlier and its holotype represents characteristics of I. turbatus; and 5) specimens referred as to I. sagittalis from Russian Platform and South China comprised of several morphotypes and need to be named as new species. This study offers a better understanding of the species concept of the conodont I. sagittalis. However, North American specimens, especially I. heckeli and I. turbatus, are better included for 3D

morphometrics analyses to verify the similarity between them and I. sagittalis.

Keyword

Moscovian-Kasimovian Boundary, Idiognathodus sagittalis, morphometrics

The chemical weathering trend of the Carboniferous to early Permian strata in the Naqing section, South China

Biao GAO[1]*, Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences (biaogao@nigpas.ac.cn)
Jitao CHEN[2], Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences
Guozhen XU[3], Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences
Wenli YANG[4], Nanjing Institute of Geology and Palaeontology of the Chinese Academy of Sciences

Abstract

The late Paleozoic ice age (LPIA) is the only archive in the Phanerozoic that recorded the permanent icehouse-to-greenhouse turnover, with complex terrestrial ecosystems and metazoan life on the plant, which provides an ideal analog for the late Cenozoic glaciation. In recent decades, abundant studies supported that the LPIA was characterized by a pattern of a dynamic, multi-centered continental icesheets with discrete glacial intervals. Continental chemical weathering, regarded as a thermostat for the habitable plant in time scale of 10^5 years, plays an important role in the evolution processes of the late Paleozoic ice age. Chemical index of alteration (CIA) is widely used as a proxy for chemical weathering in literature, despite potentially underlying uncertainties. To date, CIA records have been published from both high-middle latitude and low latitude regions during the LPIA. However, there is generally lack of a long-term CIA record from low-latitude, continuous successions, which hampers our understanding of evolution of the paleoclimate during the LPIA. Here, we present major and trace element compositions for the argillaceous limestones and calcareous shale in the continuously deposited, Naqing succession (Carboniferous to early Permian), South China. Given that the South China Block was located around the palaeoequator in isolation, the CIA record of the Naqing section provides an important opportunity for investigating the interaction between glaciation and chemical weathering during the LPIA.

Keyword

late Paleozoic ice age, South China, Chemical index of alteration, siliciclastic component, paleoclimate

Episodic marine anoxia during highly oxygenated Late Paleozoic icehouse

Jitao Chen[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (jtchen@nigpas.ac.cn)
Shihan Li[2], Texas A&M University
Isabel P. Montañez[3], University of California, Davis
Shuang Zhang[4], Texas A&M University
Tais W. Dahl[5], University of Copenhagen
Terry T. Isson[6], University of Waikato (Tauranga)
Noah J. Planavsky[7], Yale University
Feifei Zhang[8], Nanjing University
Xiang-dong Wang[9], Nanjing University
Shu-zhong Shen[10], Nanjing University

Abstract

Carbonate uranium isotopes (238U/235U, denoted as δ238Ucarb) are recently widely utilized to understand marine redox landscapes, but mostly focusing on quantitative estimation on the extent of seafloor anoxia, especially during major biotic crisis and ocean anoxic events of the Phanerozoic, which is often tied to global carbon cycle perturbations. More recently, limited δ238Ucarb data also documented repeated occurrences of marine anoxia during the deep glacial of the late Paleozoic icehouse. Nevertheless, the episodic nature and mechanism of the marine redox changes in response to global C cycling during the late Paleozoic icehouse, particularly under high atmospheric pO2 levels, remain unclear. Here we present a high-resolution time series of δ238Ucarb for a deeper-water, carbonate slope succession (Naqing, South China) spanning the Middle Pennsylvanian through to the early Permian (~310–290 Ma). Along with the high-resolution carbonate δ13C from the same succession, and multi-proxy-based atmospheric pCO2 estimates, we further explore the mechanisms of the late Paleozoic (de)oxygenation utilizing a refined, previously established CPU (carbon, phosphorus, and uranium) biogeochemical model. The modeling outcomes, integrated with proxy data, suggest a long-term atmosphere and seafloor oxygenation driven by enhanced marine organic carbon burial. The study also highlights that episodic pulses of C emission can cause repeated occurrences of marine anoxia even under more oxygenated Earth system than today.

Keyword

Carbonate uranium isotopes, marine anoxia, carbon cycle, Late Paleozoic ice age

Mercury isotope evidence for the linkage between volcanic activity and Early Permian Artinskian Warming Event

Chaosheng YUE[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (csyue@nigpas.ac.cn)
Jitao Chen[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Guozhen Xu[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Biao Gao[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Jusun Woo[5], Seoul National University
Hua Zhang[6], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Xiangdong Wang[7], Nanjing University
Shuzhong Shen[8], Nanjing University

Abstract

The Late Paleozoic Ice Age (LPIA) is one of the most significant glacial events during the Earth history, lasting for nearly 100 million years (360-260 Ma). It recorded the only complete transition from an "icehouse climate" to a "greenhouse climate" after the occurrence of advanced vegetation and complex ecosystems on land. This critical climate transition started in the Artinskian of the Early Permian (also known as the Artinskian Warming Event, AWE). Although the AWE was hypothesized to have been related to greenhouse gas emissions, its specific causative mechanisms remain unresolved. Widespread volcanic activities in the Early Permian were presumably considered to be an essential trigger for this warming event, but without direct evidence. Mercury (Hg) enrichment and isotopes have been widely used as a robust proxy for volcanic activities and paleoenvironmental perturbations in recent years. The combination of Hg enrichment and isotopes can effectively indicate volcanic activity and its association with climate events. This paper present high temporal resolution time series of Hg concentration and isotopes in three continuous outcrop sections and one drilling core from the South China, Junggar, Spitsberg, and North China blocks, in order to explore the potential driving mechanisms for the AWE, particularly its linkage with volcanic activities during the critical climate transition.

Keyword

Early Permian, warming event, volcanism, mercury isotopes

Zinc isotopes as a tracer for global carbon cycling during the onset of late Paleozoic icehouse

Yutian ZHONG[1]*, Nanjing Institute of Geology and Palaeontology, CAS (ytzhong@nigpas.ac.cn)
Jitao CHEN[2], Nanjing Institute of Geology and Palaeontology, CAS
Sheng-Ao LIU[3], State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing
Chengshuai YUAN[4], State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing
Biao GAO[5], Nanjing Institute of Geology and Palaeontology, CAS
Bo CHEN[6], Nanjing Institute of Geology and Palaeontology, CAS
Genming LUO[7], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Wuhan
Xiangdong WANG[8], State Key Laboratory for Mineral Deposits Research, School of Earth Sciences and Engineering and Frontiers Science Center for Critical Earth Material Cycling, Nanjing University
Wenkun QIE[9], Nanjing Institute of Geology and Palaeontology, CAS

Abstract

The earliest Carboniferous saw a critical climate transition from the Devonian greenhouse to the late Paleozoic icehouse climate state, which is featured by a worldwide, mid-Tournaisian positive carbon isotope excursion (TICE). Regardless of uncertainties in single versus double peaks in carbonate carbon isotope record (δ13Ccarb), the TICE was thought to have caused by increased organic carbon burial, the underlying mechanism of which, however, remains controversial.

Zinc (Zn) is a vital micronutrient for organisms, and Zn isotopic compositions (δ66Zn) of seawater are mainly controlled by marine primary productivity and continental weathering, which are tightly connected to global carbon cycling. Thus, Zn isotope has the potential to disentangle the interlinked processes during the TICE event. Here, we present the first carbonate δ66Zn record, in combination with other geochemical data, from two well-preserved, carbonate dominated successions (Malanbian and Xiasi) from the northeastern Paleo-Tethys Ocean region (South China Block). During the TICE interval, the coupled δ66Zn and δ13C profile delineates two peaks, indicating that the TICE event is a two-phase carbon cycle perturbation. Both phases are attributed to enhanced marine primary productivity, which was stimulated by increased micronutrient supply from continental weathering and oxidation of previously buried organic matter, respectively. Consequently, the two-phase, enhanced productivity and the resultant organic matter burial could have led to a stepwise climatic cooling.

Keyword

Zn isotope, carbon cycle perturbation, Tournaisian, climatic cooling

Volcanic activities, wildfires and the collapse of tropical rainforest ecosystems during the terrestrial end-Permian mass extinction in Southwest China

Hua ZHANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (hzhang@nigpas.ac.cn)
Yaofeng Cai[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Shenglin Jiao[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The end-Permian mass extinction (EPME) was the most severe extinction event in the last 500 million years, with estimated losses of >81% of marine and >89% of terrestrial species. The extreme Cu enrichments, Hg concentration spikes, presence of melt inclusions with rich Cu and sulfides within the EPME interval in South China derived from explosive super-eruptions near the South China Block during the closure of Paleo-Tethys or opening of Neotethys. Model estimates from the Community Earth System Model (CESM1) suggest such a massive SO2 release would lead to immediate post-eruptive atmospheric cooling of > 4 C on a thousand-year timescale (‘volcanic winter’) prior to the previously reported rapid global warming across the EPME. This temperature trend is consistent with a drastic sea-level fall at the onset of the EPME followed by an immediate transgression. Rapid cooling on top of longer-term warming increases the climatic extremes experienced by terrestrial ecosystems. This bolsters the case that environmental degradation due to rapid climate shifts was an important kill mechanism during the end-Permian biotic crisis. Abundant well-preserved charcoals with anatomical structures indicate the wildfires were widespread during the Permian–Triassic transition in Southwest China. Organic carbon isotopic analyses of both bulk rocks and charcoals show that the δ13Corg values in the Lower Triassic are notably more negative than those in the Upper Permian, with a negative excursion of 4.08‰ immediately above the volcanic ash bed in the middle of the uppermost coal bed of the Xuanwei Formation. The enrichment of polycyclic aromatic hydrocarbons (PAHs) in the terrestrial EPME interval in Southwest China indicates that the paleotropical rainforest ecosystem provided sufficient fuel for large-scale high-temperature wildfire combustion events. Furthermore, the extremely low PAH contents in the Lower Triassic showed a fuel shortage after the mass deforestation. These results suggest that intensified high-temperature wildfire combustion events in the paleotropical rainforest in Southwest China occurred because of global warming and aridity caused by intensive volcanic activities, and led to the eventual collapse of tropical rainforest ecosystems during the P–T transition.

Keyword

volcanic activities, wildfires, terrestrial ecosystem collapse, Permian–Triassic transition, Southwest China

Sedimentary record of the Permian Yangtze Block breakup: Evidence from the Sichuan Basin

Xuanwei LIU[1]*, China University of Petroleum, Beijing (401245411@qq.com)
Fujie Jiang[2], China University of Petroleum, Beijing
Pengwei Wang[3], Sinopec Petroleum Exploration and Development Research Institute, Beijing 102206, China
Jingqi Zhou[4], China University of Petroleum, Beijing
Xiaoqi Fan[5], China University of Petroleum, Beijing
Siyu Zhou[6], China University of Petroleum, Beijing

Abstract

At the end of the Middle Permian Guadalupian sedimentation period, the Chinese region recorded the only internationally recognized large igneous provincial eruption event, known as the Emeishan LIP. The Yangzi region of South China records a series of short and almost synchronous geological events that accompanied the development of bio-geological events such as large-scale magmatic intrusion, plate rifting, magnetic pole anomalies, and ecological collapse. These events ultimately triggered the extinction of living organisms. However, the current study leaves several questions unanswered. What was the sequence of geological events? Are the global record of these events synchronized? What is the causal relationship between these events?

For this study, the research subject consisted of seven sections located on the northwestern margin of the Yangtze Plate, such as Sanduizheng, Wangjiagou, Daliangxiang, among others. The study determined the stratigraphic time limit based on lithological characteristics and conodonts, and discussed the sedimentary responses to various geological events using isotopic and astrochronological analysis.

The results reflect: 1Fossils from the Jinogondolella.postserrata zone have been discovered in several locations, including the 28th floor of Maoertang, the 33rd floor of Sanduizheng, the 28th floor of Longfengcun Village, and the 28th floor of Wangjiagou. These sections maintain an uninterrupted sedimentary recording of the Roadian-Wordian stage; 2During the late Wordian period, regional profiles document changes in depositional patterns and paleomorphic patterns; 3The Roadian-Wordian stage continued for a total of 8.2Ma. About 2 million years ago, roughly 19 cycles of 405Ks were established, whereas the sedimentation rate notably declined after the late Wordian period (267.8Ma). Significant negative carbon isotope biases were recorded in several profiles during the same period, indicating relative sea level fluctuations.

During the late Wordian period, Relative changes in depositional patterns and sea level under the combined control of Emei mantle column activity and Yangzi rifting. Above the J.postserrata zone, the magma emplacement due to Emei mantle plume became increasingly evident, and hydrothermal fluid gradually infiltrated the paleo-ocean after the J.altudaensis zone. We want to identify the initial triggers of various geological events by analyzing the sedimentary record.

Keyword

Northwestern margin of the Yangtze, Guadalupian series, Emei mantle, Cracking of the Yangtze, Astrochronological analysis

Tipping cascades in the onset of the Carnian Pluvial Episode (Late Triassic)

Bo WANG[1]*, Nanjing Institute of Geology and Paleontology (bowang@nigpas.ac.cn)

Abstract

Exploring the onset of past hyperthermal events is essential to improve predictions on future climate change. The Late Triassic Carnian Pluvial Episode (CPE) is an interval with a dramatic increase in global humidity and temperature and profound biological turnover in marine and terrestrial ecosystems. However, its onset and drivers are still poorly understood. Here, we present an integrated high-resolution proxy from an Carnian lacustrine succession (Huangshanjie Formation in Dalongkou section) of the paleo-high-latitude Junggar Basin of northwestern China. Our U–Pb zircon dating, high-resolution chemostratigraphy and cyclostratigraphy, and palynological and sedimentological data reveal that a warm and drought climate in the region through the CPE, which is consistent with independent climate modeling evidence. Our results show that mercury concentrations increased about 45,000 years before the negative carbon-isotope excursion (CIE) but returned to normal level slightly prior to CIE. It suggests that the Wrangellia Large Igneous Province (W-LIP) is slightly earlier than CPE, may be not the major trigger of CPE. The CIE lasted about 32 kyrs and was most likely caused by the abrupt oceanic methane emissions triggered by the global warming and orbital pacing. Together, our results show that the crucial carbon perturbation and climate changes were triggered by tipping cascades of volcanism, orbital pacing, and oceanic methane emissions.

Keyword

Triassic, volcanism, orbital pacing, methane emissions, global warming

The state of the art on the redefinition of the Devonian/Carboniferous Boundary

Markus ARETZ[1]*, Université Paul Sabatier (markus.aretz@univ-tlse3.fr)
Carlo Corradini[2], University of Trieste

Abstract

The definition of the base of the Carboniferous has been back on the agendas of the Devonian and Carboniferous subcommissions for more than a decade. This became necessary after the discovery of the marker fossil for the base of the Carboniferous, the conodont Siphonodella sulcata, in a stratigraphical lower position in the GSSP section at La Serre, southern France. A joined SDS/ISCS Task group has been working on the redefinition of the base of the Carboniferous for more than ten years. Its overall aim is to regain stratigraphical stability in this critical interval of Earth history without fundamentally changing the position of the DCB in respect to previously used levels for the base of the Carboniferous.

The working group has been following the basic idea that a newly defined boundary level has to ensure the best possible correlation across facies realms and palaeocontinents, and that the recognition of the boundary should be the most user-friendly. In this respect, the new boundary should not depend on a single criterion, but be based on a suite of multiple criteria.

Hence, the working group has been focused on multi-disciplinary approaches, which combine palaeontological, sedimentological, geochemical and petrophysical methods and data, setting points in time during the latest Devonian and earliest Carboniferous.

The working group proposes to place the boundary at a point in time defined by “the end of the Devonian mass extinction and beginning of the Carboniferous radiation, the top of a major regression, and the base of the Protognathodus kockeli conodont Zone” and this level is inserted in a calendar of a succession of widely recognizable points in time for the latest Famennian and earliest Carboniferous. Since this DCB calendar combines results from very different facies realms, it is self-understanding that a section comprising all listed points will not exist. However, the application of this calendar enables to place every section as precise as possible into the framework of the DCB. Additionally, it clearly helps to identify local or regional variations and discrepancies due to e.g. facies differences or faunal particularities, and hence to adapt the position of the boundary accordingly. Thus, even a delayed entry of a stratigraphic marker would have less influence on the boundary position and the global correlation. The work on the calendar also implies revisions on existing biostratigraphic zonal schemes.

Keyword

extinction, boundary, stratigraphy

Chaotic Mars-Earth swings in precession of orbital perihelion revealed in Jurassic lake sequences, Junggar Basin, northwestern China

Yanan Fang[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (ynfang@nigpas.ac.cn)
Paul Eric Olsen[2], Columbia University
Bo Wang [3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

A fundamental problem in celestial mechanics is Solar System chaos, with the fundamental secular frequencies of the rocky planets being unpredictable after 60 Myr. Especially sensitive, is the grand eccentricity beat cycle of Mars and Earth that potentially ranges in period over a million years on times scales of 10s of millions of years and modulates the expression of higher frequency axial precession cycles. Based on stable carbon isotopic and sedimentary facies data from the lacustrine, paleo-high-latitude Early Jurassic Sangonghe Formation of the Junggar Basin (NW China), and data from eastern North America, Japan, and Europe, we posit a dramatic oscillation in period of the Mars-Earth cycle from ~1.8 Myr to ~2.5 Myr back to ~1.6 Myr from 210 to 180 Ma, spanning nearly the entire range of plausible variation due to chaotic diffusion during the last 300 Myr.

Sangonghe Formation strata were deposited under warmer and drier conditions compared to bracketing Late Triassic to earlier Jurassic and early Middle Jurassic formations, based on the absence of ice-rafted debris, rarity of coals, presence of red beds, and higher percentages of the conifer pollen Classopollis, with the Jenkyns (T-OAE) event embracing one of the ~1.6 Myr cycle and marking an even warmer interlude. As these events unfolded within the context of hypothesized true polar wander dramatically effecting Junggar Basin latitude, deciphering the role of possible true polar wander vs. true climate change will require new palaeomagnetic and geochronological data from core spanning much of the Junggar Basin Mesozoic.

Keyword

Triassic-Jurassic, Junggar Basin, Solar system chaos, g4-g3 cycle, Jenkyns Event

Carbon isotope perturbations driven by volcanism during the Late Paleozoic Ice Age (LPIA)?

Zhihui ZHANG[1]*, Shandong University of Science and Technology (zhzhihui@sdust.edu.cn)
Luojing WANG[2], Shandong University of Science and Technology
Dawei LV[3], Shandong University of Science and Technology

Abstract

Volcanic activity is considered to be one of the crucial underlying mechanisms driving extreme climate warming events in Earth's history. The late Paleozoic ice age (LPIA) was the longest-lived glaciation of the Phanerozoic, and the demise of LPIA is the Earth's only recorded transition from an icehouse to a greenhouse state. Many previous studies attributed climatic and environmental changes during the LPIA to perturbations of atmospheric pCO2, which also believe volcanism is an important driving mechanism for the warming events. However, the low-resolution carbon isotope and volcanic records during the LPIA in the North China Craton (NCC) limit the construction of a Permo-Carboniferous chemostratigraphic framework and global or local stratigraphic correlation, thus constraining the accurate understanding of volcanic activity for climate change. To investigate these issues, we analyzed high-resolution Hg concentration, total organic carbon (TOC), total sulfide (TS), and organic carbon isotope (δ13Corg) during the late Gzhelian to early Kungurian stages in the NCC, and compared the δ13Corg data with published records to build a chemostratigraphic scheme and discuss the potential climate change. The records show two global δ13Corg negative excursions which coincide with the shift in atmospheric pCO2, change of conodont oxygen isotope (δ18O), sea-level variation, and late Paleozoic deglaciation records, suggesting the presence of the global warming event in the late Gzhelian and the early Asselian. The high resolution of Hg/TOC recorded two volcanic activities, but the absence of synchronous correspondence between the δ13Corg negative excursions and Hg/TOC peaks hinted at a limited driving role of volcanism in the perturbations of carbon isotope and the change of paleoclimate in this study. It is worth noting that the onset of the early Asselian warming event coincides with the peak in volcanic intensity, which indicates that the early Asselian warming event can be attributed to volcanism with the superimposition of multiple mechanisms such as tundra conditions, methane release, or orbitally-paced climate changes. Our investigation provides a significant view that the decoupling relationship between the perturbations in the carbon cycle and volcanic activity during the LPIA. The perspective extends our understanding beyond volcanism resulting in climate change, revealing the potential multifaceted driving mechanisms behind the carbon cycle and climate change during the LPIA.

Keyword

Late Paleozoic icehouse, Paleoclimate, Organic carbon isotope, Volcanism, North China

Carbon isotopic excursions around the Smithian–Spathian boundary in southern Thailand

Kittichai TONGTHERM[1]*, 1) Princess Maha Chakri Sirindhorn Natural History Museum , Prince of Songkla University, Thailand (tongtherm@gmail.com)
Yasunari Shigeta[2], 2) Department of Geology and Paleontology, National Museum of Nature and Science, 4-1-1 Amakubo, Tsukuba, Ibaraki 305-0005, Japan
Apsorn Sardsud[3], 3) Geological Survey Division, Department of Mineral Resources, Ratchatewi, Bangkok 10400, Thailand
Kaito Asato[4], 4) Fukui Prefectural Dinosaur Museum, 51-11 Terao Katsuyama, Fukui 911-8601, Japan
Takumi Maekawa[5], 5) Osaka Museum of Natural History, 1-23 Nagai Park, Higashi-Sumiyoshi-Ku, Osaka 546-0034, Japan

Abstract

Calibrate detailed ammonoid and conodont biostratigraphic data and carbon isotopic excursions around the Smithian–Spathian boundary is reported in the Phukhaothong Dolomite Member of the marine Triassic Chaiburi Formation (part of the Sibumasu [or Shan-Thai] Block), which is exposed on the north side of an isolated mountain at Khao Thong in the Phatthalung area of southern Thailand. The 104 m+ thick section, consisting of bedded to massive, light grey dolomite, contains ammonoids in the middle to upper parts, and conodonts occur in abundant throughout the section. Two distinct lower Spathian (upper Olenekian) ammonoid zones, an upper Smithian (lower Olenekian) conodont zone and three lower Spathian conodont zones are recognized in ascending order as follows: ammonoids - Tirolites–Columbites Zone and Idahocolumbites Zone; conodonts - upper Smithian, Hadrodontina aequabilis–Staeschegnathus perrii Zone, lower Spathian Icriospathodus crassatus Zone, Triassospathodus symmetricus–Novispathodus anhuiensis Zone and Novispathodus sp. I – Novispathodus sp. J Zone. The positive excursion in δ13Ccarb with values increasing from – 0.97‰ to + 3.86‰ was recorded in the upper Smithian, Hadrodontina aequabilis-Staeschegnathus perrii Zone. The δ13Ccarb values gradually decrease in the lower Spathian Icriospathodus crassatus Zone. These δ13Ccarb isotopic patterns are correlated with well-known positive excursions around the Smithian – Spathian boundary grobally.

Keyword

Ammonoid, carbon isotope, conodont, Thailand, Smithian–Spathian boundary

[Keynote] Astrobiological significance of Stromatolites and organic walled microfossils on early Earth : Evidence from Lesser Himalayan Proterozoic stromatolitic cherty carbonates of India

VINOD CHANDRA TEWARI[1]*, Professor of Geology (Retd.), Sikkim University, Gangtok – 737102, Sikkim, India (Professorvct54@gmail.com)

Abstract

Astrobiology is the study of the origin, evolution, distribution, and future of life in the universe. This multidisciplinary field encompasses the origins, early evolution of life ,its diversification and extinction on Earth. Astrobiology studies includes the fundamental questions like how does life begin and evolve? Is there evidence of fossilized life preserved beyond Earth in the universe and, if so, how can we detect it? What is the future of life on Earth and in the universe?.Astrobiological research with other geological and planetary sciences. on Mars, Europa (Jupiter's moon),Titan and other planets in our Solar System is already included in the space bound Astrobiology Program of leading space agencies like NASA,ESA, ISRO,ASA, and Universities of UCLA,USA,Auckland and Australia in particular to name a few. Northwestern and Sikkim –Arunachal eastern Lesser Himalaya in India , Nepal and Bhutan is geologically and paleobiologically an important area in the South Asian Himalayan Orogenic belt to understand the Astrobiological paleobio events in the earth's history. The Meso-Neoproterozoic shallow marine stromatolitic carbonate sedimentary facies (Buxa Dolomite) in South Sikkim and Siang window, Arunachal Himalaya have yielded Pre –Ediacaran organic walled microfossils and stromatolites predating the Neoproterozoic (Snow Ball Earth) glacial event of global significance in the Sikkim-Arunachal Himalaya.In the Northwestern Himalaya from Jammu to Uttarakhand identical Pre –Ediacaran microfossil and stromatolitic assemblage is recorded from Jammu Limestone, Shali Limestone ,Deoban- Gangolihat Dolomite.Highly diversified assemblage of stromatolite taxa Colonnella columnaris, Conophyton garganicus, Kussiella kussiensis, Baicalia sp., Jurusania sp., Minjaria sp., Gymnosolen sp., Kalpanaella sp., Stratifera sp., Colleniella sp., Tungussia sp., Nucliella sp. and Acaciella sp., are developed in the inner South Asian Lesser Himalayan belt.The chert bands associated with the stromatolites have yielded organic walled microfossils Siphonophycus sp., Eomycetopsis sp., Obruchevella sp., Myxococcoides sp. and Oscillatoriopsis sp.The Laser Raman Spectroscopy and Confocal Laser Scanning Microscopy have shown that these cyanobacteria are biogenic and can be considered proxies for the extraterrestrial life on other planets.Recently, some Astrobiologists from NASA have compared the possible images of stromatolites, microbial mats, mud cracks ,magnetic bacteria like features found in iron deposits on the craters of Martian surface. Perseverance is collecting Martian samples to be studied on Earth in near future on Mars sample return to Earth which will inform about Martian paleoenvironment.The association of phosphorite, magnesite, iron and suphide mineralization with stromatolites indicate biomieralization in Meso-Neoproterozoic microbial carbonates of the South Asian Himalayan belt.

Keyword

Stromatolites, microfossils, Lesser Himalaya, India, Mars

Sea-level and temperature changes on the Late Permian mass extinction event

Guoqiang XU[1]*, State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation & College of Energy Resources, Chengdu University of Technology (xuugq0@163.com)
Yinhui ZUO[2], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation & College of Energy Resources, Chengdu University of Technology
Zhiwu LI[3], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation & College of Energy Resources, Chengdu University of Technology
Siding JIN[4], College of Energy Resources, Chengdu University of Technology
Changcheng WANG[5], College of Energy Resources, Chengdu University of Technology
Xiaobing ZHANG[6], College of Energy Resources, Chengdu University of Technology
Tairan YE[7], Research Institute of Exploration and Development, Southwest Branch Company of Sinopec

Abstract

Changes in global sea level and surface temperature are critical to changes in biodiversity, but how they affect biodiversity change is unclear. In this study, we reconstruct the trajectory of late Permian sea level change and compare it with the trajectory of δ13C and δ18O (a surface temperature proxy) values and the trajectory of species numbers. We fund that sea levels and temperature change synchronously and inversely under a greenhouse climate, Their impacting on organisms are consistent. Rising sea levels and decreasing sea surface temperature improve the ecosystem and, conversely, lead to ecosystem deterioration. The upper limit of optimum temperature for benthic organisms is ~22.6 °C; if the temperature beyond ~28 °C, their ecosystems will begin to collapse. However, the benthic effects of these two temperature thresholds are primarily achieved by enhancing or eliminating oxygen-rich underflows (thermohaline cycling), where the former enriches the underlying water with oxygen and nutrients, whereas the latter deoxidises it. In addition, the sudden warming at the beginning of the end-Permian extinction was not a periodic change in surface temperature but an anomalous change that have been caused by sudden events, such as the increase in atmospheric pCO2 and the paleogeomorphic change caused by plate collision.

Keyword

Sea level change, Surface temperature, The end-Permian extinction

Did CO2 emissions from the Siberian Traps volcanism outpace silicate weathering following the end-Permian mass extinction?

Ying cuiy@montclair.edu CUI[1]*, Montclair State University (cuiying00@gmail.com)
Joseph Mayala Nsingi[2], Montclair State University
Brian Beaty[3], Yale University
Feifei Zhang[4], Nanjing University
Shuzhong Shen[5], Nanjing University
Wenqian Wang[6], Nanjing University
Noah Planavsky[7], Yale University

Abstract

The end-Permian mass extinction (EPME) event is thought to be caused by significant CO2 emissions from the Siberian Traps volcanic activity. Previous studies have shown that thermogenic CO2 emissions predates volcanic CO2 outgassing, leading to strong ocean acidification, large-scale deoxygenation, and loss of marine species. Following the EPME, CO2 outgassing persisted and caused extreme greenhouse condition in the earliest Triassic. Silicate weathering rate following the large CO2 pulses from the Siberian Traps volcanism, however, has not been quantified. As a result, the idea that CO2 emissions from the Siberian Traps volcanism exceeded the rate of silicate weathering remains untested. Here, we quantify the CO2 emissions and silicate weathering using carbon and lithium isotopes (δ13C and δ7Li), and other weathering-sensitive proxies (e.g., 187/188Os and 87/86Sr) as tracers of silicate weathering combining data assimilation in an Earth system model of intermediate complexity. Proxy records suggest that chemical weathering flux remains low, while physical erosion rates are elevated, indicating the earliest Triassic warmth may be attributed to continued CO2 outgassing from the ST volcanism and contributions from reverse weathering. The low chemical weathering flux was likely attributed to the hot and dry climate in the continental interior during high continentality, as supported by climate model simulations.

Keyword

end-Permian mass extinction, CO2 emissions, Siberian Traps volcanism, Weathering, Lithium isotopes

Stratigraphic position of various stromatolitic successions in Nepal Lesser Himalaya

Megh Raj DHITAL[1]*, Tri-Chandra Multiple Campus, Tribhuvan University (mrdhital@gmail.com)

Abstract

Stromatolites occur in a few Proterozoic Lesser Himalayan sedimentary sequences of the Nepal Lesser Himalaya. Such successions are frequently considered to be of the same age. However, detailed field mapping as well as stratigraphic and sedimentological investigations demonstrate that such correlation based on stromatolite occurrence alone is untenable.

In west Nepal, Fuchs and Frank (1970) identified the Shali and Krol Formations containing stromatolites. Bashyal (1982, 1986), and Shrestha et al. (1985) mapped stromatolite-bearing units of Far-West Nepal as the Baitadi Carbonates and Lakharpata Formation respectively. In central Nepal, Stöcklin (1980) identified the Dhading dolomite with stromatolites. On the other hand, Sakai (1983, 1986) mapped stromatolitic horizons in the Chappani, Khoraidi, and Kerabari Formations from the outer Lesser Himalayan zone of central and west Nepal. Dhital and Kizaki (1987) mapped a similar rock succession from west Nepal of the Dang-Sallyan area, where the stromatolites occur in the Hapurkot, Dhorbang Khola, and Ranibas Formations. In the Lesser Himalayan zone of the Syangja area in west Nepal, Dhital et al. (2002) identified the stromatolitic Ripa Member in the Sorek Formation. In eastern Nepal, stromatolites also occur in the Halesi Dolomite (Dhital 2006).

Scrutiny of such successions demonstrates that there are at least four separate stromatolite-bearing horizons of Meso- to Neo-Proterozoic age. The lowest one is the Dhading Dolomite, Shali Formation, Baitadi Carbonates, or the Lakharpata Formation. The Sorek Formation and Halesi Dolomite occur in an intermediate position, whereas the Chappani-Khoraidi or Hapurkot-Dhorbang Khola Formations occur in the upper part. On the other hand, the Krol, Kerabari, or Ranibas Formations occupy the topmost position in the Proterozoic stratigraphic rung.

Keyword

Stromatolites, Proterozoic successions, Nepal Lesser Himalaya, Stratigraphic position

End-Permian continental vegetation collapse directly affected marine ecosystems; Evidence from Permian-Triassic successions of Australia.

Vivi Vajda[1]*, Swedish Museum of Natural History (vivi.vajda@nrm.se)
Kliti GRICE[2], Curtin University
Ashley KRUGER[3], Swedish Museum of Natural History
Susan NEHZATI[4], Diamond Light Source: Didcot, UK
Kajsa G.V. SIGFRIDSSON CLAUSS[5], MAX IV Laboratory, Lund University, Sweden

Abstract

The end-Permian mass extinction event led to major devastation in continental ecosystems with disappearance of forests, wild fires, desolated land, and toxic lake systems. Anoxic conditions triggered widespread marine extinctions, profoundly impacting various oceanic taxa. However, links between terrestrial and marine environments are lacking.

Here we demonstrate, based on palynological analyses of Permian-Triassic successions of Western Australia, Perth Basin, that the mass kill of Permian vegetation had an immediate impact on the marine faunas. Massive buildup of organic matter lead to extensive algal blooms mirrored in the overwhelming abundance of green algae (acritarchs) leading to euxinia in the photic zone (Vajda et al. 2023a,b). This dead zone is in Eastern Australia dated to 252.10 ± 0.06 Ma. We show, through X-ray absorption spectroscopy, that a drastic redox shift across took place across the extinction interval with increasing amount of reduced Fe-species followed by highly oxidized Fe-species, most resembling Fe(III) complexed with organic matter. The highly reduced iron in the extinction layer may relate to methane release from bacterial degradation, or emissions from clathrates. The presence of fulvic acid in the distinct iron-rich extinction layer indicates that an abrupt onset of the process of degradation of plant matter, lipids and calcium hydroxide (CaOH) took place, resulting in this ‘Death layer’.

The anoxia ultimately pushed the marine faunas to an ecological extinction. The last lingering occurrence of marine invertebrates of Permian aspect occur in layers that mark the Permian–Triassic boundary, positioned just below the appearance of Triassic floras and the pioneer faunas with high abundance of the bivalve Claraia. This phenomenon allows for correlation with the emergence of post-extinction pioneer floras in the Early Triassic of eastern Australia. Our findings highlight a substantial temporal gap between the recovery of terrestrial and marine pioneer biota in high-latitude Gondwana, with a significant delay observed in faunal recovery.

Keyword

mass extinction, Permian, Triassic, anoxia, methane

Stable sulfur isotope dynamics of reduced inorganic and organic sulfur phases recorded in the Permian-Triassic transition of the Meishan type section

Paul Francis Greenwood[1]*, Curtin Univeristy (p.greenwood@curtin.edu.au)
Hendrik GROTHEER[2], Alfred Wegener Institute for Polar and Marine Research
Michael E. E. BÖTTCHER[3], Leibniz Institute for Baltic Sea Research , Germany
Kliti GRICE[4], Curtin University

Abstract

Sulfur cycle fluxes of the Permian-Triassic mass extinction traditionally studied by the sulfur phase abundances in sedimentary rocks and the stable sulfur isotopic value (34S) of mineral sulfates may be complemented by studies of reduced and organic sulfur. The 34S and concentration analyses of total reduced inorganic sulfur (TRIS), kerogen (Ker) and individual organosulfur compounds (OSCs) has been conducted on sediments across the Late Permian to Early Triassic marine type section of Meishan-1 (South China). The relatively steady 34S profiles of all sulfur phases measured through the late Permian were indicative of a primary seawater sulfate control, but other biogeochemical modulators caused prominent 34S fluctuations of TRIS and OSCs adjacent to the extinction event. The late Triassic 34STRIS profile of Meishan-1 displayed a notable enrichment (+15 ‰) concomitant with a depletion in 34SOSC (-7 ‰), whereas co-eval 34SKerS values remained relatively constant. The contrasting 34SOSC and 34SKerS data suggests the dynamic behavior of specific diagenetic sulfurisation processes may be resolved by the 34S of discrete OSCs, but dissipated in the bulk kerogen fraction. The inverse isotopic trend observed between OSCs and TRIS resulted in negative 34SOSC-TRIS values identifying organic sulfurisation with an unusual preference over pyrite (FeS2) for the lighter 32S. A redox control of the 34SOSCs and 34STRIS deviations in the extinction interval was confirmed by coincident variation in TRIS/(TRIS+KerS) and FePy/FeHR ratios. Fe speciation profiles indicated a transition to ferruginous conditions (i.e., ample Fe2+) in which the 34S depletion of OSCs promoted by the ferruginous setting may arise from the rapid and irreversible reaction of organic substrates with labile sulfur anions (e.g. HS-) or be supported by an especially localised sediment-water depositional microenvironment.

Keyword

Sulfur Isotopes, Meishan, Mass Extinction, Compound Specific, Organic Sulfur

Mass Extinctions & Fossil Preservation from Organic & Inorganic Geochemical Signals

Kliti Grice[1]*, Curtin University (k.grice@curtin.edu.au)
Amy ELSON[2], Curtin University
Madison TRIPP[3], Curtin University
Alex HOLMAN[4], Curtin University
Luke BROSNAN[5], Curtin University
Andy JIAN[6], CURTIN UNIVERSITY
Stephen Poropat[7], CURTIN UNIVERSITY
Paul Greenwood[8], CURTIN UNIVERSITY
LORENZ SCHWARK[9], KIEL UNIVERSITY
VIVI VAJDA[10], SWEDISH NATURAL HISTORY MUSEUM
PETER HOPPER[11], CURTIN UNIVERSITY

Abstract

The largest mass extinction 'event' of life (end-Permian) occurred when atmospheric O2 levels were low & CO2 & H2S rising. In contrast to the meteor induced end-Cretaceous extinction event that wiped out non-avian dinosaurs, climate forces of the end-Permian event came from the aggregation of Pangea & its volcanism. Green sulfur bacteria (GSB) were globally plentiful in the Late Permian seas implying abundant H2S, used by GSB in photosynthesis. Similar conditions have been invoked during all past global warming & biotic crises. However, recent molecular data showed conflated global C cycle disruptions for the end-Triassic extinction were related to an abrupt drop in relative sea level, & transition from marine to non-marine conditions with an emergence of microbial mats (MMs). The existence of MMs in the 'extinction zone' of the Chicxulub asteroid crater show that photosynthesis in the seas recovered within 200 kyrs. Detection of perylene (a fungal wood biomarker) in the crater tracked tsunami which flooded the crater within days after the impact - the first molecular days to week's resolution of a tsunami.

Some exceptionally preserved fossils inside concretions record preservation of soft tissues or articulated skeletal remains. This unique preservation of biomass is likely due to sequestration, & protection from degradation by e.g. MMs, for tens to hundreds of Ma by a rapid (days) microbial-induced carbonate deposition within days to months. Fossil concretions are a previously untapped biochemical record - providing many unique insights: e.g. diet; role of MMs in fossilisation; & the unique chemical pathways of natural products into biomarkers. During this presentation, examples of different modes of preservation (oxidation versus reduction) of biomarkers (biomolecules) & soft tissue from a range of fossils will be presented with examples from e.g. Devonian Gogo Formation (Canning Basin), Carboniferous Mazon Creek (Illinois, USA), Cretaceous Winton Formation (Queensland), Eocene Green River Formation (US), Jurassic Posidonia shale (Germany) & Devonian Rhynie chert (Scotland).

Keyword

mass extinction, biomarkers, fossil preservation, phosphatisation, carbonate

[Keynote] The end-Permian mass extinction: Progress and unexplained questions

Shuzhong SHEN[1]*, Nanjing University (szshen@nju.edu.cn)

Abstract

The end-Permian mass extinction (EPME) was the most severe extinction event in the past 500 million years, with estimated losses of >81% of marine and ~89% of terrestrial species. Past scenarios overwhelmingly suggested that the Siberian Traps large igneous province (STLIP) released a massive amount of greenhouse and poisonous gases (e.g., CO2 and SO2), leading to rapid warming, perturbing global carbon, and sulfur cycles, causing expanded anoxic/euxinic zones in the oceans and climate drought on land. Although the STLIP scenario has been widely accepted, temporal links between the EPME and volcanism were actually established based on sedimentary records from South China, specifically, the high-precision ID-TIMS U-Pb dates from two volcanic ash beds (beds 25 and 28) at the Meishan section in southeastern China. The Permian-Triassic boundary interval in South China is associated with multiple isotope anomalies likely linked to volcanic eruptions, and these anomalies have been mostly used to argue for a causal link between the EPME and STLIP. However, geochronological studies suggest the STLIP started ~300 ka before the EPME interval and persisted for 500 ka after the extinction. This is in contrast to the main extinction occurring within an interval of 31 ± 31 ka or less based on the sections in South China. Recently, more and more studies indicate that large scale felsic volcanic eruptions within the Palaeotethys Ocean, eastern Australia, South America were synchronous with the EPME, suggesting that the STLIP may not have been the sole trigger. In contrast to the rapid and contemporaneous marine EPME, high-precision CA-ID-TIMS zircon U-Pb geochronology from the global terrestrial ecosystem suggest that the terrestrial EPME extinction occurred diachronously with latitude, beginning at high latitudes during the late Changhsingian and progressing to the tropics by the early Triassic. Thus, the EPME resulted from both basaltic and felsic volcanisms is probably much more complicated than those documented before.

Keyword

end-Permian, mass extinction, volcanism, Siberian Traps, Paleotethys

Vapour pressure deficit, drought, flood, fires, and CO2 spikes during the Permian-Triassic life mass extinction

Gregory John RETALLACK[1]*, University of Oregon (gregr@uoregon.edu)

Abstract

Floods, fires, and drought are increasing with current rise of anthropogenic CO2, and interrelationships between such disparate phenomena can now be tested from CO2 spikes of the geological past. This study examines the atmospheric CO2 spikes across the Permian Triassic boundary in South Africa from the new perspective of a paleosol proxy from the slope of oxygen and carbon isotopic correlation in carbonate for vapour pressure deficit (VPD), the drying power of air. Stable isotopic and major element data can be used as proxies for palaeotemperature. Past CO2 spikes can be quantified from carbon and oxygen isotopic data of pedogenic carbonate, with results similar to those from stomatal index of fossil leaves. Precipitation and its seasonality, can also be assessed from paleosols. Environmental disruption at the exceptional CO2 greenhouse spike during the Permian-Triassic transition in South Africa showed simultaneous spikes of VPD, precipitation, temperature, and flood. Unusually high VPD can also be seen in a compilation of stable isotopic data from calcareous paleosols at other CO2 spikes of the past, such as the Late Ordovician (Hirnantian, 446 Ma) and Late Devonian (Frasnian-Famennian, 374 Ma). High VPD, flood, fire, and drought recurred at times of high atmospheric CO2, and may have common cause in curtailed global stomatal conductance by plants, then transpiration termination by mass extinction itself.

Keyword

Permian, Triassic, Vapour pressure deficit, CO2 greenhouse, mass exinction

Proterozoic stromatolite-bearing host rocks for nickel and cobalt mineralization in western Nepal

Sunil LAMSAL[1]*, Tribhuvan University (geosunil91@gmail.com)
Kabi Raj Paudyal[2], Tribhuvan University, Nepal
Vinod Chandra Tewari[3], Sikkim University, India

Abstract

Nickel and Cobalt are strategic minerals and have diverse uses with limited known deposits. Globally, Ni-Co-sulfide deposits are known from Paleoproterozoic to Neoproterozoic and Paleozoic Period. In the Asian region, this mineralization mainly occurred in the early Neoproterozoic rock successions. In Nepal Lesser Himalaya, nickel and cobalt are reported from three places. Nickel ore associated with copper mineralization is reported from the Nangre area in the Ramechhap district. Similarly, cobalt-copper mineralization in the Tamghas-Samarbhomar area from western Nepal and nickel-cobalt-copper association at Bauli Gad (Bajhang) from far western Nepal. Among this area, the present study is focused on mineralization along the Tamghas-Samarbhamar area to determine the depositional environment of the host rock, present status, and geological controls of mineralization. The present presentation is a part of the Ph. D research project of the first presenting author. Detailed geological mapping is conducted on a scale of 1:25000 with systematic samplings for both detailed petrographic studies and geochemical analysis. The host rock for the Ni and Co mineralization in Nepal Lesser Himalaya is the Proterozoic stratified and algal mat carbonate lithological unit in investigation. These carbonate rocks are considered equivalent to the Malekhu Limestone of central Nepal. Both types of mineralization: syngenetic as well as epigenetic sulfide mineralization are reported from the field observations in the present study. Nickel and cobalt in the area are associated with pyrite, chalcopyrite, lead, and zinc belonging to a polymetallic deposit. The AAS analysis of the sample gives the presence of nickel within 0.04 to 0.3 percentage and cobalt within 0.07 to 0.5 percentage. The detailed study of both Ni and Co ores and associated sulfide ores under ore microscopy reveals that there is a strong link between the mineralization and host rock Proterozoic stromatolites carbonate. Based on the types of stratified stromatolites preserved in these host carbonate rocks; the depositional environment of sulphide-bearing mineralization is interpreted as a shallow marine. In the present preliminary study, we have delineated the petrographic characteristics of host rock and sulfides of the nickel-cobalt-sulfide deposits. The detailed geochemical analysis and field relation of mineralization will provide information about the original ore-forming processes and the origin of Ni-Co-sulfide mineralization in Nepal Himalaya. Further findings are under investigation.

Keyword

nickel, cobalt, polymetallic deposit, stromatolites, western Nepal

Identification and Significance of the Permian Guadalupian-Lopingian boundary in the northwestern margin of the Yangtze Craton

Xiaoqi FAN[1]*, China University of Petroleum (Beijing) (17863902533@163.com)
Fujie Jiang[2], China University of Petroleum (Beijing)
Di Chen[3], China University of Petroleum (Beijing)
Xuanwei Liu[4], China University of Petroleum (Beijing)

Abstract

The Guadalupian-Lopingian boundary (PLB boundary) of the Middle-Late Permian has long been a challenging issue in geoscience research. Tectonic uplift during the Middle-Late Permian transition resulted in sedimentary discontinuities and differential erosion, posing difficulties in defining the boundary and correlating it with global sections. In addition, multiple sections records negative carbon isotope excursion related to the PLB boundary, but with varying occurrence times, the cause of which remains unclear. In this study, we selected seven sections including Sandui Town, Wangjiagou, and Daliang Township in the late Guadalupian formations of the northwestern margin of the Yangtze Craton as the research objects. The stratigraphic ages were determined based on lithological characteristics and conodonts. Additionally, we supplemented the regional carbon isotope drift event with environmental evidence through the use of major, trace and rare earth element analysis methods, while also examining its relationship with geological events. The results show that: Firstly, from the Jinogondolella.postserrata to Clarkina.dukouensis zones, four lithologic intervals including bioclastic limestone (dolomitic limestone), siliceous rocks (argillaceous limestone), coal seams, and marl-bearing limestone were identified, representing three stages of sea-level stability, regression, and transgression. Then, based on palaeo-exposure surfaces, lithologic mutation surfaces, and the first occurrence of C.dukouensis conodonts, the position of the PLB boundary was identified. Subsequently, the J.postserra-J.shannoni zone and J.altudaensis-J.xuanhanensis zone in the Sandui Town section recorded two regression events, resulting in synchronous negative excursions of Sr/Ba and Y/Ho values, indicating relative enrichment of light rare earth elements. Finally, the Emeishan large igneous province became active at the J.altudaensis zone, with the input of hydrothermal fluids causing a sudden increase in the regional total rare earth element content. The biological populations were affected by an extinction event starting at the J.postserrata zone, which continued until the PLB boundary. In conclusion, this study complements the profile evidence by explaining the differences in the timing and period of negative carbon isotope excursion events between the northwestern margin of the Yangtze Craton and the global records.

Keyword

The Yangtze Craton, Biostratigraphy, Conodonts, PLB boundary, Biological extinction

Study of Meso-Neoproterozoic stromatolites and algal structures from the Lesser Himalayan carbonates of Nepal and their depositional environment

Basanta DEVKOTA[1]*, Tribhuvan University (basantadevkota012@gmail.com)
Lalu Prasad Paudel[2], Tribhuvan University, Nepal
Vinod Chandra Tewari[3], Sikkim University, India
Kabi Raj Paudyal[4], Tribhuvan University, Nepal

Abstract

In the present study, two major stratigraphic successions in the central and western parts of Nepal were traversed for the identification of stromatolites and other algal structures. These carbonate successions belong to the autochthonous units of the Nepal Lesser Himalaya. The exposed stromatolites containing carbonate formations were studied along the two road sections in the Kali-Gandaki River valley (Butwal-Tansen-Pokhara section) in western Nepal and the Malekhu area in central Nepal. Diverse stromatolites and algal structures are developed in the Dhading Dolomite unit of the Nawakot Group in central Nepal and the Chappani, Khoraidi, and Saidi Khola units of the Kali Gandaki Supergroup. Our focus was on understanding the microbial mat formation, growth of stromatolitic columns, and morphological variations ranging from simple stratiform to domal and columnar nonbranching to branching modes of occurrence. We also investigated various sedimentary and microbial carbonate facies, along with primary structures such as cherty bands and lenses, cross laminations, intraclasts, and oolites. We interpreted the paleoenvironment of deposition based on stromatolitic-algal growth, the shape of columns, and primary structures. We compared the growth pattern of the stromatolites from the Lesser Himalayas of Nepal with modern stromatolite development in Shark Bay, Australia, and Bahama, USA. The observed variation in stromatolite forms found in the carbonate successions of Nepal included crenulated mats, stratified and large domal, columnar (Colonnella columnaris), conical (Conophyton, possibly new form), and Kussiella kussiensis. These large stromatolitic columnar and conical forms were globally distributed and have been recorded from Pre-Ediacaran (Meso-Neoproterozoic pre-glacial) Lesser Himalayan carbonate formations of India (Gangolihat, Deoban, and Buxa Dolomite). These large stromatolites, domal algal structures and oolitic-intraclastic grains suggest a shallow marine tidal flat environment of deposition for carbonate rocks. Additionally, an attempt is made to understand the significance of stromatolites in the regional correlation of Lesser Himalayan stromatolitic carbonate sedimentary belts between Nepal and India during the Meso-Neoproterozoic (Pre–Ediacaran) time to understand the geological history of the South Asian region.

Keyword

Stromatolites, Meso-Neoproterozoic, Dhading Dolomite, regional correlation, Nepal Himalaya

Study of the Late Permian radiolarian fauna from the Heshan Formation in Laibin, Central Guangxi Province

XiaoXin Dong[1]*, GuiLin Univercity of Technology (2515222377@qq.com)
QiangFen Ma[2], Guilin University of Technology

Abstract

The study of radiolarian fossils is a good way to study the Late Paleozoic deep-sea sediments. During the Late Permian, relatively complete marine strata were deposited in the Central Guangxi, this paper selected the well-exposed Chengxiang section and Siguan section in the Upper Permian Heshan Formation from the Central Guangxi. We found a large number of radiolarian fossils in the study sections, the overall morphology of radiolarians is mostly spherical and ellipsoidal, the shell has no main sting. By detailed appraisal of the radiolarians fossils, 8 species belonging to 8 genera had been identified, including the albaillellids, the spherical polycystine and the stauraxon polycystine: *Pseudoalbaillella globosa*, *Hegleria mammilla*, *Paracopicyntra ziyunensis*, *Entactinosphaera sp.*, *Cenosphaera sp.*, *Archaeospongoprunum chiangdaoensis*, *Somphoentactinia saecularis*, *Quadricaulis femoris*. By comparing the previous research data, it is found that most of the fossils in the study area are small in size, and the radiolarian genera and species have a significant decrease in radiolaria found in South China at the late Permian compared with the heyday, which is consistent with the characteristics of most extinction events in the Late Permian, and also confirms the research conclusions of the Permian mass extinction, and provides a basis for the study of the evolution of the late Permian radiolarian fauna.

Keyword

Radiolarian fauna, Upper Permian, Heshan Formation, Laibin, Central Guangxi

Calcification of cell membranes: From ions to minerals

XIAO GAO[1]*, Shandong University of Science and Technology (xiaogao92@sdust.edu.cn)
ZUOZHEN HAN[2], Shandong University of Science and Technology

Abstract

Calcified microorganisms are a typical product of biomineralization. In this study, the whole process of cell membrane calcification of Bacillus licheniformis DB1-9 was studied by molecular dynamics (MD) and microbially-induced carbonate precipitation (MICP) laboratory experiments. Typical metabolitic products of Bacillus licheniformis DB1-9 were used as the calcium carbonate nucleation template to establish the organic constituents and a water-calcium carbonate two-phase system model for MD simulation, and to characterize the early stages of calcium carbonate nucleation on the surfaces of extracellular polymeric substances (EPS). The surface minerals of calcified bacteria obtained by MICP were prepared by focused ion-beam (FIB) and further analyzed using high-resolution transmission electron microscopy-selected area electron diffraction (HRTEM-SAED). We propose that the evolution process of cell membrane calcification is: ions → ion-pairs → multi-ion complexes (MIC) of large-size topological structures → pre-nucleated clusters (PNC) → amorphous calcium carbonate (ACC) → carbonate minerals (monohydrocalcite, vaterite, aragonite). In addition, ACC and the state before ACC were adsorbed on to the surface of the cell membrane after self-assembly in the aqueous solution; the ACC then underwent maturation and crystallized into ordered carbonate minerals with a crystal structure. Our study reveals the processes of microbial calcification, which has implications for the calcification of microorganisms in modern aqueous environments and for the formation of microbialites throughout the geological record.

Keyword

Calcification, Crystallization, Biological interface, Molecular dynamics, Biomineralization

The Złatne/Pieniny Basin as a part of the Alpine Tethys in Central and Eastern Europe

Jan Golonka[1]*, AGH University of Kraków (jgolonka@agh.edu.pl)
Anna Waśkowska[2], AGH University of Kraków
Michał Krobicki[3], AGH University of Kraków

Abstract

The Calcareous Alps and Central Carpathians formed the marginal platform of Western and Central Europe during the Triassic time. The Mesozoic rifting events caused the origin of oceanic type basins along the northern margin of the Paleotethys. The Pangean breakup resulted in the formation of the Alpine Tethys during Sinemurian/Pliensbachian time. This Alpine Tethys separated Eurasia (North European Platform and the Central Carpathian Plate). It was divided into the Złatne/Pieniny and Magura Basin separated by the Czorsztyn Ridge (intraoceanic submarine swell). The deeper water sediments, like radiolarites, were deposited in this basins, while shallower water carbonate sedimentation prevailed on slope of the Czorsztyn Ridge.

The Złatne/Pieniny Basin (Z/PB) existed as an oceanic basin located between Central Carpathian plate and Czorsztyn Ridge during Jurassic–Early Cretaceous times. The extremely deep-water pelagic limestones and radiolarites were followed by Albian-Miocene marls and clastic within Z/PB. Major plate reorganization happened during Tithonian-Albian times. The new Atlantic spreading entered the area between the Newfoundland shelf and Iberia. The Jurassic Pangean break-up system in Alpine Tethys was abandoned. The subduction developed along the Alpine Tethys (Z/PB) margin. The rotation of Africa and the spreading in the Eastern Mediterranean caused the Central Carpathian Plate to converge with Europe. The Alpine Tethys was gradually closed. The latest Cretaceous-earliest Paleocene was the time of the closure of Z/PB and the Late Cretaceous flysch of Z/PB Basin was deposited as a part the accretionary prism in front of the Central Carpathian Plate that reached and overrode the Czorsztyn Ridge. The turbiditic and pelagic sedimentation continued in the piggy-back setting until Neogene times. Finally, the Z/PB and accretionary prism deposits were transformed into several nappes, including Złatne Unit (nappe) of the Pieniny Klippen Belt (PKB). The PKB is located in the suture zone between the Central and Outer (Flysch) Carpathians, stretching from Austria to Romania in the Central and Eastern Europe. The tectonic Złatne Unit is best exposed in the western part of PKB in Poland.as well as in the Haligovce - Vel'ký Lipník area in Małe Pieniny Mountains in Slovakia. Type locality is in the Złatne area (Spisz Pieniny Mountains) in Poland The huge olistoliths in Haligovce – Vel'ký Lipník area represent shallow water sequences of the southwestern margin of Alpine Tethys. These olistoliths are surrounded by Upper Cretaceous and Paleogene flysch sequences forming sedimentary mélange.

This research was financially supported by the Polish National Science Center grant NCN – 2019/35/B/ST10/00241 and grant of the AGH University of Krakow (16.16.140.315).

Keyword

Central Carpathians, Pieniny Klippen Belt, North European Platform, flysch, mélange

The Tethyan Seaway during the Early to Middle Miocene – new data and a review

Werner E. E. Piller[1]*, University of Graz, Austria (werner.piller@uni-graz.at)
Mathias Harzhauser[2], Natural History Museum Vienna
Matthias Kranner[3], Natural History Museum Vienna
Oleg Mandic[4], Natural History Mesum Vienna
Tayebeh Mohtat[5], Geological Survey of Iran, Tehran
Jahanbakhsh Daneshian[6], Kharazmi University, Tehran

Abstract

The Tethyan Seaway was the connection between the Eastern and Western Tethys which became restricted and finally closed during the Early and Middle Miocene. The uplifted Zagros Mountains split the seaway into two entities, the Iranian Gateway in the northeast and the Mesopotamian Gateway in the southwest. The reconstruction of the seaway is based on sedimentological and paleontological data of the Qom, Asmari and Gachsaran formations predominantly on biostratigraphy. This paper presents an evaluation and new data on the occurrence of the Qom Formation in the Zanjan area (Sheikh Jaber section) of Iran. The Qom Formation there is dominated by marls and sandstones and only subordinated limestones occur. Unusual for the Qom Formation is the high share of volcanic rocks (basalt, tuff, tuffitic marls, lapilli, coarse volcanoclastic components in all types of lithologies) which indicates that the Qom Formation in the Zanjan area belongs either to the Sanandaj-Sirjan Basin or the Urumieh-Dokhtar Basin. Planktonic foraminifers and mollusks, in particular, pteropods, indicate a deposition of the succession in the late Burdigalian to Langhian. The mollusk fauna exhibits a pure Mediterranean character and no overlap with the Indo-Pacific fauna occurs. Both the fauna and the overlying continental deposits of the Upper Red Formation preclude a marine connection along the Iranian Gateway in the Langhian between the Proto-Mediterranean and Indian Ocean, the mollusk fauna also obviates a connection between the Proto-Mediterranean/Indian Ocean and the Eastern Paratethys. The sediments in the Mesopotamian Gateway are represented by the Asmari Formation, which is similar in facies and stratigraphy to the Qom Formation, and the Gachsaran Formation dominated by evaporites and shallow marine sediments. This gateway may have not been completely blocked in the Langhian but the very shallow water connection was paleoceanographically ineffective and not passable for biota such as mollusks.

Keyword

Qom Formation, Asmari Formation, Gachsaran Formation, Iranian Gateway, Mesopotamian Gateway

Late Paleocene-middle Eocene calcareous nannofossils in western Tarim Basin

Xuejiao WANG[1]*, Polar Research Institute of China (xuejiaowang410@hotmail.com)

Abstract

The western Tarim Basin is located between the Tianshan Mountains and the Kunlun Mountains and was situated in shallow epicontinental northeastern part of the Tethys Sea during the Late Cretaceous to Eocene. Three cycles of sea regressions are recorded in Qimugen, Wulagen and Bashibulake formations and PETM (Paleocene-Eocene Thermal Maxmum) event is identified by carbon isotope excursion in Qimugen Formation in previous studies. Here, calcareous nannofossils assembalges from late Paleocene-middle Eocene sediments from three sections (Bashibulake, Kuzigongsu and Simuhana) were correlated to dicuss the biostratigraphy and paleoecology in the Tianshan Mountains area (western Tarim Basin). The third sea transgression occurred concomitant to the Qimugen Formation, and calcareous nannofossil assemblages indicate the highest relative sea level occurred near the middle part of NP9a in the Tianshan Mountains area. The gradually increasing sea level from the base of the Qimugen Formation is dated to the nannofossil zones NP7 to 9a (Thanetian), in which the first occurrence of *Heliolithus riedelii* and of *Discoaster multiradiatus* have been recorded. The highstand of the sea level cycle coincides with increasing *Discoaster* spp. amounts near the Paleocene/Eocene boundary (NP9a-10), which is dated by the occurrence of RD assemblages (namely, *Discoaster araneus* group-*Rhomboaster* spp.). Evidence of regression, observed in the top of Qimugen Formation (NP10-11) corresponds to low abundance and diversity of nannofossils, and is characterized by a rapid increase of *Micrantholithus* spp. in the assemblage. And combining with the previous model of PETM event, the recovery phase may not be recorded completely in the western Tarim Basin. The fourth episode represents a period of shallowing upward in the Kalataer and Wulagen formations, which is dated as CNE12-13 (Lutetian) for the occurrence of *Nannotetrina* spp., *Discoaster bifax*, *Reticulofenestra umbilicus*, *Cribrocentrum reticulatum* and *Chiasmolithus solitus*. The maximum depth of water documented near the boundary of CNE12/13 zone. The presence of a diverse assemblage of discoasters in the top Kalataer to basal Wulagen suggests deposition occurred in oligotrophic, warm water with a connection to the open ocean. Progressive shallowing over time led to the formation of a restricted basin in which only *Coccolithus pelagicus* could survive. Alternating dry and wet condition was shown by large proportion of illite and montmorillonite in the middle Wulagen Formation, indicating that the abrupt disappearance of calcareous nannofossil was mainly controlled by water depth. The fifth major episode of marine incursion is preserved in the middle part of the Bashibulake Formation, which is dated as Zone CNE17 (Bartonian/Priabonian) based on the presence of common *Cribrocentrum erbae*.

Keyword

Tarim Basin, Calcareous nannofossils, Sea regresssion, Tethys, Paleoenvironment

The base of the Maastrichtian at the Oslen-Krivodol Peritethyan reference section, Bulgaria: bioevents, isotope events and paleoceanography

Michael WAGREICH[1]*, University of Vienna (michael.wagreich@univie.ac.at)
Docho Dochev[2], Sofia University
Polina Pavlishina[3], Sofia University
Veronika Koukal[4], University of Vienna

Abstract

The base of the Maastrichtian as defined by the GSSP at Tercis-de-Landes, France, is currently in investigation by the newly installed Maastrichtian Working Group. Originally, the Campanian-Maastrichtian boundary (CMB) was set at a mean of marker bioevents, near the guide event of the first occurrence (FO) of the ammonite Pachydiscus neubergicus, estimated to be ca. 35 ka younger than the GSSP level. The main calcareous nannofossil marker so far provides the last occurrence (LO) of Uniplanarius trifidus, estimated at ca. 750 ka younger. Paleogeographically, Tercis was situated in the Tethys-Atlantic transition to the cooler northern temperate realm.

A largely similar Peritethyan paleogeographic position at the northern Tethyan-European margin is provided by the Upper Cretaceous sedimentary successions cropping out in the western Fore-Balkan Mountains area in Bulgaria. One of the most representative section comprising the Upper Campanian-Lower Maastrichtian interval is the Oslen-Krivodol section, situated in the western part of the Central Balkan–Fore-Balkan Zone in the northern segment of the Balkan Orogen.

At the section of Oslen-Krivodol, a 7 m succession of glauconitic limestones, clayey to nodular limestones and chalky sediments is exposed that includes inoceramids and belemnites. The lower part is composed of green to greenish glauconitic limestones (Darmantsi Formation), overlain by thin- to medium bedded limestones, clayey and nodular limestones (Kunino Formation). Belemnite rostra occur in the entire section, whereas inoceramid bivalves were collected from one level in the upper part of the Kunino Formation. A complete nannofossil zonal succession could be established, from the uppermost Campanian to the lowermost Maastrichtian, with subzones UC15cTP, UC15deTP, UC16aTP (uppermost Campanian), and UC16bTP (basal Maastrichtian). The nannofossil bioevent for the base of the Maastrichtian, the LO of U. trifidus, is at 3.25m in the section. Strontium isotope stratigraphy indicates the CMB interval around values of 0.707728 ±0.000004. Additional nannofossil bioevents in the CMB interval include the FO and LO of Microrhabdulinus ambiguus below those two inferred CMB levels, and the sudden decrease of warm-water nannofossil indicators like Watznaueria spp., which seems to indicate a threshold crossing for global cooling along the CMB carbon isotope event. Higher in the section, Arkhangelskiella maastrichtiensis s.str. occurs.

Two dinocyst zones have been recognized in the section: the upper Campanian Areoligera coronata and the lower Maastrichtian Cerodinium diebelii Zone. Their boundary is marked by the last occurrence of typical Campanian taxa (Odontochitina, C. robusta, C.horridum, A. fenestra) and the appearance of characteristic Maastrichtian forms (C. diebelii, M. carpentierae,

Glaphyrocysta).

Only one level from the upper part of the Kunino Formation have yielded abundant, but badly preserved (as internal moulds) inoceramid bivalves. The inoceramids are represented mainly by the genus Cataceramus, but Endocostea is also present: Endocostea typica Whitfield, 1880; Cataceramus pallisieri (Douglas, 1942); Cataceramus subcircularis (Meek, 1876) and Cataceramus barabini (Morton, 1834). Based on the presence of E. typica we can indicate the eponymous inoceramid zone at the base of the Maastrichtian.

The CMB interval is generally marked by global cooling and the broadly negative Campanian-Maastrichtian Boundary carbon isotope Event, with positive peaks (CMBE1 to 5).

Keyword

stratigraphy, Maastrichtian, Campanian, Peritethyan

The opening time constraints of both Bangong-Nujiang Ocean and Neotethys Ocean: evidences from both stratigraphy and palaeobiogeography in the Qinghai-Tibet Plateau

Yichun ZHANG[1]*, Nanjing Institute of Geology and Palaeontology (yczhang@nigpas.ac.cn)
Shuzhong Shen[2], School of Earth Sciences & Engineering, Nanjing University
Yujie Zhang[3], Chengdu Center of China Geological Survey
Dongxun Yuan[4], School of Resources and Geosciences, China University of Mining and Technology
Haipeng Xu[5], School of Earth Sciences & Engineering, Nanjing University
Qi Ju[6], School of Earth Sciences & Engineering, Nanjing University

Abstract

The opening time of both the Bangong-Nujiang Ocean (or the Mesotethys Ocean) and the Neotethys Ocean have been a focus of debate. Several paleogeographic models have been proposed. We have undertaken several years of hard fieldwork in various regions in the Tethys Himalaya area, the Lhasa Block, the South Qiangtang Block and eastern Myanmar, with the purpose to establish the correlations of different tectonic blocks as well as to constrain the opening time of both Bangong-Nujiang and Neotethys oceans. Our studies indicate that: (1) The South Qiangtang Block rifted away from the Gondwanan margin during the Artinskian time (~290 Ma). And shortly after its departure, a rifted valley developed within this Block during the late Kungurian time. (2) The Permian of the Lhasa Block is very stable, which is characterized by a stable transition from glacio-marine diamictes during the Early Permian to carbonated during the Middle and Late Permian. Also, some faunas (such as late Kungurian Vjalovognathus-Mesogondolella conodont assemblage and Capitanian Nankinella-Chusenella fusuline assemblage) are characteristic faunas in the Lhasa Block. (3) The Neotethys Ocean must have opened before the late Kungurian time as evidenced by the contrast depositional sequence between the Lhasa and Tethys Himalaya. Also, the development of Middle Permian seamount within the Yarlung-Tsangpo suture zone as well as the distribution pattern of the typical Shanita-Hemigordiopsis foraminiferal assemblage both suggest the existence of a Neotethys Ocean during the Middle Permian time.

In conclusion, both the Bangong-Nujiang Ocean and Neotethys Ocean have opened in different time during the Permian time. So, the Cimmerian Continent is much more complex than previously recognized.

Keyword

Tethys, Bangong-Nujiang Ocean, Neotethys Ocean, Permian, palaeobiogeography

[Keynote] The Permian-Triassic amalgamation in the Altaids-Tethysides interaction

Wenjiao XIAO[1]*, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (wj-xiao@mail.iggcas.ac.cn)
Qigui Mao[2], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Dongfang Song[3], Institute of Geology and Geophysics, Chinese Academy of Sciences
Qingqing Qiao[4], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Miao Sang[5], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
He Yang[6], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Xiaoliang Jia[7], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Zhou Tan[8], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Hao Wang[9], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Rui Li[10], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences

Abstract

The Altaids and Tethysides are two considerable orogenic systems on our planet. The closure of the Paleo-Asian Ocean (PAO) formed the Altaids, and the closure of the Tethyan Ocean (TO), Tethysides. Most previous reconstructions regarded the Tarim-Alxa-North China as a long continent chain in the Paleozoic that blocked the internal TO from the external PAO. However, it is controversial how and when the key continental blocks, including Tarim, Alxa and NC, formed a continental chain. We summarize new advances in the tectonic evolution of the intervening orogenic belts to address the Permian–Triassic amalgamation for the Altaids-Tethysides interaction. Paleogeography and paleomagnetism data show that Kazakhstan, Tarim, Alxa and South China shared similar Gondwana affinity, but the NC was different from these blocks. In particular, recent paleomagnetic studies indicate that the Alxa block was not unified with NC until Permian. In the late Paleozoic, there were still some wide oceans between Tarim, Alxa, and NC. Therefore, there was no such integrated Tarim-Alxa-NC blockage that existed since the early Paleozoic. Systematical petrological and isotopic data on the ophiolites in the Altaids verify that some oceans in the western Altaids (West Tianshan and West Junggar) had origins from the TO, indicating that the TO was located not only to the south of the Tarim block, but also to some areas north to the Tarim in the late Paleozoic. A complicated archipelago system may have existed in which some intra-oceanic arcs might link some of those continental blocks, forming irregular boundaries between TO and PAO. Considerable interactions might have happened between the Altaids and Tethysides, in a way similar to the Pacific plate penetrating into the Atlantic ocean through the Caribbean Sea. There was one larger, major composite continental mass, composed of Kazakhstan, Tarim, Alxa, Qaidam, NC, South China (SC) and Indochina (INC) blocks, called the KTANSI, which finally formed in late Permian to Triassic. This is based on the final amalgamation timing of the intervening orogens, which all converge to the late Permian–Triassic. The South Tianshan, the major suture welding Kazakhstan orocline and Tarim, was capped by a Triassic accretionary basin. The eastern Tianshan shows its similar Triassic final amalgamation history. The Tarim block was amalgamated with the Qaidam block by closing oceans along the

Beishan and Eastern Kunlun orogens in the Permian–Triassic. Paleomagnetic data suggested that the Alxa block was not part of the NC until Permian, and a transform boundary was proposed between them until Triassic. In Triassic, there was a unified Kazakhstan-Tarim-Qaidam-Alxa-NC continental chain in the northern part of East Asia, joined by the SC along the Qinling-Dabie-Sulu, which was amalgamated with the INC along the Ailaoshan–Red River orogen in the Triassic. These intervening orogens were almost terminated in the Triassic, which finally formed a gigantic S-type continental chain. Together with the “giant tadpole” that are composed of the Siberia and Tuva-Mongol orocline, complicated continental chains and their multiple oroclines played an important role in the architecture of orogens and continental growth of East Asia.

Keyword

Tethysides, Altaids, Triassic, East Asia, Orogeny

Early Triassic anachronistic microbial and pisoid-facies carbonates in the eastern Paleotethys

Katsumi Ueno[1]*, Department of Earth System Science, Fukuoka University (katsumi@fukuoka-u.ac.jp)
Thasinee CHAROENTITIRAT[2], Program in Energy Geoscience, Faculty of Science, Chulalongkorn University, Thailand
Yoshihito KAMATA[3], Graduate School of Life and Environmental Sciences, University of Tsukuba, Japan

Abstract

In view of biocommunity development through the Earth history, the Early Triassic lasting for some 5 m.y. is unique in continuing biodiversity suppression after the Permian–Triassic boundary (PTB) mass extinction. In this period, carbonate deposits showed unusual, somewhat anachronistic features, such as dominating microbialites, thrombolites, pisoids (giant ooids), and the poverty of skeletal grains, probably reflecting peculiar marine environmental conditions after the catastrophic PTB event. Primary dolomite production is also common. We examined a continuous, latest Permian to Middle Triassic carbonate succession distributed in the Lampang area of Northern Thailand to closely investigate its Early Triassic sedimentary and biotic features.

The Lower Triassic in this area has been attributed to the Phra That Formation of the Lampang Group, and previous studies described the main lithology of the formation as being predominant in siliciclastic rocks. Thus, the examined carbonate succession is regarded as time-equivalent with the Phra That Formation but showing different lithofacies. The Early Triassic succession studied herein consists mainly of dolostone and dolomitic limestone and directly overlies conformably latest Permian *Palaeofusulina*- and *Colaniella*-bearing limestone. It is subdivided lithologically into two parts. The lower (basal) portion (ca. 100–150 m thick) is composed of bedded to massive dolostone and dolomitic limestone with laminated microbialites made by clotted micritic particles in some levels. Sporadically occurring *Postcladella kalhori* supports an Induan age for this interval. Tiny crystals of pyrite (partly hematite?) are sometimes observed in fine-grained dolomite beds, and thin layers consisting of ooid (rarely pisoid) grains are also recognized in some dolomitic limestone beds. The latter represents inflow deposits by storm and other intermittent events and characteristically contains broken ooids, which suggest strong reworking and/or possible breakdown by desiccation. Overall, the lower part of the succession presumably exhibits an intertidal to supratidal environment. The middle–upper portion (ca. 700–750 m thick) is dominated by cross-laminated oolitic and pisolitic dolomitic limestone and dolostone. A broad Olenekian age is supposed by rarely yielded monotonous and restricted foraminiferal assemblages composed of *Postcladella*? (or primitive *Arenovidalina*?) and "*Glomospirella sygmoidalis*". An uppermost subtidal to intertidal environment is suggested for the depositional setting of this dolomitic limestone and dolostone interval in the studied carbonate succession, based on the abundant occurrence of ooids and pisoids. Then, this middle–upper part is succeeded by micritic limestone of the Middle Triassic Pha Kan Formation,

which contains the Anisian *Citaella dinarica* assemblage.
The present Early Triassic succession in Northern Thailand is characterized by unusual foraminiferal features and carbonate lithology, such as restricted faunal diversity and anachronistic laminated microbialites and pisoid-rich dolomitic limestone, while its conspicuous carbonate production represented by >800-m-thick strata. The studied carbonates formed in the eastern Paleotethys would have good potential for elucidating shallow-marine paleoenvironments in the process of recovery from the PTB extinction. In addition, this is the first documentation of Early Triassic carbonates and foraminifers in Southeast Asia.

Keyword

Early Triassic, carbonate, posoid, microbialite, post-PTB

Late Neoproterozoic–Cambrian eclogites and high-pressure granulites in the Central Qilian terrane (China) record the earliest subduction of Proto-Tethyan Ocean in the eastern Tethysides

Hao WANG[1]*, Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences (paulwh@126.com)
Wenjiao XIAO[2], Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences
Rui LI[3], Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences
Hongxu CHEN[4], SinoProbe Center, Chinese Academy of Geological Sciences and China Geological Survey
Zhou TAN[5], Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences
Qigui MAO[6], Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences

Abstract

The Central Qilian terrane (CQT) of the northern Tibetan Plateau played a key role in the tectonic evolution of the Proto-Tethyan Ocean in the Tethysides, but its formation and tectonic attribution have been hotly debated. Here, we report the discovery of eclogites and HP mafic granulites in the Beidahe Complex of the western CQT. These occur as blocks of various sizes within a sequence of metavolcanic–sedimentary rocks, exhibiting typical a ‘block-in-matrix’ and thrust imbrication structure. The eclogite facies metamorphic rocks preserve distinct mineral assemblages and textures corresponding to prograde, peak, and retrograde metamorphism. By combining phase equilibrium modelling with SHRIMP and LA-ICPMS U–Pb dating of metamorphic zircon, sphene, and rutile, the Late Neoproterozoic–Cambrian (ca. 553–516 Ma) eclogite facies peak with low thermal gradients of 10–14℃/km, Cambrian (ca. 515–506 Ma) post-peak decompression and Ordovician (ca. 495–455 Ma) cooling histories for these metabasic rocks have been restored. These constitute hairpin-type clockwise pressure–temperature–time (P–T–t) paths depicting in detail the sequence of deep subduction and subsequent exhumation in Central Qilian during the Late Neoproterozoic to Early Palaeozoic. Our new findings suggest that the CQT represents a Japan-type arc-accretionary system that formed as a result of the North Qilian oceanic plate, one of the major branches of the Proto-Tethys Ocean, being subducted southward. Eclogites in the Beidahe Complex in western CQT offer the earliest (ca. 553 Ma) metamorphic record of subduction in the Qilian orogen, indicating that the North Qilian Ocean commenced subducting southward prior to the Late Neoproterozoic.

Keyword

Central Qilian, Proto-Tethys Ocean, eclogite, P–T–t path, Paleogeography

Subduction and Obduction-Scenario structural analysis of the Indosinian orogenic belt

Wei LIN[1]*, State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences (linwei@mail.iggcas.ac.cn)
Yin Wang[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences
Fei Liu[3], Wuhan Center of China Geological Survey (Central South China Innovation Center for Geosciences)
Lingtong Meng[4], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The evolution of eastern Paleo-Tethys, between the South China and Indochina blocks, recorded the whole process of rifting from Gondwana and their northward migration and convergence. To understand the tectonic implications, the structure geology, arc-related magmatism, and matrix of ophiolitic mélange were realized in the classic Indochina orogenic belt. This Mesozoic orogenic belt consisted of three segments of Ailaoshan, Song Ma, and Song Chay, which located in the North Vietnam-Southeast Yunnan region. Based on our regional comprehension, we reviewed the previous structure, zircon U-Pb dating, and Lu-Hf isotopic analyses from the Ailaoshan, Song Ma, and Song Chay ophiolitic mélange. Accordingly, we subdivide the matrix of the ophiolitic mélange into four parts (M1, M2, M3, and M4). M1 is mainly located in the middle segment of the Ailaoshan-Song Ma belt. It shows the age peaks of 440 Ma and 960 Ma with εHf(t) values of -19.6 ~ +10.3. M2 is mainly located in the NW segment of the Ailaoshan-Song Ma belt, showing a dominant age peak of ~260 Ma. Particularly, it has εHf(t) values of -28.9 ~ +8.1. M3 is mainly located in the SE segment of the Ailaoshan-Song Ma belt, showing peaks at ~250 Ma, 440 Ma, and 960 Ma with εHf(t) values of -21.9 ~ +10.1. M4 is mainly located in the Song Chay belt, showing peaks at ~310 Ma, 470 Ma, 610 Ma, 770 Ma, and 965 Ma with εHf(t) values of -28.2 ~ +10.8. The geochronological data of the detrital zircon from the matrix of the Ailaoshan, Song Ma, and Song Chay ophiolitic mélange zone, documents a temporal heterogeneity between the M1, M2, M3, and M4 units at 310-270 Ma, 265-250 Ma, 245-240 Ma, and 310-255 Ma, respectively. The different components and provenances of each unit reflect a strike-parallel heterogeneity. The M1 unit was mainly sourced from the Paleozoic sedimentary rocks of the IB. The main provenance for the M2 unit is Emeishan large igneous province (ELIP). The magmatic arc developed in the IB provided the materials for the M3 unit, and the detrital materials of the M4 were mainly sourced from the SCB. The M1, M2, M3, and M4 units contain information from different evolutionary stages, likely recording the comprehensive history of the ancient oceanic basin. Importantly, our results demonstrate that both the active continental margin of the IB and the passive continental margin of the SCB acted as provenance sources that supplied a significant amount of detrital material in the ophiolitic mélange matrix, indicating a limited ocean of Paleo-Tethys. Combined with the structure magmatism analysis, the Indochina orogenic belt recorded

that the subduction and obduction were coexisting. This phenomenon creates the heterogeneity in this orogenic belt and provides a classical anatomical example of the different manifestations (subduction and obduction) during two-block interaction. It is of great significance in recognizing the relationship between the Paleotethys and the Panthalassa (Paleo-Pacific).

Keyword

Eastern Paleo-Tethys, Indosinian orogenic belt, Spatial and temporal heterogeneity of the ophiolitic mélange zone, Coexisting subduction and obduction, Paleogeography reconstruction

Revisiting the Structure and Stratigraphy of the Bentong-Raub Suture Zone: Insights from Field Investigation and Geochemical Analysis

Norasiah Binti SULAIMAN[1]*, The National University of Malaysia (UKM)
(norasiahs@ukm.edu.my)
Mohd Basril Iswadi BASORI[2], National University of Malaysia
Muhammad Ashahadi DZULKAFLI[3], National University of Malaysia
Azrin AZMI[4], National University of Malaysia
Muhammad Fuad RAZALI[5], National University of Malaysia

Abstract

The Bentong-Raub Suture Zone, located in Peninsular Malaysia, is part of a north-south trending lineament that extends from west Thailand through west Malaysia and into east Indonesia, representing Paleo-Tethys. This study utilizes field investigation, structural analysis, biostratigraphy, and geochemistry to extensively reexamine the structure and stratigraphic framework of the units within this suture zone. This study updates lithological units in the suture zone that extend beyond earlier proposed boundaries. The suture zone is characterized by the association of ophiolitic units, localized tectonic melange, and sedimentary deposits. The sedimentary deposits are deformed (folded, faulted, and sheared) and show blocks in a matrix fabric in some areas, forming a chaotic mass representing accretionary remains that structurally overlay the ophiolite unit. The limestone block in the mélange is determined to be of Early-Middle Triassic age based on the discovery of Triassic foraminifera, while siliceous-chert rocks exhibit Late Devonian to Middle Triassic age based on radiolarian biostratigraphy. Geochemical data from mafic rocks of the ophiolitic units hint at a possible origin from oceanic crust, while geochemical analysis of the siliceous-chert rocks affirms a biogenic origin in pelagic-oceanic basin and continental margin environments. The ophiolite was emplaced in a supra-subduction zone-type due to intra-oceanic subduction initiation as a result of the collision between the Sibumasu and Indochina blocks. Tectonic transport direction reflects collisional influence, yet disrupted deformation patterns imply strike-slip movements in the northwest-southeast and northeast-southwest directions. The discovery of the Middle Triassic radiolarian biozone suggests an open Palaeo-Tethys basin in Peninsular Malaysia up until the Middle Triassic, and the age of the mélange limestone block hints at accretion post-Middle Triassic. This comprehensive study contributes valuable insights into the geological evolution of the Bentong-Raub Suture Zone and its regional tectonic context.

Keyword

Bentong-Raub Suture Zone, Ophiolite Unit, Paleo-Tethys

A PALEOENVIRONMENTAL MODEL FOR THE RUS FORMATION: FACIES CHARACTERISTICS AND THEIR SEDIMENTARY ENVIRONMENTS

Osman Abdelghany[1]*, UAE University (osman.abdelghany@uaeu.ac.ae)
Abdel-Rahman Fowler[2], UAE University
Ahmed Gad[3], Ain Shams University, Egypt
Mahmoud Abu Saima[4], UAE University

Abstract

To the south of Al-Ain, in southern Abu Dhabi Emirate, a Lower Eocene to Miocene mainly marine carbonate sequence is well exposed at Jabal Hafit Mountain. This sequence includes the Rus Formation (lowest, no base exposed) of Lower Eocene age, overlain by the Middle to Upper Eocene Dammam Formation, followed by the Lower Oligocene Asmari Formation. The Dammam and Asmari Formations at Jabal Hafit have been the targets of numerous biostratigraphic studies, while the Rus Formation has received scant attention. The Rus Fm regionally is composed of a very shallow water platform sequence that includes significant evaporites (gypsum deposits). This is true for the exposures in Qatar, Saudi Arabia, Bahrain, Kuwait, Iraq and Oman. The Rus Formation in Jabal Hafit is markedly different in lithologies, with no clear evaporite horizons. It includes three members – a) the recently defined Mubazzara Member of nodular brown fine-grained cherty limestones, b) the Wadi Tarabat Member of white coralgal limestones, and c) the dolomitic Hili Member Alveolinid limestones.. A paleoenvironmental analysis of the Rus formation is the objective of this study, since no previous work has been published on this topic for the Rus Formation. Systematically sampled carbonate rocks were thin sectioned for microlithofacies analysis and micro-paleontological survey. For the Mubazzara Member the carbonate rocks were found to be mudstone-wackestones that contained planktonic foraminifera, ostracods, echinoids and sponge spicules. Less abundant Nummulites and Discocyclina fossils were present. The Wadi Tarabat Member is a packstone-grainstone with oolitic facies; stromatolitic facies including large Orbitolites; and miliolid-rich facies with Nummulites and Alveolina. The Hili Member is found to be a dolomitized wackestone-packstone rich in minute limonite particles, and hosting abundant disarticulated fossils of small Nummulites, Assilina and algal bodies. The three Rus Formation Members appear to describe a succession of environments on a carbonate ramp with tidal flat to inner shelf lagoon represented by the Hili Member, an above-wave-base shoal water environment for the Wadi Tarabat Member, and an open marine environment for the Mubazzara Member. The Rus Formation at Jabal Hafit preserves the deposits at the edge of the regional evaporitic carbonate platform that dominated the Arabian Peninsula in the Early Eocene. The carbonate ramp probably formed the margin of the Muthaymimah Trough.

Keyword

Paleoenvironment, Rus Formation, Microlithofacies, Lower Eocene, Jabal Hafit

Newly discovered Late Paleozoic magmatic rocks link to Paleo-Tethyan evolution in Hainan Island, South China

Lei WANG[1]*, Wuhan Center, China Geological Survey (Geosciences Innovation Center of Central South China) (wlei_a@mail.cgs.gov.cn)
Guang-Yue Cao[2], Chinese Academy of Geological Sciences
Xiang-Dong Wang[3], Wuhan Center, China Geological Survey (Geosciences Innovation Center of Central South China)
Dai Zhou[4], Wuhan Center, China Geological Survey (Geosciences Innovation Center of Central South China)

Abstract

The Song Ma suture zone in Southeast Asia is a segment of the main suture zone of the Paleo-Tethys Ocean, whereas the suture zone extends to South China is not well constrained. Previous studies have focused on metabasites and high-pressure metamorphic rocks from Hainan Island to discuss this issue, i.e. Bangxi-chengxing tectonic zone and Mulantou Complex. In this study, we present SHRIMP and LA-ICP-MS U-Pb dating, elemental and Nd-Hf isotopic data for newly discovered Late Paleozoic magmatic rocks link to Paleo-Tethyan evolution in Hainan Island.

The geochronological data show that three granitoids from northeastern Hainan Island yield zircon U-Pb ages between 366.4±2.2Ma and 370.4±2.4Ma, indicating a Late Devonian intrusive age. They exhibit unique geochemical signatures, characterized by enrichment in light rare-earth element, and large-ion lithophile elements (e.g. Rb, Th, U) with positive Pb spikes. Additionally, they show depletion in high-field-strength elements like Nb, Ta, and Ti, along with low contents of Sr and P. Isotopically, these rocks show uniform whole-rock Nd isotopic compositions with negative epsilon Nd values, but variable zircon Hf isotopic compositions and epsilon Hf values. The model age of Nd and Hf isotope are coincide with those of Precambrian metamorphic basement in Hainan Island. Titanite and apatite samples for four metabasites from western Hainan Island yield U-Pb intercept ages between 254.3±4.2Ma and 267.4±3.0Ma, indicating a Late Permian emplacement age. They were mainly alkaline-subalkaline basalt, with OIB-like and MORB-like geochemical features. All samples show positive epsilon Nd values ranging from 2.93 to 7.13.

Synthesizing the published data in Hainan Island, alongside the suture zone of the Paleo-Tethys Ocean, we propose that tectonic affinity of Hainan Island during the Late Paleozoic belongs to an arc-basin system related to the Paleo-Tethyan evolution from Tibetan plateau extended to South China. Late Devonian granitoids and Late Permian metabasites record the early-stage subduction of Paleo-Tethys Ocean and late-stage spreading of back-arc basin, respectively.

Keyword

Late Devonian granitoids, Late Permian metabasites, arc-basin system, Paleo-Tethyan, Hainan Island

Late Paleozoic sedimentary successions and basin structure variation of the Baoshan-Shan Block (China-Myanmar)

Xiaochi JIN[1]*, Institute of Geology, Chinese Academy of Geological Sciences (jinxchi@sina.com)

Abstract

The Baoshan-Shan block is a Gondwana-derived continental block straddling western Yunnan, China and Myanmar. It is separated from the Tengchong block and the Tenasserim unit to the west by the Nujiang and Shan Boundary faults, and from the Changning-Menglian belt and the Inthanon zone to the east by the Lancangjiang, Kejie, Nandinghe and Mae Yuam faults.

The Baoshan-Shan block has rather well-developed Paleozoic successions. But a hiatus resulted from the mid-Carboniferous (or Namurian) uplift is apparent and has varied magnitudes over the block. The mid-Carboniferous uplift is a widely recognized event in east Gondwana and its northern marginal region, where the Baoshan-Shan block was located. It changed the relief of the Baoshan-Shan block, interrupted the sedimentation on it, and caused erosion over a large area. Consequently, Late Carboniferous sediments are hardly seen on the block. Early Permian siliciclastics (120-150 m) with glacio-marine sediments were deposited on tilted Early Carboniferous limestones in the northern Baoshan block (referring to the Yunnan part) and on Devonian siliciclastics in the southern Baoshan block. The southwestern Baoshan block through to the Shan block (referring to the Myanmar part) stayed emerged. Deposition of limestones started around the Sakmarian/Artinskian boundary in the northern and southern Baoshan block. But was soon disrupted by the eruption of the Woniusi Basalts, which filled up the basin on the Baoshan block, with a thickness of ca. 700 m in the northern part and about 500 m in the southern part. The southwestern part and Shan block stayed as highland and was not reached by the basalts. This eruption resulted in a rather flat surface on the Baoshan block.

About the Roadian time, coastal clastic sediments, mainly red beds, formed on a weathered surface of the Woniusi Basalts in northern and southern Baoshan block, and on Middle Devonian limestone in southwestern Baoshan block, but are barely reported in the Shan block. Carbonate deposition with a transgression somewhat in the early Wordian took place in the whole Baoshan-Shan block. Carbonate formations rest conformably on the Roadian clastic deposits on Baoshan block. But in the Shan block, they rest on (often Middle) Devonian or older sediments. This round of carbonate deposition sustained through to at least the Middle Triassic in most places of the Baoshan-Shan block, resulting in the formation of thick carbonate successions.

Such an architecture of Late Paleozoic –Triassic sedimentary successions shows that the basement of the Baoshan-Shan basin as whole stayed stable, only in the Baoshan area (about 1/5 of the whole), block-faulting happened in the early Permian. It was in the Middle Permian the whole block submerged accepting carbonate deposition, which was more a result of an eustatic sea level rise. A less interrupted carbonate environment continued to at least the Middle Triassic.

Keyword

Upper Paleozoic, Baoshan-Shan Block, Yunnan, Myanmar

Deciphering Miocene Geodynamics and Sedimentation in Eastern Turkey: Insights from Plate Tectonics and Basin Analysis

Erhan Gulyuz[1]*, Department of Geological Engineering, Van Yuzuncu Yil University, Van, Turkiye (gulyuzerhan@gmail.com)
Meryem Dilan Ince[2], Department of Geological Engineering, Middle East Technical University, Ankara, Turkiye
Nilay Gulyuz[3], Department of Geological Engineering, Van Yuzuncu Yil University, Van, Turkiye
Bora Uzel[4], Department of Geological Engineering, 9 Eylul University, Izmir, Turkiye
Fatih Karaoglan[5], Department of Geological Engineering, Cukurova University, Adana, Turkiye
Nuretdin Kaymakci[6], Department of Geological Engineering, Middle East Technical University, Ankara, Turkiye

Abstract

This study deals with the geodynamic evolution of Eastern Turkey, elucidating the temporal and spatial dynamics of sedimentary and tectonic processes in the Oligo-Miocene. Initiated by the convergence of the Arabian and Eurasian plates around 35 Ma, this geological activity induced notable crustal shortening and uplift across Eastern Turkey, the Lesser Caucasus, Talysh Mountains, and the Greater Caucasus, enhancing sediment deposition in adjacent basins due to increased erosion in uplifted terrains. A pivotal outcome of these tectonic shifts was the formation of the Paratethys, a vast inland sea that experienced episodic isolation from global oceans, fostering unique marine life by the late Eocene. Despite its significance, the precise chronology of the Paratethys' inception and regression remains in debate.

Aiming to pinpoint the timing of the Paratethys' progression in Eastern Turkey and offer detailed spatio-temporal insights into its development, this study includes a suite of integrated stratigraphic techniques. These include marine biostratigraphy, magnetostratigraphy, strontium (Sr), and neodymium (Nd) isotope analyses, alongside low-temperature thermochronology. The investigation targets Miocene marine lithologies across Eastern Turkey to the Iranian border, with focus areas in Bölükova and Çayırlı (Erzincan), Yedisu, Hamamlı, Tekman, Aşkale (Erzurum), and Çobanbeyi (Ağrı).

Analyzing 278 magnetostratigraphic samples from Hamamlı and Bölükova, alongside over 200 biostratigraphic samples for foraminifera and nannofossil content, the study also utilizes 17 samples for Sr- and Nd-isotope dating to ascertain the ages and depositional environments of intercalated carbonates. Furthermore, five samples were analyzed by low-temperature thermochronological techniques and their time-temperature graphs were conducted.

Findings suggest the sections' youngest ages align with the late Burdigalian, placing the Hamamlı section within the C6 Chron (20.7-19.05 Ma). Initial Nd isotope data suggest a Mediterranean and Indian Ocean connection during the Burdigalian, indicating the youngest marine deposits in Eastern Turkey formed within an open marine setting linked to global oceans.

Briefly, this study contributes significantly to understanding the geodynamic interplay between continental collision processes and marine sedimentation in Eastern Turkey, underscored by the

Arabian-Eurasian plate convergence.

Supported by TÜBİTAK (Grant No: 121N080)

Keyword

Continental collision, Neotethys Ocean, Paratethys, Arabian-Eurasian collision, Tectonostratigraphy

Quantifying the Late Jurassic post-rift subsidence trends of Alpine Tethys: Constraints on the passive margin stage of the Vienna Basin area, Austria

Darko Spahić[1], Geological Survey of Serbia, Belgrade, Serbia
Eun Young Lee[2]*, Department of Geology, University of Vienna, Vienna, Austria
(eun.lee@univie.ac.at)
Aleksandra Šajnović[3], Faculty of Chemistry, University of Belgrade, Belgrade, Serbia
Rastimir Stepić[4], Geological Survey of Serbia, Belgrade, Serbia; Institute "Jaroslav Černi" for the Development of Water Resources, Belgrade, Serbia

Abstract

The process of rifting, followed by oceanic opening and subsequent development of post-rift passive margins, constitutes well-studied phases in the extensional processes shaping the formation of Earth's oceans. A critical aspect connecting these stages involves accurately quantifying the extensional activity that varies throughout the processes. In collisional orogenic settings, ancient passive continental margins frequently undergo either tectonic exhumation or significant burial, leading to the obscurity of their pre-existing configuration due to the involvement of crustal shortening processes.

In the area of the Vienna Basin, the main sedimentary succession overlying the crystalline basement is divided into three tectonostratigraphic units; the autochthonous Mesozoic unit, the allochthonous unit with different tectonic nappes, and the Miocene sedimentary rocks of piggy-back and pull-part basin systems. During the Middle Jurassic period, the region was located in a rifting zone of the Penninic Ocean, which transitioned to a passive margin basin setting with the deposition of post-rift sediments extending into the late Cretaceous. Across the Vienna Basin area, Austria, the rocks spanning from syn- to post-rift stages are closely linked with hydrocarbon formation and accumulation. In particular, the Mikulov Formation comprising deep marine marlstones deposited during the Late Jurassic is considered the major source rock pod for conventional hydrocarbons. However, due to the late Cretaceous to Paleogene structural deformations and the Miocene basin subsidence, the precursor rifting and passive margin strata preserve rarely the original configuration and remain largely underexplored. According to previous research, the passive margin phase is marked by notable age discrepancies attributed to varying onsets of syn-rift extension in the Alpine Tethys or Penninic oceanic realm along the peri-Tethyan margins. This study aims to investigate the extensional activity by evaluating the subsidence linked to the opening of Alpine Tethys beneath the Vienna Basin. Through utilizing drilling data and employing 1D basin modeling techniques, we quantify sedimentation rates and therefore place constraints on the effects of extensional faulting on rifted margin(s). The numerical 1D modeling method takes into account the pre-nappe-staked configuration (as well as Paleogene - Miocene sequences), whereby the thickness and properties of the 1D pseudo model layers are painstakingly collected from the available wealth of borehole and literature data. Although we were unable to apply the extensive organic geochemical database to 1D modeling calibration

(accounting for the tectonically displaced nappe-stacking geometry), our results demonstrate consistency between the various modeling scenarios. Our findings reveal that the Late Jurassic passive margin phase (during the period of Mikulov Formation) exhibits markedly lower subsidence rates (ranging from 140 to 170 m per myr) compared to both the underlying syn-rift phase and the subsequent thermal subsidence phase. This underscores the presence of significantly slower extensional trend including subsidence and faulting in the Late Jurassic beneath the Vienna Basin. The observation of elevated thicknesses exceeding 1.5 km indicates that sourcing materials underwent a considerably faster rate of accumulation compared to the computed post-rift subsidence.

Keyword

Alpine Tethys, Jurassic, subsidence, Vienna Basin, Mikulov Formation

Flysch and mélange in the North-Eastern Part of the Alpine Tethys

Anna WAŚKOWSKA[1]*, AGH University of Krakow (waskowsk@agh.edu.pl)
Jan Golonka[2], AGH University of Krakow
Kamil Cichostępski[3], AGH University of Krakow
Jerzy Dec[4], AGH University of Krakow
Monika Łój [5], AGH University of Krakow
Sławomir Porzucek [6], AGH University of Krakow

Abstract

The Alpine Tethys originated during the Pangean breakup in the Early Jurassic. This oceanic system constituted the extension of the Atlantic system, so the Atlantic Tethys name was also being used. The rocks deposited in the North-Eastern Part of the Alpine Tethys realm are recently exposed mainly in the Pieniny Klippen Belt and Outer Carpathians in Austria, Czech Republic, Slovakia, Poland, Ukraine and Romania.

Several evolutionary stages could be distinguished in the Western Outer Carpathians development:

1/ The synrift–postrift stage is expressed by rifting of terranes off the major continent and opening of oceanic basins, formation of passive margins and basins with the attenuated crust. The opening of the Alpine Tethys and formation of two major basinal domains – the northern Magura and the southern Złatne/Pieniny basins occurred during this stage. These domains were separated by the intraoceanic submarine swell - Czorsztyn Ridge. The basins gathered deep water deposits, mainly radiolarites cherty limestones and synrift clastics, the shallow-water carbonates were deposited on the basin's margins and on the intraoceanic swell.

2/ The synorogenic, contractional, collisional stage that took place in Cenomanian–Eocene is characterized by development of subduction zones along the active margin, partial closure of oceanic basin, partial destruction of ridges, formation of deep-marine flysch basins, development of accretionary prism and partial closing of oceanic basins. At that time the flysch sedimentation occurred in the Alpine Tethys. Thick complexes of sandy-muddy and muddy-sandy turbidites were deposited within the shortening Magura and Złatne/Pieniny basins. The subaqual mass movements were characteristic for that stage of development. They were accompanied by the turbiditic sedimentation and as a result, the olistostromes were formed. Intense gravity mass sedimentation occurred in the Złatne/Pieniny Basin during the Late Cretaceous, producing chaotic sediments of mélange-type with olistoliths of Jurassic rocks. Slightly later, in the Late Cretaceous–Paleocene, olistostromes formations were frequently deposited in the southern part of Magura Basin, as an effect of accretionary prism overriding the Czorsztyn Ridge. The characteristic morphology of the Pieniny Klippen Belt is connected with the occurrence of the limestone klippen standing out in the landscape. These klippen are results of separation of olistoliths from the soft mélange matrix by erosion. The carbonate deposits developed also along the northwestern margin of the Alpine Tethys. These rocks are known from olistoliths occurring in

the mélanges of the Magura Nappe and Subsilesian-Ždanice-Waschberg units. The largest olistoliths occurs in the Kurovice in Czech Republic.
3/ The late orogenic stage, Eocene–Miocene in age, is characterized by further development of accretionary prism closing of oceanic basins, final destruction of ridges and development of remnant flysch basins. The Alpine Tethys ceased to exist during this stage. The remnant flysch basins became part of the Paratethys.

This research was financially supported by the Polish National Science Center grant NCN – 2019/35/B/ST10/00241 and grant of the AGH University of Krakow (16.16.140.315).

Keyword

Paleogeography, flysch, mélange, Carpathians, Pieniny Klippen Belt

Paleogeograpy of the Tethys oceans in South-East Asia

Khuong The HUNG[1]*, Hanoi University of Mining and Geology, Vietnam
(khuongthehung@humg.edu.vn)
Nguyen Khac Du[2], Hanoi University of Mining and Geology, Hanoi, Vietnam
Jan Golonka[3], AGH Unversity of Krakow, Krakow, Poland

Abstract

Paleogeographic analysis has shown that the continents of Gondwana, Baltica, Laurentia, Siberia, South China and North China, as well as several smaller plates and other tectonic elements were present during Paleozoic times. These elements included Indochina and Sibumasu, presently in South-East Asia. The Prototethys (Paleoasian) Ocean extended between Siberia, Baltica and the Asiatic plates. This ocean originated perhaps during late Cambrian – Early Ordovician times. It separated Indochina and South China plates.

Paleotethys Ocean existed during Paleozoic and Early Mesozoic times. It was located between the Gondwana continent and Avalonian ribbon of terranes that broke-off Gondwana and moved north. Indochina belonged to this ribbon,

Indochina collided with South China along Song Ma – Truong Song – Ailaoshan suture during latest Silurian-earliest Devonian times. In northwestern Vietnam, the late Silurian Song Chay complex granitoid is connected to this event. This collision was followed by the subduction of the Paleotethys Ocean below Indochina and the formation of a new oceanic basin between Indochina and South China recorded by the ophiolite belt consisting of several complexes and formations. This basin was closed during Permian-Triassic times by the Indosinian Orogeny marked by magmatic, metamorphic, and deformation events in various structural zones.

The Sibumasu belonged to the Cimmerian Chin of microcontinents that was detached from Gonwana during late Paleozoic times opening the Neotethys Ocean. The collision of these microcontinents with Indochina trigger the Indosinian Orogeny. This orogeny was concluded at the Triassic-Jurassic boundary, leading to closure of Paleotethys and the consolidation of a new large Chinese-SE Asian plate. The Indosinian orogeny events are marked by ophiolites and related structural zones along Raub-Bentong, Sra Kaeo and Nan-Uttaradit suture between Sibumasu and Indochina and Song Ma- Ailaoshan suture between Indochina and South China.

This research was financially supported of the Vietnam Ministry of Education and Training (VMOET) under grant number B2023-MDA-08.

Keyword

Prototethys, Paleotethys, Neotethys, Indochina, Sibumasu

Study on coal-bearing deposits of the Lower Gosau Subgroup (Turonian to Campanian) in the Northern Calcareous Alps, Austria: High-resolution insights into the paleoenvironment

xinxuan Xiang[1]*, University of Vienna (xiangxxcumtb@hotmail.com)
Eun Young Lee[2], University of Vienna
Wagreich Michael[3], University of Vienna

Abstract

During the late Cretaceous, the southward subduction of the Penninic plate resulted in the formation of a series of basins at the front edge of the Austroalpine microplate. The sediments deposited in these basins, overlying the Northern Calcareous Alps, and forming a terrestrial to deep-water succession, are recognized as the Gosau Groups. The Gosau Group reflects the variation of paleoenvironment from the late Cretaceous until the Eocene. It has been divided into the Upper Gosau Subgroup and the Lower Gosau Subgroup according to the sedimentary facies. The Lower Gosau Subgroup indicates a transitional environment from terrestrial to shallow water, composed of fluvial, lacustrine, and shallow marine sediments deposited during Turonian to Santonian-Campanian times. The Upper Gosau Subgroup is characterized by deep water successions up to the Eocene in age. The shallow-to-deep environmental transition was derived from the subsidence of the continental margin, associated with the subduction movements. This study investigates environmental signals by analyzing coal-bearing deposits in the Lower Gosau Subgroup to reconstruct. We selected seven outcrop sites including coal seams ranging from the Turonian to Campanian in Austria, which showed fluvial and/or lacustrine depositional settings, and collected fine-grained sediment and coal samples. Based on industrial analysis and vitrinite reflectance, the coal samples were evaluated as low to medium ranks. Our results indicate a wide range of variations in siliciclastic, oxides, organic matters, and clay contents that are related to changes in the depositional environment and water energy. These correspond to occasional occurrences of pyrite and carbonates, which could have been caused by interaction with seawater intrusions. Changes in the maceral contents could also be influenced by varying (ground)water levels. Our study suggests that the coal-bearing sediments of the Lower Gosau Subgroup in Austria were deposited in unsteady environments and occasionally affected by seawater, which might correspond to the short-term sea-level fluctuations reconstructed for the Late Cretaceous.

Keyword

Lower Gosau Subgroup, paleoenvironment, coal, short term sea level

Final amalgamation processes of the southern Altaids: insights from the Triassic ophiolitic mélange in the eastern Tianshan-Beishan orogen (NW China)

Qigui MAO[1]*, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (qg-mao@ms.xjb.ac.cn)
Wenjiao Xiao[2], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Songjian Ao[3], Institute of Geology and Geophysics, Chinese Academy of Sciences
Dongfang Song[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Miao Sang[5], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Zhou Tan[6], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Hao Wang[7], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Rui Li[8], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences

Abstract

The Permian–Triassic tectonic setting is still controversial in the southern Altaids. Some studies have attributed it is post-orogenic and intracontinental setting (Han et al., 2014; Wang et al., 2016; Zhang et al., 2015); In contrast, many geologists have proposed that it was the far-distance effects of the northward subduction of the Paleo-Tethys (Zhang et al., 2015; Zhang et al., 2009; Zhu et al., 2012); Furthermore, some researchers suggest that multiple supra-subduction accretion to terminal closure of the Paleo-Asian Ocean (Mao et al., 2021; Windley et al., 2007; Xiao et al., 2018). The eastern Tianshan-Beishan orogen is an ideal region to address the final tectonic of the Altaids. To address this issue, systematic mapping, geochemical and geochronological studies are carried out on the Haluo ophiolitic mélange in the middle segment of the Kanguer accretionary complex in the eastern Tianshan and the Houhongquan ophiolitic mélange in Liuyuan accretionary complex in the southern Beishan orogen, respectively. The studies reveal that the Paleo-Asian Ocean closed during late Triassic in the eastern Tianshan to Beishan orogens, southern Altaids, NW China. The Haluo ophiolitic mélange consist of the blocks of gabbro, massive basalt, diabase dikes, chert and limestone that are embedded in the imbricated chlorite-phyllite schist and cleaved sandstone matrix, whereas the Houhongquan ophiolitic mélange are mainly composed of the gabbro, basalt and chert, and some blocks of cleaved sandstone. (1) The studies of the Haluo ophiolitic mélange determined that a basaltic fragment yields zircon U-Pb age of 257 Ma and owns normal-mid-ocean-ridge-basalt (N-MORB) geochemical signature; the other mafic fragments display N-MOR and supra-subduction zone (SSZ) types of oceanic lithosphere; the sandstone matrix display two different types of provenances, the first type in the northern part has maximum depositional ages ranging from 316 Ma to 234 Ma and the detrital zircon age patterns vary from a single peak to multiple peaks after ca. 244 Ma, and their zircon $\varepsilon Hf(t)$ values vary from uniquely high positive to some negative values; the second type in the southern part has maximum depositional ages of 271 Ma to 234 Ma and multiple-peak detrital zircon-age patterns, and positive to negative zircon $\varepsilon Hf(t)$ values. These data suggest the Kanguer Ocean / Northern Tianshan Ocean experienced double-sided subduction, the Dananhu intraoceanic arc and Japan-

type central Tianshan-Yamansu arc finally amalgamated timing after 234 Ma. (2) The studies of the Houhongquan ophiolitic mélange obtain the similar results that the mafic fragments are Permian (~ 286 Ma to 270 Ma) relics of N–MOR and SSZ types of oceanic lithosphere; the matrix samples yield the maximum depositional ages of 264 Ma to 222 Ma, also indicating that the youngest sandstones were tectonic emplaced in the Houhongquan ophiolitic mélange after ca. 222 Ma. Thus, complicated archipelago systems may have existed in eastern Tianshan-Beishan area during the Permian to early Triassic. Combining the previous regional data, we argue that the terminal amalgamation timing of the southern Altaids was probably during ca. 222 Ma to 217 Ma.

Keyword

Haluo and Houhongquan ophiolitic mélange, Triassic, archipelago systems, eastern Tianshan-Beishan, southern Altaids

Early Ordovician to Early Permian tectonic evolution of the northern Western Kunlun Orogen (NW China)

Miao SANG[1]*, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (sangmiao@ms.xjb.ac.cn)
Wenjiao Xiao[2], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
He Yang[3], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Qigui Mao[4], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Zhou Tan[5], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Hao Wang[6], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Rui Li[7], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences

Abstract

The Paleozoic tectonic evolution of the Western Kunlun Orogen (WKO) plays an important role in deciphering the Tethyan tectonic evolution. The WKO, located along the northern periphery of the Tibetan plateau, extends over 1000 km from the Pamir syntaxis in the west to the Altyn–East Kunlun Orogen in the east. Occupying a key tectonic position between the Tarim block to the north and the Tethyan domain to the south, the WKO is thought to be an accretionary orogen, resulting from the subduction and closure of the Tethyan Ocean(s). The timing of the closure and tectonic evolution of the Proto- and Paleo-Tethys Oceans remain debated, with controversies persisting about the location and nature of tectonic boundaries, as well as the poorly understood active marginal and oceanic complexes and Precambrian basement within the WKO, which limits our understanding of its tectonic evolution from the Precambrian to the Paleozoic.

This study provides new geochemical and geochronological findings, complemented by Lu-Hf isotopic analysis, derived from an ophiolite complex in the eastern sector of the WKO. These insights shed light on the tectonic framework and source characteristics of the region. Based on these new data, combined with previous data, we propose a new tectonic model for the eastern section of the northern Western Kunlun Orogen, suggesting a continuous evolution process of multi-terrane subduction-accretion collage from the Early Ordovician to the Middle Devonian in the Paleo-Tethys Ocean, which evolved into an Andean-type active margin in the Early Permian, contributing to the substantial continental growth of the southern Tarim margin.

Keyword

Tethys, Western Kunlun, Tectonic evolution, Ophiolite complex, Adakite

Andean-type orogenic plateau as a potential trigger for Permian aridification of North China in northeast Pangaea

Dongfang SONG[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (dfsong@mail.iggcas.ac.cn)
Wenjiao Xiao[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Qigui Mao[3], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The relationship between Pangea assemblage and climate change during the late Paleozoic remains ambiguous. The Central Asian Orogenic Belt (CAOB), an accretionary orogen formed through closure of the Paleo-Asian Ocean (PAO), is significant for understanding the paleogeographic architecture and associated tectonic-climate interaction of northeast Pangea. The orogenic process of the southern CAOB and its role in Permian aridification of North China is highly controversial. We present new sedimentologic and provenance study of Permian-Early Triassic sediments and first estimate of crustal thickness of northern North China. The early-middle Permian coal-bearing sandstones/conglomerates gradually gave way to late Permian-Early Triassic fluvial redbeds. Sandstone compositions and detrital zircon U-Pb ages with pervasive negative εHf(t) values indicate that the Permian-Early Triassic sediments were sourced from Paleoproterozoic-Neoarchean (1600-2700 Ma) basement of the North China Block and associated late Paleozoic (260-410 Ma) continental arc, devoid of any input from the juvenile Altaid arcs. The Permian-Early Triassic sedimentation is interpreted as a retroarc foreland system due to southward subduction of the PAO prior to final collision between the Altaid arcs and North China. Crustal thickness estimated from whole-rock La/Yb yields an average value of 58 ± 11 km, which corresponds to a palaeoelevation of 3.8 ± 0.7 km, indicating the development of an orogenic plateau comparable to the Altiplano of Andes, which possibly blocked the moisture from the PAO. The Permian paleoclimate change as indicated by significant sedimentary facies shift from coal-bearing humid alluvial fan deposit to continental redbeds is therefore interpreted as a rain shadow effect due to the orographic barrier uplift of the northern margin of North China. Our study provides significant insights into the study of tectonic-climate interaction in ancient orogens.

Keyword

NE Pangea, North China, Aridification, Tectonics, Late Paleozoic

Late Paleozoic and Triassic clastic rocks in the Changning-Menglian Belt: insights into paleogeography of the Paleo-Tethys in western Yunnan, China

Jianbin ZHENG[1]*, Institute of Geology, Chinese Academy of Geological Sciences (jianbinzheng_1990@126.com)
Xiaochi JIN[2], Institute of Geology, Chinese Academy of Geological Sciences
Hao HUANG[3], Institute of Geology and Geophysics, Chinese Academy of Sciences, China
Zhen YAN[4], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The Changning-Menglian Belt in western Yunnan, China, has been widely recognized as the remains of Paleo-Tethys in Southeast Asia. It extends north–south and divides the Simao Block of Cathaysia-affinity to the east and the Baoshan Block of Gondwana-affinity to the west. Many researchers considered it as the major Tethyan suture, representing a long-lived ocean from early Devonian to Late Triassic, based mainly on slices of Devonian-Triassic radiolarian-bearing cherts, some ophiolites and possible seamount limestones of Permo-Carboniferous age. Some researchers, on the other hand, have argued that this belt represents a passive continental margin, with a cryptic suture further east representing the now-vanished Tethys. We have been studying the late Paleozoic-Triassic clastic rocks in this belt, as a significant component of the Changning-Menglian belt, in order to investigate the structural patterns of this region and better understand its geological evolution. The identifiable clastic rock sequences within the belt are, respectively, the Lower Carboniferous Nan Duan Formation, the Late Devonian-Early Carboniferous Nanpihe Formation, and the Lower-Middle Triassic cherts with clastic interlayers.

Petrological and geochemical studies have identified two distinct types of rock sequences from the late Paleozoic clastic rocks: the early Carboniferous Nanduan Formation developed and the late Devonian-early Carboniferous Nanpihe Formation, developed in the east and west zone and of this belt respectively. Quartz sandstones of the Nanduan Formation preserved dominant age populations of ca. 950 Ma and ca. 550 Ma. Similar zircon age peaks are also shared by the early Paleozoic metasedimentary rock groups (the Ximeng, Mengtong and Lancang Groups) widely developed in this belt, and other Gondwana-derived blocks (e.g. Baoshan-Shan and Tengchong Blocks). These results let us consider that the Nanduan Formation and the Lancang, Ximeng and Mengtong Groups were deposited along the passive continental margin of Gondwana-derived blocks (most possibly the Baoshan Block). While detrital zircon age spectra of the lithic sandstones from the Nanpihe Formation show remarkable age clusters of ca. 435 Ma and ca. 950 Ma, which is similar to those sandstones from the Indochina-Simao Block. Namely, the Nanpihe Formation in the west zone of this belt is of Cathaysia origin. Taking all into consideration, it can be speculated that sometime in the Permian or Early Triassic, as the eastward subduction of the Paleo-Tethys progressed, the Nanpihe Formation was sheared off or collapsed from the overriding margin of the Simao Block and entered the accretionary wedge, which contained a significant amount of rock slices scraped off the subducting oceanic plate. During the closure of Paleo-Tethys in the Late Triassic, this formation and some other slices of the accretionary wedge were thrust

onto the east flank of the Baoshan Block.

Additionally, we have recently identified several new sequences of Early-Middle Triassic age, including clastic rocks and bedded cherts-clastic rocks. The petrological and sedimentological features indicate a sufficient detrital supply for these Triassic sequences. Specifically, these rocks suggest a continental margin environment during that time rather than a pelagic oceanic environment.

Financial support from the National Science Foundation of China (92155202, 42372046, 42172040) are gratefully acknowledged.

Keyword

Changning-Menglian Belt, Paleo-Tethys, Late Paleozoic, Triassic, clastic rocks

Zircon U-Pb age of an intermediate dike intruding into the Selenge igneous rock complex at the Jargalant Village, Northern Mongolia

Sukhbaatar PUREVDULAM[1]*, School of Environmental Studies, Nagoya University
(puujee.0@yahoo.com)

Abstract

Abstract
In northern Mongolia, the volcanic/plutonic rocks of the Permian-Triassic Selenge igneous rock complex (SIC) are widely exposed and its intruded by many intermediate dikes with clear chilled margins, in some places. Numerous studies have examined magmatism in the SIC, but little attention has been given to the intermediate dikes within it. Umeda et al. (2022) and others revealed that the SIC is a product of large-scale adakitic magmatism caused by the melting of subducted oceanic slab at ca. 250 Ma. They also mentioned that the intermediate dikes which have almost the same geochemical features with the SIC the evidence that the slab-melt-origin adakitic magmatism lasted after ca. 250 Ma. Therefore, clarifying the age of the dikes is necessary to confirm the span of the adakitic magmatism, i.e. magmatic history of the ancient volcanic arc along the “Siberian continent”. This study describes a zircon U-Pb age of the intermediate dike in the Jargalant area, northern Mongolia, and discusses the span of the adakitic magmatism along the “Siberian continent”.

Three samples of the comparatively coarse intermediate dike were examined. The zircons, colorless with about 200μm in the major axis, generally show clear oscillatory zoning in the cathodoluminescence image. A total of 17 grains (36-spots) were examined and the weighted mean age is 211 ± 5 Ma and MSWD is 2.9. Their Th/U ratio is from 0.61–1.27. Clear oscillatory zoning in the CL image evidences less alteration for the dated zircons. Furthermore, Th/U ratio of the dated zircons suggests their magmatic origin (e.g. Hartmann et al., 2000). Therefore, it is quite likely that the zircon U-Pb age of 211 ± 5 Ma from the intermediate dike points the age of its igneous activity.

Now, the age of the dikes intruding into the SIC is ca. 210 Ma was suggested by this study. That is, taking together with the geochemical data Umeda et al. (2022), the slab-melt-origin adakitic magmatism had occurred under the Siberian continental margin at Late Triassic. Umeda et al. (2022) pointed out the geochemical homogeneity of the 250 Ma SIC and dikes with inference that the adakitic magmatism had lasted after 250 Ma till the time of the dikes. Given that their view is correct, adakitic magmatism would have lasted from 250 Ma to 210 Ma for 40 m.y. Is this reasonable?

It is suggested that oblique subduction and slab-tearing along a L-shaped trench cause the slab-melt-origin adakitic magmatism in the Aleutian–Kamchatka region (Yogodzinski et al., 2001). It is assumed that the oceanic plate of the Mongol-Okostk ocean had subducted beneath the Siberian continental margin along a L-shaped trench in the Permian–Triassic time, similarly to the Aleutian–Kamchatka arc (Pan Zhao et al., 2023). Therefore, it might be possible to consider that

the "slab-melt-origin adakitic magmatism for 40 m.y." would be attributed to the long-lived L-shaped trench system and slab-tearing.

Keyword

Siberian continent, Intermediate dike, U-Pb age, Slab-melt-origin adakitic magmatism

The geochemical signature of the mafic rocks in the accretionary complexes of the western Khangai-Daur belt, Central Asian Orogenic belt, central Mongolia

BAYART NADMID[1]*, Department of Earth and Environmental Sciences, Nagoya University, Japan (n.bayart@yahoo.com)

Abstract

The geochemistry of accreted oceanic mafic rocks is crucial for understanding volcanic activity and the evolution of ancient oceanic plates. Within the western Khangai-Daur belt, in central Mongolia, Late Paleozoic accretionary complexes of the Tsetserleg, Kharhorin, and Ulaanbaatar terranes are situated between the Siberian continent and the South Mongolian block, formed through the subduction of previous oceanic plate of the Mongol-Okhotsk Ocean (MOO). Previous studies of the mafic rocks have primarily focused on specific local areas and did not comprehensively address the past oceanic plate of the MOO. This study aims to provide new geochemical data of the mafic rocks in the Khangai-Daur belt, and a comprehensive discussion of the nature of the MOO plate by integrating data together with the previous studies.

Whole-rock chemical composition of 21 samples from 4 localities within the Khangai-Daur belt (Uubulan, Ikh-Oortsog, the Takhilt area in the Ulaanbaatar terrane, and the Burd area in the Kharhorin terrane) was determined. The samples can be divided into the following three major types in their geochemical characteristics: Type-1 (Uubulan and Ikh-Oortsog areas), Type-2 (Takhilt area), and Type-3 (Burd area). The geochemical nature of the mafic rocks, enriched in large ion lithophile elements and light rare-earth elements compared with high field-strength elements and heavy rare earth elements, suggest that they are alkaline basalts. The TiO2 vs. Zr/(P2O5*10000) diagram also supports that the samples have an alkaline signature, but, they differ in their concentrations of incompatible elements: Type-1 is highly enriched in incompatible elements, while Type-3 is less enriched and shows a gently reducing trend in the spidergrams and REE patterns, and the Type-2 is the moderate between them. Despite these differences, all three types show an affinity with Ocean Island Basalt (OIB) in TiO2/Yb vs. Nb/Yb diagram.

As a result of comparison to the previous studies, the following insights were led. In the Ulaanbaatar terrane, the Type-1 and Type-2 are included, and, the mafic rocks in the Tsetserleg terranes display Type-2 and Type-3. While the Type-3 mafic rock was recognized in the Kharhorin. In contrast, mid-ocean ridge basalt (MORB) (Type-4) is reported only in Tsetserleg terranes. Therefore, compositions in the (La/Sm)n vs. (Gd/Yb)n plot along the melting curve of garnet lherzolite with a primitive mantle composition, indicating a degree of partial melting ranging from 1–3% (Type-1), 3–5% (Type-2), and 10%–20% (Type-3 and 4), respectively. These observations suggest that varying magma sources and degrees of partial melting at different depths contribute to the production of alkaline OIB and MORB within the MOO plate.

Keyword

Khangai-Daur belt, Mongol-Okhotsk ocean, mafic rocks, accretionary complex, Oceanic island Basalt

The last viscous coupling in the Neo-Tethys subduction plate interface

Zhou TAN[1]*, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (tanzhou@ms.xjb.ac.cn)
Wenjiao Xiao[2], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Rasoul Esmaeili[3], INSTITUTE OF GEOLOGY AND GEOPHYSICS, CHINESE ACADEMY OF SCIENCES
Parisa Gharibnezhad[4], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Miao Sang[5], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Qigui Mao[6], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Hao Wang[7], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Rui Li[8], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Zhiyong Zhang[9], INSTITUTE OF GEOLOGY AND GEOPHYSICS, CHINESE ACADEMY OF SCIENCES
Jien Zhang[10], INSTITUTE OF GEOLOGY AND GEOPHYSICS, CHINESE ACADEMY OF SCIENCES

Abstract

The Neo-Tethys is one of the most extensive subduction architectures on Earth with large-scale oceanic deep subduction occurred in the Jurassic-Cretaceous. Yet, when it lasted into Cenozoic and how the subduction interface behaved remain unclear due to no records of younger subduction milestones (i.e., blueschists). Herein, we present a comprehensive study for representative blueschist-facies rocks from Zeyarat metamorphic complex to uncover the time frame and metamorphic process affecting Neo-Tethys suture zone in the Makran area in Iran. Our new bulk-rock geochemical data show that Zeyarat Bs-facies metavolcanics are typical of oceanic protolith from depleted mantle. A counter-clockwise P-T trajectory, from burial along a typical warm subduction gradient (~15 °C/km) with moderate heating to peak temperature condition of 0.74-0.88 GPa, 510-550 ˚C at amphibolite-facies, subsequently reaching Bs-facies condition of 1.12-1.28 GPa, 370-400 ˚C with slightly cooling, is retrieved. Efforts are made to correlate the ages of dated amphibole, titanite, and zircon with their respective metamorphic and igneous origins. In detail, titanite U-Pb ages of 74.9 ± 1.80 Ma and metamorphic zircon rim U-Pb ages of 80.0 ± 5.84 Ma could constrain the timing of early-stage peak burial slightly after amphibolite-facies peak temperature metamorphism. The igneous core domain of zircon displays Concordia age of 117 ± 4.70 Ma, coinciding with comparable age of 118 ± 2.00 Ma obtained for igneous zircon and 117 ± 0.40 Ma age of hydrothermal zircon, echoing with the origin from oceanic protolith and seafloor hydrothermal setting during the subduction of Neo-tethys ocean. By comparison, step-heating 40Ar-39Ar radiometric dating of amphibole, with predominantly glaucophane composition, yields consistent weighted plateau ages at 49.7 ± 0.60, 46.1 ± 0.30, and 46.4 ± 0.60 Ma, disclosing, for the first time, a Neo-Tethys related Eocene Bs-facies metamorphism in the territory of Iran. An updated model for the still active Neo-Tethys subduction in the Makran area is thus proposed, highlighting the decrease of convergence rate with scarce reports of Eocene localized viscous coupling, between the plate interface, which would facilitate the rescue of LT-HP rocks in Zeyarat

(Makran, Iran), Tso Morari (India) and Kaghan Valley (Pakistan), compared with the large-scale Late Cretaceous interplate mechanical coupling across thousands of kilometers that affected the whole Neo-Tethys subduction zone beneath Eurasia.

Keyword

Blueschist, P-T-t history, The Eocene, subduction plate interface, Neo-Tethys

SEDIMENTARY RECORD OF A BASIN MARGINAL TO THE TETHYS OCEAN: THE CERGOWA BEDS (OUTER CARPATHIANS; OLIGOCENE)

Marek WENDORFF[1]*, AGH University of Krakow (wendorff@agh.edu.pl)
Joanna PSZONKA[2], Polish Academy of Sciences, Mineral and Energy Economy Research Institute, Krakow, Poland
Paweł GODLEWSKI[3], AGH University of Kraków, Poland

Abstract

The eustatic sea level fall in the Eocene-Oligocene, crucial for the Paratethys isolation from the Tethys Ocean, was caused by global climate cooling. This change influenced the Carpathian basins located marginally to the ocean, resulting in reduced circulation and anoxic conditions recorded in the Outer/Flysch Carpathians by the Menilite Formation (Oligocene) characterised by dark shales. The Menilite Fm. contains arenaceous lenticular lithosome of the Cergowa Beds composed of sandstones and subordinate sandstone-mudstone associations deposited by sediment gravity-flows during two nannoplankton zones NP 23 and NP24. The older part of the Cergowa Beds, which originated during the NP23 zone, was deposited by mainly dense, sandy sediment gravity flows, including high-density turbidity currents. The associated nannoplankton species indicate brackish water conditions, which reflect a significant freshwater influx into the basin confined and isolated from the Tethys Ocean. A direct connection between the basin and the terrestrial source via a fluvial system and probably a shelf-edge delta is suggested by the abundance of coalified plant matter. Basin shallowing and the resulting isolation were caused by tectonic uplift during the Alpine orogenesis and eustatic sea-level fall induced by global cooling. The succeeding strata and nannoplankton representing the NP24 zone indicate an open sea environment and deposition by low-density turbidites declining with time and finally returning to the anoxic mudstone facies typical for the Menilite Fm. In general, continuing global cooling and eustatic sea-level fall did not prevent the Cergowa Basin from deepening. This relation shows that the local subsidence rate in the Cergowa Basin must have exceeded the sediment supply, and accumulation, rate. In effect, the marginal position of the Cergowa Basin relative to the Tethys Ocean and the Oligocene climate resulted in the stratigraphic record influenced by: (i) oscillations of coccolithophorid productivity reflecting the CCD fluctuations and recorded by the pelagic laminated Tylawa Limestone; (ii) local slope instability recorded by slumps and hybrid flows recording synsedimentary tectonic deformations of the sea bottom; (iii) salinity changes between open marine and restricted brackish basin; (iv) variations in subsidence and sediment supply rates.

Keyword

Oligocene, Marginal basins, Carpathians, Flysch, Climate

High-resolution sequential thrust propagation in the Nepalese Himalaya: response to the Miocene anticlockwise rotation of the Indian plate

Rui LI[1]*, Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences (lirui@ms.xjb.ac.cn)
Songjian AO[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Wenjiao XIAO[3], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Hao WANG[4], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Karel SCHULMANN[5], Centre for Lithospheric Research, Czech Geological Survey
Qigui MAO[6], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Dongfang SONG[7], Institute of Geology and Geophysics, Chinese Academy of Sciences
Miao SANG[8], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Zhou TAN[9], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
Saunak BHANDARI[10], Department of Mines and Geology, Government of Nepal

Abstract

Describing the detailed propagation sequences of thrust imbrication is crucial for understanding orogenic architecture and orogenesis. In this study, we investigate the pressure-temperature-timing and deformation characteristics of a suite of metamorphic rocks within the Main Central Thrust Zone (MCTZ) in the eastern Nepalese Himalaya. Our data reveal a southwestward shearing pattern of the major thrusts within the MCTZ, following a piggyback-style propagation since approximately 17 Ma. At around 12.8 Ma, a significant event occurred when a thrust sheet moved southeastward over an allochthonous mica-schist in the hinterland via an out-of-sequence thrust (OOST), coinciding with the accretion of the Lesser Himalaya to the MCTZ. Subsequently, another phase of piggyback-style thrust propagation occurred until about 10.4 Ma. Notably, this OOST differs from an earlier identified OOST, the High Himalayan Thrust, suggesting the presence of at least two distinct OOST events within the metamorphic core of the Himalaya. The younger OOST is associated with a structural shift from northeast to northwest and appears to have occurred nearly simultaneously with changes in the velocity and rate of rotation of the Indian plate at around 13 Ma. This synchronization implies that the OOSTs responded to the anticlockwise rotation of the Indian plate, influencing and reconciling the regional geometric evolution.

Keyword

Nepalese Himalaya, Miocene, out-of-sequence thrust, plate rotation, P-T-t-D

Progress of IGCP 679: Cretaceous Earth Dynamics and Climate in Asia

Gang LI[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, PR China (gangli@nigpas.ac.cn)
Takashi Hasegawa[2], Department of Earth Sciences, Faculty of Science, Kanazawa University, Kakuma, Kanazawa 920-1192, Japan
Dae Kyo Cheong[3], Department of Geology, College of Natural Sciences, Kangwon National University, Chunchon, Kangwon-do, 200-701, South Korea
Vandana Prasad[4], Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow 226007, India

Abstract

The Cretaceous was the most recent, warmest period in the Phanerozoic Era. It was characterized by more elevated atmospheric CO2 levels and significantly higher global sea levels than today. The IGCP 679 project (Cretaceous Earth Dynamics and Climate in Asia) is based on the Earth system sciences to reveal the Cretaceous 'Greenhouse' Earth's oceanic and terrestrial climates and environmental conditions and their evolution, leading to an in-depth understanding of the existing characteristics of rapid climate and environmental changes and global warming. This project explores the processes and mechanisms of the rapid change in climate and environment under greenhouse conditions during the Cretaceous and the evolutionary responses of biodiversity on land and in the oceans of the Asian continent. The main goals of IGCP 679 will address: (1) high-resolution Cretaceous geological records of sea and land facies in Asia; (2) climate and environment; (3) the nature of linkages between major geological events and rapid climate and environmental changes, to understand biodiversity evolution under greenhouse climate conditions. These results will provide scientific evidence for human response to contemporary global warming trends. The project has played an important role in promoting geoscience communication among Asian countries, including some countries outside Asia. In the last year, our project have made exciting research results and received good achievement on palaeontology, sedimentology, palaeoecology and palaeoclimate. The discovery of Masstrichtian dinosaur egg shells and teeth from the high latitude Far East Russia suggests special nesting strategies. The mercury contents and isotope ratios in marine and terrestrial archives across the Cretaceous/Paleocene boundary suggest the end-Cretaceous mass extinction was a complex catastrophe caused by the Deccan volcanism driving climate fluctuations and oceanic acidification, and perhaps exacerbated by the Chicxulub impact.

Keyword

Cretaceous, palaeontology, palaeoecology, palaeoclimate, Asia

Development of a new silicate weathering index (RW) and its application to the Early Cretaceous strata distributed in East Asia

Tenichi CHO[1]*, Waseda University (tianct@fuji.waseda.jp)
Tohru OHTA[2], Waseda University
Gang LI[3], Nanjing Institute of Geology and Palaeontology

Abstract

Quantification of past weathering intensity is crucial for understanding paleoclimate changes. Given that the chemical composition of sediments/ sedimentary rocks reflects the weathering environment in which they were generated, this can provide insights into the intensity and style of weathering in the past. Weathering indices calculated from the whole-rock geochemical compositions of sedimentary rocks are widely used, however, these indices have limitations. For example, the conventional indices like CIA, WIP, and W index can only be applied to deposits consisting mainly of silicates, with low concentrations of materials like biogenic calcite. To develop a weathering index applicable to sedimentary rocks formed under various source rocks and environmental conditions, we used multivariate statistics (Independent Component Analysis) to analyze a dataset consisting of igneous rocks and their weathering profiles. The chemical variations of the igneous rocks and weathering trends were independently extracted from the dataset, and a new weathering index (the robust weathering index; RW) was proposed. The performance of the RW index is assessed using modern sediments. The RW index shows robust results even for sediments containing a large amount of non-silicate materials, enabling the comparison of weathering intensity across a wide range of sedimentary rocks.

We applied the RW index to the mudstone of the Lower Cretaceous terrestrial strata in southeast Asia. The studied sites include the Gobi area in Mongolia, the Junggar basin in Western China, Heilongjiang and Liaoning Provinces in NE China, Shangdong Province in Eastern China, Sichuan Province in SW China, Iwate Prefecture in Northern Japan, Banhang area in NE Vietnam. The RW index showed a tendency to increase as latitude decreases from mid-latitude to low-latitude areas. In addition, the RW index showed higher values along the coastal areas and lower values in inland areas. This distribution pattern of the RW index reveals a more temperate and humid paleoclimate condition in low-latitude area and an arid paleoclimate condition in inland areas. This paleoclimate interpretation is obviously consistent with the geographical distribution of each site and confirm that the RW index is useful in terms of paleoclimate reconstructions. It is expected that an accumulation of more data at various points will enable a detailed spatial-temporal reconstruction of paleoclimate in Cretaceous Asia, and further chronostratigraphic studies and geochemical analyses are therefore essential.

Keyword

RW index, chemical weathering, independent component analysis, paleoclimate, Cretaceous

[Keynote] A synthesis of provenance studies of the Cretaceous Gyeongsang Basin, SE Korea and its tectonic implications for active continental margin in East Asia

Yong Il LEE[1]*, Seoul National University (lee2602@snu.ac.kr)

Abstract

In the middle to late Mesozoic period, the Korean Peninsula was in an active continental margin with an accretionary complex developed in the direction of trench to the southeast. The Cretaceous Gyeongsang Basin is the largest nonmarine basin distributed in the southeastern part of the Korean Peninsula. The sedimentary succession of the Gyeongsang Basin is subdivided into the Sindong and Hayang groups with decreasing age, which are unconformably overlain by the Yucheon Group which is mainly composed of intermediate to acidic volcanic rocks that make up a volcanic arc ('Yucheon Arc'). This basin is considered a transtensional or extensional basin formed by oblique subduction of the Paleo-Pacific (Izanagi) Plate or Izanagi slab rollback. Because the Gyeongsang Basin developed geographically behind the Japanese Arc in the Cretaceous, and the Yucheon Arc was considered an extension of the Japanese Arc, the Gyeongsang Basin has been considered to be a back-arc basin, even though sedimentation within the basin occurred before the development of the Japanese Arc and Yucheon Arc. Here, the results of provenance studies of clastic/volcanogenic sediments in the early−middle depositional phases (the Sindong and Hayang groups) are synthesized to reinterpret the tectonic setting and basin formation mechanism of the Gyeongsang Basin. The sediments were mostly derived from western and northwestern sources (the Yeongnam Massif), which currently do not contain records of Early Cretaceous arc magmatism. The modal and geochemical compositions of these sediments and their detrital zircon U−Pb geochronology indicate that these sediments originated from arc-related crystalline basement rocks of the Yeongnam Massif with a record of arc magmatism from the Early Cretaceous Period (143−100 Ma). Additionally, the Sindong Group contains detrital chromian spinel grains derived from forearc peridotites or their equivalents, and the Hayang Group contains radiolaria-bearing chert pebbles derived from the Jurassic accretionary complex at several stratigraphic levels. Thus, the Gyeongsang Basin is proposed to be a forearc basin formed between the Yeongnam Massif (then arc) and the Jurassic accretionary complex on the seaside, and the basin may have been formed by extensional stresses related to the subduction of an oceanic plateau during the Early Cretaceous.

Keyword

Cretaceous, active continental margin, the Gyeongsang Basin, Izanagi Plate

Interpretations from detrital zircon geochronology of Lesser Himalaya strata, Nepal, regarding the Paleozoic-Mesozoic dispersal of Gondwana

Upendra BARAL[1]*, Institute of Fundamental Research and Studies (upendrabaral@gmail.com)
Ding Lin[2], State Key Laboratory of Tibetan Plateau Earth System Science, Resources and Environment, Institute of Tibetan Plateau Research, Chinese Academy of Sciences

Abstract

The study of the breakup of Gondwana to the India-Asia collision is crucial for the study of plate tectonics. Detrital zircon U-Pb geochronology has quickly developed into an effective method for retracing the processes of supercontinent construction and dispersal. The ages of detrital zircon from the Gondwana (Kakaha Diamictite, Carboniferous-Permian, and Jurassic-Cretaceous SaptKoshi Formation) and post-Gondwana (Tamrang Formation, Miocene, and Lesser Himalaya, eastern Nepal) sequences give some insightful information on it. The zircon ages from the Carboniferous-Permian sequence peak at 544 Ma, 890 Ma, 1178 Ma, and 1752 Ma. In addition to this, there is a peak of ~123 Ma in the Jurassic–Cretaceous sequence. The Miocene strata yield the peaks at 526 Ma, 987 Ma, and 1740 Ma. By contrasting these recently discovered ages with those of neighboring places, the present study can verify that the Indian continent remained connected to Gondwana during the Carboniferous-Permian period. The Tethys Himalaya and the Kokaha Diamictite have similar U-Pb age dispersals which raises the hypothesis that this unit was recycled or shared a similar genesis with the Tethys Himalaya. Magmatism associated with the Triassic–Jurassic rift along the Indian continental margin provides evidence that the Indian plate rifted from Gondwana and migrated northward throughout the early Mesozoic. Surprisingly, the Rajmahal Basalt contributed significantly to the Jurassic–Cretaceous sequence's deposition. Furthermore, a significant number of zircons from the Miocene sequence bear a striking resemblance to those from the Greater Himalaya, suggesting that the latter may have previously undergone uplift.

Keyword

Gondwana, Plate Tectonics, India-Asia Collision, U-Pb geochronology, Nepal

A new Early Cretaceous bird shed new light on the evolution of avian cranial kinesis.

MIN WANG[1]*, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (wangmin@ivpp.ac.cn)

Abstract

Cranial kinesis, referring the independent movements and flexibility of various parts of the skull, is an evolutionary innovation found in living vertebrates only in some squamates and crown birds, and considered to be a major factor underpinning much of the enormous phenotypical and ecological diversity of extant birds. Compared to the postcranium, our understanding of the evolutionary assemblage of the characteristic modern bird skull has been hampered by sparse fossil records of early cranial materials. Consequently, little is known about how the bulky and akinetic dinosaurian skull became transformed into the delicate, kinetic, and functionally diverse extant bird skull. Here we present digital three-dimensional reconstruction of the entire skull of the Early Cretaceous enantiornithine Yuanchuavis kompsosoura, including poorly known elements among early diverging birds but are central to deciphering the evolutionary pathways of modern avian cranial kinesis. Our reconstruction shows evolutionary and functional conservation of the temporal and palatal regions by retaining the ancestral theropod dinosaurian configuration within the skull of this otherwise derived and volant bird. Geometric morphometric analysis of the palatine suggests that loss of the jugal process represents the first step in the structural modifications of this element leading to the crown avialan condition. The mixture of plesiomorphic temporal and palatal regions and derived facial anatomies captured in this single enantiornithine skull vividly demonstrates how the avian cranium has been shaped deeply by evolutionary mosaicism—a hypothesis proposed by studies involving crown birds but still awaiting paleontological evidence.

Keyword

Birds, Cranial morphology, Kinesis, Mesozoic, Enantiornithes

The sedimentological characteristics of the intermontane desert system in the Jurong Basin, South China and its relationship with the Late Cretaceous hot climate

Shuo CAO[1]*, China University of Geosciences, Beijing (caoshuo@cugb.edu.cn)

Abstract

As a typical greenhouse period, the Late Cretaceous was characterized by an extremely warm and arid climate. In this period, intermontane deserts were widely distributed in South China, which can be used to inform the evolution of the palaeogeography and palaeo-wind patterns during the hot climate of the Late Cretaceous. The Jurong Basin is located at the eastern margin of South China and close to the palaeo-Pacific Ocean; it has typical aeolian deposits but is hitherto less studied. In this study, four sedimentary facies (aeolian dune, dry/damp/wet interdune, sandsheet, and desert lake facies) and three forms of aeolian dunes (simple, compound, and complex) are identified in the Upper Cretaceous Chishan Formation, confirming the development of an intermontane desert in the Jurong Basin. The dynamic evolution models show that the intermontane desert transitioned from a lacustrine-dominated to an aeolian-dominated system, which indicates a gradual drying trend. We suggest that the development of the Chishan intermontane desert was controlled by the Late Cretaceous greenhouse climate, the accelerated aridification of the subtropical high, and the rainshadow effect of the coastal mountains. Palaeowind directions in the Chishan desert show westerlies and possible palaeo-monsoon wind patterns. The input of palaeo-monsoon moisture led to the development of desert lake and damp/wet interdune deposits in the Chishan desert, which indicates that the Jurong Basin might have been on the windward side of the coastal mountains during the Late Cretaceous. Our study extends the eastern boundary of the South China intermontane desert system during the Late Cretaceous.

Keyword

aeolian deposit, intermontane desert, South China, greenhouse climate, coastal mountain

Vegetation response against environmental change during the Oceanic Anoxic Event 2 recorded by terrestrial plant biomarkers in sediments from the Tomamae (Hokkaido, Japan)

Masashi A. IKEDA[1]*, Faculty of Geosciences and civil Engineering, Institute of Science and Engineering, Kanazawa University (ma_ikeda@sci.hokudai.ac.jp)
Ken SAWADA[2], Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University
Takuto ANDO[3], Graduate School of International Resource Sciences, Akita University
Hideto NAKAMURA[4], Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University
Reishi TAKASHIMA[5], The Center for Academic Resources and Archives, Tohoku University Museum
Hiroshi NISHI[6], Institute of Dinosaur Research, Fukui Prefectural University

Abstract

The Cretaceous was one of the warmest periods in the Phanerozoic eon. Especially in the mid-Cretaceous, the Oceanic Anoxic Events (OAEs) occurred several times and had a significant impact on marine and terrestrial ecosystems. Although OAE2, which occurred across the Cenomanian/Turonian Boundary (CTB), was the most severe of the OAEs and was a global event, previous studies suggest that the impact on terrestrial ecosystems may have varied from region to region. In the present study, we analyzed biomarkers of terrestrial plants in the sediments deposited across the CTB from northern Hokkaido, Japan, to reconstruct paleovegetation changes and to evaluate for the plant paleoecology during the environmental disturbance event.

We analyzed sediments across the CTB in the Saku Formation, Yezo Group, collected from the Omagari-zawa sections of the Tomamae area, northern Hokkaido, Japan. The sediments used correspond to the OAE2 intervals (1st build-up, Trough, 2nd build-up, Plateau, and Recovery phases), determined by δ13C stratigraphy. For the biomarker analysis, the extractions of crashed sediments were fractionated using a silica-gel column and analyzed by GC-MS.

The higher plant parameter (HPP), which indicates the expansion of conifer vegetation, varied considerably during the environmental disturbance phases (1st to 2nd build-up phases) and was synchronous with the δ13C curve, suggesting that conifer vegetations were strongly affected by climate change due to strong perturbations in the carbon cycle at the study area. On the other hand, the compositions of higher plant-derived terpenoids differed significantly between the 1st and 2nd build-up phases. In the 1st build-up, the triterpenoids (angiosperm origin)/diterpenoids (gymnosperm origin) ratio (ar-AGI) varied wildly, suggesting that conifers expanded after the temporary expansion of angiosperms. In contrast, the predominance of sesquiterpenoids relative to diterpenoids and triterpenoids in the 2nd build-up suggested a temporary decline of seed plants (gymnosperms and angiosperms) among terrestrial plants followed by the expansion of coniferous vegetation. Vegetation response in each phase might be depended on the extent of environmental disturbances in the study area. These can help to understand the impact of the OAE2 period on the

terrestrial ecosystems of the eastern margin of the Asian continent.

Keyword

Cretaceous, Oceanic Anoxic Event, biomarker, paleovegetation

Stratigraphic, sedimentary and basin evolution and its chronological constraints on the transition from Yanliao biota to Jehol biota during the Late Meosozoic in North China

Yongqing LIU[1]*, Institute of Geology, CAGS (liu_cags@126.com)
Hongwei Kuang[2], Institute of Geology, CAGS
Nan Peng[3], Institute of Geology, CAGS
Yuchong Wang[4], Institute of Geology, CAGS
Xiaoshuai Chen[5], Institute of Geology, CAGS

Abstract

1. During the transition from Yanliao biota to Jehol biota in Yanshan of the North China, depositional succession from the Jiulongshan and Tiaojishan formations of the Late Jurassic, Tuchengzi to Zhangjiakou formations of Late Jurassic to Early Cretaceous and Yixian Formation of the Early Cretaceous were deposited. In the same time, significant migration and evolution of sedimentary basins took place in both time and space, that is, during the Yanliao biota period, the depocenters of Jiulongshan and Tiaojishan formations were in the eastern region of Yanshan, Tuchengzi Formation to Zhangjiakou Formation were in the northwestern Hebei region of the middle-western region of Yanshan, and Yixian Formation migrated back to the eastern Yanshan region.
2. The sedimentary sequence within the basin of the Tuchengzi Formation can be divided into five members, exhibiting the most complete development in Xuanhua and Shangyi regions in the western Yanshan and northwestern Hebei. Conversely, in northern Hebei and western Liaoning, only the third and fourth members of the same Tuchengzi Formation are present, while the fifth member is confined to Chaoyang and Beipiao, which further reflects the basin's patterns and the migration of its depocenter.
3. The Zhangjiakou Formation can be divided into the lower member aged ~145-140Ma and the upper member aged ~139-130Ma. The former and the Tuchengzi Formation and the latter and the Dabeigou Formation all show obvious depositional facies variation relationship. At the same time, the acidic volcanics of Zhangjiakou Formation are present at the end of the 3rd member (~ 145Ma) of Tuchengzi Formation in western northern Hebei, and (~145Ma) regional thick rhyolite breccia tuff or volcanics developed at the top and bottom of the 3rd member and the 4th member, followed by (~145-140Ma) rhyolites and thick tuffaceous conglomerate rhythm. It continued to develop (~139-135Ma) and expand to the eastern part of northern Hebei and (~130Ma) western Liaoning. The tuffaceous conglomerate association on the bottom of the 4th member of Tuchengzi Formation may indicate a larger scale and range of extension and basin development across the North China.
4. The 3rd member of Tuchengzi Formation (~145Ma) represents an isochronous regional period or horizon marked by the presence of dinosaurs, birds, and other vertebrates, predominantly in the form of footprints. The assemblages of flora and fauna that show differences between Yanliao biota and Jeohe biota, the 3rd to 5th member of Tuchengzi Formation and Zhangjiakou/Dabeigou

Formation are characterized by dinosaurs, and birds (mainly footprints) in the 4th member of Tuchengzi Formation (~145Ma) and fly and fish fossils in Dabeigou Formation. It is believed that the Jeohe biota started from the upper part of the 3rd member of Tuchengzi Formation during the Jurassic/Cretaceous transition (from the end of Late Jurassic to the beginning of the Early Cretaceous) from ~150-145Ma.

5. More importantly, both the Yanliao and the Jehol biotas and their transitional ecological environments show close links with volcanism, and in particular, the three different ecological environments have extremely significant specific burial mechanisms related to volcanism.

This research was founded by NSFC (42288201,41688103,41672111).

Keyword

the Yanliao and the Jehol biotas, transition, environment, chronology

Cretaceous stratigraphy, paleogeography and major geological events in eastern Neotethys

Dangpeng XI[1]*, China University of Geosciences (Beijing) (xdp1121@163.com)

Abstract

The Cretaceous period was important for understanding the evolution of the Neotethys. The Cretaceous stratigraphy, paleogeography, and major geological events of the eastern Neotethys are carried out in this study, to establish a new stratigraphic framework, recover the paleogeography of different periods, and explore the major geological events. The Cretaceous stratigraphy of the Qinghai-Tibetan Plateau and its surroundings is mainly marine, with a small amount of interbedded marine and terrestrial deposits. The Indus-Yarlung Tsangpo suture zone developed deep-sea sediments. To the south, the Tethys Himalayas and Indus Basin developed shallow to semi-deep to deep-sea sediments, whereas to the north, the Xigazê and Ladakh forearc basin developed marine sediments; the Lhasa Massif, Karakorum Massif, western Tarim Basin, and West Burma developed shallow marine, interbedded marine-terrestrial, and terrestrial deposits; the Qiangtang Basin and other areas are dominated by terrestrial sediments. Based on multiple stratigraphic divisions and correlations of the lithostratigraphy, biostratigraphy, geochronology, and isotope stratigraphy, a comprehensive stratigraphic framework for the Cretaceous of the eastern Neotethys was proposed. The Cretaceous paleogeographic evolution of the eastern Neotethys can be divided into three phases: 1) gradual breakup of the Indian Plate and the Australia-Antarctica continent, as well as the early collision phase of the Lhasa-Qiangtang Massif (145–125 Ma); 2) northward drift of the Indian Plate and the late collision phase of the Lhasa-Qiangtang Massif (125–100 Ma); 3) rapid northward drift of the Indian Plate, formation of the Tarim-Karakorum Bay and early uplift of the Gangdise Mountains (100–66 Ma). With the northward drift of the Indian Plate and subduction of the Neotethys, the eastern Neotethys experienced a series of major geological events, such as the Great Igneous Province, oceanic anoxia (OAE), and extinction event.

Keyword

Cretaceous, Tethys, stratigraphy, paleogeography, geological events

GEOCHEMICAL AND PALYNOLOGICAL ANALYSES OF THE KHOVIL COAL DEPOSIT, CHOIR-NYALGA BASIN, CENTRAL MONGOLIA

Nyamsambuu ODGEREL[1]*, National University of Mongolia (n.odgerel@num.edu.mn)
Niiden Ichinnorov[2], Mongolian Academy of Sciences, Institute of Paleontology, Ulaanbaatar, Mongolia
Khukhuudei Ulambadrakh[3], National University of Mongolia, School of Arts and Sciences, Department of Geology and Geophysics, Ulaanbaatar, Mongolia
Adiya Eviikhuu[4], Uyan Geo Resource LLC, Ulaanbaatar, Mongolia

Abstract

The Lower Cretaceous vegetation changes during the Apt-Albian, their climatic and environmental alteration are poorly studied in Mongolia. In this study, large amount of work done on spore pollen changes in the plant community structure are reconstructed based on spore pollen records and geochemical analyses of the Khovil coal deposit, Choir-Nyalga basin of the Central Mongolia.

Palynological data, 30 of the 18 samples contain rich palynological fossils providing important information on paleovegetation, paleolandscape and paleoclimates.

A total of 150 palynomorph consisting of spores and pollen of *pteridophytes*, *bryophytes* and *coniferous* pollen grains, and very rare angiosperm pollen grains were recovered in the present study.

As a result of geochemical analysis of major oxides, SiO2 has the highest content with 50.58-63.38%. Following this Al2O3 (1.55-21.63%), K2O (0.2-4.38%) and TFe2O3 (total iron) (1.82-7.52%) are the second most abundant oxides. The rest of the oxides (MgO, Na2O, P2 O5, MnO, CaO and TiO2) have concentration of less than 3.01%. The Al/Si ratio was between 0.16-0.50, SiO2 is related with quartz. The chemical weathering parameter CIA varies 31.13-86.14, with an average of 68.56, showing intermediate chemical weathering. Also, the Zr/Rb ratio 0.93 can be seen the hydrodynamic force was weak. Generally, V/Cr:0.98, U/Th: 0.97, δU:2.23 implies oxidation environment. All weathering parameters show oxidation environment during sedimentation indicating that the paleoclimate is warm and humid.

This palynological and geochemical data indicates that the at Khovil's coal bearing sediments vegetation change dynamics were controlled probably by the regional tectonic palaeolandscape development within a very equable, warm-temperate, and humid climate.

Keyword

Mongolia, palynology, Khovil, geochemistry, paleoclimate

Diverse microbially induced sedimentary structures (MISS) from the Cretaceous deposits of Korea: occurrences and paleoenvironmental implication

Hyun Joo KIM[1]*, Pukyong National University (sunstay@pknu.ac.kr)
In Sung Paik[2], Pukyong National University

Abstract

Diverse microbially induced sedimentary structures (MISS) occur from the Cretaceous nonmarine deposits (Haman, Jindong, and Sayeonri formations) of South Korea. Their occurrences are documented and paleoenvironmental implications are interpreted preliminarily. These formations are composed of siliciclast-dominated lithofacies that were deposited in alluvial plain and lake margin to shallow lake. MISS from the formations include roll-up structure, reticulated surface, wrinkle structure, kinneyia structure, honeycomb-like texture, knobby texture, sieve-like surface, and chipped mat which are related to microbial mat growth and destruction. FE-SEM and EDS analysis of their thin sections and surfaces show microbial traces such as filamental and coccoidal organic matters and chipped microbial mats. MISS are observed on mudstone layers of interlaminated fine-grained sandstone to siltstone and mudstone and planar- to cross-laminated fine-grained sandstone to siltstone covered with mudstone layer. These lithofacies are interpreted to have been formed by unconfined flows in alluvial plain and lake margin under semi-arid paleoclimatic conditions with alternating wetting and drying intervals. Evaporite mineral casts and pedogenic carbonates suggesting the semi-arid condition are occasionally associated with the alluvial plain and the lake margin to shallow lake deposits. The occurrences of MISS in these deposits imply that microbial ecosystem was thriving in the evaporitic and stressed terrestrial environments under semi-arid climate during the Cretaceous in Korean Peninsula. The diverse occurrences of MISS from the Cretaceous deposits suggest that ancient MISS may occur throughout wide stratigraphic and paleoenvironmental ranges, in spite that most of MISS have been documented in Precambrian shallow marine and tidal flat deposits.

Keyword

Cretaceous, MISS, Paleoenvironment, Korea

Mineral magnetic variations across an inland sea-way excursion around Late Maastrichian/Danian deposition of the Jhilmili intertrappean in the Deccan Volcanic Province, Mandla lobe, Madhya Pradesh, India.

Jyotibala SINGH[1]*, savitribai Phule Pune university (balajyotisingh@gmail.com)
S.J. Sangode[2], Savitribai Phule Pune university
Bandana Samant [3], RTMNU , GEOLOGY DEPARTMENT

Abstract

The Late Maastrichtian-Danian sedimentary sequences associated with Deccan large continental flood volcanism are commonly associated with fluviatile, lacustrine and pedogenic environments. The discovery of Danian zone-P1a planktic-foraminifera (during the time of rapid global sea level fall) from a thin-horizon of an otherwise entirely lacustrine-palustrine section at Jhilmili in the Central India, makes it a unique inland marine incursion record. The ~66 cm thick unit comprising foraminifera and benthic calcareous algae is suggestive of the brief inland seaway and record anomalous peak in magnetic coercivity (B(0)CR). Close interval Magnetic mineralogy and clay mineral study offer robust semiquantitative estimates on the paleoenvironmental conditions with humid to warm arid fluctuations. The largely variegated shale-silt-marl intervals are dominated by antiferromagnetic mineralogy with phases of goethite/hematite predominance that are quantified here using new mineral magnetic proxies based on IRM field cancellation technique, into various degrees of oxidative/hydrous conditions within the profile. The anomalous peak in coercivity precisely match with the P1 zone depicting extremely humid depositional environments marked by the production of goethite. On the other hand, the topmost ~50 cm sequence contain the SD-MD detrital/insitu ferrimagnets depicting the complete withdrawal of marine conditions and reducing lacustrine environments. The mineral magnetic based paleoenvironmental analogue developed for the Jhilmili section is further integrated with biostratigraphic information and the quantification is achieved that is useful for inter-site correlation of such intertrappean sections within Deccan province. The sections with and without marine excursions may be identified with great implications on the K/Pg boundary in Deccan intertrappeans.

Keyword

Mineral magnetism, Jhilmili, Depositional environments

Evaluation of the hinterland paleoweathering during the mid- to late-Cretaceous in Northwestern Kyusyu, Japan

Arisa NAKANO[1]*, Waseda University (risa.arisa@ruri.waseda.jp)
Niko TODA[2], Waseda University
Tenichi CHO[3], Waseda University
Tohru OHTA[4], Waseda University

Abstract

Cretaceous is characterized by high atmospheric CO2 levels and the consequent elevation in paleotemperature. Therefore, reconstruction of the paleoclimate during this period is important for understanding the Earth system under super-greenhouse condition. However, Cretaceous paleoclimate studies of continental margin basins in eastern Asia are scarce than that of inland basins.

The present contribution aims to reconstruct hinterland paleoweathering during the mid- to late Cretaceous in Kyusyu, which is located in western part of Japan as an example of paleoclimate information on the mid-latitude continental margin. Mudstone samples were collected from the mid- to late Cretaceous strata distributed in the Amakusa-Mifune district, Northwestern Kyusyu, which were mostly deposited in marine to fluvial environments. The whole rock chemical composition and clay mineral composition were obtained by XRF and XRD, respectively. The degree of continental weathering was investigated using the geochemical weathering indices (RW index, W index, and Rb/Sr ratio) and clay mineralogy.

Geochemical weathering indices show relatively low values from upper Albian to lower Cenomanian (the Eboshi Formation), and then increase from lower Cenomanian to middle Cenomanian (the Enokuchi Formation). These values reach maximum during the Cenomanian-Turonian interval (the Mifune Group) and then decrease. RW index maintain low values from Santonian to Coniacian (the lower Himenoura Group), though W index and Rb/Sr ratio show large fluctuation. This discrepancy may be due to non-silicate input (carbonate minerals), and it suggests that RW index is more robust when carbonate mineral contamination are present. The values of RW index and W index obtained from this study range from 25 to 47 and from 24 to 76 respectively. These values are comparable to the RW and W indices obtained from modern soils developed under temperate climates. (Smectite+Kaolinite)/Illite ratio also increases during Cenomanian-Turonian interval. These lines of evidence suggest that the mid-latitude area of the east Asian continental margin became warmer and/or more humid climate condition during the Cenomanian-Turonian interval, which is consistent with the extremely high global temperatures during the mid-Cretaceous.

Keyword

paleoclimate, chemical weathering, clay minerals, RW index, W index

Interpretation of Cretaceous geomorphology in eastern China based on palynological data

Suping LI[1]*, Institute of Geology, Chinese Academy of Geological Sciences (lisuping@live.com)
Tianquan QU[2], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The uplift and collapse of the coastal mountains in East China has been a highly concerned and controversial topic in the geoscience aspect in recent years. Compared to the studies of the uplift of Tibetan Plateau, researches on the geomorphic evolution of the coastal mountains are still lacking. The uplift and collapse process is still unclear. It is necessary to provide more research clues and new thoughts from different aspects to understand the transformation process of geomorphic pattern in East China from “High-East, Low-West” to “High-West, Low-East” during Mesozoic-Cenozoic. Pollen and spores have incomparable advantages in the study of paleoclimate and paleoenvironment. Over the last few decades, sporopollen data have been applied to reconstruct the paleoelevation, and some remarkable Neogene paleoelevation works have been published. However, few efforts have been made concerning the Mesozoic-Cenozoic eras especially the critical Cretaceous, the potential in paleoelevation reconstruction has not been deeply explored. Based on large numbers of sporopollen data in Cretaceous and early Paleogene, we found that there might be a high-altitude landform in northeast China during the early Early Cretaceous. Additionally, it is likely that coastal mountains existed in the Fujian and Zhejiang regions during the Early Cretaceous. In early Late Cretaceous, the range of coastal mountains in eastern China reached its maximum. From the late Late Cretaceous to early Paleocene, the mountains in eastern China gradually collapsed, and by the early Paleocene, the mountains probably disappeared. Although supporting evidences from other aspects still necessary, this work providing paleontological interpretations for the solution of this scientific question from a new perspective.
This work was supported by the National Natural Science Foundation of China (Grant No. 42372041) and the China Geological Survey (Grant No. DD20221646).

Keyword

Cretaceous, palynological data, paleoclimate, geomorphology, eastern China

Stable carbon isotope stratigraphy of the Tetori Group, Upper Jurassic to Lower Cretaceous siliciclastic shallow-marine to non-marine succession in central Japan: application for non-marine regional correlation

Mayuko KAMIMURA[1]*, Graduate School of Natural Science and Technology, Kanazawa University (f6ogtoad@gmail.com)
Koichi Hoyanagi[2], Department of Geology Institute of Science Shinshu University
Takuto Ando[3], Graduate School of International Resource Sciences, Akita University
Takashi Hasegawa[4], Faculty of Geoscience and Civil Engineering Institute of Science and Engineering Kanazawa University

Abstract

The Tetori Group is an Upper Jurassic to Lower Cretaceous siliciclastic shallow-marine to non-marine successions in central Japan. Understanding terrestrial environmental transitions in the eastern margin of East Asia from the Tetori Group requires crucial studies of the regional correlation. However, the correlation of non-marine strata is challenging due to lateral lithological variations and a lack of reliable index fossils. Carbon isotope stratigraphy would contribute to solve this problem.

The study measured stable carbon isotope ratios of organic matter (δ^{13}Corg) and total organic carbon contents in bulk sediments from three sections: The Tamodani section was selected because of its good stratigraphic continuity, the Itoshirogawa section as a type section, and the Shokawa section as it provided chronological anchors. To minimize local effects, multiple samples were collected and treated from each single horizon in the Tamodani and Itoshirogawa sections. Rock-eval pyrolysis was performed in the Tamodani and Itoshirogawa sections to evaluate origins of organic matter. Additionally, maceral components were examined in the Shokawa section.

In the Tamodani and Itoshirogawa sections, kerogens were recognized as over matured and identified as Type III or IV. In the Shokawa section, kerogens were largely composed of vitrinite. Therefore, the organic matter in these sections is believed to have originated from terrestrial higher plants. As a result, the fluctuations of δ^{13}Corg in this study is unlikely to be associated with mixing rate of organic matters from different sources.

Maximum intra-horizontal difference of δ^{13}Corg of these sections were as large as 1.56‰. The average value of each horizon was bracketed in the ranges of 3.08‰ and 4.92‰ in the Tamodani and Itoshirogawa sections, respectively. As this variation is larger than that in a single horizon, time stratigraphic trend of these sections are interpreted to be significant. The δ^{13}Corg fluctuation curves were tentatively employed for regional correlation.

The δ^{13}Corg curves are also correlated with regional curves from previous studies based on some datums and two isotopic correlative horizons showing higher (-22 to -20‰) and lower (~-25‰) were recognized. This stratigraphically correlative δ^{13}Corg stratigraphy is compared with Tethyan δ^{13}C stratigraphy established with carbonate carbon. The two key horizons could be correlated

with global Aptian and Hauterivian $\delta^{13}C$ events, respectively. The ranges of $\delta^{13}C$ fluctuation in the Tetori Group and Tethyan carbonate are almost identical or that of the Tetori Group is a little larger. It strongly supports our idea that the $\delta^{13}C$ stratigraphy from the Tetori Group reflects global $\delta^{13}C$ fluctuations and available for global correlation.

These two isotopic key beds can provide important datums for the Tetori Group and the Tamodani section will play an important role as a regional reference section. To compare the Tetori Group with East Asian non-marine sequences, the application of $\delta^{13}Corg$ stratigraphy there with similar technique is eagerly awaited.

Keyword

carbon isotope stratigraphy, Tetori Group, organic carbon, non-marine deposit, regional correlation

The South America Map of Orogens

Daniela MATEUS ZABALA[1]*, Servicio Geológico Colombiano (dmateusz@unal.edu.co)
Jorge GÓMEZ TAPIAS[2], Servicio Geológico Colombiano
Nohora Emma MONTES RAMÍREZ[3], Servicio Geológico Colombiano
Victor A. RAMOS[4], Universidad de Buenos Aires and Conicet
Mónica HEILBRÓN[5], Universidade do Estado do Rio de Janeiro
Lêda Maria BARRETO FRAGA[6], Serviço Geológico do Brasil
Camille FRANÇOIS[7], Royal Museum for Central Africa and Commission for the Geological Map of the World
Manuel PUBELLIER[8], CNRS, Ecole Normale Supérieure de Paris and Commission for the Geological Map of the World

Abstract

The South America Map of Orogens is part of the project IGCP–667 The World Map of Orogens supported by Unesco and the International Union of Geological Sciences (IUGS). It is led by the Commission for the Geological Map of the World (CGMW). This project aims to design a digital and global map for geological time layers and which shows the mountain ranges formed through the Earth's geological history. The map then constitutes a tool to visualize the evolution of continents and, therefore, the distribution of Earth resources, seismic hazards, and global change.

Orogens develop in convergent settings and, generally, involve two or more continental or oceanic plates or blocks. For their representation on the global map, four types of orogenic systems were defined: (i) Type I, ocean–continent convergence accommodated by subduction (e.g., Andean Cordillera); (ii) Type II, accretion/collision of crustal elements derived from subduction (island arc or back–arc basin), a microcontinent, an oceanic shelf, or a ridge (e.g., North American Cordillera); (iii) Type III, continental collision, often after subduction (e.g., Himalayas), and (iv) Type IV, shortening of an intracontinental sedimentary basin and continental crustal material (inverted rift) (e.g., Atlas Mountains).

The South American Map of Orogens corresponds to one of the continental maps that make up the global map. It was carried out based on the Geological Map of South America 2019 and filtering the Tectonic Map of South America 2016 by orogenic tectonic setting and geological time. Also, sourcebooks on South American geology and scientific papers were reviewed. Databases and different CGMW maps allowed for identifying deformation features (folding, faulting), regional metamorphism indicators (high and ultra–high pressure rocks and high to ultra–high temperature rocks), magmatism, ophiolites, and molassic basins. All indicators of orogenic events.

The South American map is presented in 11 layers showing the orogens identified for the Paleoproterozoic, Mesoproterozoic, Neoproterozoic, Cambrian–Ordovician–Silurian, Devonian–Carboniferous, Permian–Triassic, Jurassic, Cretaceous, Paleogene, and

Neogene–Quaternary. Because the beginning for modern–style plate tectonics and therefore orogens (according to the defined typology) at or following 2.5 Ga is considered, for the Archean only cratons are presented. For South America, the Trans–Amazonian, Sunsás, Putumayo, Brasiliano, Famatinian, Alleghanian, Gondwanide, and Andean orogens were represented, among others.

One of the great challenges for the construction of the map in South America was the overlapping of orogenies from the Ordovician to the present, since the most recent events have masked the features of previous deformation. Another limitation was the deficiency in the characterization and period of activity of lineaments, folds, and faults that can be used as indicators for the boundaries of orogenic events and, therefore, limits of the polygons on the map.

This map of South America, along with the rest of the continents, was built with an educational approach. It was designed as a geoscientific knowledge product that can be explained simply to non–specialized audiences. It is expected to be an input for other world maps. The goal is that it can then be presented in paleogeographic reconstructions using 3D tools.

Keyword

mountain building, Andes, orogeny, collision, subduction

Continental migration does not conflict with the gyroscope

ZHAINA YERZHANOVA[1]*, IT Company Prime Source (zhaina.yerzhanova@gmail.com)

Abstract

The geological evolution of the Earth's crust, like the lithosphere, begins upon a single and unique (?) continent Pangea or probably the second variant - from Gondwana in terms of the rotating planets dynamics. A giant continent was naturally originated according to the laws of gravitational forces that are not yet controlled at the South Pole or very close to it. The residual magnetic field indicates only the drift of the Earth's crust, and not the mutation of the magnetic poles. Different plates have minerals in the rocks with primary paleomagnetism, which allows often to determine the interval of stratigraphic correlation on different continents. The changes in the pole position, both on the magnetic axis and the axis of rotation, are the motion of continents that move north along a spiral path, if you carefully look at the global map of any scale of with the plotted geographic objects. It can be assumed that there was such a unique island northward of Iceland with slowed-down subsidence of the Earth's crust, for example, the Atlantis civilization. It can be assumed that there was such a unique island northward of Iceland, which has already been drowned to the depths of the Greenland Sea on the edge of the North Pole swirl. With fading of activity the number of volcanoes increases mainly in the oceans, which allows framing large blocks within the oceanic crust. It’s amazing that areas of the Arctic Ocean (14756 mln), the Antarctic (14110 mln km2) are equal, which emphasizes the gravitational balance of the rotating planet and the shift of active volcanism to the northern hemisphere, where the continents collide on subsidence in the North Pole swirl.

Keyword

balance, crust, continent, correlation, stratigraphic

Palynological variability within the Permian (Changhsingian) Umm Irna Formation (Jordan): implications for biostratigraphy and fluid flow character in alluvial formations

Michael H Stephenson[1]*, Stephenson Geoscience Consulting Ltd (mikepalyno@me.com)
B Bomfleur[2], Münster University
H Kerp[3], Münster University
P Blomenkemper[4], Münster University
R Bäumer[5], Münster University
J Schneider[6], Technische Universität Bergakademie Freiberg
A Abu Hamad[7], University of Jordan
P Jardine[8], Münster University

Abstract

The Permian (Changhsingian) Umm Irna Formation in Jordan contains one of the world's foremost Palaeozoic plant fossil localities which has influenced our understanding of the origin and early evolution of plant groups that later rose to dominate the vegetation of the Mesozoic. The formation was deposited in a transitional fluvial regime characterized by stacked small-scale braided channels and by larger channels with deposition on point bars. Between these channel-influenced areas were floodplain interfluves that were characterised by low-energy sheetflood deposits, shallow lakes and ponds, and peaty mires. Floodplain sediments, where not waterlogged, are generally pedogenically altered red-beds with ferralitic palaeosols, indicating a fluctuating groundwater table and humid to semi-arid climate. The three-dimensional structure of facies changes in the Umm Irna Formation indicates a flood plain in continual change with shifting channels and local depositional environments through a probable several million-year period. The result is a complex pattern of arenaceous and argillaceous sediments in a non-layer cake form, where arenaceous rocks may have several forms including channel sandstones, point bar sandstones, and braided channels; and where argillaceous rocks occur in the form of coaly lenses reflecting local peat accumulation, or in the form of abandoned-channel and oxbow-lake fills and of stacked crevasse-splay deposits. Unusually for an arid, hot desert environment, the argillaceous sediments exposed in outcrop yield well for palynology. A major project involving more than 150 palynology samples collected from different kinds of argillaceous unit across the formation's outcrop over around 2 km2, reveal the variation within single argillaceous units, both laterally and vertically, and between argillaceous units in the same sedimentary complex at similar stratigraphic levels.

When combined with fossil plant data, the results have implications for the palynological study of alluvial sequences of Mesozoic and Palaeozoic age, and for understanding the ability to identify mudstone units via palynological fingerprinting. Such individual units are of great importance as baffles to fluid flow in reservoirs that might be used for oil and gas, low temperature geothermal, carbon capture and storage, and hydrogen storage, in alluvial successions.

Keyword

Permian, alluvial, palynology, sedimentology, reservoirs

Expression of the Prague Event (Lochkovian-Pragian boundary) in the Carnic Alps (Italy and Austria)

Carlo CORRADINI[1]*, Università di Trieste (ccorradini@units.it)
Maria Giovanna Corriga[2], Università di Trieste
Monica Pondrelli[3], IRSPS - Università D'Annunzio
Thomas James Suttner[4], Czech Geological Survey

Abstract

In the late Lochkovian a regression is documented in several areas of the world, followed by a transgression in the early Pragian. Connected with the eustatic variation, a minor extinction event occurred (“Prague Event”), affecting several fossil groups, a strong reduction of carbonate production and sedimentary facies changes. The Carnic Alps are a key area for studying this event, because Lower Devonian rocks are widely exposed, representing diverse sedimentary environments from shallow water to relatively deep shelf. Six formations were discriminated in the upper Lochkovian and Pragian. Several sections were measured along the Carnic Alps across the Lochkovian-Pragian boundary. In the shallower part of the basin, both the Polinik and the Seekopf fms span the boundary, but evident erosional surfaces are observable in the field at the Lochkovian-Pragian boundary; unfortunately, up to date, it was not possible to constrain chronostratigrafically the hiatus in the Polinik Fm. due to the missing of stratigraphically useful fossils. In correspondence of the Seekopf Fm., above the unconformity, at places the so-called megaclast horizon is present. In intermediate settings the Rauchkofel Fm. is uncorfomably followed by the Kellerwand Fm., and different parts of the upper Lochkovian and the lower Pragian are missing in the various sections. In the deeper parts of the basin the transition from the La Valute Fm. to the Findenig Fm. is slightly diachronous from the latest Lochkovian to the earliest Pragian; however, conodonts and tentaculites are rare in the marly boundary beds, preventing a precise chronostratigraphic calibration of these levels. At places, evidence of subaerial exposure at the formational boundary are documented. In general, the hiatus seems to be larger in the western part of the Carnic Alps, in correspondence with the shallower parts of the succession, suggesting a sea level drop in the uppermost part of the Lochkovian, followed by a transgression in the lower part of the Pragian.

Keyword

Lower Devonian, Basin evolution, conodonts, Lochkovian-Pragian boundary

Integrating geochemical and geochronological methods to improve geological mapping in Aus, Southern Namibia

Claudia MUTONGOLUME[1]*, Geological Survey of Namibia
(claudia.mutongolume@mme.gov.na)
Ewereth Muvangua[2], Geological Survey of Namibia

Abstract

Geochemical and geochronological analyses have been employed to discern and characterize the prevalent granitoid intrusions of the Aus area, southern Namibia. Aim of the project was to enhance the understanding of the tectonic setting and stratigraphy of this part of the Namaqua-Natal Metamorphic Province, which straddles southern Africa from the Atlantic to Indian coasts. The oldest rocks in the area consist of slivers of the Palaeoproterozoic Garub Group, comprising marble, calc-silicates, metapelites, garnet-biotite quartz gneisses, amphibolites, mafic granulites, and serpentinites extensively intruded by granitoids displaying variable degrees of deformation (e. g. Tsirub, Aus and Kubub orthogneisses). Geochemical analyses indicate that all granitoids within the area exhibit acidic characteristics, are strongly peraluminous, and products of shoshonitic and high-K calc-alkaline magma sourced from an A-type origin. The A-type granites resulted from crustal contamination during a phase of continental extension, and subsequently underwent compressional deformation. Chondrite-normalized spider diagrams depict negative anomalies in Ta, Nb, P, and Ti, alongside enrichments in Th and LREE, indicative of an arc environment origin. Plots correlating K2O with SiO2 exhibit considerable scatter, possibly attributable to the influence of crustal contamination. Three distinct geotectonic settings have been established: syn-collisional Granite (syn-COLG), Volcanic Arc Granites (VAG), and Within Plate Granites (WPG). The erratic plots observed in samples may be ascribed to hydrothermal alteration and/or varying degrees of fractionation within multiple flows, supporting a model of crustal fragment collision. Geochronological analyses give emplacement ages for the Tsirub augen gneiss and the Aus granite gneiss of 1110 ± 7 Ma and 1085 ± 36 Ma, respectively.

Keyword

Intrusives, Mapping, tectonic, setting, stratigraphy

Key findings of the geoscientific mapping in the Aukam Valley, Namaqua Metamorphic Complex, Southwestern Namibia

Ewereth MUVANGUA[1]*, GEOLOGICAL SURVEY OF NAMIBIA (emuvangua@gmail.com)
Jason Indongo[2], Geological Survey of Namibia
Claudia Mutongolume[3], Geological Survey of Namibia
Paul Macey[4], Council for Geoscience/University of Cape Town

Abstract

The Geological Survey of Namibia has embarked on a joint geological mapping programme with the Council for Geoscience of South Africa in the Namaqua Metamorphic Complex in southern Namibia, which commenced in 2013. The study of the 1: 50 000 scale geological mapping provides new aspects of the regional tectonostratigraphy of the various domains. The Paleoproterozoic Sperrgebiet Domain (~2.02 Ga) and Richtersveld Magmatic Arc (~1.9 Ga) and high grade ~1.3-1.1 Ga Mesoproterozoic rocks of the Kakamas and Aus Domains forms the Namaqua Metamorphic Complex in southern Namibia . The Aukam Valley basement rocks occur as an inlier of the Nama Group southeast of the Aus village. The mapping in this area was limited, with large parts shown as “Undifferentiated Namaqua” on the existing 1:250 000 geological survey map. Our mapping reveals the Aukam Valley geology consists of a variety of high-grade gneisses and granites. Cordierite-sillimanite-garnet-K-feldspar metapelite and associated garnet-quartz-feldspar leucosome bodies, that formed during granulite facies anatexis, are intruded by dykes of mafic granulite and voluminous sheets of coarse-grained and augen-textured leucogranite gneiss. The penetrative gneissic Namaqua fabric extends in the WNW direction and dips to the northeast. The metapelites resemble the ~1.22 Ga Garub and the Narries Groups in the Aus and Kakamas Domains, respectively. Similarly, the leucogranite gneisses are comparable with the ~1.2 Ga Aus Gneiss and Ham Suites of the Aus and Kakamas Domains. The high-grade rocks are intruded by late-tectonic ~1.1 Ga porphyritic enderbite and granodiorite of the Komsberg Suite and ~1.0 Ga pegmatites related to the terminal-Namaqua dextral shear event. The new mapping confirms that the Aukam Valley inlier forms part of the Aus-Kakamas granulite mega thrust sheet. The area is of economic significance as it hosts graphite mineralization at the Aukam graphite mine. Through this mapping programme coupled with detailed research, other potential mineral occurrences may be delineated within the Aukam Valley and surroundings.

Keyword

Mapping, Namaqua Metamorphic Complex, Aukam Valley, Mineralization, Namibia

U–Pb Geochronology of Detrital Zircons from San Carlos Basin, Costa Rica: Evidence of Miocene Volcanism and Implications for the Precambrian and Paleozoic History of the Central American Isthmus

Martin Rojas Barrantes[1]*, Directorate of Geology and Mines, Costa Rica (martinr@minae.go.cr)
Sofia Huapaya-Rodríguez Parra[2], Directorate of Geology and Mines, Costa Rica
Luigi A. Solari[3], UNAM, México
Vladimír Žáček[4], Czech Geological Survey, Czech Republic

Abstract

Central America encloses a variety of geological units whose evolution is related to six major tectonic plates (North American, Caribbean, Cocos, Nazca, South American) and Farallón during the Lower Miocene, as well as continental and oceanic slivers of tectonostratigraphic blocks (Maya, Chortís, Chorotega, and Chocó), and a possible series of other hidden terranes. The Maya and Chortís blocks are the continental crust, meanwhile, the Chorotega and Chocó blocks are composed of piles of accreted/collided oceanic crust sequences. Southern Central America is characterized by the absence of pre-Mesozoic rocks, in contrast, the northern region of Central America contains a variety of Precambrian/Paleozoic, Triassic metamorphic, and igneous rocks with a wide age range. The San Carlos Basin (SCB) is an extensional back-arc basin located in northwestern Costa Rica and southern Nicaragua (10°22′–11°08′) within the Central American back-arc region, a convergent margin of the Cocos oceanic plate beneath the Caribbean continental plate. The basement of the basin is composed of Middle Jurassic to Upper Cretaceous rocks, mainly mafic and ultramafic rocks and pelagic radiolarites. Likewise, it comprises Paleogene and Neogene volcano-sedimentary rocks. The objective and method were to sample clastic sediments (sandstones) in outcrops and borehole cuttings from the Middle Miocene to Pliocene age sedimentation of the SCB to date detrital zircons through U-Pb/LA-ICPMS standard analysis, in search for information about the geological and tectonic history of this area of southern Central America. The 206Pb/238U ages were considered for dates <1000 Ma, whereas 207Pb/206Pb ages were preferred above such a limit. The majority of the analyzed zircons in all the samples seem mainly to be dominantly of igneous origin, while some crystals may be related to metamorphism. The results show that there is a wide distribution of ages and generations of zircons in the SCB. Twelve per cent of the dated zircon grains are recycled from Paleozoic and Proterozoic sources, whereas 88% of the zircon grains are from the Cenozoic and Mesozoic arc magmatism and volcanism. The most frequent population is Cenozoic (79%), followed by Mesozoic (9%), Proterozoic (8%) and Paleozoic (4%). The Miocene population (66%) was constrained to a maximum depositional age of 6.9 ± 0.2 Ma of late Miocene-Pliocene basin sedimentation. According to the chondrite-normalized REE patterns and U/Yb–Y geochemistry the large majority of the analyzed zircons (96%) have a continental origin, while 6% of the Miocene population shows an oceanic origin probably associated with a MORB-type source arc volcanism. The Cenozoic and Mesozoic detrital zircon ages show the development and evolution

of the southern Central America volcanic arc, while the Proterozoic and Paleozoic detrital zircon ages indicate a possible connection with northern Central America or southern Mexico, or a possible Gondwanic or Laurentian origin. However, it could also indicate the presence of hidden continental crust fragments underneath southern Central America. These ancient detrital zircons ages constitute a new contribution to revealing the evolution of these continental complexes and provide a paradigm for future studies about the geologic and geotectonic evolution of the Central America isthmus.

Keyword

Detrital zircons, U–Pb dating, Crust growth, Precambrian terrane, Central America

Research advances and a reference subdivision of the Meso-Neoproterozoic stratigraphy in China

Hongwei KUANG[1]*, Institute of Geology, CAGS (kuanghw@126.com)
Yongqing Liu[2], Institute of Geology, CAGS
Yuansheng Geng[3], Institute of Geology, CAGS
Nan Peng[4], Institute of Geology, CAGS
Yuchong Wang[5], Institute of Geology, CAGS
Xiaoshuai Chen[6], Institute of Geology, CAGS
Yanxue Liu[7], Institute of Geology, CAGS
Fengjie Yang[8], College of Earth Science and Engineering, Shandong University of Science and Technology
Fenghua Zhao[9], College of Geosciences and Surveying Engineering, China University of Mining and Technology
Pengju Liu[10], Institute of Geology, CAGS
Lilin Du[11], Institute of Geology, CAGS
Huanxin Song[12], College of Resources and Environment, Yangtze Univerisity
Dehai Wang[13], College of Earth Science, Jinlin University
Changyong Wang[14], Insitute of Sedimentary Geology, Chengdu University of Technology
Huaqing Bai[15], Chinese Academy of Geological Sciences
Guilin Dong[16], College of Geosciences and Surveying Engineering, China University of Mining and Technology
Kening Qi[17], Institute of Geology, CAGS

Abstract

This report systematically sorts out the Meso-Neoproterozoic stratigraphic problems on the Stratigraphic Chart of China (2014), based on the achievements of relevant experts and the author's team in stratigraphic chronology in the past 10 years, and combining with the spatio-temporal development and correlation relationship of geological events, focuses on studying the definition of the bottom boundary of the Mesoproterozoic and the Mesoproterozoic Undefined System, the stratigraphic relationship in the Meso-Neoproterozoic transition period, and the division of the lower boundary of the Cryogenian, as well as the time age of the Ediacaran Luoquan glaciation. On this basis, a subdivision and correlation frame work of the Meso-Neoproterozoic strata of China, were presented and the similarities and differences among the North China, Yangtze, and Tarim Block are further discussed. The researches indicate that it is more reasonable to set 1800 Ma as the lower boundary of the Mesoproterozoic than 1600 Ma; Although the Mesoproterozoic Undefined System is developed in both the northern and southern margins of North China and South China Block, the Shennongjia Group in the northern margin of the Yangtze Block is favorable than others and as a result, suggests it as the temporary stratotype of the Undefined System in China and emphatically research on it; The proto-Qingbaikou System in Jiao-Liao-Xu-huai-Ji-Yu of North China Block, is probably older than 1000 Ma, i.e., parts of it belonging to the Mesoproterozoic; We proposal that the proto-Nanhuan System corresponds to the international Cryogenian (720~635 Ma); The Qingbaikou System is bounded by a tectonic plane

of 820 Ma, with the lower part is named as the Lower Series of the Qingbaikou System (1000~820 Ma), and the upper part is named as the Upper Series the Qingbaikou System (820~720 Ma), and the decision on whether to divide into two systems will be made when there are more evidences in the future; The Luoquan Formation and coeval strata in the southern margin of North China Block probably belong to the upper Sinian. Our researches provide data, evidence and the reference subdivision, to revise and improve for "the Meso-Neoproterozoic" division and correlation in the Stratigraphic Chart of China.

It is co-funded by the National Key Research and Development Program (No. 2022YFF0800302, 2016YFC0601001), the National Natural Science Foundation of China (No. 42072135), the project of China Geological Survey (No. DD20221649) and the International Innovation Resources Cooperation Project of the Beijing Science and Technology Commission (No Z201100008320007).

Keyword

Meso-Neoproterozoic, reference subdivision, chronostratigraphy, event stratigraphy

Meso-Neoproterozoic Simlipal Complex, Eastern India; an impact induced basin, post amalgamation of Singhbhum Craton and North Singhbhum Mobile Belt.

Jayaprakash Mohakul[1]*, Geological Survey of India (jayaprakash.mohakul@gsi.gov.in)
Maya Tripathi[2], Geological Survey of India
Itishree Chinara[3], Geological Survey of India

Abstract

The Simlipal Complex is located at the north eastern periphery of Singhbhum Craton, close to its interface with the Palaeo-Mesoproterozoic North Singhbhum Mobile Belt (NSMB). It is an ovoid basin consisting of three distinct horizons of inward dipping sandstone alternating with mafic volcanic, while the centre is occupied by the differentiated Amjori sill with dunite member at the base, which grades through peridotite, picrite, gabbro, diorite to dolerite at the top (Iyengar & Banerjee, 1964; Iyengar et al., 1981). The present study primarily focuses on the basement cover relationship of the lower most sandstone unit with that of the cratonic mass as well as NSMB, constrain its age based on available data of basement rocks and propose a theory of basin formation due to meteorite impact based on new evidences from the Bhuasuni Felsic Complex at the northern periphery of Simlipal Complex.

The north eastern part of Simlipal Complex is fringed by metamorphosed pelitic and psammopelitic assemblages of NSMB while in the rest of the part it clearly overlies the cratonic mass represented largely by Singhbhum Granite Complex, Mayurbhanj Granite and Gabbro. The basal sandstone layer occurs as a near continuous ring with strata consistently showing moderate dips towards the centre except at the north eastern part where dips are rather shallow. Near horizontal attitude of beds at this part has resulted in several outliers of sandstone clearly overlying the foliated grey phyllite of NSMB which gives a deceptive appearance of bifurcation of lower sandstone. Inclusion of this grey phyllite as a part of Simlipal Complex by many of the early workers is untenable as there is a clear angular unconformity between them. Sandstone is typically fine- to medium-grained, having herringbone stratification, tidal bundles, soft sediment deformation structures along with ubiquitous trough cross-stratification. Petrographic study suggests these sandstones as quartz arenites and reveals their high textural and mineralogical maturity. The Bhuasuni Felsic Complex occurs as a near circular body northeast of the Similipal Complex and west of the southern extension of Singhbhum Shear Zone across which the lithopackage of NSMB are thrusted upon the cratonic mass to the west. Recent work by authors clearly establishes it to be alkali feldspar granite, largely granophyric in nature, showing both plutonic and volcanic variants. Presence of deformational imprints of NSMB indicates it to be synkinematically emplaced during accretion of NSMB with Singhbhum Craton and can be correlated with the Arkasani granophyres. Planar deformation fabric (PDF) in quartz and suspected diapletic glass recorded in the aphanitic variant of Bhuasuni Felsic Complex suggests

that the Simlipal basin could have originated due to meteorite impact.

References:

Iyengar, S.V.P. and Banerjee, S. (1964) Magmatic Phases associated with the Pre-Cambrian Tectonics of Mayurbhanj District, Orissa, India. Report, 22nd International. Geol. Congress, v.10, pp.515–538.

Iyengar, S.V.P., Chandy. K.C. and Narayanaswamy, R. (1981) Geochronology and Rb-Sr systematics of the igneous rocks of Similipal Complex. Orissa. Ind. J. Earth Sci., 8(1): 61 -65.

Keyword

Simlipal Complex, Meteoritic impact, Singhbhum Craton, North Singhbhum Mobile Belt, Bhuasuni Felsic Complex

STRATIGRAPHIC REVISION OF AN EOCENE-MIOCENE CARBONATE-EVAPORITE SUCCESSION IN UAE-OMAN GUIDED BY SENTINEL-2 MULTISPECTRAL DATA ANALYSIS

Abdel-Rahman FOWLER[1]*, UAE University (afowler@uaeu.ac.ae)
Karim Abdelmalik[2], Ain Shams University, Egypt
Osman Abdelghany[3], UAE University, U.A.E.
Abdelaziz Al Azzani[4], UAE University, U.A.E.
Mahmoud Abu Saima[5], UAE University, U.A.E.

Abstract

The carbonate-evaporite sequence exposed at Jabal Hafit, south of Al-Ain, Abu Dhabi Emirate, is the most complete Eocene to Miocene succession in the UAE. Stratigraphic subdivision of this ~ 1200 m thick sequence began in the late 1970's as part of hydrocarbon exploration activities in the region. The currently accepted stratigraphic scheme for the Jabal Hafit sequence dates from 1984 and includes (from oldest to youngest) the Lower Eocene Rus Formation (nodular wackestone, marl, coralgal and gastropodal grainstones, foraminiferal stylonodular packstones, and dolomite), Middle to Upper Eocene Dammam Formation (brown marls, massive Nummulitic limestones, and brown coarse-grained calcarenites), the Oligocene Asmari Formation (green marls, Nummulitic wackestone-packstone and coralline reefal boundstone), and the Miocene Lower Fars Formation (gypsiferous mudstones and gypsite). Division of the formations into members has been suggested based mainly on mapping in the northern (UAE) part of Jabal Hafit. Mapping of the extent of the formations and members, and recognition of facies variations within each unit, in the southern (Omani) parts of Jabal Hafit, have been hampered by the mountainous terrain of Jabal Hafit, poor accessibility, international border restrictions and poor discrimination of the mainly carbonate rocks on unprocessed satellite images. In this work, remote sensing techniques, including Principal Component Analysis, improved by Decorrelation Stretching, have been applied to Sentinel-2 data for the Jabal Hafit area in UAE and Oman. The results provide excellent discrimination of the formations and members of the Hafit sequence, including the first mapping of the members of the Rus Formation that mainly occupy the crest of Jabal Hafit.

Keyword

Jabal Hafit, UAE, stratigraphy, carbonates, RS-assisted

Are Ordovician ferruginous ooids and microbialites indicators of cool-water realms and upwelling-active zones?

Xiaocong LUAN[1]*, Nanjing institute of Geology and Palaeontology, CAS (xcluan@nigpas.ac.cn)
Jisuo JIN[2], Western University
Colin D. SPROAT[3], University of Saskatchewan
Renbin ZHAN[4], Nanjing institute of Geology and Palaeontology, CAS

Abstract

The Phanerozoic Ooidal Ironstone (POI) is an important ore and usually considered as the result of warm climate, but POI in Ordovician, as one of the richest periods, mostly develops with cool-water faunas and sediments. It is also suggested by the distribution of most Ordovician POI in high-latitude Gondwana area. This study examines the Middle–Late Ordovician POI in South China, a unique warm-water anomaly, and coeval ferruginous deposits (iron ooidal limestone and ferruginous microbialites). These ferruginous deposits can be divided into ferruginous ooids (Types A and B) in warm-waters carbonate and microbialites (Types C and D) in cool-water sediments, controlled by depositional differentiation. Their similar structures and δ56Fe values suggest a shared iron source and formation pathway, in relation to dominant cool-water ramp with active upwelling background. This hypothesis is attested by the integrated summary of global distribution of Ordovician ferruginous deposits, revealing a consistent association with cool-water realms and upwelling-active zone. Along with global cooling, the unique ocean–land configurations contributed to the formation of Ordovician POI and other ferruginous deposits. The Darriwilian peak in POI abundance corresponds not only to intensified upwelling but also to the emergence of ice sheets, indicating the potential link between glaciation and the ocean-atmosphere circulations.

Keyword

Ordovician, ferruginous ooids, ferruginous oncoids, cold current, South China

Unravelling the Evolution of the Richtersveld Magmatic Arc: Insights from Integrated Regional Geological Mapping

Paul Hugh Macey[1], Council for Geoscience
Robert Thomas[2], Council for Geoscience
Conrad Adolf GROENEWALD[3]*, Council for Geoscience (cgroenewald@geoscience.org.za)
Smith Hendrik[4], Council for Geoscience
Shane Doggart[5], Council for Geoscience
Gerhard Shifotoka[6], Geological Survey of Namibia
Moses Angombe[7], Geological Survey of Namibia
Minnaar Hendrik[8], University of the Freestate
Pieter Gresse[9], Council for Geoscience
Chris Lambert[10], Council for Geoscience
Jodie Miller[11], University of Stellenbosch
Dirk Frei[12], University of Western Cape
Johan Diener[13], University of Cape Town
Alexander Kisters[14], University of Stellenbosch

Abstract

Following the successful conclusion of the Southern Namibia Mapping Program (SNMP), a 10-year joint venture between the Council for Geoscience (CGS) and the Geological Survey of Namibia, we have embarked on an in-depth exploration of the Paleoproterozoic Richtersveld Subprovince/Magmatic Arc (RMA). The RMA, part of the Namaqua Metamorphic Province, spans southern Namibia and adjacent NW South Africa, and has been the subject of extensive study aiming to unravel its complex evolutionary history. Integrating recent findings with previous work from this study, has led to a comprehensive model for the evolution of the RMA, shedding light on its tectonic and magmatic processes.

The RMA was variably affected by the ~1 Ga Namaqua orogeny. In the west, low-grade metamorphic rocks (Vioolsdrif Domain) record a limited Namaqua imprint whereas in the east, the equivalent rocks were converted to amphibolite-facies gneisses (Pella Domain). Tectonic slivers of RMA rocks are also found in an imbricate thrust zone that forms the base of the over-riding Namaqua age Kakamas Domain further east.

The volcanic and equivalent plutonic rocks (Orange River Group (ORG) and Vioolsdrif Suite respectively) of the RMA form a coeval calc-alkaline magma series with characteristic island-arc geochemical signatures. The entire magmatic history took place between 1910 and 1865 Ma, contrary to the much longer timespans previously suggested.

Recent geological mapping, U-Pb LA-ICPMS zircon geochronology, and Sm-Nd isotopic studies conducted during the SNMP reveal older crustal "rafts" hosted within the RMA. These include inherited zircons in RMA plutonic rocks (~1.9 Ga Vioolsdrif Suite) and detrital zircons in coeval

RMA meta-sedimentary rocks (Orange River Group), indicating ages ranging from Neoarchaean to Paleoproterozoic (~3.3 to 2.0 Ga). Nd isotopic data further supports the presence of older crust within the source region of RMA magmas.

The SNMP has identified the ~2.02 Ga inheritance and detrital zircon peak in the RMA rocks as sourced from the Wasserkuppe Suite of the Sperrgebiet Domain, a pre-existing arc domain cannibalised by the RMA. Moreover, two older crustal rafts have been discovered, the Bankwasser Migmatite (~2.9 – 2.5 Ga detrital ages) and an even older Archaean crustal inclusion, the Blue Mountain Group (3.3 -2.7 Ga) on the NW margin of the RMA, providing further evidence of ancient crustal components within the RMA. U-Pb analyses of detrital zircons obtained from the nearby Neoproterozoic low-grade diamictite (Halifax Formation) of the Gariep Supergroup yield a broad range of ages from 3.3 to 1.0 Ga, with the older detritus affirming the presence of ancient crust in the vicinity, thereby underscoring the heterogeneous nature of the RMA.

These findings emphasize the importance of continued mapping and geochronology in resolving the complexities of geological terrains. The integrated approach employed in this study provides crucial insights into the evolution of the RMA and broader geological processes in the region, contributing to our understanding of crustal evolution and tectonic dynamics in Paleoproterozoic settings.

Keyword

Richtersveld Magmatic Arc, Namaqua Metamorphic Province, Geochronology, Archean, Paleoproterozoic

Provenance studies of the Cuyuja Unit in the Quebrada Yaguana, Napo-Ecuador

Christian Wladimir ROMERO CÓNDOR[1]*, INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO (criscescz@gmail.com)
Marilyn Del Cisne Castillo[2], Universidad Central del Ecuador
Fausto Rodolfo Carranco[3], INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO
Gabriela Andrade[4], INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO

Abstract

To the east of the Ecuadorian Andes, the Cordillera Real represents a core of sedimentary and metamorphosed igneous rocks, which traditionally has been studied in terms of lithotectonic terranes: Guamote, Alao, Loja, Salado, Zamora. Previous research considered the Salado Terrane as a marginal basin of the Jurassic to Cretaceous age, which developed on the edge of the South American craton and within which the Upano, Cuyuja, Cerro Hermoso, and Azafrán units were deposited. Along the Cuyuja to Baeza route, the Cuyuja Unit extensively outcrops in the Yaguana Ravine (UTM: 833320E, 9954106N). The Cuyuja Unit unconformably overlies the Upano Unit. At the base of the Cuyuja Unit, meta-conglomerates are observed, matrix-supported, silicified, with sub-rounded quartz granules and clasts, intercalated with quartz ± graphite ± muscovite schists and black phyllites. The top of the Cuyuja Unit is dominated by phyllites, shales, graphite ± sericite schists, and meta-sediments. The meta-sediment levels consist of intercalations between metapsamites and metapelites where remnants of tidal structures are observed: wavy lamination, flaser bedding, and bidirectional ripples. The provenance and tectonic environment of the Cuyuja Unit in the Yaguana Ravine were evaluated through whole-rock geochemistry. The Cuyuja Unit exhibits SiO2 and Al2O3 contents comparable to the average composition of the upper continental crust (UCC). These rocks are strongly depleted in CaO and MgO and enriched in K2O, Ba, and Rb relative to UCC, reflecting the addition of K during diagenesis. Zr, Ti, and Ni ratios suggest that the Cuyuja Unit originated from a sedimentary protolith. The REE patterns normalized to PAAS are nearly flat, with a slight depletion of LREE relative to HREE and null or weakly positive Eu anomalies. Their REE patterns normalized to chondrites are parallel to sub-parallel, enriched with LREE, and show distinct negative Eu anomalies and weakly fractionated HREE segments. Overall, they are geochemically mature and have undergone sedimentary recycling. The La, Th, and Hf ratios indicate an increase in an ancient sedimentary component, probably from a cratonic source, deposited on a passive margin. U-Pb ages in detrital zircons results show the dominant influence of cratonic sources east of the basin, yielding prevailing age groups of 1550–1300 Ma (Rodonian-San Ignacio) and 1300–900 Ma (Sunsás) from the westernmost cratonic provinces. Secondary cratonic sources (~25%) include older eastern provinces such as Rio Negro-Juruena (1800–1550 Ma) and Ventuari-Tapajós (2150–1800 Ma). Minor Neoproterozoic-early Paleozoic populations suggest limited input from the Andean metasedimentary basement (200 –150 Ma).

Keyword

Cuyuja Unit, Cordillera Real, Cretaceous, Provenance Analysis, Stratigraphy

When and how did the Sturtian glaciation begin? insights from the Shennongjia area, northern Yangtze Craton

Yuchong Wang[1]*, Institute of Geology, Chinese Academy of Geological Sciences (yuchongwang@Foxmail.com)
Hongwei KUANG[2], Institute of Geology, Chinese Academy of Geological Sciences
Yongqing LIU[3], Institute of Geology, Chinese Academy of Geological Sciences
Fenghua ZHAO[4], China University of Mining and Technology, Beijing
Nan PENG[5], Institute of Geology, Chinese Academy of Geological Sciences
Xiaoshuai CHEN[6], Institute of Geology, Chinese Academy of Geological Sciences
Kening QI[7], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The two low-latitude glaciations, commonly referred to as the "snowball Earth", occurred during the Cryogenian, were periods of unprecedented frigidity in Earth's history that exerted a profound influence on the evolution of life and global environments. Supported by the National Key Research and Development Program of China (No. 2022YFF0800302 and No. 2016YFC0601001), this study analyses the sedimentary evolution of the northern Yangtze Craton from the late Tonian to the Early Cryogenian based on the continuous sedimentary record of the Shennongjia region in the northern Yangtze Craton, and explores the onset of the Sturtian snowball Earth. Initial deposition in the northern Yangtze Craton began around 767.3 ± 6.1 Ma and the sedimentary environment was dominated by terrestrial fluvial action with a provenance from the continental magmatic arc on the South Qinling Belt. Around 753.8 ± 2.9 Ma, a sedimentary translation from the fluvial-dominated terrestrial system to the transgressive tidal-influenced marine system, which coeval with the peak rifting related to the supercontinent Rodinia breakup. Approximately 722.5 ± 2.1 Ma, the northern Yangtze Craton experienced a period of intense chemical weathering and enhanced water cycle, followed by the distal glaciomarine ice-rafted deposits and then proximal glaciomarine subaqueous debris flows. The sedimentary sequences, isotopic ages, and geochemical data analyzed in this study suggest that the initiation of the Sturtian glaciation in the Shennongjia area of the northern Yangtze Craton occurred after 723 Ma, which aligns with the timing of the onset of glaciation in the Laurentian Craton. Furthermore, these results provide new insights and basic data for understanding the onset of the snowball Earth, thereby supporting the continental weathering hypothesis of the supercontinent Rodinia as a trigger for the Sturtian glaciation.

Keyword

Northern Yangtze, Late Tonian, Onset of the Sturtian glaciation, Sedimentary evolution, Paleoenvironment

Factors affecting sequence structure and sequence-stratigraphic dynamics

Haoyuan LV[1]*, College of Energy Resources, Chengdu University of Technology
(lvhy97@qq.com)
Guoqiang XU[2], College of Energy Resources, Chengdu University of Technology

Abstract

The stratigraphic structure pattern and phase distribution in the third-order sequence are mainly controlled by three factors: periodic sea level change, tectonic uplift and decline, and sediment supply rate. Among them, periodic sea level change is the basic driving force of sequence structure change. Tectonic processes and sediment supply in different periods in different regions can affect the change of relative sea level or base level, which is the external driving force of stratigraphic structure change. Sequence-stratigraphic dynamics mainly investigate how the above three factors collectively drive variations in the sequence-stratigraphic architecture. The influence of three factors on the sequence structure can be summarized into the following three patterns: (1) When the basement subsidence and sediment supply rate are normal, a base-level cycle corresponds to four genetic stratigraphic units: transgression unit, highstand normal regression unit, forced regression unit and lowstand normal regression unit; (2) When the subsidence rate of the basin is high or the sediment supply rate is low, the scale of transgression unit will increase, the scale of forced regression unit will decrease, and the types of genetic unit in a single sequence will decrease. On the contrary, when the rate of tectonic uplift is high, the scale of regression unit will increase, and the transgression unit will decrease; (3) When the subsidence rate is particularly high and the sediment rate is normal, the relative sea level change of the third-order cycle shows a rapid rise, and the strata are all the genetic units of transgression, and the third-order sequence cannot be identified by the transgressive and regressive cycle. When the rate of tectonic uplift is particularly high, the strata all converted to forced regression units.

Keyword

Sequence structure, Genetic stratigraphic unit variation, Sequence-stratigraphic dynamics

Provenance of Late Precambrian quartzite- schist sequences of the western Central Asian Orogenic Belt

Nadezhda KANYGINA[1]*, Geological Institute, Russian Academy of Sciences, Moscow, Russia (kanygina.nadia@gmail.com)
Andrey Tretyakov[2], Geological Institute, Russian Academy of Sciences, Moscow, Russia
Kirill Degtyarev[3], Geological Institute, Russian Academy of Sciences, Moscow, Russia
Anfisa Skoblenko[4], Geological Institute, Russian Academy of Sciences, Moscow, Russia

Abstract

The Central Asian Orogenic Belt (CAOB) is the largest accretionary orogen in the world formed during evolution of the Paleo-Asian Ocean through the accretion and collision processes of the late Precambrian to early Mesozoic age. The terranes with Precambrian continental crust play a significant role in the structure of the western segment of the CAOB. Meso- and Neoproterozoic igneous and metamorphic formations mostly comprise the Precambrian terranes in this part of the belt, whereas Early Precambrian complexes are extremely limited (Degtyarev et al., 2017).

Another characteristic feature of the Precambrian terranes is the presence of late Precambrian sedimentary and metasedimentary formations, which mostly include metaterrigenous schist, quartzite schist and quartzite. Their widest distribution is known from the Northern Kazakhstan (Kokchetav, Ishkeolmes, Erementau–Niyaz), Aktau–Yili (Aktau–Mointy, Junggar Alataw, Yili block), Chu–Kendyktas, Issyk–Kul and Chinese Central Tian Shan terranes (Degtyarev et al., 2017).

The accumulation of these units began approximately at ca. 1.1 Ga, and their sources were Mesoproterozoic, Paleoproterozoic and Neoarchean complexes (Kanygina et al., 2021). When comparing detrital zircon ages from the quartzite–schist sequences of the Aktau–Mointy, Junggar Alataw, Northern Kazakhstan and Issyk–Kul terranes, similarities in age distributions are observed. However, the Aktau–Mointy and Junggar Alataw terranes sequences are characterized by a significant predominance of early Mesoproterozoic–Paleoproterozoic (1400–1800 Ma) detrital zircon ages, while the Northern Kazakhstan and Issyk–Kul terranes exhibit the predominance of Mesoproterozoic (1200–1500 Ma) detrital zircon ages.

Quartzite-schist and quartzite-schist-carbonate sequence with similar structures and ages are developed within the Yili block and Chinese Central Tien Shan in the west CAOB. Detrital zircons here have similar age distributions and εHf(t) values. The accumulation of strata of these terranes began at ca. 1000 Ma, and the main sources were Mesoproterozoic, Paleoproterozoic and Neoarchean complexes. Quartzite- schist sequences are also developed in the structure of the Chu-Kendyktas terrane but their accumulation began around 1700 Ma and Paleoproterozoic and Neoarchean complexes prevailed in the provenance (Kanygina et al., 2021). The Early Neoproterozoic sedimentary strata of the northern part of the Tarim Craton also lacking detrital zircons aged 1200 - 1700 Ma.

The structural features of the stratigraphy and sedimentation environments and the age range and nature of the quartzite–schist sequence provenance areas of the Late Mesoproterozoic to Early

Neoproterozoic indicate the proximity of the Aktau–Yili, Chinese Central Tian Shan, Kokchetav, Ishkeolmes, Erementau–Niyaz and Issyk–Kul terranes that likely formed a single continental block during that period, while they show significant differences with the Late Precambrian formations of the Chu-Kendyktas terrane and Tarim Craton (Kanygina et al., 2021).

This study was financially supported by the Russian Science Foundation (Grant No. 22-77-00082) and was conducted following the plans of the scientific research of the Geological Institute of RAS.

Degtyarev, K., Yakubchuk, A., Tretyakov, A. et al 2017. Precambrian geology of the Kazakh Uplands and Tien Shan: an overview. Gondwana Res. 47. 44–75

Kanygina N., Tretyakov A., Degtyarev K., et al. 2021. Late Mesoproterozoic–early Neoproterozoic quartzite–schist sequences of the Aktau–Mointy terrane (Central Kazakhstan): Provenance, crustal evolution, and implications for paleotectonic reconstruction. Precambrian Res. 354. 106040

Keyword

Central Asian Orogenic Belt, Kazakhstan, U-Pb dating, provenance, paleogeographic reconstruction

Vanadium isotope reveals the interval of marine oxygenation during early Cambrian, South China

Hao RAN[1]*, Development Research Center, China Geological Survey (ranhao@mail.cgs.gov.cn)
Zhixun LIU[2], Development Research Center, China Geological Survey
Tao ZHANG[3], Development Research Center, China Geological Survey

Abstract

The early Cambrian is a key period to understand the co-evolution of the paleo-marine environment and biotic events. However, the process of marine oxygenation in the early Cambrian is still hotly debated. Vanadium isotope system in fine siliclastic sediments is widely used to investigate rapid marine redox fluctuations . In this study, we analyze V isotope composition (δ51V) of Liuchapo and Niutitang Formations deposited in the early Cambrian, from the Yangtze Block, western Hunan, South China. The isotope values (δ51Vauth) of authigenic V (from -0.72‰ to -0.38‰) from the upper Liuchapo and lower Niutitang Fromations indicate the anoxic depositional environment. The values of δ51Vauth (from -0.31‰ to -0.14‰) from the middle Niutitang Formation indicate the euxinic environment (presence of H2S). However, the low value of δ51Vauth (-0.66‰) from upper Niutitang Formation indicates that the depositional environment changes back to anoxic environment. It records the occurrence of euxinic environment of slope during the stage 3 of the early Cambrian. The low values of open-ocean seawater δ51V (δ51Vosw) (from -0.71‰ to -0.54‰) from middle Niutitang Formation are significantly lower than the modern δ51Vosw value (+0.20‰ ± 0.15‰). It suggests that the local redox environment is consistently oxygen-depleted during the deposition of Liuchapo and Niutitang Formations in South China. As one of the most pioneer representative area for biodiversification in early Cambrian, the presence of free oxygen in South China seems relatively restricted and the secular oxygenation process is not successive during early Cambrian, which is inconsistent from previous Mo and V isotopes studies.

Keyword

Early Cambrian, V Isotope, South China, Paleo-marine Environment

40Ar/39Ar ages from rocks of the southern part of the Mozambique Belt

Umberto Giuseppe Cordani[1], University of São Paulo
Fátima Roberto Chaúque Nampete[2]*, National Institute of Mines (fchauque27@gmail.com)
Maria Helena Bezara Maia De Hollanda[3], University of São Paulo
Caetano Juliani[4], University of São Paulo

Abstract

Thirteen 40Ar/39Ar age determinations were made on ten rocks of central-western Mozambique, at the southernmost part of the Mozambique Belt. The study area includes the eastern tectonic contact of the Zimbabwe Craton with two nappes of Pan-African age, formed when the Kalahari and Antarctica continental blocks collided at about 520-500 Ma, during the Kuunga Orogeny. Peak metamorphism in that region is set at about 500 Ma by zircon overgrowth in granitoid rocks. The measurements included two biotites and one amphibole taken from two granitoid rocks of the northern Mungari Nappe, three biotites and two amphiboles taken from four medium-grade rocks near Chimoio at the southern part of the Chimoio-Macossa Nappe, as well as a biotite and a muscovite from a quartzite of the Gairezi Formation, located near the contact with the Zimbabwe Craton. With one exception, a biotite with 488 Ma of an orthogneiss near the town of Sussundenga, these 40Ar/39Ar ages were enclosed within the 455-475 Ma time interval, dating the regional cooling age related to the 300oC isotherm. However, a much younger cooling age was registered for biotites taken from three high-grade paragneisses with garnet, cordierite and sillimanite, located near Macossa. These Pan-African rocks presented detrital zircons with maximum ages close to 700 Ma. Their 40Ar/39Ar ages, as young as 400 Ma (lower Devonian), may indicate a thicker crust in the eastern part of the Chimoio-Macossa Nappe, where the material was subjected to high-pressure metamorphism and brought to the surface after a long lasted exhumation.

Keyword

Mozambique, Belt, regional, cooling, age

Tectonics and Geodynamics of Antarctica

German LEICHENKOV[1]*, Institute for Geology and Mineral Resources of the World Ocean (german_l@mail.ru)
Garrik E Grikurov[2], Retired

Abstract

Antarctic region extends from 60S to the South Pole and includes the Antarctic continent surrounded by the southern parts of Atlantic, Indian and Pacific Oceans. The continent is almost completely (over 14 million sq.km, by 99%) covered by ice with an average thickness of 1.9 km. Since the outbreak of scientific exploration of the continent, its tectonic interpretations have advanced from the earliest simplistic sketches to modern geodynamic models, which, however, still remain largely speculative due to shortage of direct geological evidence. Views developed prior to the 2007-2009 International Polar Year were synthesized in the first edition of the International Commission for Geological Map of The World (CGMW) 1:10,000,000 Tectonic Map of the Antarctic published in 2012. Subsequent accumulation of data required updating of this map and preparation of the second upgraded edition, which was published in 2023. The new map gives realistic presentation of actually mapped tectonic units against their inferred subglacial extrapolations; provides an advanced characterization of the East Antarctic crystalline basement complexes by showing the ages of protolith emplacement and subsequent reworking events; visualizes the polyphase magmatic arc history of the onshore part of the present-day Pacific margin; offers a more accurate structural image of Antarctica's continental margin, including the position of marginal rifts, the location of the continent-to-ocean boundary and the distribution of sediment thickness; displays the refined ages of oceanic crust based on revised identification of magnetic anomalies. Archean complexes are grouped in the legend in a separate block designating the continental protocrust that lacks clear plate tectonics markers. Protocrustal inheritance is found in many Proterozoic rocks previously viewed as the juvenile additions. With rare exceptions, most orogenic complexes reveal crustal residence considerably pre-dating the age of final stabilizing event. The Pacific margin of Antarctica represents the amalgamation of proximal para-autochthonous fragments of diachronous magmatic arcs that experienced transpressional displacements relative to the in situ Gondwana crust and were partly rimmed by the allochthonous accretionary wedges. A large part of Antarctic landmass and its sub-bottom margin is occupied by sedimentary basins formed on rifted (stretched and thinned) continental crust in the course of Gondwana breakup and opening of the Southern Ocean. The continental margin comprises magma-rich and magma-poor segments. Extreme crustal stretching of magma-poor margins is documented within the zones of dramatic seaward necking of continental crust and its substitution by the serpentinized and exhumed continental mantle material. Disengagement of the Antarctic continental fragment from Gondwana began in Middle Jurassic time in the Atlantic sector of the present-day Southern Ocean. It progressed with seafloor spreading in a clock-wise direction, until completed in the Cenozoic by separation of landmasses in the Indian and Pacific sectors.

Generalized view of Antarctic tectonic structures, including their inferred distribution under ice, is provided in a smaller-scale inset. It also shows the rates of sea-floor spreading and areas with thickened oceanic crust. The map is accompanied by extended Explanatory Notes booklet with illustrations and references. The Map and Explanatory Notes can be found at https://ccgm.org/en/catalogue/.

Keyword

Antarctica, Tectonics, Earth's crust, Cratons, Orogens

Discovering Remnants of the Earliest Continents: 3.4 Ga Basement in the South West Terrane of the Yilgarn Craton and Implications for Archean Geodynamics

Catherine GILL[1]*, University of Western Australia (cat.gill@research.uwa.edu.au)
Nico Thébaud[2], University of Western Australia
Naomi Tucker[3], University of Western Australia
Tony Kemp[4], University of Western Australia
Raphael Quentin de Gromard[5], Geological Survey of Western Australia
Tim Ivanic[6], Geological Survey of Western Australia

Abstract

Our geochronological study documents previously unrecognised 3.4 Ga migmatitic gneisses forming the basement of 3.3 – 3.2 Ga supracrustal successions in the South West Terrane of the Archean Yilgarn Craton in Western Australia. Our results do not match any other magmatic or gneissic units within the Yilgarn craton, returning older ages than adjacent terranes to the east but generally younger ages than the Narryer Terrane in the north. Combined with detrital spectra in derived from quartzites belonging to the overlying greenstone sequence, our data suggests that the South West Terrane did not share the same history with the rest of the Yilgarn and may be an exotic component appended to the craton later in its evolution.

This study builds off recent work by the Geological Survey of Western Australia, who have rearranged the boundary between the South West and Youanmi Terranes (Quentin de Gromard et al., 2021) of the Yilgarn Craton which were initially outlined in Cassidy et al., (2006). The terrane boundary now aligns with a highly deformed and metamorphosed belt known as the Corrigin Tectonic Zone. In the context of Cassidy et al., (2006), terranes are defined as fault-bounded bodies of rock, characterized by a geologic history different from that of contiguous terranes. Meaning that the boundaries between the terranes must be tectonically significant, preserving evidence relating to early-earth continent assembly. Accordingly, the recent changes and data presented in this study suggest that the Corrigin Tectonic Zone could represent a suture zone of two unrelated crustal blocks or Terranes. This preliminary conclusion provides an opportunity to discuss early earth continental assembly with specific reference to the Yilgarn Craton.

References

Cassidy, K. F., Champion, D. C., Krapez, B., Barley, M. E., Brown, S. J. A., Blewett, R. S., Groenewald, P. B., & Tyler, I. M. (2006). A revised geological framework for the Yilgarn Craton, Western Australia. Western Australia Geological Survey, Record 200.

Quentin de Gromard, R., Ivanic, T., & Zibra, I. (2021). Pre-Mesozoic interpreted bedrock geology of the southwest Yilgarn, 2021.

Keyword

Archean, Tectonics, Geochronology, Craton

Picture Perfect Photogrammetry: mapping the remnants of long-gone glaciers in northern Namibia in unprecedented resolution

Ricarda WOHLSCHLÄGL[1]*, University of Vienna (ricarda.wohlschlaegl@univie.ac.at)
Christoph KETTLER[2], Geosphere Austria
Paulina MEJÍAS OSORIO[3], University of Vienna
Daniel LE HERON[4], University of Vienna
Andreas NDUUTEPO[5], Geological Survey of Namibia

Abstract

Extensive research is continuously improving our picture of the penultimate and most widespread icehouse interval of the Phanerozoic – the Late Paleozoic Ice Age (LPIA). As a result, the blank spots on reconstructed paleo-maps are gradually filling in, but entire regions of the former supercontinent Gondwana have still been neglected. Today's northern Namibia is one of them.

The glacial features of the LPIA in northern Namibia have been disproportionately understudied compared to the southern part of the country.

The initial insights gained from mid-20th century expeditions (e.g. Martin & Schalk, 1959) form the basis for the long-overdue reinvigoration of research in this remote region (e.g. Fedorchuk et al., 2023) – but this time equipped with the rapid technological progress of the 21st century.

Utilizing advanced techniques of aerial and close-range photogrammetry, we have conducted a thorough mapping of former glacier beds at an unprecedented resolution. Quantitative analyses of macroscale ice flow features, including over 16,000 measurements of striae and crescentic markings, allow us to determine the directions of ice flow with great precision and to correlate the results with the suggested local flow directions of a large-scale paleo-fjord network (Dietrich et al., 2021). This approach enables previous issues of conflict in the literature, specifically confusion over ice-flow directions, to be resolved. In turn, it has major implications for accurate paleo-glacial reconstructions.

By examining specific regions of potential subglacial bedrock failure using high-resolution outcrop photos and detailed 3D models, we have investigated the impact of meltwater and overlying ice masses on erosional features like crescentic markings and joint-bounded scars. Our discoveries raise significant questions regarding the conditions beneath the glacier, including the different glaciation phases evident in the exposed bedrock, subglacial bedrock failure, and the extent and influence of meltwater activity.

In summary, deploying a photogrammetric approach to the former glaciated landscapes of Namibia greatly improves our understanding of the behavior of LPIA ice masses on Gondwana.

Keyword

Photogrammetry, LPIA, Gondwana

Modern ocean island basalt–like 182W signature in Paleoarchean mafic rocks: A negative μ182W endmember in the lower mantle

Qing-Feng MEI[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (meiqingfeng@mail.iggcas.ac.cn)
Jin-Hui YANG[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Komatiites and picrites generated by high degrees of mantle partial melting serve as potential probes of Earth's deep mantle. Tungsten (W) isotopes in these rocks offer a rare chance to better understand early differentiation, late accretion, core-mantle interaction, and subsequent evolution of Earth's mantle. We present new W isotope data for Archean komatiites and basalts from the Barberton (South Africa) and Suomussalmi (Finland) Greenstone Belts and Permian picrites from the Emeishan large igneous province (China). The Paleoarchean samples from the Barberton Greenstone Belt have modern ocean island basalt (OIB)–like μ182W values ranging from –20.4 to +5.6, whereas the Mesoarchean komatiites from the Suomussalmi Greenstone Belt show μ182W values of –2.2 to +11.3. The Permian Emeishan picrites give μ182W values of –7.1 to +3.1. Notably, our Paleoarchean Kromberg sample has a μ182W value of –19.1 ± 4.3 (2SE), identical to the most negative μ182W value observed in modern OIBs (–22.7 ± 3.3, 2SE). The negative μ182W values of Paleoarchean samples in the Barberton Greenstone Belt and modern OIBs likely result from either early differentiation or core-mantle interaction and indicate the long-term preservation of a negative μ182W endmember in the Earth's lower mantle. Moreover, Phanerozoic plume-derived rocks (e.g., Emeis- han picrites in this study) indicate that recycling of crustal materials and mantle mixing would have partially homogenized W isotopes in the lower mantle since the onset of plate tectonics on Earth.

Keyword

tungsten isotope, core-mantle interaction, early differentiation

Sequence biostratigraphy of early Paleogene lignite-shale succession of western India: A case study on an integrated approach to Hydrocarbon Exploration

Shalini PARMAR[1]*, Banaras Hindu University (shalinigary02@gmail.com)
Vandana Prasad[2], Birbal Sahni Institute of Palaeosciences

Abstract

Hydrocarbon exploration in a sedimentary basin requires an understanding of the superposition and lateral arrangements of the depositional sequences to delineate the spatial and temporal distribution of coal/lignite beds and potential reservoirs within a stratigraphic window. In a coastal setting, the vertical and lateral deposition of these sequences are controlled by the ratio of the rate at which accommodation space is being created below the depositional base level to the rate at which the space is being filled with sediment supply following the marine transgression and regression. Over the last few decades, sequence stratigraphy has been an efficient tool in discovering the good quality hydrocarbons as it enables to describe, analyse, and categorize the genetically related strata of the depositional sequences. In hydrocarbon exploration, microfossils are another crucial tool since they provide correlation of strata, age determination and paleoenvironmental interpretation of contemporaneously deposited sequences. Although sequence stratigraphy is frequently employed in exploration, very few studies consider microfossils which typically offers more detailed interpretations. With the integration of biostratigraphic data (microfossils) to sequence stratigraphy, the sequence biostratigraphy technique has evolved, allowing the estimation of age of the flooding surfaces as well as depositional cycles based on the distribution of microfossils in the sedimentary succession. The sequence biostratigraphy can offer more precise data for defining the 3rd order sea level fluctuations during the deposition of sedimentary successions.

Palynomorphs (dinoflagellate cysts, foraminifera, nannofossils and, spores and pollen) are among the most important microfossil groups that helps in developing the precise sequence biostratigraphy of sedimentary succession. The organic walled microfossils (dinoflagellate cysts, pollen and spores) with high abundance in the sedimentary deposits of a shallow marine region are useful owing to their microscopic size and resistance to acidic treatments. The study of palynomorphs (palynology) has considerably strengthened the system tracts models by offering more reliable assessments of bounding surfaces and categorization of genetically related strata. Within the depositional sequences, palynomorphs assemblage characterized by fluctuating relative abundance and diversity of marine (dinoflagellate cysts) and terrestrial palynomorphs (spores and pollen) reflect the changes in sea level. An increase in the abundance and diversity of marine palynomorphs represents the maximum flooding surfaces (MFS) during the marine transgression. On the other hand, the richness of terrestrial palynomorphs suggests high sediment supply during the still stand or slowly falling sea level (regression). Other than that, a coastal region associated with paralic mires exhibits distinctive facies in coal and lignite bearing sedimentary sequences following the transgressive-regressive cycles.

With a combined sedimentological and palynological data, shallowing and deepening upward facies have been demarcated precisely by observing the variations in facies pattern and palynomorphs assemblage in early Paleogene lignite-shale succession of the Barmer Basin, Rajasthan, India. Along the western continental margin of India, the succession shows the 2nd and 3rd order sea level changes, with parasequences and hemicycles corresponding to transient marine invasions (higher order) during early Paleogene period. Thus, the sequence biostratigraphy provides a more accurate framework of transgressive-regressive cycles in a basin which is extremely important in hydrocarbon exploration.

Keyword

Transgressive-Regressive cycles, Sequence biostratigraphy, Palynofacies, Hydrocarbon exploration, Early Paleogene

The Cadomian unconformity and the stratigraphy of the Neoproterozoic "Schist-Greywacke Domain" (Portugal)

Carlos A.P. Meireles[1], Laboratório Nacional de Energia e Geologia, Rua da Amieira, Apartado 1089, 4466-901 S. Mamede de Infesta, Portugal
Paulo F. Castro[2], Laboratório Nacional de Energia e Geologia, Rua da Amieira, Apartado 1089, 4466-901 S. Mamede de Infesta, Portugal
Nuno Vaz[3], Department of Geology, University of Trás-os-Montes e Alto Douro
Carlos Ângelo[4], Laboratório Nacional de Energia e Geologia, Rua da Amieira, Apartado 1089, 4466-901 S. Mamede de Infesta, Portugal
Narciso Ferreira[5], Laboratório Nacional de Energia e Geologia, Rua da Amieira, Apartado 1089, 4466-901 S. Mamede de Infesta, Portugal
António J.D. Sequeira[6], Laboratório Nacional de Energia e Geologia, Rua da Amieira, Apartado 1089, 4466-901 S. Mamede de Infesta, Portugal
Artur Abreu SÁ[7]*, Department of Geology, University of Trás-os-Montes e Alto Douro (asa@utad.pt)

Abstract

The Iberian Massif offers the most extensive exposure of Variscan and pre-Variscan rocks across Europe. It has been partitioned into various tectonometamorphic zones, namely the Cantabrian, West-Asturian-Leonese, Galicia-Trás-os-Montes, Central Iberian, Ossa-Morena, and South-Portuguese Zones, arranged from north to south. The Central Iberian Zone (CIZ) is distinguished by the presence of numerous Variscan granitoids that have intruded into autochthonous Neoproterozoic to Paleozoic metasedimentary and igneous rocks. These rocks are part of the continental margin of Gondwana and provide evidence of both the Cadomian orogeny and the Cambrian-Ordovician rifting. Another feature is the unconformity of Lower Ordovician rocks (Armorican Quartzite) over Ediacaran - lower Cambrian rocks (Schist-Greywacke Domain). This study aims to provide a stratigraphic synthesis of this sequence in Portugal, namely in the Ediacaran sequence (Beiras sector) and its correlation with Spanish sequences recently described.
In Portugal the "Schist-Greywacke Domain" sequence has been recently reviewed into Douro Group (Ediacaran to lower Cambrian), and Beiras Supergoup (Ediacaran). The latter is composed of two separate metasedimentary sequences, namely the Fróia and Lousã groups, which are separated by an intra-Cadomian (Alcudian) unconformity. A correlation is made with the Spanish sequences of the lower and upper Alcudian, respectively.
The cartographic and structural evidence of this unconformity is presented and a critical analysis of the lithostratigraphic proposals currently under discussion is made.

Keyword

Cadomian, Variscan, unconformity, Schist-Geywacke Domain, Portugal

Zircon U-Pb-Hf isotopic age of gneissic inlier of Aravalli Fold Belt, Rajasthan, India: evidences of Protracted crustal building events from Archean to Mesoproterozoic.

Krishnapriya BASAK[1]*, Geological Survey of India (kbasak.gsi@gmail.com)
Siladitya Sengupta[2], Geological Survey of India

Abstract

Aravalli Fold Belt (AFB) represents a Proterozoic accretionary fold belt bordering the cratons of Aravalli of north western India. Sarara inlier is one of the few orthogneissic bodies that occur within AFB as basement inlier. The lithological contact between the ASG and gneisses of inlier is highly sheared with the formation of mylonitic foliation, shear bands and stretching lineation in both the rock groups. The field observations suggest that gneisses of inliers and supracrustals of AFB have participated in major deformation events during evolution of the belt.

The geochemistry of the gneisses dominantly corresponds to more evolved, calc-alkaline, crustal melt with volcanic-arc granitic signature.

One of the orthogneisses of Sarara yielded euhedral zircons with homogeneous core and fine concentric zoning at rim. Often the cores are full of inclusions. Th/U ratios of zircons vary between 0.40 and 1.15. Th/U ratio is indistinguishable from zircons of different ages. Interestingly, homogeneous core and rim with concentric zoning yield similar age. Zircons of this Gneiss yield two dominant clusters of age with minor Archaean population. The dominant and concordant age clusters are at 1847.7 Ma and 2550 Ma. Few zircon analyses yield slightly discordant Archaean age of 3100 Ma.

These zircons are characterized by homogeneous Hf isotopic composition having 176Hf/177Hf isotopic ratio of 0.2815-0.2816 with εHf (t) of -2.9 to -8.6. The εHf (t) values of 2550 Ma zircon are dominantly negative and Archaean grains show positive values. The negative and unimodal distribution of εHf (t) values for 2550 Ma, imply involvement of crustal component at source. The Archaean xenocrystic zircons and 1850 Ma zircons have high positive εHf (t) value of + 11.2 implying their derivation from a depleted mantle source.

The 3100-3063Ma xenocrystic zircons indicate crustal growth and cratonization of this part of the Aravalli Craton of India during Archaean. The two dominant populations of zircon age may reflect crystallization of the orthogneiss during 2550 Ma that experienced extensive remelting or modification during later orogenic event at 1850 Ma. The age 3100 Ma is considered to be the oldest magmatic event to form the initial crust followed by 2500 and 1850 Ma events. Another possible interpretation is that orthogneiss is a 1880 Ma igneous rock with inheritance of 2550 Ma and some minor inheritance of ca. 3100 Ma xenocrystic zircons.

Keyword

Aravalli Fold Belt, Zircon U-Pb age, gneissic inlier, Mesoproterozoic

Lithostratigraphy, structure and metamorphic evolution of Naga Metamorphics, Nagaland, India

NEIPEKREIZO KESIEZIE[1]*, GEOLOGICAL SURVEY OF INDIA
(neipekreizo.kesiezie@gsi.gov.in)
Dileepkumar Reddy[2], GEOLOGICAL SURVEY OF INDIA
Ranjit Gangadhar Khangar[3], GEOLOGICAL SURVEY OF INDIA

Abstract

The Naga Metamorphic Group in Naga-Arakan Orogeny of North-East India on the Indian plate are parts of the over-riding Burmese tectonic plate with wedge remnants of dismembered Ophiolite units in between. The lithostratigraphy, structural and metamorphic evolution of these rocks are not well established till date. This study intends to solve this conundrum based on field evidences, petrography and geochemistry. The study area exposes serpentinized peridotite, parts of the dismembered Ophiolite units, phyllite, arkosic quartzite and schist intercalations with limestone and marble which are part of the Nimi Formation whereas schists and phyllite intercalations with arenitic quartzites and micaceous quartzite with ptygmatically folded quartz veins belonging to the Saramati Formation.The regional strike of the area is NE-SW. Two phases of deformation are observed with intense first phase deformation evidenced by parallel secondary and primary foliation. Foliation boudins, large scale recumbent folds and other structural evidences defines second deformation event. The younger Nimi Formation is less deformed and metamorphosed than the older Saramati Formation. The quartz piezometric study of these rocks indicates that there is a gradual transition from primary to advanced quartz recrystallization stages, from younger to older units implying gradual increase in temperature. Oldest lithounit in SaramatiFormation have undergone very high temperatures resulting in complete grain size reduction and in the verge of remelting. Schists, phyllites, and slates of Nimi Formation have narrow ranges of major oxide concentrations with SiO2 (49.96-76.33%), TiO2 (0.37-1.54%), Al2O3 (15.96-23%), MgO (0.47-2.59%) and CaO (0.1-5.96%) are considered as high-Al metapelites. Meta arenites comprises quartzites having wide ranges of major oxide concentrations in comparison with meta-pelites such as SiO2 (43.48-85.51%), TiO2 (0.08-2.58%), Al2O3 (5.23-15.35%), MgO (0.11-4.67%) and CaO (0.09-9.2%) are present in Saramati Formation and as intercalations in Nimi Formation. The low values of SiO2/Al2O3 (2.22-4.78) in meta-pellites analogous to igneous rocks (3-5) indicates a lesser mature nature of the metasediments whereas meta-arenites show high values of SiO2/ Al2O3 (3.2-16.35). The high-Al meta-pellites are controlled by aluminous minerals (Biotite and clay minerals) in composition compared to meta-arenites indicating higher grade of metamorphism in Saramati formation.

Keyword

Naga Metamorphics, Ophiolite, Quartz Recrystallization, Saramati Formation, Nimi Formation

In situ Rb–Sr age mapping of micas, feldspars, and clay minerals

DARWINAJI SUBARKAH[1]*, UNIVERSITY OF ADELAIDE
(darwinaji.subarkah@adelaide.edu.au)
Sarah Gilbert[2], ADELAIDE MICROSCOPY
Angus Nixon[3], UNIVERSITY OF ADELAIDE
Alan Collins[4], UNIVERSITY OF ADELAIDE
Juraj Farkas[5], UNIVERSITY OF ADELAIDE
Jarred Lloyd[6], UNIVERSITY OF ADELAIDE
Morgan Blades[7], UNIVERSITY OF ADELAIDE

Abstract

Micas, feldspars, and clay minerals are commonly found in metamorphic, igneous, and sedimentary rocks. They can also form as byproducts of potassic alteration in mineral deposits, hydrothermal systems, and fault zones. As such, dating these minerals can help constrain a number of intricate geological processes. Recent advancements in laser ablation mass spectrometer technology has allowed these K-rich (and therefore Rb-rich) phases to be dated in situ via Rb–Sr geochronology. Consequently, samples can be analysed with high spatial resolution. Nevertheless, dating these minerals can still prove to be challenging. The Rb–Sr isotopic system in K-bearing aluminosilicates can readily be disturbed by secondary processes. Notably, these perturbations can be difficult to detect through simple petrography. Another issue is a potential lack of spread between radiogenic Rb and stable Sr isotopes within the sample. These predicaments can result in mixed ages and/or large uncertainties making the method unsuccessful.

Here, we have adopted a novel approach to date micas, feldspars, and clay minerals through in situ Rb–Sr age mapping in order to address these issues. Our case study looks to test the technique by dating mica from Li-mineralized pegmatites in the Minas Gerais region of Brazil and from the Tabba Tabba pegmatite in Western Australia, feldspar and glauconite from the Ediacaran Amadeus Basin, an altered vein system from the Cambrian Delamerian Orogen and illite from a pepperite contact in the Neoproterozoic Adelaide Superbasin. Consecutive laser rasters are combined into isotopic maps where spatial and geochemical criteria can be triaged to define subdomains within the sample. These subdomains can be mm-scale and range from zones within a singular crystal or multiple generations of minerals. Pixels within these subdomains can be treated separately and pooled into analytical points which may highlight different age populations. The spread of data on an isochron can be maximized using this approach, resulting in improved precision and accuracy.

Keyword

geochronology, geochemistry, stratigraphy

Archean continental crustal growth and reworking of the North China Craton: Constraints from zircon U-Pb age and Hf isotopic composition

Chunrong DIWU[1]*, Northwest University (diwuchunrong@nwu.edu.cn)

Abstract

Crust growth curves of the North China Craton (NCC), based on U-Pb age and Hf isotopic composition of zircons from a global database, reveal that more than 70% of the present crustal volume of the NCC had been generated by the end of the Neoarchean. The NCC nearly reached its present volume of continental crust by the Neoproterozoic. The oldest rocks, dating to ca. 3.8 Ga, have been identified in trondhjemite-dominated gneiss complexes in the Anshan and eastern Hebei areas of northeastern NCC. Hf isotopic compositions in zircons reveal that the Eoarchean continental crust in the NCC was derived from depleted mantle reservoirs. Hf isotope data in zircons from the 3.6–2.9 Ga rocks in NCC indicate that the relative proportion of juvenile material added to the crust gradually decreased during the Paleoarchean to early Mesoarchean period. Crustal reworking/recycling from older crustal reservoirs has in turn gradually dominated, with the proportion increasing from 5% to 45%. This suggests that long-term reworking of continental crust has previously occurred in the NCC during the Mesoarchean. The NCC shows relatively high net rates of continental growth during the late Mesoarchean to the end of the Neoarchean period, with at least 50–60% of the present volume of continental crust established in the time interval. Juvenile material extracted from the mantle input to continental crust has dominated in the NCC, and the proportion of newly generated crust significantly exceeds that of reworked ancient crust, with an estimated cumulative juvenile proportion over 85%. The strongly episodic distribution of U-Pb ages based on mineral systems is tightly linked to tectonothermal events of the continental crust, with peak clusters at around 2.92 Ga, 2.72 Ga, and 2.51 Ga, which is also a characteristic of crustal growth of the NCC during the late Mesoarchean to Neoarchean. The rock associations from circa 2.6–2.5 Ga were widely distributed in the NCC, occupying more than 80-90% of the Archean basement. The late Neoarchean is dominated by a large volume of juvenile material extracted from the mantle with an estimated cumulative proportion of about 85%. Meanwhile, approximately 15% of the continental crust has been reworked or recycled from older crustal reservoirs.

Keyword

Archean, continental crust, crustal growth and reworking, North China Craton, Hf isotopic composition

Updating the Cambrian Time Scale: A Bayesian approach

Valentin Jamart[1]*, Institute of Earth Sciences (ISTE), University of Lausanne, CH-1015 Lausanne, Switzerland (vjamart.phd@gmail.com)
Linda A. Hinnov[2], Atmospheric, Oceanic & Earth Sciences Department, George Mason University, 4400 University Drive Fairfax, Virginia (USA)
Damien Pas[3], Institute of Earth Sciences (ISTE), University of Lausanne, CH-1015 Lausanne, Switzerland
Allison C. Daley[4], Institute of Earth Sciences (ISTE), University of Lausanne, CH-1015 Lausanne, Switzerland

Abstract

The Cambrian Period recorded numerous fundamental events in the history of life on Earth, including the Cambrian Explosion, the Cambrian Substrate Revolution, and the onset of the Ordovician Planktonic Revolution. Despite the importance of these evolutionary milestones, a thorough understanding of the timing and driving mechanisms of these events has been impeded by relatively limited time constraints coupled with widespread endemism, leading to unclear biostratigraphic correlations among key localities.

In the Geologic Time Scale 2020 (GTS2020), the time calibration of the Cambrian Period relies on 16 radioisotope ages (Peng et al., 2020). Information about age uncertainties is not included in GTS2020 or the International Chronostratigraphic Chart v. 2023/09 (ICC 2023/09), with the exception of the Ediacaran/Cambrian and Cambrian/Ordovician boundaries. Since 2020, an additional 31 radioisotope ages and 5 cyclostratigraphic sections providing astrochronology for 15 biozones have been identified. Integrating these new age data with the existing GTS2020 and adopting a Bayesian approach for the age model substantially refines and improves the Cambrian Time Scale, and provides uncertainty estimates at all points along the time scale.

The compilation of all data into a single dataset is accomplished by assigning each of the 10 Cambrian stages a stratigraphic “thickness” of 1, starting with a value of 1 for the Ediacaran/Cambrian boundary and 11 for the Cambrian/Ordovician boundary. Biozones defined in GTS2020 are assigned fractional thicknesses within the stages. The age model for this dataset was obtained with the R package ModifiedBchron (Trayler et al., 2020), which yields an updated and improved Bayesian Cambrian Time Scale in which the stage boundaries (and any time point between boundaries) are presented with their associated uncertainties.

This new Bayesian Cambrian Time Scale aligns closely with GTS2020 and ICC 2023/09 except for the base of the Wuliuan Stage (equal to the base of the Miaolingian Series), which is approximately 3 million years younger than in GTS2020 or ICC 2023/09 (506.474±0.62 Ma vs. 509 Ma). This difference is attributed to the integration of the new radioisotope ages from Sundberg et al. (2020) and Landing et al. (2023), which are precisely located in the biozones

defining the base of the Wuliuan Stage. The new time scale also clearly identifies stratigraphic intervals with limited or no numerical age constraints, i.e., key intervals needing additional age information (e.g., the middle Fortunian to Stage 3, and Wuliuan to Jiangshanian).

References:
Landing, E., et al., 2023, Geol. Mag., 160(9), 1790-1816.
Peng, S.C., et al., 2020, in Gradstein et al., eds., GTS 2020, Pt. 2, 565-629.
Sundberg, et al., 2020, Geol., 48(5), 441-445.
Trayler, R.B., et al., 2020, GSA Bull., 132, 233-244.

Keyword

ModifiedBchron, Radioisotope, Cyclostratigraphy, Biostratigraphy, Age Model

PROTEROZOIC CARBONATITES IN THE SUL-RIOGRANDENSE SHIELD (SRS), SOUTH BRAZIL

Cimara Francisca MONTEIRO[1]*, Geological Survey of Brazil (cimara.monteiro@sgb.gov.br)
Ítalo Lopes de Oliveira[2], Brasília University
José Affonso Brod[3], Goiás Federal University
Érico Natal Pedro Zacchi[4], Brasília University
Carlos Eduardo Ganade[5], Brazil Geological Survey
Elton Luiz Dantas[6], Brasília University
Reinhardt Adolf Fuck[7], Brasília University

Abstract

The SRS, located in southern Brazil, was formed during the Brasiliano orogeny from the closure of the Charrua ocean (900-680 Ma), followed by a collision between the Rio de la Plata and Kalahari cratons, marked by granitogenesis, volcanism and sediment deposition at the end of the orogenesis (650-550 Ma) (Chemale Jr., 2000; Hartmann et al., 2008). Seven carbonatite intrusions were identified within the SRS, the first discovery being made in 2010. In terms of degree of deformation and texture, it is possible to separate these intrusions into at least two groups: foliated carbonatites with the occurrence of gneiss banding and non-foliated carbonatites or with incipient foliation (Bogo, 2020). This study has as its main object the four intrusions that were part of the deformed carbonatites, namely Três Estradas, Santa Clara, Picada dos Tocos and Passo Feio, which present similar textural, mineralogical and geochemical features. The remaining ones, Joca Tavares, Santa Inês and Porteira exhibit similar characteristics and weak or incipient deformation. The Três Estradas and Santa Clara metacarbonatites are contiguous and approximately 4 km apart. Both have a linear shape along the NE direction with a preferential subvertical dip to the NW and intrude paleoproterozoic/archaean rocks from the Santa Maria-Chico complex, in the Taquarembó terrane, in the vicinity of the Ibaré lineament, on the northeaster limit of the Rio de la Plata Craton. They range from incipient foliation to gneiss banding with alternating bands of biotite and actinolite and bands calcitic, containing dolomite and apatite, and are metamorphosed into greenschist to amphibolite facies. Age estimates obtained by U/Pb in zircon (Monteiro et al., 2020) in the Três Estradas metacarbonatites provide 1,110±4.8Ma, considered coherent for the Santa Clara body as well, although it does not have specific age estimations yet. The Picada dos Tocos and Passo Feio carbonatites, 12 km a part, are located in the Passo Feio complex inside of the São Gabriel terrane and both bear Neoproterozoic ages. Despite laying 140km northeast of the Três Estradas and Santa Clara bodies, they exhibit textural, mineralogical, geochemical features and types of deformation similar to the latter two. The Picada dos Tocos intrusion was dated at 603.2±4.5Ma using U/Pb in zircon (Cerva-Alves et al., 2017). It is estimated that neighbouring Passo Feio intrusion presents this same age. Based on the Sm/Nd, Sr/Sr, Lu/Hf isotopic signatures of Três Estradas (Monteiro et al., 2020), the different intrusion ages and similar geochemical signatures among the Três Estradas (Bogo, 2020), Picada dos Tocos (Cerva-Alves et al., 2017) and Passo Feio (Morales et al., 2019) bodies, it is possible to suggest that carbonatite magmatism

occurred in pulses over time, and that these intrusions, subjected to similar petrogenetic processes, were originated from the melting of the same asthenospheric mantle enriched with REE (Monteiro et al., 2020).

Keyword

Três Estradas carbonatite, Sul-Riograndense Shield, Mesoproterozoic

UNRAVELLING THE ORIGIN OF ALTERNATING FE- AND SI- LAYERS IN IRON FORMATIONS: A MULTISCALE RHEOLOGICAL INVESTIGATION

Gabriella Fazio[1], Institute of Geosciences,University of Brasília
Elder YOKOYAMA[2]*, Institute of Geosciences, University of Brasília (eyokoyama@unb.br)
Paola Ferreira Barbosa[3], Institute of Geosciences,University of Brasília
Sebastião William Silva[4], Physics Institute, University of Brasília
Filipe Corrales[5], Universidade do Estado do Rio de Janeiro
Leonardo Evangelista Lagoeiro[6], Universidade Federal do Paraná
Edi Mendes Guimarães[7], Institute of Geosciences,University of Brasília
Ingrid Moerschberger Nedel[8], VETRIA Mining

Abstract

Iron formations are geological records exclusive to the Precambrian era and hold significance not only in economic terms, associated with vast iron deposits, but also as valuable geochemical and paleoenvironmental archives. Despite their significance, the mechanisms driving their formation remain unclear, primarily due to the absence of modern analogues. This study delves into the temporal aspects of Fe- and Si-layer genesis through a multiscale rheological approach. Our investigation focus on from the ice-rafted debris-bearing iron formation samples from the Brazil's Cryogenian Banda Alta Formation (Urucum District). This geological context provides an instructive example for this research, due to its persistent parallel laminations and minimum post-depositional thermal influence. Employing macroscopic, microscopic, and crystallographic analyses (Raman and EBSD methodologies), we explore two hypotheses: a depositional and a diagenetic origin for the layer alternations. Examination of impact structures beneath clasts in both macro and microscopic analyses reveals deviation and deformation of the expected parallel lamination, suggesting discernible layering predating clast impacts. This challenges the proposed diagenetic layering formation, which posits a homogeneous Fe-Si gel coprecipitation mechanism with band separation during diagenesis. Exploring the depositional hypothesis, we identify two possibilities: separated compositional precipitation or a greenalite-rich proto-layering mechanism. To discuss the latter, we question whether the estimated depositional timeframe allows sufficient time for diagenesis to achieve proper layering through silica cementation and to imprint syndepositional ice-rafted debris deformation. Considering these findings, we argue for a primary alternating iron and silica depositions as the most plausible depositional mechanism for iron formation genesis.

Keyword

Iron Formation, Cryogenian, Ocean chemistry, Multiscale rheology, dropstone

The Portuguese (PT) version of the “International Chronostratigraphic Chart”: a new approach

João Luís Cardoso[1], Academia das Ciências de Lisboa, Portugal; ICArEHB - Universidade do Algarve, Portugal; Centro de Estudos Arqueológicos do Conselho de Oeiras/Câmara Municipal de Oeiras, Portugal
Rui Dias[2], Academia das Ciências de Lisboa, Portugal; Universidade de Évora, Portugal; Instituto de Ciências da Terra, Portugal
Manuel João LEMOS DE SOUSA[3]*, Academia das Ciências de Lisboa, Portugal; Fundação/Universidade Fernando Pessoa, Portugal; MARE - Centro de Ciência do Mar e Ambiente/URI Coimbra, Portugal (lemosdesousa@gmail.com)
Patrícia Moreira[4], Fundação/Universidade Fernando Pessoa, Portugal; MARE - Centro de Ciência do Mar e Ambiente/URI Coimbra, Portugal
Cristina F.A. Rodrigues[5], Academia das Ciências de Lisboa, Portugal; Fundação/Universidade Fernando Pessoa, Portugal; MARE - Centro de Ciência do Mar e Ambiente/URI Coimbra, Portugal
Ana Salgado[6], Academia das Ciências de Lisboa, Portugal; CLUNL - Centro de Linguística da Universidade NOVA de Lisboa, Portugal

Abstract

The Academy of Sciences of Lisbon conducted an extensive study to establish an updated Portuguese (PT) terminology for chronostratigraphic/geochronologic units of selected Geological Timetables.

The study, coordinated by M.J. Lemos de Sousa and Ana Salgado, was developed by a joint task force between the Earth and Space Sciences section of the Class of Sciences and the Institute of Lexicology and Lexicography of the Academy.

In addition to establishing an updated terminology in the subdomain of Stratigraphy, the study should also be regarded as a valuable contribution to the Academy’s newly developed Dictionary and Vocabulary, which is currently available online.

In pursuit of this objective, the authors considered the mandatory rules of both the International Stratigraphic Guide (Salvador 1994, reapproved 2013), and the erudite norm of the Portuguese language variety.

The following Geological Timetables were considered in the study:

• International Geological Timetable, usually referred to as the “standard” or “global” table, published by the International Union of Geological Sciences/International Commission on Stratigraphy as the “International Chronostratigraphic Chart”.

• Detailed Geological Timetable of the Quaternary, traditionally considered as a complementary chart of the global one.

• Geologic Timetable of the Bohemo-Iberian Ordovician regional chronostratigraphic units, specifically needed for the classification of Portuguese Ordovician units.

• Geologic Timetable of the West European Carboniferous regional chronostratigraphic units, specifically needed for the classification of Iberian terrestrial Carboniferous units.

In this poster, the authors present the “International Chronostratigraphic Chart” in both English

and its corresponding new version in Portuguese (PT). In cases where linguistic rules allowed for the validation of various Portuguese orthographic variants, the variant used in the general table corresponds to the preferred form.

Note: The coordinators and other authors have been listed alphabetically on purpose, as each has contributed an equal amount of time and expertise in the development of the present research.

Keyword

Geologic Timetable, International Chronostratigraphic Chart, Portuguese (PT) version, Iberian Peninsula

Study on high-precision sequence stratigraphic characteristics and lake level variation trend: A case study of the lower part of the fourth Member of the Paleogene Shahejie Formation (Es4x) in the Niuzhuang Sub-sag

Zhaoxiang CHEN[1]*, China University of Petroleum (East China) (1132349254@qq.com)
Yanzhong Wang[2], 18253266698
Yingchang Cao[3], 18243526548
Rongkun Li[4], 17682506984

Abstract

Through exploration and development, Es4x in the Niuzhuang Sub-sag is primarily composed of reddish-toned clastic deposits formed in a continental depositional environment, commonly known as the red bed. However, the period of red bed formation was unfavorable for biological survival, resulting in a scarcity of fossil remains and unstable lithology, which poses significant challenges for traditional biostratigraphic and lithostratigraphic classification methods. This, in turn, has hampered the progress of deep oil and gas exploration efforts in the region. Therefore, the focus of this study is on the high-resolution sequence stratigraphic division of Es4x in the Niuzhuang Sub-sag, aiming to provide geological evidence for oil and gas exploration and development. Guided by the theoretical frameworks of the Vail sequence stratigraphy and Cross's high-resolution sequence stratigraphy, this study comprehensively utilizes a range of data, including 3D seismic data, drilling core samples, well logging data, and well testing data, through techniques such as well logging wavelet transformation, stratigraphic stacking patterns, and Δlog(R) analysis, the study successfully identifies the top and bottom interfaces, T7x and T7, of the third-order sequence within Es4x in the Niuzhuang Sub-sag. Within this framework, two fourth-order sequences and nine fifth-order sequences are further delineated. The results indicate that the overall sedimentary strata of Es4x are relatively thin, with the thickness varying gradually from south to north and from east to west. The fourth-order sequence interfaces within Es4x gradually overlie the base interface towards the south and approach the top interface towards the east, potentially culminating in truncation or overlap onto the top interface. The fifth-order sequence T7w-1 gradually disappears towards the south, while T7w-4 disappears towards the east. The fifth-order sequence T7w-9 is only present in certain regions of the central and western parts of the study area. Based on the analysis of the third-order sequence, it is observed that during the initial stages of deposition in Es4x, the lake level was on a rising trend, peaking during the fifth-order sequence T7w-3, when the maximum lake flooding surface was reached. Subsequently, the lake level began to decline, a trend that persisted until the deposition of Es4x came to an end. On the other hand, when considering the fourth-order sequences, the lake level initially rose, peaked during the T7w-3 period, and then declined. It subsequently rose again during the T7w-5 period and began to decline during the T7w-6 period, persisting until the boundary of that particular fourth-order sequence. This study holds positive implications for subsequent research on deposition and exploration in Es4x in the Niuzhuang Sub-sag. It also serves as a valuable

reference for sequence stratigraphic classification in similar strata in other regions.

Keyword

Niuzhuang Sub-sag, High-resolution sequence stratigraphy, Fourth order sequence, Fifth order sequence

On the origin of continents: Insights from Archaean Terrains of Arctic Fennoscandia

Jaana HALLA[1]*, Finnish Museum of Natural History, University of Helsinki
(jaana.halla@helsinki.fi)
Kumar Batuk Joshi[2], National Centre for Earth Science Studies, Solid Earth Research Group, India
Arto Luttinen[3], University of Helsinki
Esa Heilimo[4], University of Turku
Matti Kurhila[5], Geological Survey of Finland

Abstract

The conversion of basaltic crust into a thick, buoyant felsic crust of tonalite-trondhjemite-granodiorite (TTG) composition has been a fundamental process in the Earth's evolution during the Archaean Eon (4.0–2.5 Ga). The proposition that TTGs have formed because of melting of hydrated mafic rocks is now well established by geochemical modelling and experimental methods, although these processes have only rarely been tested or documented by field studies. Here, we investigate the migmatite structures and major and trace element geochemistry of the Neoarchaean Lake Inari TTG-amphibolite terrain in northern Finland, in the Lapland-Kola Province of Arctic Fennoscandia. The Lake Inari amphibolites comprise basalts that have flat or slightly LREE-enriched REE patterns, geochemically resembling younger flood basalts. The TTGs have two coeval and intermingled geochemical endmembers, namely low- and high-HREE types, which differ in their garnet-compatible trace element abundances (HREE, Mg, Sc, Y, Co, and Zn), which is attributed to the presence or absence of garnet in their respective sources. The TTG-metabasalt association shows various migmatite structures such as metatexites, metatexite-diatexite transitions and massive diatexites that have formed in response to weakening of the crust, melt SEMR (Segregation, Extraction, Migration, and Redistribution) processes, and syn-anatectic strain. The Lake Inari terrain was a melt-rich crustal horizon with widespread migmatization instigated by partial melting of a basaltic plateau generated over a mantle plume, consistent with a stagnant to sluggish lid tectonic setting for their formation. The Lake Inari terrain formed by migmatization of a basaltic source. Overall, the present denudation level of the terrain mostly corresponds to the metatexite-diatexite transition and diatexite zones. Plateau basalts were converted to buoyant TTGs through mid-crustal migmatization that set off the evolution of continents.

Keyword

Archaean, TTG, metabasalt, migmatite, diatexite

Provenance analysis of the Tena Formation in the Anzu River, Puyo – Ecuador

Christian Wladimir ROMERO CÓNDOR[1]*, INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO (criscescz@gmail.com)
Emilio Jose Oyague[2], INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO
Antonio Patricio Proaño[3], INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO
María Angelica Ortíz[4], INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO

Abstract

In Ecuador, the tectonic evolution of the Subandean zone has sparked interest from both academia and industry due to the region's economic potential. Several authors have devoted their efforts to characterizing the area's lithostratigraphy, which includes a crystalline basement covered by mega-sequences of volcanic, volcaniclastic, and sedimentary rocks spanning from the Carboniferous to the Quaternary.

The Upper Cretaceous sedimentary mega-sequence of the Oriente Basin, composed of the Hollín, Napo, and Tena formations, has been extensively studied due to its economic significance in the petroleum industry. However, the lack of information about the petrographic and geochemical characteristics of the source rocks of the Tena Formation in the central and southern Subandean zone has created uncertainty in the regional geological evolution model, particularly in the Maastrichtian to Paleocene interval. The Anzu River section, northwest of Puyo, provides the opportunity to analyze the provenance of the Tena Formation, exposing its stratigraphic sequence comprehensively and continuously. This research details the lithostratigraphy, petrography, geochemistry, heavy mineral assemblages, and U-Pb ages in detrital zircons of the Tena Formation in the Anzu River section to define the detrital source of the Tena Formation. Petrographic analysis reveals that the sandstones of the Tena Formation consist of feldspathic litharenites, lithic arkoses, and sublitharenites, originating from sources rich in quartz and mixing zones. Heavy mineral assemblages and concentrations of major oxides, trace elements, and rare earth elements indicate that these sandstones are sourced from recycled sedimentary provinces and felsic igneous provinces deposited on a passive margin. U-Pb ages in detrital zircons show a major U-Pb age concentration at 1550–1300 Ma (Rondonian-San Ignacio) and subsidiary peaks in 1800–1550 Ma (Rio Negro Juruena) and 1300–900 Ma (Sunsás); additionally, a peak age is observed at 110 - 70 Ma (Andes). These sources would be linked to Andean regions that assimilated blocks or tectonic wedges from the Oriente Basin during orogeny, where the erosion of these blocks has controlled the available detritus for the sedimentation of the Tena Formation in the study area.

Keyword

Stratigraphy, Tena Formation, Subandean Zone, Provenance analysis, Geochronology

Geological and Geomorphological Mapping in Northern Luzon, Philippines using Field Data and Red Relief Image Map (RRIM)

CLOD ANNE VILLALUNA PUNZALAN[1]*, University of the Philippines (cvpunzalan1@up.edu.ph)
NOELYNNA RAMOS[2], University of the Philippines
REYNALDO SAN JOSE[3], University of the Philippines
LHIANA REIGN BAÑARES[4], University of the Philippines
ACE MATHEW CANTILLEP[5], University of the Philippines
LYNDON NAWANAO[6], University of the Philippines

Abstract

In this study, we investigate the geology of northern Luzon and the geomorphological evidence associated with the active deformation and development of the three stratigraphic terranes in the region: Ilocos Basin, Central Cordillera (CC), and Cagayan Valley Basin (CVB). From Ilocos Sur on the west to Kalinga on the east, ten geological formations ranging from Cretaceous to Quaternary were recognized. 1) The Cretaceous to Eocene Pugo Formation serves as the basement unit of CC and consists of jointed, columnar, and massive andesite and andesite porphyry. 2) The Eocene Abuan Formation forms the basement unit of the CVB and consists of basalt and porphyritic andesite with epidote and plagioclase phenocrysts. 3) The Early Oligocene Dibuluan Formation which unconformably overlies the Abuan Formation, consists of massive pyroclastic deposits and agglomerates with clasts of andesite, gabbro, and diorite. 4) The Late Oligocene to Early Miocene Zigzag Formation, overlying the Pugo Formation, consists of interbedded indurated mudstone and sandstone that are intercalated with tuffaceous clastics. 5) The Late Oligocene to Middle Miocene Central Cordillera Diorite Complex (CCDC), which intruded both the Pugo and Zigzag formations consists mainly of diorite and andesite porphyry. 6) The Late Oligocene to Early Miocene Lubuagan Formation that unconformably overlies the Dibuluan Formation is composed of steeply dipping and highly deformed interbedded sandstone and mudstone. 7) The Late Middle Miocene to Late Miocene Batac Formation consists of a thick sequence of interbedded fissile mudstone and lithic sandstone. 8) The Late Pliocene to Early Pleistocene Ilagan Formation that conformably overlies the Lubuagan Formation is composed of interbedded sandstone, mudstone, and conglomerate with fossils of leaves, ferns, and mollusks. 9) The Early Pliocene to Pleistocene Laoag Formation is distinctly composed of reefal limestone, fossiliferous sandstone, and conglomerate. 10) The Middle to Late Pleistocene Awiden Mesa Formation, which consists of dacitic welded tuffs, tuffaceous clastics, and indurated lahar deposits, unconformably overlie the Ilagan Formation. Faults, lineaments, offset streams, and other geomorphic features, including the Tabuk Plateau and Pangul Anticline, were delineated using red-relief image maps (RRIM). The Tabuk Plateau consists of pyroclastic and fluvial sediments that were deposited along the footslopes of the Central Cordillera. The Pangul Anticline, which forms part of the CVB anticlinal belt, is characterized by overturned folds caused by oversteepening and accelerated uplift. Lineaments are generally NW trending, while the

majority of the faults are strike-slip as inferred from offset streams. These geological units, along with the delineated geomorphological features, provide additional insights into the geotectonic development and deformation of northern Luzon during the Cenozoic.

Keyword

Ilocos Basin, Central Cordillera, Cagayan Valley Basin, Philippines, geology, neotectonics

New data on the stratigraphy of the Middle and Upper Jurassic strata of northeastern Iran

Niki MAJIDIFARD[1]*, Student of the University of Science and Technology (nikimajidifard.mfa@gmail.com)
MAHMOUDREZA MAJIDIFARD[2], Research Institute for Earth Sciences in Geological Survey of Iran

Abstract

The Middle and Upper Jurassic rocks of the Alborz Mts. (northern Iran) and Koppeh Dagh (northeastern Iran) are chiefly represented by the Shal, Dalichai, Lar, Bashkalateh, Kashafrud, Chaman Bid and Mozduran formations. They are distributed over a large area and reach a maximum thickness of nearly 1600 m at the type locality of the Chaman Bid Formation . In North Iran, the Jurassic system consists of two distinct Sedimentary- Tectonic megacycles. The first started after the closure of the Palaeo-Tethys (in the Late Triassic). From the early Norian onward, widespread transgression of the Shemshak sea led to deposition of siliciclastic rocks of the Shemshak Group (Norian-Middle Bajocian). This cycle ended in the early Bajocian with the Mid-Cimmerian tectonic event. The second megacycle began in the late Bajocian. The transgression gave rise to an epicontinental sea subdivided into basinal and platform area in north-central and north-eastern Iran. This situation continued into the Cretaceous when, in the Neocomian, the Late Cimmerian tectonic event terminated the second sedimentary cycle. The similarity of the sediments and faunas with those of the same age in Afghanistan and Armenia indicates that north and central Iran were situated at the southern margin of Laurasia. The second sedimentary megacycle consists mostly of marl and limestones Dalichai Formation (= Chaman Bid Formation of earlier authors) and limestones (Lar Formation, Mozduran Formation) indicative of basinal and carbonate platform environments. These sediments began to form from the end of the Mid Cimmerian tectonic phase until the Late Jurassic and in some place continued into the “Neocomian”. For example, in some areas of the Alborz and Koppeh-Dagh, the same style of sedimentation continued from the Late Jurassic (Tithonian) to the Early Cretaceous (Berriasian). At some localities, such as Minodasht, Firouzkouh and Jam the sedimentary basin was not only deep but also pelagic in nature. Therefore, the Middle and Upper Jurassic rocks of northeastern Iran consist seven formations; Dalichai, Lar and Shal (Alborz) and Chaman Bid, Mozduran, Kashafrud, and Bash Kalateh (Koppeh Dagh). However there is no difference with respect to lithology and depositional environment between the Dalichai, Chaman Bid and Shal formations, nor between the Lar and Mozduran formations or between the Bashkalateh and Kashafrud formations. For this reason it is proposed to discontinue the usage of the lithostratigraphic terms Shal Formation, Chaman Bid Formation, Mozduran Formation, and Bashkalateh Formation.
Based on ammonites, the Dalichai Formation is strongly diachronous: If many strata in the Upper Bajocian until the Late Jurassic. The Lar Formation ranges from the Oxfordian to the Neocomian, the Shal Formation from the Late Bajocian to the Neocomian and the Kashafrud Formation from

the Late Bajocian to the Late Bathonian.

Keyword

Ammonites, Lithostratigraphic, Sedimentary, Tectonic, Transgression

New insight into crustal exhumation induced by granitic intrusion following intracontinental contractional deformation: a possible model for Hohhot thermal upwelling-extensional structure, Inner Mongolia, north China

Yu ZHANG[1]*, Chinese Academy of Geological Sciences (yuzhang000@126.com)
Shuwen Dong[2], Chinese Academy of Geological Sciences
Wei Shi[3], Chinese Academy of Geological Sciences

Abstract

Contemporaneous A-type granites, mylonitic shear zones, and low-angle normal faults are the first-order features of the “metamorphic core complexes (MCC)” in the North China Craton (NCC). Strongly deformed middle-lower crustal rocks exposed in the ancient orogenic belt of NCC, whether these rocks were exhumed via diapiric upwelling or low-angle detachment faulting is debated. The Hohhot “MCC”, located at north NCC, records top-to-southeast normal-sense exhumation of the deformed Archean-Proterozoic metamorphic basement that was intruded by Jurassic-Cretaceous complex granite mass. We conducted geological mapping of the Hohhot extensional structures, with integrated structural, the quartz lattice preferred orientation (LPO), geochemical, and thermo-/geochronological analyses to characterize the geometry and kinematics of extension and exhumation of the mylonitized footwall. The basement was intruded by deformed Jurassic adakitic and undeformed Cretaceous A-type intrusions in the footwall. The mylonitic shear zone (S1) located between undeformed Cretaceous granite and low-angle detachment faults was separated from the doming system, characterized by pervasively top-to-SE simple shearing (ca. 146–141 Ma). Based on this, we defined the three units composed Hohhot “MCC” and reestablished Hohhot thermal upwelling-extensional structure (TUES) model: (a) the core-granite composed of Early Cretaceous (136–127 Ma) A-type granites; (b) the pure-shear-dominated shear zone (S21) distributed in the core-granite periphery, with foliation (no lineation), characterized by high-temperature (>500℃) deformation; (c) the low-angle detachment system (S22) characterized by low-angle normal faults separating the footwall top-to-the-SE ductile structures and microbreccia zone from the hanging-wall Cretaceous supra-detachment basin along the flank of domal S1, with the deformation temperature decreasing from high-temperature (>500℃) to low temperature (ca. 300°C) as away from the core-granite, characterized by simple shear sense. We propose that the Early Cretaceous mantle-derived magmatism led to coeval diapiric upwelling of the lower crust, exhumated the footwall, and overprinted previous compressional structures with the generation of pure shear zone and low-angle detachment system. Therefore, the exhumation of footwall rocks of Hohhot TUES was not driven by low-angle detachment faulting.

Keyword

Early Cretaceous, mylonitic shear zone, diapiric upwelling, North China Craton, thermal upwelling-extensional structure

Late Cretaceous rapid uplift and denudation of northern Tibet and its climatic effects

Hao WU[1]*, Guilin University of Technology (wuhaojlu@126.com)

Abstract

The Tibetan Plateau is the broadest and highest elevated surface on Earth and is thought to have formed in response to the collision between India and Asia during the Cenozoic. Formation of the plateau had a significant effect on Asian climate and may have been responsible for gradual cooling of the global climate. However, an increasing number of studies have suggested that growth of the Tibetan Plateau was a complex process due to a series of accretionary events involving several Gondwana-derived terranes in Asia that began in northern Tibet during the Mesozoic. These pre-Cenozoic subduction and collision events provided favorable preconditions for the formation of a proto-plateau prior to the India–Asia collision. Therefore, any hypotheses involving the formation of the modern Tibetan Plateau during the Cenozoic should include the Mesozoic contribution to crustal thickness and topographic relief.

We present a combined geochronological and geochemical study of terrestrial molasse deposits and interlayered volcanic rocks in northern Tibet that, along with regional geological data, reveal that rapid uplift and denudation occurred during the Late Cretaceous (105–75 Ma) and formed the p-TP. We propose that this rapid uplift event was a result of isostatic rebound in response to post-collisional lithospheric foundering, which was controlled mainly by the nature of the overthickened lithosphere beneath the Lhasa–Qiangtang collisional zone. Provenance analysis of the molasse sediments defines a newly revised paleo-topographical framework for the collisional zone, which reached a high elevation (~4000 m) with a narrow Bangong–Nujiang paleo-valley (<2000 m) inside the suture zone. This Late Cretaceous uplift-related erosion contributed to lower atmospheric pCO2 levels, which probably caused global cooling.

Keyword

Tibetan Plateau, Late Cretaceous, Surface uplift

When did the Mongol-Okhotsk Ocean close?

Zhiyu YI[1]*, SUN YAT-SEN UNIVERSITY (yizhy5@mail.sysu.edu.cn)
Yushu Liu[2], SUN YAT-SEN UNIVERSITY
Yongqing Liu[3], Institute of Geology, Chinese Academy of Geological Sciences
Joseph Meert[4], University of Florida
Pengfei Wang[5], SUN YAT-SEN UNIVERSITY

Abstract

The Mongol-Okhotsk Ocean (MOO) suture, which separates the Siberia Craton to the north and North China-Amuria Block to the south, play a critical role in understanding the Mesozoic tectonics of East Asia. However, there exists a significant discrepancy between the timing of MOO closure based on paleomagnetic data and geological evidence, ranging from the Late Triassic to Early Cretaceous. We analyze paleomagnetic data from Mongolia, Siberia and North China, incorporating a refined geochronology for the key Siberian poles, we argue that previously published apparent polar wander paths (APWPs) for North China and Siberia are insufficient to precisely constrain the timing of MOO closure. We present a set of high-quality paleomagnetic poles derived from the late Triassic and Jurassic igneous rocks (including lavas, dykes and sills) from the North China craton in an effort to refine the timing of the MOO closure. The late Jurassic pole, obtained from volcanic rocks of the Tiaojishan Formation (at 51 sites), indicates a paleolatitude of 36.6 ± 5.1° N for North China during ~152-161 Ma, using Beijing as the reference site. The late Jurassic pole, derived from dykes and sills intruding the Nandaling Formation (at 19 sites), defines a paleolatitude of 36.8 ± 7.4° N for North China at 155 ± 3.4 Ma, which is in agreement with that derived from the Tiaojishan Formation. The middle Jurassic pole, based on volcanic lavas of the Nandaling Formation (24 sites), places North China at ~61.7 ± 9.1° N during ~168-180 Ma. The late Triassic paleopole, obtained from dykes and sills, positions North China at 75.6° ± 6.8° N at ~220 Ma. The paleogeographic reconstructions, based on the new poles and the updated global APWPs, support the idea that the North China-Amuria Block and Siberia had already amalgamated prior to ~220 Ma. In contrast, our reconstruction conflicts with previous interpretations based on paleomagnetic evidence, which predominantly suggest a late Jurassic-early Cretaceous closure of the MOO. Furthermore, the late Triassic (~220 Ma) reconstruction implies that the East Asian blocks were already part of Pangea long before its eventual break-up at ~170 Ma, indicating that Pangea comprises ~99% of available continental crust and was perhaps the largest of all known supercontinents.

Keyword

Mongol-Okhotsk Ocean, Paleogeography, Paleomagnetism, Late Triassic, Jurassic

Extensional Tectonics and North China Craton Destruction — insights from the Magnetic Susceptibility Anisotropy (AMS) of granite and Metamorphic Core Complex

Wei LIN[1]*, State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences (linwei@mail.iggcas.ac.cn)
Lingtong Meng[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The craton is long-lived and stable on the Earth surface. However, since the Mesozoic, the North China Craton (NCC) was characterized by large-scale lithospheric removal, the fundamental change of physical and chemical characteristics of the lithospheric mantle, widely distributed crustal deformation, and extensive magmatism. This complex evolution contrary to other cratons has been called the NCC destruction. The widespread magmatism in the eastern NCC was an important response to the lithospheric removal in-depth and crustal deformation on the surface geology. The plutons were emplaced under a tectonic context and therefore recorded the information of the tectonics, especially, the Magnetic Susceptibility Anisotropy (AMS) pattern of the pluton which was acquired with the influence of regional stress. In the past fifteen years, about 22 plutons, intruding during the different periods from the Late Triassic to the late stage of the Early Cretaceous, have been studied with AMS. The emplacement mechanism of plutons, and the contemporary tectonic setting were discussed to constrain their relationship with the NCC destruction in different stages of magmatism. As a result, the Late Triassic, Early Jurassic, and Late Jurassic plutons exhibit consistent N(E)-S(W) trending magnetic lineation. The early stage of Early Cretaceous plutons displays NW-SE trending magnetic lineation while the late stage of Early Cretaceous plutons shows magnetic lineation with various orientations. Combined with the previous studies, it is concluded that the emplacement of the plutons, intruding in the three stages were controlled by the weak N(E)-S(W) orientated extension, regional NW-SE trending extension, and a weak extension in the shallow, respectively. The transformation of regional extension from the N(E)-S(W) to the NW-SE direction was accompanied by a strain-increasing tendency. The extensional tectonics in the eastern NCC was interpreted to represent the interaction between the Mongol-Okhotsk belt, the Paleo-Pacific plate, and eastern Eurasian continent.

Keyword

Mesozoic granite, Anisotropy of Magnetic Susceptibility (AMS) of granite, eastern NCC, extensional tectonics, NCC destruction

The Central Asian fold belt (CAOB): granite domes of the Erguna Massif as indicator of Mesozoic extension (evidence from the Trans-Baikal geotransect and parametric borehole of 2 600 m depth)

Ivan KUDRIAVTCEV[1]*, VSEGEI (ivan_kudryavtsev@yahoo.com)
Juliia Golysheva[2], VSEGEI

Abstract

The Trans-Baikal geotransect crosses fold framing of the Siberian Craton, including Erguna Massif of CAOB, south of the Mongol–Okhotsk suture zone. Due to geophysical data several dome structures were distinguished within the Erguna Massif, on the surface these structures are presented by granites domes.

The nearest to the Mongol–Okhotsk suture Borshchovochnyi dome, having features of metamorphic core complex, was drilled by the Trans-Baikal parametric borehole of 2 600 m depth. The objective of this borehole was to study the geological nature of the dome structure and to obtain the parametric information on the section based on study of the sampled core and the results of geological and geophysical studies of the borehole. The uniqueness of this project is that the metamorphic core complex as the target for deep geophysical data verification by deep drilling was never before.

Metamorphic core complexes belts have been identified and studied in Northern Mongolia and the Trans-Baikal region where it's traced at a distance of more than 900 km. These processes recorded the global intracontinental extension in the Asian region during the Early Cretaceous.

The borehole section is characterized by continuous core sampling, a wide range of geophysical surveys in the borehole (logging), and analytical studies of the rock's samples. Within the section three main structural elements of metamorphic core complexe were identified: the upper plate, detachment, and the lower plate. The upper plate (slightly metamorphosed rocks) is represented by a serpentinite mélange separated from the underlying rocks of the lower plate by a zone of chlorite breccias (detachment). The lower plate comprises of granites, schists and plagiogneisses. The upper part of the lower plate is composed of mafic and intermediate schists with amphibolites and quartzites. Biotite granite is widespread in the section as layered veins with synkinematic signs, the age of biotite granite is about 130 Ma. Schists are characterized by a mylonite structures at intervals of interbedding with biotite granites. The geophysical logging data and the petrophysical characteristics of cored rocks confirms that the mylonite zone is the provenance of a series of inclined reflectors in the seismic section, which can be traced to a depth of at least 10 km.

Below the schists the section is composed of plagiogneisses, leucogranites and gneissic granites. The protolith of plagiogneisses is monzodiorite-granite series of Permian-Triassic age. The age of amphibolite facies metamorphism is about 140-150 Ma. The Borshchovochnyi dome sections demonstrates signs of the cordilleran metamorphic core complex, which was formed due to crust detachment evolution as the result of extension.

The other domes within the geotransect are characterized by similar morphology. According to the

geophysical data these structures are also related to detachments having a northern dip. All identified detachments are connected with the crust basal detachment on the 15-20 km depth. The detachments and domes system are the indicator of the global extension, which reworked the Erguna Massif crust.

Keyword

geotransect, deep drilling, metamorphic core comlex, Erguna massif

Decoding the link between magmatic cyclicity and episodic extensional and contractional tectonics: insights from the Late Mesozoic granites of the eastern China

Lingtong MENG[1]*, State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences (tone18@mail.iggcas.ac.cn)
Wei Lin[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences
Yang Chu[3], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The cyclical change in subduction style is the favorable mechanism to elucidate the cyclicity of continental arc magmatism, however, the role of episodic tectonics and variation of the lithosphere in overriding plates is much underestimated. Here we focus on the Late Jurassic to Early Cretaceous granites related to Paleo-Pacific Ocean subduction in the Jiaodong Peninsula, eastern China. Based on our structural analysis, magnetic fabric measurement, and gravity modeling, polyphase deformation and magma emplacement have been recognized within the Late Mesozoic granites.

Late Jurassic (160-150 Ma) NE-SW extension was expressed by a high-temperature, top-to-the-NE normal shearing. Accompanied by this extension, the Late Jurassic granite has concentric magnetic foliations with NE-SW magnetic lineations, and several NW-SE trending feeder zones at depth. The Latest Jurassic-Earliest Cretaceous (150-135 Ma) NE-SW contraction resulted in a lower-temperature, top-to-the-SW ductile shearing with magmatic lulls. Early Cretaceous (130-120 Ma) NW-SE extension is characterized by detachment faults with either top-to-the-SE or top-to-the-NW kinematics around the Late Jurassic granites, leading to their exhumations. Meanwhile, the Early Cretaceous (130-120 Ma) granite is “syn-kinematic”, which has NW-SE mineral/magnetic lineations, top-to-the-NW kinematics, and wedge-shaped geometry at depth. Finally, with the space opened by regional extension, isotropic pluton is permissively emplaced at the upper crust during the late stage of the Early Cretaceous (120-110 Ma).

By summarizing previous geological records and our new data, we build the feedback mechanism among magmatic cyclicity and episodic tectonics in the overriding plate. We show that (a) the magmatic flare-ups correspond to extensional tectonics, while the magmatic lulls are coeval with regional contraction; (b) a multi-feeder model of granite emplacement is dominated at the Late Jurassic weak extension, while changes to extensional structure controlling at the Early Cretaceous intensive extension; (c) with the increasing regional extension of the overriding plate, the magmatic flux is enhanced. Our model emphasizes episodic the deformation of the lithosphere and associated crustal thickness variation in controlling magma production, which may shed new light on understanding the magmatic cyclicity under continuous subduction.

Keyword

Late Mesozoic tectonics, Magmatic cyclicity, Episodic extension and contraction, Eastern China, Structural geology study

The Lateral Accretionary Orogenic Process at Pangea's Conveyable Zone: Insights from the Borneo's Oldest Granitoids in Southeast Asia

Shan Li[1]*, University of Chinese Academy of Sciences (lishan@ucas.ac.cn)
Long Xiang Quek[2], University of Chinese Academy of Sciences

Abstract

Pangea stands as the last known supercontinent of the Phanerozoic era, its gradual reorganization around 250 Ma ultimately leading to the formation of the present-day continental edifices. Our research delves into the emergence of juvenile magmatism in tandem with autochthonous orogenesis, which challenges allochthonous ancient blocks across the Tethyan Realm—the only conveyable zone of Pangea. Our investigation centers on the oldest (Permo-Triassic) granitoids in Borneo, once considered ancient basement rocks. The Permian-Triassic granitoids from West Malaya, East Malaya, Bangka-Belitung, and Sumatra show ilmenite series granitoids, owing to contributions from recycled sediments related to the Tethys system, whereas North Borneo shows magnetite series granitoids related to the Paleo-Pacific system. However, the geochemical patterns of West Borneo Permian-Triassic granitoids seem to show superimposed imprinting in both systems. Our comprehensive analyses of geochemical data in southeast Tethyside, reveal contrasting (ancient vs. juvenile) sources for Borneo Permian-Triassic granitoids. Importantly, this study finds two distinctive periods of juvenile additions at ~240 Ma and ~210 Ma, characterized by positive zircon εHf(t) values and mantle-like zircon δ18O values. These findings provide crucial evidence for the initiation of juvenile magmatic "flare-up" events and the crustal growth in the Triassic during Pangea's reorganization. A combination of the sideway drift towards Pangea's subduction girdle and heat release from Pangean Eurasia during Sibumasu's final approach at ~240 Ma may have caused the Paleo-Pacific subduction system to retreat, contributing to the autochthonous growth of the southeast Tethyside edge. The later juvenile addition at ~210 Ma may not originate from the Paleo-Pacific system, as it is conceivable that Neo-Tethys subduction-induced magmatic "flare-ups" with zircon εHf(t) values in Sumatra could extend their influence to Borneo. This study sheds new light on the Borneo continent that hosts much of the juvenile crust added to the Pangean Eurasia continents since the Triassic via accretionary orogenesis. This study thus substantiates the central role of accretionary orogens in making and shaping southeast Tethyside continents.

Keyword

Southeast Tethyside, multi-plate convergent, Borneo granitoids, Accretionary orogeny

Middle-Late Jurassic crustal shortening in the central–western North China craton in response to multi-plate convergence in the East Asia

Wei SHI[1]*, Chinese Academy of Geological Sciences (shiweinmg@163.com)
Shuwen Dong[2], SinoProbe Lab, Chinese Academy of Geological Sciences
Yueqiao Zhang[3], Nanjing University

Abstract

The Jurassic multi-plate convergence in East Asia led to the intra-continental deformation in the North China craton. However, much controversy is highlighted in the intra-continental deformation style and timing, and unanimous kinematics. The central–western North China craton is marked by the Ordos block surrounded by a number of Mesozoic structural belts, containing Lvliangshan–Taihangshan belt to the east, Yinshan belt to the north, Helanshan–Liupanshan belt to the north, and by Jurassic basins grow in the structural belts, comprising Ningwu–Jingle, Yungang basins in the Lvliangshan belt, Shiguai basin in the Yinshan belt, Ruqigou, Tujuan basins in Helanshan belt, recording inter-continental deformation due to multi-plate convergence in East Asia. Here, using new structural analysis, the definition of Jurassic growth strata, and paleo-stress inversion, grouping with our previous work on the North China craton, we reconstructed a multi-directional shortening pattern in the central–western North China craton during the Middle–Late Jurassic (170–160 Ma), which is characterized by N–S shortening along the northern margin of the North China craton, by NW–SE shortening in the western margin and along the central zone of the North China craton. In combination with regional structural analysis, we propose that the central–western North China craton is roughly situated at the center of the multi-plate convergence during the Middle–Late Jurassic, and the southward compression was caused by the closing of the Mongolia–Okhotsk Ocean in the north, the northwestward compression by the subduction of paleo-Pacific plate beneath the East Asia continent in the east, and southeastward compression by the closure of the Meso-Tethys in the west.

Keyword

multi-plate convergence in East Asia, North China craton, crustal shortening, Middle–Late Jurassic, paleo-stress inversion

Gondwanan Flood Basalts Linked Seismically to Plume-Induced Lithosphere Instability

Yanan SHI[1]*, Southern University of Science and Technology (shiyn@sustech.edu.cn)
Jason Morgan[2], Southern University of Science and Technology

Abstract

Delamination of continental lithospheric mantle is well-recorded beneath several continents. However, the fate of the removed continental lithosphere has been rarely noted, unlike subducted slabs reasonably well imaged in the upper and mid mantle. Beneath former Gondwana, recent seismic tomographic models indicate the presence of at least 5 horizontal fast-wavespeed anomalies at ~600 km depths that do not appear to be related to slab subduction, including fast structures in locations consistent with delamination associated with the Paraná Flood Basalt event at ~134 Ma and the Deccan Traps event at ~66 Ma. These fast-wavespeed anomalies often lie above broad slow seismic wavespeed trunks at 500-700 km depths beneath former Gondwana, with the slow wavespeed anomalies branching around them. Numerical experiments indicate that delaminated lithosphere tends to stagnate in the transition zone and mid-mantle above a mantle plume where it shapes subsequent plume upwelling. For hot plumes, the melt volume generated during plume-influenced delamination can easily reach ~2-4×106 km3, consistent with the basalt eruption volume at the Deccan Traps. This seismic and numerical evidence suggests that observed high wavespeed mid-mantle anomalies beneath the locations of former flood basalts are delaminated fragments of former continental lithosphere, and that lithospheric delamination events in the presence of subcontinental plumes induced several of the continental flood basalts associated with the multiple breakup stages of Gondwanaland. Continued upwelling in these plumes can also have entrained subcontinental lithosphere in the mid-mantle to bring its distinctive geochemical signal to the modern mid-ocean spreading centers that surround southern and western Africa.

Keyword

Lithosphere, Plume, Delamination, Craton, Flood Basalt

Late Jurassic true polar event revealed by paleomagnetic study in North China and its implication for regional tectonics and biota evolution in East Asia

Yifei Hou[1], Insititute of geology and geophysics, Chinese Academy of Sciences
PAN ZHAO[2]*, Insititute of geology and geophysics, Chinese Academy of Sciences
(panzhao@mail.iggcas.ac.cn)
Huafeng Qin[3], Insititute of geology and geophysics, Chinese Academy of Sciences

Abstract

The reorientation of Earth through rotation of its solid shell relative to its spin axis is known as True polar wander (TPW). It is well-documented at present, but the occurrence of TPW in the geologic past remains controversial. This is especially so for Late Jurassic TPW, where the veracity and dynamics of a particularly large shift remain debated. Here, we report three palaeomagnetic poles at 153, 147, and 141 million years (Myr) ago from the North China craton that document an ~12° southward shift in palaeolatitude from 155–147 Myr ago (~1.5° Myr-1), immediately followed by an ~10° northward displacement between 147–141 Myr ago (~1.6° Myr-1). Our data support a large round-trip TPW oscillation in the past 200 Myr. By comparison of Jurassic paleomagnetic poles of the NCC and SIB, we suggest that the Late Jurassic true polar wander event may have biased paleomagnetic results and thereby affected the interpretation of the final closure of the Mongol-Okhotsk Ocean. Combining paleomagnetic data with regional geological evidence, we propose that the Mongol-Okhotsk Ocean was closed in its eastern segment in the Late Jurassic, marking the formation of the central Asian continent. We suggest that the shifting back-and-forth of the continents may contribute to the biota evolution in East Asia and the global Jurassic–Cretaceous extinction and endemism.

Keyword

North China, true polar wander, paleomagnetism, Late Jurassic

Cyclical and progressive destruction of the cratonic lithosphere of South China

Yang CHU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences
(chuyang@mail.iggcas.ac.cn)
Wei Lin[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Continents with cratonic cores can resist deformation, and thus survive billions of years in the geological record. Tectono-thermal reworking is a key process in continental evolution because it alters composition and structure of some continents, weakens, and finally destructs or even dismembers them.

In western Pacific, East Asian continental margins suffered extensive continental reworking and lost part of their continental lithosphere and developed a wide extensional province. Across the South China Block, Mesozoic cyclical tectonics destructed a large portion of its cratonic lithosphere. We analyzed and synthesized the structural evolution of the extensional structures and illustrated the process of lithospheric thinning of Mesozoic South China.

Unlike the previous rapid, one-cycle delamination model occurred in the North China Craton, the destruction process of South China operates in a cyclical, progressive manner in which compression destabilized the edge of the cratonic lithosphere and the following extension destructs the unstable part to thin the lithosphere. This process, as an endmember of lithospheric destruction mechanisms, requires cyclical tectonics of the subduction zone and the overriding plate, which has been widely reported in the Cordilleras of the eastern Pacific margin. The progressive lithosphere destruction model may also explain how ancient cratons shrink by subduction-related tectonics.

Keyword

South China, Lithosphere destruction, Cyclical tectonics, Continental extension

Discussion on the Metallogenic Geological Body of the Qixiashan Pb-Zn Polymetallic Deposit in Jiangsu Province, China

Mingchao ZHANG[1]*, China University of Geosciences, Beijing (cgszhangmc@foxmail.com)

Abstract

Chinese mineral exploration expert Mr. Ye Tianzhu proposed the "Theory and Method of Prospecting and Prediction of Metallogenic Geological Body" since 2007. This theoretical framework systematizes large-scale mineral prediction techniques, focusing on Metallogenic geological body, Metallogenic structural planes and Metallogenic characteristics. In practical mineral exploration, this framework plays a pivotal role, contributing significantly to China's mineral exploration endeavors in the past two decades and yielding commendable results.

The Qixiashan Pb-Zn polymetallic deposit, situated within the Nanjing-Zhenjiang area of Jiangsu Province. Through the analysis of metallogenic geological characteristics, fluid inclusions, and isotopic compositions, the mineralization of the Qixiashan deposit is a magmatic hydrothermal deposit primarily influenced by the Calcium-Silicon Interface between Carboniferous limestone of the Huanglong Formation and sandstone of the Gaolishan Formation, the absence of an identified intrusive rock body linked to mineralization within the mining area has sparked controversy regarding the determination of the Metallogenic geological body. Metallogenic Geological Body pertains to geological bodies intricately linked to mineral deposit formation concerning time, space, and genesis. The physical carrier of Metallogenic geological processes is the Metallogenic geological body, specifically referring to the structural characteristics and rock combination types. Identifying Metallogenic geological bodies facilitates precise prediction of deep mineral deposit locations, thus providing crucial insights for further exploration efforts.

Through comparative studies encompassing geological phenomena, geochronology, isotopic geochemistry of this mining area, and rare earth element geochemistry of relevant intrusive rock bodies, we infer the Metallogenic geological body of the Qixiashan deposit to be a moderately acidic concealed intrusive rock body formed by magmatic activity within the Tangshan-Zhenjiang rock foundation. Our assertions are supported by the following observations: 1) To date, Although no intrusive rock formations are directly observable within the mining area, scattered occurrences of diorite porphyrite veins have been identified on the surface of Ganjiaxiang and within boreholes.Such vein formations typically develop in the vicinity of intrusive rock bodies and serve as significant indicators for the potential existence of concealed intrusive formations. And alongside the presence of Yanshanian granodiorite and pyroxene diorite in neighboring regions. 2) The genesis of the Qixiashan deposit ore and the emplacement of the principal acidic intrusive rock body within this locale are governed by nearly east-west (northeast) trending faults of this area, suggesting a spatial correlation between the two phenomena. This alignment hints at a potential synchronicity in their formation epochs and tectonic dynamic processes. 3) The Qixiashan mining area exhibits subtle gravitational and magnetic anomalies characterized by a gentle and low magnitude. Studies propose that the underlying magnetic source responsible for

these anomalies likely corresponds to a concealed intrusive rock body situated at the core of the Da-Ao Mountain anticline. This hidden intrusive body is estimated to be shallowly buried, with depths ranging approximately 1300 meters and extending over a width of around 2300 meters.
In mineral exploration and prediction endeavors, the identification of metallogenic geological body is paramount for determining deep mineral exploration spaces. We suggest that future exploration efforts at the Qixiashan deposit should prioritize the search for hidden metallogenic geological.

Keyword

Qixiashan Pb-Zn polymetallic deposit, Metallogenic Geological Body, Theory and Method of Prospecting and Prediction of Metallogenic Geological Body

Mesozoic Uplift of the Dabashan and the Micangshan-Hannan Dome in the South Qinling Orogenic Belt determined by analysis of lithospheric flexure

Xiong XIONG[1]*, China University of Geosciences (xxiong@cug.edu.cn)
Yongdong Li[2], China University of Geosciences

Abstract

The knowledge of the evolution of topography in continental orogeny is vital for understanding continental orogenic processes, geodynamic mechanisms, and climate and environmental changes. The Qinling orogen is a major orogenic belt in mainland China, and its uplift history is key to the tectonic configuration and geodynamics of China and East Asia. Previous studies have shown that the Dabashan and the Micangshan-Hannan Dome in the South Qinling orogen were uplifted during the Mesozoic, however, the amplitude of the uplift remains unresolved. In this study, based on the sedimentary records of the northern Sichuan Basin and using lithospheric flexural modeling, we have estimated the scale of Mesozoic uplift of the Dabashan and the Micangshan-Hannan Dome, and the effective elastic thickness (Te) of the Sichuan Basin. The results show that the Dabashan and the Micangshan-Hannan Dome were uplifted approximately 1220 and 880 m during the Middle Jurassic and Early Cretaceous, respectively. On this basis, we propose that the present-day elevation of the Dabashan and the Micangshan-Hannan Dome is primarily the result of Mesozoic uplift. The differences in uplift duration and amplitude of different tectonic units indicate that the uplift processes and driving mechanisms of the South Qinling orogen were different in the Mesozoic and Cenozoic. While Mesozoic uplift was a result of the convergence of the North China and the South China Blocks from east to west, Cenozoic uplift was driven by ongoing indentation of the Indian plate into Eurasia from southwest to northeast. The lithospheric strength of the northern Sichuan Basin weakened from the Middle Jurassic to the Early Cretaceous, and Te decreased from 73 to 57 km, which may have been caused by the bending stresses developed in the lithosphere beneath large topographic loads due to flexure.

Keyword

South Qinling orogenic belt, Dabashan, Micangshan-Hannan Dome, Mesozoic Uplift, lithospheric flexure

Identification of seismic activity and basin inversion based on soft-sediment deformation structures: An example from SE Korea

Jinhyun Lee[1]*, PUKYONG NATIONAL UNIVERSITY (Jinhyunlee747@gmail.com)
Sambit Prasanajit Naik[2], PUKYONG NATIONAL UNIVERSITY
Ho-Seok Choi[3], PUKYONG NATIONAL UNIVERSITY
Jinhyeon So[4], PUKYONG NATIONAL UNIVERSITY
Donghwa Yun[5], Gyeongsang National University
Young-Seog Kim[6], PUKYONG NATIONAL UNIVERSITY

Abstract

Deformed soft-sediment deformation structures (SSDS) may reveal multiple phases of deformation, offering crucial clues about the inversion mechanisms in a basin. In this study, we detail the deformation inversion history from the Miocene to the Holocene (phases 1–4) within the Bomun sub-basin, located in the Gyeongju area of southeastern Korea. The consistent direction of the WNW-trending folds that plunge westward across different sites suggests they were formed by tectonic forces. Our analysis of paleostress in reverse faults that have shifted Miocene deposits and SSDS identified an ENE compression direction (σ_Hmax) that aligns with the current stress orientation. The presence of distinct liquefaction features, their widespread distribution, and the repeated vertical occurrence of SSDS point to significant seismic influence. The brittle deformation seen in outcrop and microscopic analyses near reverse faults, including the formation of clastic dikes within SSDS, suggests seismic triggers. Evaluating the Environmental Seismic Intensity (ESI-07) scale with SSDS data indicates that the area around the Bomun sub-basin likely experienced seismic events ranging in intensity from IX to X, which contributed to the noted deformation characteristics. The investigation into SSDS not only sheds light on the area's dynamic processes but also aids in advancing research on seismic risks and the mechanisms of basin inversion.

This research was supported by a grant(2022-MOIS62-001(RS-2022-ND640011)) of National Disaster Risk Analysis and Management Technology in Earthquake funded by Ministry of Interior and Safety(MOIS, Korea).

Keyword

SSDS, Basin inversion, ESI intensity

Intraplate neotectonics and activity of thrust segment in the Ulsan fault, SE Korea

Kiwoong PARK[1]*, Pukyong National University (pko8108@naver.com)
Sambit Prasanajit Naik[2], Pukyong National University
Young-Seog Kim[3], Pukyong National University

Abstract

Challenging the traditional perception of seismic stability in the Korean Peninsula despite its distance from major plate boundaries, recent moderate earthquakes near the Yangsan and Ulsan faults in the southeastern region, notably the 2016 Mw 5.5 Gyeongju earthquake and the 2017 Mw 5.4 Pohang earthquake, have underscored the imperative of comprehending regional seismic activity, thus prompting heightened interest in paleoseismological research focusing on these fault systems. The Ulsan fault zone, which extends approximately 60 km from Ulsan to Gyeongju city, represents a significant reverse-dominant fault system trending NNW-SSE in the region. Direct evidence of Quaternary reactivation along the Ulsan fault zone remains scarce despite inference from geological mapping, geomorphological features linked to the eastern mountain range uplift, and geophysical surveys, primarily due to extensive sediment cover in urbanized zones. Additionally, the presence of numerous continuous active faults along the mountain front area, situated approximately 4 to 5 km east of the Ulsan fault, not only manifestation ongoing activity in the region but also emphasizes the importance of comprehending the intricate nature of fault development. Therefore, this study aims to comprehensively investigate the Ulsan fault zone by examining both geomorphological thrust segmentation and paleoseismic parameters, such as slip rate and recurrence interval. Furthermore, we propose a systematic method of examining deformation activity of thrust segment in Ulsan fault, integrating kinematic fault behavior, structural characteristics, and geomorphological features of the mountain front. This comprehensive approach seeks to provide a detailed understanding of fault characteristics within the intraplate region.

Keyword

Active fault, Ulsan fault, fault segmentation, Thrust, neotectonics

Long-term patterns of paleo-earthquakes influenced by climate change on the Korean Peninsula

Man-Jae KIM[1]*, Pusan National University (amond0314@pusan.ac.kr)
Moon Son[2], Pusan National University
Hee-Kwon Lee[3], Kangwon National University

Abstract

The periodicity of earthquakes, whether time-dependent or time-independent, has been a focal point in fault research across various tectonic settings. Moreover, recent studies highlight an intriguing connection between climate change and its influence on tectonic activity. In this study, paleo-earthquake records were established by utilizing electron spin resonance (ESR) age data to conduct a statistical analysis of Quaternary fault activity patterns in four fault zones (Keumwang, Wangsukcheon, Yangsan, and Ulsan) on the Korean Peninsula. The primary objective of this analysis is to distinguish between competing models of earthquake periodicity. By employing 454 ESR data, we identified four active paleo-seismic phases for the Keumwang fault zone, four for the Wangsukcheon fault zone, eight for the Yangsan fault zone, and seven for the Ulsan fault zone. The calculated COVs and p-values indicate that the distribution of active paleo-seismic phases within each fault zone shows a quasiperiodic pattern over an extended timeline. Both the Keumwang fault zone (COV: 0.129 ± 0.076; p-value: 0.018) and the Wangsukcheon fault zone (COV: 0.143 ± 0.120; p-value: 0.028) demonstrate quasiperiodic patterns of active paleo-seismic phases. Similarly, the Yangsan fault zone (COV: 0.258 ± 0.106; p-value: 0.005) and the Ulsan fault zone (COV: 0.270 ± 0.121; p-value: 0.012) exhibit quasiperiodic patterns of active paleo-seismic phases. These observed patterns align with a time-dependent earthquake recurrence model, suggesting a regional baseline for fault activity with a periodicity of approximately 100 kyr.

We further correlated the distribution of active paleo-seismic phases from four distinct fault zones with the δ18O record from the LR04 marine benthic stack. This record serves as a reliable proxy for marine isotope stages (MIS), offering insights into the frequency of fault activities within the context of climatic variations. Over the past 650 kyr, the periodicity of active paleo-seismic phases has aligned with the interglacial periods of MIS 15, 13, 11, 9, and 7. On the Korean Peninsula, we hypothesize that long-term differential stress changes, resulting from sea-level rises in the Pacific Ocean, have played a significant role in driving Quaternary fault activities during these interglacial stages. As a result, this study proposes that the ongoing global warming might lead to a potential increase in earthquake frequency on the Korean Peninsula.

Keyword

Fault gouge, ESR dating, Paleo-earthquake, Recurrence patterns, Glacial-interglacial cycle

New Constraints on the Active Tectonics of Gulf of Kuşadası, Western Turkey: Insights from a Comprehensive Offshore Survey

Gülsen Ucarkus[1]*, Istanbul Technical University (ucarkus@itu.edu.tr)
Derman Dondurur[2], Dokuz Eylül University
Denizhan Vardar[3], Istanbul University
Kürşad Kadir Eriş[4], Istanbul Technical University
Semih Ergintav[5], Bogazici University
Devrim Tezcan[6], Middle East Technical University
Neslihan Ocakoğlu[7], Istanbul Technical University
Aslıhan Nasif Dondurur[8], Dokuz Eylül University
Nurettin Yakupoğlu[9], Istanbul Technical University
Figen Eskiköy[10], Bogazici University
Erhan İlkmen[11], TUBİTAK MAM

Abstract

The Western Anatolian Extensional Province features E–W trending graben systems formed under Aegean N–S extension. Tectonics along the Aegean coast of Western Anatolia involve a mix of extension and strike-slip faulting, leading to frequent earthquakes due to seismically active normal faults. The 30 October 2020, Mw 7.0 Samos earthquake ruptured an east–west normal fault located offshore the northern coast of Samos Island, Greece, near the Gulf of Kusadası, Western Turkey. Analysis of the main shock and aftershocks revealed an east-west trending, north-dipping normal fault, with aftershocks exhibiting strike-slip and normal faulting component. However, the unknown continuation of onshore faults from Kuşadası to the Gulf of Kusadası complicates interpretation of the interaction between the ruptured Samos fault and neighboring active faults. To address this, TÜBİTAK organized extensive offshore surveys in 2021 and 2022 to characterize submarine faults in the Gulf of Kusadasi and assess the future earthquake risk of the region. R/V TÜBİTAK Marmara conducted two surveys, collecting bathymetry, CHIRP, and Sparker data to map offshore faults, and recover sediment gravity cores to evaluate submarine paleoseismology. Multi-beam bathymetry and seismic reflection data from the Gulf of Kuşadası show morphologic and sub-bottom traces of numerous normal faults within a deformation zone widening westward. Most of these faults cut the basin fill and the sea bottom with vertical throws ranging from ~7-18 m. Faults mapped within the Gulf of Kuşadası exhibit typical graben and horst structures consistent with the regional extensional tectonics. North of the Gulf, several N-S striking strike-slip faults i.e. Seferihisar and Tuzla Faults extend offshore. However, based on seismic reflection data, these faults appear to dissipate towards the south. Several normal faults are mapped between Samos Island and the southern part of Kuşadası. Interestingly, some of these faults seems to be the extension of unmapped onland faults in Western Turkey.

The Late Pleistocene-Holocene sediment stratigraphy within the Gulf of Kuşadası was analyzed by CHIRP data and multi-parameter analysis of sediment gravity cores. CHIRP data show

evidence of syn-tectonic sedimentation during the Last Glacial Maximum and the later post-glacial transgressive periods that are marked by the prominent reflection surfaces. Correlation of the sediment cores with high-resolution seismic data allow us to calculate vertical throw rates ranging between ~0,5 mm/yr to ~2.2 mm/yr. Multi-parameter analysis based on geochemical and physical proxies of the gravity cores reveal evidence of earthquake triggered mass flow deposits (seismo-turbidites). The gravity cores also yield sedimentary evidence of the 2020 Mw 7.0 Samos earthquake, along with records of past seismic events dating back to 2500 yrs BP, 3700 yrs BP, 4300 yrs BP.

There is ongoing aftershock activity along the Samos Earthquake rupture zone and neighboring extensional faults controlling the Gulf of Kuşadası, which overlaps with 20 years of persistent earthquake activity. Following the 2020 earthquake, triggering events (Mw>4) were observed both in the Ikeria basin and in the eastern part of the Gulf of Kuşadası. This activity pattern, together with the dataset obtained during the surveys, suggest potential seismic risk for future earthquakes within this region.

Keyword

Western Anatolia, Extensional Tectonics, Submarine Paleoseismology, Gulf of Kuşadası, Samos Earthquake

Decoding Paleostress Conditions from the Morphology of Quaternary Volcanic Craters along the Western Branch of the East African Rift System: Implications for Volcanic Hazard Assessment

Francois HATEGEKIMANA[1]*, Pukyong National University, Department of Earth and Environmental Sciences, Geological and Geo-Hazard Research Lab (francoishate@pukyong.ac.kr)
Sambit Prasanajit Naik[2], Active Fault and Earthquake Hazard Mitigation Research Institute, Pukyong National University, Busan, Republic of Korea
Digne Edmond Rwatangabo Rwabuhungu[3], University of Rwanda, College of Science and Technology, School of Mining and Geology
Theophile Mugerwa[4], University of Rwanda, College of Science and Technology, School of Mining and Geology
Young-Seog Kim[5], Pukyong National University, Department of Earth and Environmental Sciences, Geological and Geo-Hazard Research Lab

Abstract

Volcanic hazard assessment has been extensively studied all over the world by considering active volcanoes, but little concern was given to the dormant volcanoes. However, these dormant volcanoes can be reactivated by stress changes as well as fluid pressure in the substrate. Therefore, the analysis of fracture patterns and stress conditions is crucial for determining the possibility of the occurrence of volcanic eruption in the area. The study of volcanic morphology has revealed its importance in understanding subsurface fractures, substrate stress, and volcano-tectonic processes within the area. The change in substrate stress greatly controls the opening of fractures and thus affects the activity of volcanoes and earthquakes in the region. This study focuses on discerning the volcanic activity dependencies on the orientation of stress within the Kivu Rift, the western branch of the East African Rift. Several parameters, such as ellipticity, crater diameter, breaching azimuth, and volcanic cone alignment, were measured on 150 volcanoes within the Virunga Volcanic Complex. An intriguing pattern emerges, highlighting that volcanoes, such as Nyiragongo and Nyamuragira aligned along the N-S-striking faults, exhibit active behavior, correlating with the prevalent regional extensional stress directed in the E-W orientation. In contrast, most of the volcanoes following E-W, NE, and NW trends portray dormant characteristics, possibly related to the rotation of the extensional stress in the area. This study underscores the critical interplay between structural factors and volcanic activity, suggesting a potential predictive model for volcanic hazards based on stress orientation. Furthermore, it could offer significant implications to their potential reactivation with stress change for volcanic hazard assessment and proactive risk management strategies in the Kivu Rift region especially in countries such as Rwanda, the Democratic Republic of Congo, and Uganda.

Keyword

volcanic morphology, stress, Kivu Rift, East African Rift, hazard

Intracrystalline deformation may explain the recurrence of small-magnitude tremors in an intraplate region- A case study from the Koyna-Warna Seismogenic Region, Western India

PIYAL HALDER[1]*, Birbal Sahni Institute of Palaeosciences (DST, Govt. of India), Lucknow-226007, Uttar Pradesh, India; Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India (piyalhalder.org@gmail.com)
MATSYENDRA KUMAR SHUKLA[2], Govt. of India, Ministry of Earth Sciences (MoES), Borehole Geophysics Research Laboratory (BGRL), Karad-415105, India
KAMLESH KUMAR[3], Birbal Sahni Institute of Palaeosciences (DST, Govt. of India), Lucknow-226007, Uttar Pradesh, India; Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India
ANUPAM SHARMA[4], Birbal Sahni Institute of Palaeosciences (DST, Govt. of India), Lucknow-226007, Uttar Pradesh, India; Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India

Abstract

At Shallow crustal depths, crystals compensate for strain through brittle deformation; however, as depth increases, the grain scale deformation mechanism turns into ductile through the migration of lattice defects. Even though these dislocations may not be observed under an optical microscope, other microscopic features like twinning, kinking etc. may indicate their effects in a crystal lattice. In addition to the primary constituent minerals such as quartz, and feldspar, the secondarily formed clay minerals may also accommodate strain in such a manner which can have control over the recurrence and magnitude of the earthquakes. The subsurface faults (0.9 to 3 km depth) in the granitoid basement rocks of the Koyna-Warna intraplate Seismogenic Region in Western India are highly stressed due to the combined action of the plate tectonic forces transmitted from the boundaries and impoundment of the reservoirs. The major elemental geochemistry on the core samples collected from 0.9 to 3 km depths, as a part of the Continental Scientific Drilling Program, suggests that fluid percolated through the permeable faults and interconnected fractures has caused the fluid interaction with primary constituent minerals like biotite and plagioclase and resulted in the formation of several secondary minerals with a predominance of chlorite which the XRD studies have also reaffirmed. In addition, the in-depth petrologic investigation has revealed kinking in the neoformed chlorites which demonstrates the intracrystalline ductile deformation in response to immense stress. Actually, the talc-like T-O-T sheets and brucite-like octahedral sheets that make up the chlorite crystal are bonded together by weak hydrogen bonds. Stress buildup in the fault zones causes the shortening of the hydrogen bonds which makes it stronger. Hence, in order to accommodate strain, the chlorite crystal forms a number of atomic scale ripples on its basal plane. Later, the bonds become weaker owing to the bond angle reduction when the imposed stress reaches a threshold. However, the bonds are not broken, as the small-scale ripples formed earlier begin to migrate with the energy gained and merge into kink bands. Thus, the yield strength of chlorite increases with an increase in stress keeping the hydrogen bonds intact which makes its crystal capable of withstanding most of the stress, through visco-elastic intracrystalline

deformation. This type of ripplocations mechanism brought on by chlorite is far more favourable for fault creep, which could be a cause of recurrence of small magnitude earthquakes rather than a large and destructive one, as also seen over the past 50 years in the Koyna-Warna Seismogenic region.

Keyword

Chlorite, Kinking, Ripplocations, Hydrogen bonds, Creep

Earthquake Geology of the Mogod Fault, Mongolia

Hankyung Bae[1], Korea Institute of Geoscience and Mineral Resources
Jin-Hyuck CHOI[2]*, Korea Institute of Geoscience and Mineral Resources (cjh9521@kigam.re.kr)
Dong-Eun Kim[3], Korea Institute of Geoscience and Mineral Resources

Abstract

The 1967 Mw 7.0 Mogod earthquake is the largest earthquake in the central Mongolia, one of the slow-deforming yet active regions. The earthquake rupture occurred on the complex fault system composed on the strike-slip and reverse-slip dominant inherited geologic structures. Here, together with rupture mapping using high-resolution satellite/drone images, we conduct geological surveys and geophysical explorations to understand the segment geometry of the fault system and its roles on rupture behaviors. As results, the ~47-km-long ruptures used five fault geometric segments; four strike-slip segments and one reverse-slip segments, as the pathway of the rupture propagation. We estimate an average horizontal slip of 1.9 ± 1.4 m and a vertical component of ~0.7 m from the 1967 event, and cumulative offsets larger than a few meters suggesting multiple seismic events. We test the rupture history for each fault segment by paleoseismological excavations. The results imply that strike-slip segments have ruptured more with a shorter recurrence time rather than the reverse-slip segments. This suggests that the 1967 earthquake was unusually large in scale. Also, we estimate the long-term slip-rate based on 3D trench survey and a grand cumulative offset aged by cosmogenic dating. Along-fault complexity of rupture geometry, variations in offset and rupture history imply that rupture behaviors and recurrence are strongly controlled by inherited fault structure.

Keyword

earthquake, fault segment, inherited structure, Mogod

Paleoseismic event timing and surface rupture scenarios on the Yangsan Fault, SE Korea

Taehyung KIM[1]*, Korea Institute of Geoscience and Mineral Resources (adrian0305@kigam.re.kr)
Jin-Hyuck CHOI[2], Korea Institute of Geoscience and Mineral Resources

Abstract

Understanding the spatiotemporal behavior of faults from a seismic hazard assessment perspective is crucial. However, deriving paleoseismic information in regions with slow deformation, such as intraplate areas, is challenging. This study synthesizes the results of multiple trench surveys conducted on a section of the Yangsan Fault (YF) within the intraplate environment, presenting paleoseismic surface rupture scenarios. These are discussed in conjunction with previous studies. The YF, having undergone multiple deformations since the Cretaceous, has developed over 200 km as a long-lived fault. In the current tectonic stress environment, it is an active dextral strike-slip fault. This fault merges with the large reverse Ulsan Fault (UF) in a NW-SE direction near Gyeongju City, delineating the northern Yangsan Fault (NYF) and Southern Yangsan Fault (SYF). Paleoseismic trench surveys conducted over approximately 10 km of the SYF suggest that the most recent earthquake (MRE) occurred between 28-16 ka. Penultimate seismic events took place between 39-35 ka, with earlier ones occurring between 74-49 ka. The trench-derived paleoseismic records indicate two possible scenarios: (1) a complete rupture across the entire studied segment during each seismic event, or (2) multiple partial ruptures affecting the two structurally distinct parts of the studied fault segment, namely the Wolsan–Miho and Inbo north–Inbo sections. While the NYF and UF indicate MRE in the Holocene, the SYF may not have experienced a paleoearthquake during this period. However, this suggests the possibility of undiscovered paleoseismic records at these locations, necessitating further investigation.

Keyword

Intraplate, Yangsan Fault, Rupture scenario, Paleoseismology, Trench survey

The silent and slow active faults of Germany: results from paleoseismological trenching

Klaus REICHERTER[1]*, RWTH Aachen University, Inst. of Neotectonics and Natural Hazards (k.reicherter@nug.rwth-aachen.de)

Abstract

The phenomenon of silent and slow faults presents a particularly intriguing challenge in the study of active tectonics, especially in regions classified as Stable Continental Regions (SCR) or Active Intraplate Regions (AIR), such as Central Europe. The term "silent faults" encompasses various meanings, either indicating a lack of seismic activity, absence of faulting that generates earthquakes (though possibly exhibiting creep), or referring to faults with minimal geomorphic and geological visibility.

Slow active faults typically exhibit slip rates of ≤ 0.1 mm/yr, often lacking significant topographic features in regions with humid to moderate climates. The slip rate of a fault is a critical parameter governing earthquake occurrence and seismic hazard, with decreasing slip rates extending the average recurrence intervals of earthquakes of a particular magnitude. Consequently, earthquakes on low slip-rate faults are frequently absent from historical records and standard seismic hazard assessments due to their lengthy recurrence intervals.

New fault data from several AIR, specifically the Rhine Graben rifts, and SCR regions in Germany, particularly the Lower and Upper Rhine Grabens, are presented based on seismological, geophysical, and trenching investigations. Holocene surface rupturing events are uncommon, with recurrence intervals typically spanning 1,000-10,000 years, and associated slip rates remaining below 0.5 mm/yr, or even ≤ 0.1 mm/yr. While secondary earthquake effects are observed more widely, some faults exhibit distinct linear scarps and topographic features, as evidenced by highresolution Digital Elevation Models (DEMs) and field surveys.

The preservation of minor scarps in agricultural areas poses an enigma, with scarps as low as approximately 50 cm from a single event being preserved for 1,000-10,000 years. However, recurring paleo-earthquakes are documented in surface deposits, as demonstrated by trenching in the Upper Rhine Graben. Geodetic techniques such as GPS and Differential Synthetic Aperture Radar Interferometry (DInSAR) offer means for detecting silent faults, although signals may be influenced by factors such as groundwater extraction and vegetation. Moreover, some normal faults in the Lower Rhine Graben exhibit evidence of "Clustering and Quiescence" earthquake occurrence, potentially explaining the persistence of scarps over time and contrasting the "One Shot" hypothesis sometimes proposed for SCR faults.

The integration of high-resolution geodetic techniques with classical paleoseismological

investigations offers a promising approach for uncovering the history of silent and slow faults. Despite challenges posed by environmental factors, these methods hold potential for enhancing our understanding of fault activity in such regions.

Keyword

intraplate tectonics, trenching, slow deformation

The Evaluation and Morphometric analysis of Active Tectonics in Zagros Folded Belt (ZSFB), West of Iran

Reza Mansouri[1], Department of Physical Geography, Faculty of Geography and Environmental Planning, University of Sistan and Baluchestan, Zahedan, 98167-45845, Iran
SAMBIT PRASANAJIT NAIK[2]*, PUKYONG NATIONAL UNIVERSITY (sambitnaik@gmail.com)
Swakangkha Ghosh[3], NIIT University, NH-8, Neemrana, Rajasthan, India

Abstract

Geomorphic indices are useful tools in the evaluation of active tectonics because they can provide rapid insight concerning specific areas within a region that is undergoing adjustment to relatively rapid, and even slow, rates of active tectonics. Thus, Tectonic geomorphology, due to its rapid, low-cost, and easy-to-perform techniques, can be an excellent tool to improve the understanding of the development of fold belts such as the Zagros that contain some 49% of the global fold and thrust belt-related hydrocarbons. Zagros orogenic belt is one of the best examples of active orogeny in the world, arising from deformation caused by Neogene continental collision between the Arabian and Eurasian plates. The study area is geographically located in the west of Iran and geologically in the northwestern part of the Zagros Simply Folded Belt (ZSFB). The aim of this study is the assessment of active tectonics and neotectonics movements in three selected anticlines in west of Iran (north of Ilam province) using Geomorphic indices, GIS, RS, and fieldworks. Morphometric analysis in this study involve 8 geomorphic indices such as: Mountain front facet (FMF), Mountain front sinuosity (SMF), Aspect Ratio (AR), Ratio of Valley Floor Width to Valley Height (VF), Fold Front Sinuosity (FFS), Fold Symmetry Index (FSI), Percentage undissected escarpments (EU), Percentage dissected mountain fronts (FD). These Morphometric indices were integrated together to obtain the Relative Tectonic Activity Index (Iat) using the GIS and RS approach. These three anticlines are: Bayeh, Bankoul and Keteh Pifak anticlines, that are stretched parallel with the main direction of the Zagros folded belt from northwest-southeast. The pressure direction of the Arabian plate in the study area is N30-40E. In terms of structural geomorphology, the general landscape of the study area has anticline-syncline structures. The morphometric features of these anticlines were determined using topographical and geological maps, Landsat 9 and Sentinel 2 satellite imageries, Google Earth, DEM 12.5 m, GIS and RS and several fieldworks. The findings obtained for the investigated indices in these anticlines showed that the structure of them is young and the neotectonics movements are still continuing; Therefore, they are in an active state in terms of tectonics. The high values of the FMF, EU, AR indices and the low values of the FD, VF, FFS, FSI, SMF indices show the young and asymmetry of the anticlines, the continuation of the effect of neotectonics movements and uplifting, and less erosion in them. In addition to the calculated quantitative values for these indices, the geomorphological evidences in the study area including straight and faulted mountain fronts, faulted escarpments, V-shaped valleys, asymmetric fold, larger triangular facets with longer base length, shorter and steeper limb, more Percentage Undissected Escarpments and lesser Percentage Dissected

Mountain Fronts in the southwest limb, indicates the more active tectonic condition in this section compared to the northeast limb of the anticlines. The output of this study shows the importance of using several datasets with different origins and their overlay in a GIS platform for evaluating the neotectonics activities in these anticlines or elsewhere.

Keyword

Active Tectonics, Zagros Simply Folded Belt (ZSFB), Anticline, Geomorphic Indices, Geomorphological Evidences

Numerical modelling of tectonic stress and deformation of the Andaman Subduction Zone

Radheshyam YADAV[1]*, CSIR-National Geophysical Research Institute, Hyderabad (shamgpbhu@gmail.com)
Virendra M Tiwari[2], CSIR – National Geophysical Research Institute, Hyderabad, India

Abstract

The Sumatra-Andaman subducting zone evolved from the Indo-Australian plate's oblique subduction beneath the Eurasian overriding plate. Due to oblique subduction, variations of age and convergence velocities of Indo-Australian make the Andaman subduction zone complex and active seismic region. Therefore, a three-dimensional (3D) numerical simulation model of the Andaman subduction region (88 to 980E & 5 to 140N) was developed to investigate the tectonic process and model parameters which were mainly responsible for the observed surface deformation and stress in the interaction boundary of the subducting and overriding plate. The geometry of the numerical simulation model was derived from the 3D density model that was derived from the joint modelling of satellite free air anomalies and geoid undulation with accessible other geophysical and geological constraints. The boundary condition is taken from the plate velocity of the subducting plate and material properties from the seismic velocities and density. The results (stress, strain and velocities) are calculated for different rheologies (elastic and viscous). The calculated velocities of the numerical simulation model show a good correlation with the observed Global Positioning System (GPS) velocity component (East-West and North-South). The stress of this FEM is fit with the hypocenter of the earthquakes at the interaction of the subducting and overriding.

Keyword

Andaman, Subduction, Stress, Abaqus, Seismicity

The Eastern English Channel (North of France) : Some examples of intraplate tectonics and seismicity

Virginie GAULLIER[1]*, LOG - Université de Lille - France (virginie.gaullier@univ-lille.fr)
Olivier AVERBUCH[2], LOG - Université de Lille
Aboubacar DIBOUSSE[3], LOG - Université de Lille
François Guillaume SCHMITT[4], LOG - Université de Lille

Abstract

The Eastern English Channel, between SE of England and the French coast, is a complex domain, resulting from the major tectonic deformations that affected the West European margin at the Late Jurassic-Early Cretaceous (extension and subsidence due to the propagation of the opening of the North Atlantic Ocean) and during the Cenozoic (compression causing the inversion of basins linked to the African-Eurasian convergence). Both extensional and compressional deformations involve the reactivation of older major regional structures, inherited from the Variscan Orogeny. However, the detailed structural development of this domain still remains poorly constrained, as well as the detailed stratigraphic framework of Cenozoic series, notably in terms of sequence stratigraphy. Since 2014, an intensive exploration has been carried out to acquire approximatively 4500 km of very high-resolution seismic data (Sparker) during several oceanographic cruises (TREMOR 1, 2014; TREMOR 2, 2017, GEOBAS 2016-2023; MARCOPALE, 2023), onboard the R/V “Côtes de la Manche”, “ANTEA” and “SEPIA II”. The interpretation of these new data allowed to precisely map many tectonic features, as faults, folds and monoclinal flexures, especially in the Dieppe-Hampshire Basin. We especially imaged the complexity of the deformation within the highest tectonized zones of the region, along the North-Bay of Seine Basin and offshore the Boulonnais coast with an unprecedented resolution. This deformation pattern illustrates two major structural trends, respectively E-W and NW-SE directed, both syn- to post-Bartonian in age. The first one is consistent in age and orientation with a late Pyrenean or early Alpine de-formation phase, while the second one appears to have a different origin, in regards to the overall geodynamic framework. We suggest that the major heterogeneities of crustal blocks underlying the basin played an important role on the development and orientations of these deformations. In the framework of these offshore works, we undertaken onshore study, along the Boulonnais coast, especially in front of the Dover Strait. Gris-Nez Cape is one of the most striking features of the fault system bordering the inverted Weald-Boulonnais basin. The Sirène beach, which has been heavily cleared of sand over the past 20 years, reveals the complexity of the folded and faulted geological structures. Over the last few years, detailed structural surveys have been carried out onshore, using GNSS layer-to-layer mapping. This mapping has been recently completed by photogrammetric surveys by drone at very high spatial resolution (5 cm) allowing to obtain an ortho-mosaic and a digital terrain model of the foreshore and cliffs of Cape Gris Nez. The interpretation of these very high-resolution images leads to a better understanding of the geometry and kinematics of the deformations of this complex area. Since the Eastern English

Channel is affected by a moderate but regular seismicity (up to 5-6 in magnitude) et considering the presence of numerous human infrastructures such as Seveso sites, nuclear power plants and the Channel Tunnel, we aim to characterize the fault pattern in order to better define the alea and therefore the seismic risk.

Keyword

Eastern English Channel, Faults, Seismicity, earthquakes, sparker

A study on petrofabrics of garnet in calc-silicate rocks in the Yeongnam Massif, South Korea

Seokyoung HAN[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea (hs04111@snu.ac.kr)
Ji-Hoon KANG[2], Department of Earth and Environmental Sciences, Andong National University, Andong, Republic of Korea
Haemyeong JUNG[3], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea

Abstract

Garnet, a prevalent mineral in metamorphic rocks, is found across various lithologies within the continental basement, subducted crustal slab, and upper mantle. Quartz is also an important constituent mineral which occurs widely in most rock types in both upper and middle crust. Understanding the deformation mechanism of quartz and garnet in nature is essential, as they potentially influence rheological properties of rocks forming major tectonic structures. The Cheongsong area in South Korea is the region where Precambrian gneiss and Paleozoic calc-silicate rock, gneiss, and amphibolite are exposed. These metamorphic complexes are situated close to the granite suites associated with the Permo-Triassic tectonic event, and structures formed in several stages of ductile and brittle deformations, and intrusion of felsic dykes are preserved in outcrops. It is expected that petrofabric analysis of deformed garnet, along with highly deformed and recrystallized quartz, can contribute to understanding the deformation conditions of garnet and quartz. For this purpose, samples of calc-silicate rocks and metasedimentary rocks in the Cheongsong area were collected and the lattice-preferred orientations (LPOs) of constituent minerals were analyzed using the electron backscattered diffraction (EBSD) technique. The analyzed samples consist mainly of quartz and feldspar, with minerals formed by contact metamorphism such as garnet, wollastonite, and diopside, as well as minor titanite, apatite, prehnite, and pumpellyite. Our EBSD data of samples for the c-axis distribution of totally recrystallized quartz showed an activation of prism<c> slip system of quartz, indicating the deformation of quartz at high temperature. In the EBSD maps (grain reference orientation deviation) of these samples, garnet showed deformation microstructures indicating plastic deformation by dislocation creep. Based on plastic deformation of garnet and large c-axis opening angle of quartz LPO, it is inferred that the deformation temperature of the calc-silicate rock was relatively high (above 600 ℃). Additionally, four-grain junctions in the other area of sample were observed in the clusters of small garnet grains, indicating grain boundary sliding of garnet.

Keyword

EBSD, microstructure, garnet, quartz, deformation

Preliminary results of the deformation texture of diopside in serpentinite

Jungjin LEE[1]*, Seoul National University, Seoul, Republic of Korea (ljj2718@snu.ac.kr)
Haemyeong Jung[2], Seoul National University, Seoul, Republic of Korea

Abstract

Seismic anisotropy has been ubiquitously observed in worldwide subduction zones, and the strong crystallographic preferred orientation (CPO) of composite minerals in subduction-related rocks, especially serpentinites in hydrated forearc mantle, has been regarded to strongly influence the seismic anisotropy in subduction zones. Diopside is an important pyroxene group mineral present in serpentinites. However, the CPO of diopside and its deformation mechanism in serpentinites are poorly understood. In this study, a new CPO type of diopside was observed in diopside aggregates in the foliated serpentinites from Monte San Petrone in Alpine Corsica (France). CPOs of diopside and antigorite were analyzed using the SEM-EBSD technique. The diopside CPOs showed a strong alignment of the (100) poles subnormal to the foliation and a girdle distribution of [010] and [001] axes subparallel to the foliation, which have been rarely reported in previous studies. The antigorite CPOs showed strong maxima of the (001) poles subnormal to the foliation and a girdle of [100] and [010] axes subparallel to the foliation. Seismic anisotropies induced by the new CPO type of diopside were also calculated. The results indicate that the new CPO of diopside influences trench-normal seismic anisotropy of S-wave, lower Vp/Vs ratios, and negative radial anisotropy in anhydrous portion of subducting lithosphere. Future research is needed to understand the effect of the diopside CPO on the formation of the CPOs of other major minerals in subduction zones.

Keyword

diopside, antigorite, serpentinite, CPO, subduction zone

Seismic anisotropy of slaty rocks: Unveiling the effect of the CPO on seismic properties

Victor CARDENES[1]*, Department of Geology, University of Oviedo (cardenesvictor@uniovi.es)
Marco A. López-Sanchez[2], University of Oviedo
Sergio LLana-Fúnez[3], University of Oviedo

Abstract

Slaty rocks form a group belonging to the greenschist facies which have in common a deep and penetrative structure formed by the alignment of mica minerals, the slaty cleavage. There are four rocks displaying different degrees of this structure: metapelites, slates, phyllites and mica-schists. These rocks are also a major component of the continental crust and sedimentary basins, playing a crucial role in seismic-wave propagation and fluid flow within the middle and upper continental crust. Their pronounced seismic anisotropy and low permeability make them particularly significant. Despite their volumetric significance, most seismic property studies on phyllosilicate-rich rocks have been predominantly focused on shales, a sedimentary rock displaying an incipient slaty cleavage, driven by their economic relevance in the petroleum industry. This has led to a notable imbalance in the research conducted on the seismic properties of shales compared to slaty rocks, and it remains unclear whether the seismic properties of shale can be directly extrapolated to metamorphic rocks. We aim to address this gap by establishing the average and variance of seismic properties of slaty rocks with different degrees of metamorphism. We have used state-of-the-art Voigt-Reuss-Hill (VRH) averaging schemes based on wide-coverage Electron Backscatter Diffraction (EBSD) maps. Our data allows us to discuss the validity of different models of polar seismic anisotropy in slaty rocks and identify cases where these models break down. We also explore whether mica content and Crystallographic Preferred Orientation (CPO) intensity are reliable predictors of seismic properties

Keyword

slate, Cristallographic Preferred Orientation CPO, seismic anisotropy

Deformation microstructures and seismic anisotropy of Yeoncheon amphibolites in the Imjingang Belt, South Korea

Sejin JUNG[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul (shazabi7@snu.ac.kr)
Junha Kim[2], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea
Haemyeong Jung[3], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea

Abstract

The Imjingang Belt preserved the deformation and metamorphism of rocks related to the Permo-Triassic continental collision between the North and South China Cratons. To understand the microstructural evolution of amphibolites, microstructures of amphiboles in Yeoncheon amphibolites and psammitic schists were analyzed using electron back-scattered diffraction mapping and transmission electron microscopy. Two different types of lattice preferred orientations (LPOs) of amphibole were observed: type-II and type-IV. The subgrain boundaries of amphibole, misorientation axes distribution of amphibole, and existence of relict clinopyroxenes inside the amphibole indicate that the type-IV LPO of amphibole resulted from deformation by dislocation creep and topotactic growth of amphibole. Type-IV LPOs of amphibole can be interpreted as a fabric developed at the peak metamorphic condition. The low-angle boundaries of amphibole associated with cracks and fractures in some samples indicate that type-II LPO of amphibole resulted from cataclastic flow associated with rigid body rotation during retrogression. The seismic velocity and anisotropy of the Yeoncheon amphibolites showed that the seismic anisotropy of the amphibolites followed that of the amphibole. Seismic anisotropy of the amphibolites with the type-IV LPO of amphibole was significantly weaker than that of the amphibolites with the type-II LPO, suggesting that the fabric transition from type-IV to type-II LPO of amphibole may significantly strengthen the seismic anisotropy of the amphibolite.

Keyword

Yeoncheon amphibolite, microsctructure, lattice preferred orientation, deformation mechanism, seismic anisotropy

Chlorite dehydration in chlorite peridotite and implications for intermediate-depth earthquakes in subducting slabs

Haemyeong JUNG[1]*, Seoul National University (hjung@snu.ac.kr)
Dohyun KIM[2], Seoul National University
jungjin LEE[3], Seoul National University

Abstract

Intermediate-depth earthquakes are common in the double seismic structures of many subduction zones under high pressures (~1–4 GPa). Serpentine dehydration exhibits well-established links with double seismic zone earthquakes. Additionally, dehydration of several hydrous minerals including lawsonite and chlorite underlying the upper and lower layers, respectively, may be responsible for intermediate-depth earthquakes. Chlorite exhibits a wide stability range in subduction zones under high P-T conditions. Chlorite peridotite is stable in the lower layer of double seismic zones. Based on previous laboratory experiments and seismicity correlation studies, researchers have inferred that seismicity in the lower plane of double seismic zones could be linked to the dehydration of hydrous minerals, including serpentine and chlorite. Here, we present experimental evidence suggesting that chlorite dehydration can trigger intermediate-depth earthquakes at the lower plane (~700 °C). We conducted deformation experiments on chlorite peridotite under high-pressure (0.5–2.5 GPa) and high-temperature (500–750 °C) using a modified Griggs apparatus. Experiments revealed the presence of faults in samples that had undergone partial chlorite dehydration with the presence of the dehydration product Ca-amphibole along these faults. Our findings confirm, together with correlation studies between seismicity and mineral stability, that a part of intermediate-depth seismicity in the lower plane of double seismic zones can be attributed to chlorite dehydration.

Keyword

Chlorite, Dehydration embrittlement, Intermediate-depth earthquakes, Subduction zone, Seismicity

Lattice-preferred orientations of glaucophane, zoisite, and epidote in zoisite-epidote blueschist from Río San Juan metamorphic complex, Dominican Republic

Yong PARK[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, Republic of Korea (dark2444@snu.ac.kr)
Seungsoon CHOI[2], Research Center for Geochronology & Isotope Analysis, Korea Basic Science Institute, Cheongju 28119, Republic of Korea
Seokyeong HAN[3], School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, Republic of Korea
Haemyeong JUNG[4], School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, Republic of Korea

Abstract

To understand deformation mechanisms and developments of lattice-preferred orientation (LPO) of minerals in the subducted oceanic crust, deformation microstructures of naturally deformed zoisite-epidote blueschists (high pressure metabasites) from Río San Juan metamorphic complex in Dominican Republic were studied. LPOs of minerals were determined using the electron backscattered diffraction (EBSD) technique, and intracrystalline deformation microstructures were observed by high-resolution EBSD mapping. The LPOs of amphiboles (glaucophane and barroisite) mostly showed that the [001] axes were aligned subparallel to the lineation and the [100] axes were aligned subnormal to the foliation. The LPOs of zoisites showed that the [010] axes were aligned parallel to the lineation and both [100] and [001] axes were distributed in a weak girdle shape perpendicular to the lineation with clusters aligned normal to the foliation. The LPOs of epidotes mostly showed that the (010) poles were aligned subparallel to the lineation with girdle distribution parallel to the foliation and the [100] axes and/or [001] axes were aligned subnormal to the foliation. The misorientation less than 1º along the chemical composition boundary between sodic (glaucophane) to sodic-calcic (barroisite) amphibole in a single grain suggests that the transition of the chemical composition can moderately affect the tilting of the crystal lattice. However, the dominant misorientation lines, independent of the chemical transition boundary, suggest that the main development mechanism of the LPO of amphibole is likely to be a deformation in dislocation creep. The high density of subgrain boundaries and high grain reference orientation deviation (GROD) angles in zoisite porphyroclasts suggest that they were deformed by dislocation creep and developed LPO with strong fabric strength. The small amount of subgrain boundaries, weak fabric strength, and low grain orientation spread (GOS) values of epidote aggregates, which are regarded as the porphyroclastic lawsonite pseudomorph, suggest that LPO of epidote in aggregates might not have been developed by the recrystallization of epidote porphyroclast in dislocation creep. Instead, the LPO of epidote in these aggregates is likely to be developed through the metamorphic transition from lawsonite to epidote, following the pre-existing subgrain boundaries of the lawsonite porphyroclast. These results suggest that although the subducted oceanic crust metamorphosed under similar blueschist-facies condition,

main deformation mechanism, which develops the LPO of the constituent minerals, can vary due to the rheological heterogeneity among these minerals.

Keyword

Zoisite-Epidote Blueschist, Lattice Preferred Orientation, Glaucophane, Dislocation Creep, Electron Backscattered Diffraction

All six typical olivine CPO types discovered in single research area and its seismic implications

Yilun Shao[1]*, Jilin University (ylshao@jlu.edu.cn)
Marianne Negrini[2], 2Department of Geology, University of Otago, Dunedin 9054, New Zealand
Cai Liu[3], 1College of Geoexploration Science and Technology, Jilin University, Changchun 130026, China
Rui Gao[4], 3School of Earth Science and Engineering, Sun Yat-Sen University, Guangzhou 510275, China

Abstract

Generally, olivine exhibits six primary crystallographic preferred orientation (CPO) types (i.e., A-E and AG-type). It has long been believed that these fabrics arise from various environmental conditions, such as different pressure, temperature, water content, stress, and the presence of second phases. Conversely, mantle undergoes multiple deformation events may exists multiple types of olivine CPO, often associated with grain size reduction. In the Red Hills Massif (part of the Dun Mountain Ophiolite Belt) in northern South Island, New Zealand, all six olivine CPO types have been discovered within a 1 km square research area, exhibiting similar coarse-grained textures. This unique occurrence suggests that the latest simple shear, in conjunction with the presence of second phases (orthopyroxene or spinel) and hydrous environment, has contributed to these deformation characteristics. Given that seismic velocities and anisotropies in the mantle correlate with olivine CPO, it is plausible that the dominance of olivine B/C/E-types could result in weakened seismic properties. Furthermore, the direction of SKS splitting is also influenced by olivine CPO. For instance, if B-type olivine CPO were predominant, the actual direction of mantle flow would be normal to the SKS direction. Consequently, seismic data may exhibit ambiguities under microstructural view. The discovery of all six typical olivine CPO types further exacerbates the potential ambiguities within the natural mantle. To improve our understanding of mantle flow processes, it is crucial to conduct detailed research on olivine CPO data alongside related seismic data. This interdisciplinary approach is essential for better comprehending the complexities of mantle geodynamics and seismic behavior.

Keyword

Olivine CPO, Deformation mechanismss, Seismic properties

Differential Stress Affecting Preservation of Intergranular Coesite in UHP Rocks from the Dabie Shan: Ultra-microstructure Insights from TEM

Jinyu ZHENG[1]*, School of Earth Sciences, Chinua University of Geosciences (gemfisher@cug.edu.cn)
Tao CHEN[2], Gemmological Institute, State Key Laboratory of Geological Process and Mineral Resource, China University of Geosciences
Junfeng ZHANG[3], School of Earth Sciences, State Key Laboratory of Geological Process and Mineral Resource, China University of Geosciences
Wenlong LIU[4], School of Earth Sciences, State Key Laboratory of Geological Process and Mineral Resource, China University of Geosciences
Feng SHI[5], School of Earth Sciences, State Key Laboratory of Geological Process and Mineral Resource, China University of Geosciences

Abstract

Coesite is a key indicator mineral in ultrahigh-pressure (UHP) metamorphic rocks. The local “dry” environment provides an explanation for the preservation of intergranular coesite during continental exhumation from the reaction kinetics. However, the deformation behaviors of coesite and surrounding minerals at the ultra-microstructural scale remains poorly understood. In this study, electron backscatter diffraction (EBSD), focus ion beam (FIB), and transmission electron microscopy (TEM) techniques were used to investigate the ultra-microstructure of intergranular coesite and surrounding minerals in a metasedimentary rock from the Ganjialing area of the Dabie Shan region, China. Our findings reveal that coesite exhibits no intracrystalline deformation or dislocation. In contrast, dolomite and apatite adjacent to coesite exhibit much higher density of dislocation compared to those away from coesite. Furthermore, retrograde palisade quartz rimming the coesite displays high dislocation density and tangles. The calculated differential stress based on the free dislocation density indicating that the palisade quartz underwent high differential stress. Dolomite and apatite form a closed system that encloses the coesite, while the palisade quartz is strengthened through work-hardening induced by dislocations, forming a protective buffer crust around the coesite. This closed system acts as an excellent container, preserving the differential stress recorded by the palisade quartz during the survival of coesite. The required pressure for coesite to back-transform into quartz is reduced under differential stress conditions, enabling the preservation of coesite under lower lithostatic pressures during the exhumation of deeply subducted continental. The observations of the ultra-microstructure confirm the presence of differential stress in the surrounding minerals, highlighting its crucial role in the preservation of intergranular coesite. The study of differential stress may serve as a suitable approach for investigating the formation and preservation environments of other UHP minerals, providing valuable insights into the processes involved in the exhumation of deeply subducted continental crust.

Keyword

intergranular coesite, differential stress, deformation, dislocation, Ganjialing area, Dabie Shan

Intracrystalline deformation microstructures in natural olivine with implications for stress estimation

Jian MA[1]*, State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences, China University of Geosciences (wjmajian@gmail.com)
Wenlong Liu[2], State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences, China University of Geosciences
Yi Cao[3], State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences, China University of Geosciences
Junfeng Zhang[4], State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences, China University of Geosciences
Chuanzhou Liu[5], Laoshan Laboratory, Qingdao, China

Abstract

Constraining the stress related to lithospheric deformation in natural rocks is key to develop and test a geodynamic model. However, the cautions of extrapolating piezometers that are established on experimental samples to natural rocks are less addressed. In this study, we investigated the microstructures of a natural harzburgite sample using the electron backscatter diffraction (EBSD) technique. The geometries of subgrain boundaries (SGBs) unveiled a preponderance of (010)[100] and {0kl}[100] dislocation slip systems in olivines. More importantly, multiple low-angle misorientation boundaries (LAMBs) variants are recognized for the first time in olivine based on their distinctive characteristics with the change of EBSD mapping step size. The LAMBs that exist at a small step size (≤ 1 μm) are mostly equivalent to real SGBs, while other LAMBs that appear only when the step size is larger (> 1 μm) are artificial SGBs. Besides, the former develop mainly in the high LAMB density grains, whereas the latter are mostly found in the low LAMB density grains. This revelation corroborates the prevailing understanding that stress calculations derived from subgrain-related piezometers are meaningful only when authentic SGBs are captured at sufficiently minuscule step sizes. Furthermore, we provide a proof of concept that SGB density and kernel average misorientation (KAM) are two viable metrics to estimate stress. These two alternative piezometers, which still need calibrations using the experimentally deformed samples, are anticipated to have wide applications in natural rocks.

Keyword

piezometer, stress, subgrain boundary, subgrain size, olivine

PROGRESSIVE STRAIN LOCALIZATION AND FLUID-ASSISTED DEFORMATION IN MANTLE EXHUMATION DURING RIFTING: PETROSTRUCTURAL CONSTRAINTS FROM THE ZABARGAD PERIDOTITES, RED SEA)

Mérope Anne CHARDELIN[1]*, CNRS/Université de Montpellier (m-chardelin@caramail.fr)
Andréa Tommasi[2], CNRS
José Alberto Padron Navarta[3], Instituto Andaluz de Ciencias de la Tierra

Abstract

The three peridotite massifs in the Zabargad island (northern Red Sea) document the exhumation of the mantle during continental rifting and the rift to drift transition. Deformation evolved from pervasive at the massif scale to localized in metric shear zones. To characterize the active processes and the role of melts and aqueous fluids in the deformation, we performed a petrostructural study of 40 samples representative of the different stages of deformation in the three massifs. Microstructures recording synkinematic crystallization of plagioclase, clinopyroxene, and orthopyroxene in the southern and amphibole-bearing spinel-websterite layers in the central and northern massifs indicate that pervasive deformation occurred in the presence of melts, but at lower pressure in the south. In the shear zones, deformation was accommodated by concomitant dislocation and dissolution-precipitation creep. Evolution from protomylonites to ultramylonites produced increasing volumes of a fine-grained polymineralic matrix where amphibole progressively replaces plagioclase and clinopyroxene. Fluid-assisted deformation at all stages is attested by the interstitial shapes of pyroxene neoblasts intermixed with olivine in the matrix. Local deformation at the brittle-ductile transition is accompanied by the crystallization of scapolite. Thermobarometry and thermodynamic modelling constrained by the microstructural observations document shearing under decreasing pressure and temperature from near solidus conditions at >1 GPa in the north and central massifs and ~0.7 GPa in the southern massif to < 600°C and <0.3 GPa in all three massifs. These data also imply increasing hydration, indicating fluid focusing and local aqueous fluid saturation in the shear zones, with sea water ingression to >10 km depth. However, fluid supply was spatially heterogeneous and probably intermittent, with equilibrium only achieved locally in the ultramylonites. The present study documents therefore how progressive strain localization and fluid-focusing in extensional shear zones enable thinning and exhumation of the mantle during continental rift and rift-to-drift transition.

This work was supported by the European Research Council (ERC) under the European Union Horizon 2020 Research and Innovation programme [grant agreement No 882450 – ERC RhEoVOLUTION].

Keyword

shear zone, mantle exhumation, olivine deformation, fluid-assisted deformation

Rheological inhomogeneities in the geodinamic structures of the earth' s crust

GENNADY ERMOLAEV[1]*, IMR (egs25@mail.ru)

Abstract

ERMOLAEV G.S.
RHEOLOGICAL INHOMOGENEITIES IN THE GEODINAMIC
STRUCTURES OF THE EARTH'S CRUST

Numerous inhomogeneities identified during the studythe study of continents, oceans and ore objects, contributed to an in-depth analysis of the material composition to decipher the structure of the Earth. «The material composition of geological formations determines not only the morphology,but also the most important tectonic(geodynamic) features»(V.P.Fedorchuk,1921-2011).

The study of ore deposits of Central Asia (Northern, Central and Southern Tien Shan) through the science of RHEOLOGY to combine tectonics, geophysics, geochemistry, geomorphology and establish a geodynamic relationship between form and content, space and time, to determine the decisive the role of endogenous forces in the formation of geomorphostructures of the Earth.

Continents and oceans, platforms and mobile belts, ore and barren areas, represent rheological heterogeneities. They appear in the form of structural (rigid-block) and structureless (plastic-inextricable) formations.

Within the Tien Shan, hard formations - terranes make up predominantly elevated areas of the relief. Plastic-continuous ones (mainly silt-shales) correlate with its leveled part. The ore mineral complex occupies an intermediate position, located on the boundaries of the pre-Mezozoic and Meso-Cenozoic, often associated with the boundaries of elevated and leveled relief.

These patterns are reflected in the cartographic material of geological, geophysical, geochemical, geomorphological studies and satellite photographs.They represent the post-Alpine fault-block tectonic flow of rock masses, including ore ones.

The driving force is siltstone-shale, thermodynamic plastic geomass. Originating in the bowels of the Earth, it penetrates the rift structures of the mid-ocean ridges, causing spreading of the ocean floor and rupture, of the continental crust. A similar relationship has been established between the complex system of the Mid-Arctic ridges and the central part of the continent of Eurasia, in which stretching processes occur.

The interaction of subcrustal (plastic) and crustal (hard) formations forms melange complexes (schist or ophiolite). Similar complexes make up most of Central Asia.

The conditions the disband of geological structures, including ore ones, have been established. This is due to the horizontal extension of the Earth's crust in the post-Alpine time, the rise of hot depth matter and its lateral movement (flow) along the fracture marked from the surface of the Mesozoic-Cenozoic sediments. This is manifested in the interaction of the arcuate structures of the Tien Shan with the Indian plate.

Their movements in a southerly direction contribute to a collision with each other. The structures

of the Tien Shan, like small blocks, unfold, stratify, and move apart, facilitating the penetration of siltstone-shale geomass, causing earthquakes and complicating the structural plan of the region.
The Central Tien Shan and the southwestern spurs of the Gissar ridge are commensurate with each other and, as it were, connect into a single whole the arc-shaped structures of the Northern and Southern Tien Shan and Kopetdag. Under compression conditions, they form a single mountain system vertically.
Rheological processes are evidence of the evolutionary development of the Earth and the geodynamic interaction of crustal and subcrustal formations in conditions of its expansion.

Keyword

material composition, rheological properties, block structures, plastic geomass, ore objects

Evolution of Deformation Microstructures and Fluid Inclusions in Peridotite Xenoliths beneath the Rio Grande Rift

Munjae PARK[1]*, Chungbuk National University (mpark@cbnu.ac.kr)

Abstract

Mantle heterogeneity is closely related to the distribution and circulation of volatile components in the Earth's interior, and the behavior of volatiles in the mantle strongly influences the rheological properties of silicate rocks. In mantle xenoliths, these physicochemical properties of the upper mantle can be recorded in the form of microstructures and fluid inclusions. In this paper, I summarized and reviewed the results of previous studies related to the characteristics of microstructures and fluid inclusions from peridotite xenoliths beneath the Rio Grande Rift (RGR) in order to understand the evolution and heterogeneity of upper mantle. In the RGR, the mantle peridotites are mainly reported in the rift axis (EB: Elephant Butte, KB: Kilbourne Hole) and rift flank (AD: Adam's Diggings) regions. In the case of the former (EB and KB peridotites), the type-A lattice preferred orientation (LPO), formed under low-stress and low-water content, was reported. In the case of the latter (AD peridotites), the type-C LPO, formed under low-stress and high-water content, was reported. In particular, in the case of AD peridotites, at least two fluid infiltration events, such as early (type-1: CO2-N2) and late (type-2: CO2-H2O), have been recorded in orthopyroxene. The upper mantle heterogeneity recorded by these microstructures and fluid inclusions is considered to be due to the interaction between the North American plate and the Farallon plate.

Keyword

Peridotite, Olivine, Microstructure, Fluid inclusion, Mantle heterogeneity

Tectonic characteristics and petroleum geological significance of the CiCun fault

Jun YANG[1]*, China University of Petroleum (East China) (2735942419@qq.com)
Li LI[2], China University of Petroleum (East China)

Abstract

The complex fault system had been formed in Luxi block due to multi-stage tectonic activities. The CiCun fault was one of the many radial faults in the north of the Luxi block, which extended northward into the Dongying Depression and connected to the faults in the oil zone. There are few researches on the CiCun fault in the past, so this paper uses the method of structural analysis to clarify the tectonic characteristics of the CiCun fault and analyze its petroleum geological significance based on the field outcrop data and indoor rock slices.

The CiCun fault was a right-lateral extension-strike-slip fault with a nearly north-south strike and a large east dip. The structure derived from the two plates of the fault was relatively developed. The scratches with a strike of 105° can be seen in the limestone strata of the western plate of the fault, which reflects the characteristics of left-lateral fault activity. Two sets of conjugate fractures with a strike of 203° and 143° can be seen in the carboniferous siltstone on the western side of the fault. The sharp Angle points to 173°, indicating that it is compressed from south to north, corresponding to the stress field of the Indochinese period. Two groups of joints are also visible in this formation, with strike of 110° and 187° respectively, indicating the NW-SE compression, corresponding to the early Yanshan stress field. To sum up, the CiCun fault was formed in the Indochinese period and was dominated by sinistral strike-slip, then experienced the compression-torsion sinistral strike-slip in the early Yanshan period, and became a right-lateral extension-strike-slip fault dominated by strike-slip in the Cenozoic due to the influence of the Tanlu fault zone.

Field samples of the CiCun fault zone were observed under microscope, and a certain number of hydrocarbon inclusions showed two different colors under fluorescence irradiation, indicating the existence of two kinds of hydrocarbons with different maturity, which is similar to the oil-gas geochemical characteristics of the Pingnan fault in Dongying Depression. It can be concluded that the CiCun fault was once a migration channel for oil and gas, and some oil and gas in Dongying Depression migrated to the Luxi block along the CiCun fault. The northern part of the Luxi block may be a potential area for oil and gas.

Keyword

Strike-slip fault, Tectonic characteristic, Fault mechanism, Petroleum geology significance, Luxi block

Deformation microstructures of blueschists in Alpine Corsica, France, and implications for seismic properties in subducting oceanic crust

Seungsoon CHOI[1]*, Korea Basic Science Institute (sechoi1@kbsi.re.kr)
Yong Park[2], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea
Seokyoung Han[3], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea
Sejin Jung[4], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea
Olivier Fabbri[5], Université de Franche-Comté, Besançon, France
Haemyeong Jung[6], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea

Abstract

Understanding the deformation microstructures and seismic properties of blueschists is crucial for interpreting seismic anisotropy and low velocity layer at the top of cold and warm subducting oceanic crust. In this study, we investigated the deformation microstructures and seismic properties of epidote blueschist, epidote-lawsonite blueschist, and lawsonite blueschist from Alpine Corsica, France. The crystal preferred orientations (CPOs) of glaucophane exhibited the strong maximum of [001] axes aligned sub-parallel to the lineation, while the maximum of (010) poles of epidote was aligned sub-parallel to the lineation. The [001] axes of lawsonite were strongly aligned sub-normal to the foliation. Intracrystalline misorientations and dislocations of glaucophane and epidote suggest that the CPOs of glaucophane and epidote were mainly developed through dislocation creep. In contrast, the existence of subhedral to euhedral-shaped, foliation-parallel aligned long axis of lawsonites, as well as misorientations and twins in lawsonites, indicate that the lawsonite CPO was developed by a combination of rigid body rotation and dislocation creep, with a minor effect of lawsonite twins. The seismic anisotropies of the blueschists showed higher P-wave anisotropy (AVp) and maximum S-wave anisotropy (max.AVs) in epidote blueschists (AVp = 12.3–16.9% and max.AVs = 6.53–11.75%) than in lawsonite blueschists (AVp = 8.9–9.1% and max.AVs = 4.44%). The seismic velocities of the blueschists ranged from 8–12% for P-wave and 10–14% for S-wave, which are lower than those of mantle peridotites. These values are comparable to those of low velocity layers in modern subduction zones. The coexistence of epidote and lawsonite in the blueschist resulted in various seismic anisotropies and P-wave velocity of the whole rock, depending on the modal content of epidote and lawsonite. A high content ratio of epidote to lawsonite in blueschist produced strong P- and S-wave anisotropies when the glaucophane content exceeded ~50%. P-wave velocity of blueschist linearly decreased with increasing epidote content. Our results suggest that the seismic properties of deformed blueschist can contribute to the seismic anisotropy and low velocity layer in subducting oceanic crusts in subduction zones.

Keyword

Blueschist, Microstructure, Deformation mechanism, Low velocity layer, Seismic anisotropy

Petrofabrics and microstructures of phyllite from Geumseongri Formation, South Korea: Implications for seismic anisotropy

Seokyoung HAN[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea (hs04111@snu.ac.kr)
Haemyeong JUNG[2], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea

Abstract

Minerals in mica group exhibit the strongest seismic anisotropy in continental crust, subducting slab, and upper mantle in subduction zone. Alignment of mica significantly influences magnitude and symmetry of seismic anisotropy, especially when seismic wave passes through a rock composed of mica more than 20-40%. Therefore, analyzing mica-rich natural rocks is crucial to investigate the origin of seismic anisotropy observed in nature. In this study, muscovite-quartz phyllites from Geumseongri Formation in South Korea were analyzed using Electron Backscattered Diffraction (EBSD) to measure lattice preferred orientation (LPO) of minerals. The samples are mainly composed of muscovite, quartz, albite, chlorite, and biotite with minor calcite and rutile. The EBSD analysis showed that the muscovite [001] axis was strongly aligned normal to the foliation while both [100] and [010] axes were dispersed parallel to the foliation. Chlorite and biotite also exhibited similar LPO except for the chlorite [001] axis in the sample G102, dispersed normal to the lineation. LPOs of quartz showed combinations of basal<a>, rhomb<a>, prism<a> slip system. The albite (010) pole or (001) pole was aligned subnormal to the foliation. Seismic anisotropy was calculated based on the LPO and modal composition of the samples. The anisotropy of P-wave (Vp) for quartz was in the range of 4.3 - 9.3% and 3.3 - 6.7% for albite. The maximum shear wave anisotropy (AVs) was in the range of 5.3 - 11.2% for quartz and 3.9 - 5.4% for albite. The Vp anisotropy and maximum AVs anisotropy of mica were in the range of 19.3 - 53.4% and 11.6 - 62.9%, respectively, which are much larger than those of other minerals. As a result, the Vp and maximum AVs anisotropy for whole rock were in the range of 11.8 - 44% and 11.6 - 51.8%, respectively. These results show that modal composition and alignment of mica mainly control the magnitude and symmetry of seismic anisotropy.

Keyword

EBSD, microstructure, seismic anisotropy, quartz, deformation

Microstructures of deformed granites and calc-silicate rocks in Yeoncheon, South Korea

Sena SIM[1]*, School of Earth and Environmental Sciences, Seoul National University , Seoul, Republic of Korea (senasim@snu.ac.kr)
Haemyeong JUNG[2], School of Earth and Environmental Sciences, Seoul National University , Seoul, Republic of Korea

Abstract

Quartz is one of the major constituent minerals of the crust. To understand the deformation mechanisms of quartz, we studied mylonitized granites and calc-silicate rocks from Yeoncheon in the Gyeonggi Massif, South Korea. Crystal preferred orientation (CPO) of quartz in the samples was measured using the scanning electron microscope (SEM) with electron backscattered diffraction (EBSD) facility. Recrystallized quartz grains were identified using the grain orientation spread (GOS) derived from the EBSD analysis. The mylonitized granites predominantly consist of quartz (41 - 45%), plagioclase (35 - 49%), and alkali feldspar (5 - 23%), while the calc-silicate rocks consist of quartz (25 - 40%), plagioclase (40 - 54%), alkali feldspar (19 - 20%) with a small amount of biotite. EBSD analysis showed that c-axes of quartz in the mylonitized granites are aligned subnormal to the lineation and parallel to the foliation, indicating a prism <a> slip system of quartz. The poles of the (11-20) plane of quartz were aligned parallel to the lineation. In contrast, the c-axes of quartz in the calc-silicate rocks were distributed as a girdle subnormal to the lineation, which are considered to have been influenced by the rhomb <a> and prism <a> slip systems of quartz. The observations of the CPOs of quartz and the resultant slip system indicate that the mylonitized granites were deformed at a moderate temperature (~400 - 550 °C), while the calc-silicate rocks were deformed at low temperature (~300 - 500 °C). The recrystallized grain size of quartz was 47 μm on average for the mylonitized granites and 28 μm for the calc-silicate rocks, indicating that the granites and calc-silicate rocks were deformed at differential stresses of approximately 46 MPa and 57 MPa, respectively. A thorough study of the microstructures of other constituent minerals such as plagioclase, alkali feldspar, and biotite, in addition to quartz, is crucial for a complete understanding of the deformational processes of the rocks in the study area.

Keyword

microstructures, quartz, granite, calc-silicate rock, crystal preferred orientation(CPO)

Lattice-preferred orientation and deformation mechanisms of amphibole in amphibolites from Jenner Headlands, Sonoma County, and Ring Mt., Marin County, California, U.S.A.

Junha KIM[1]*, Seoul National University (ratoria1001@snu.ac.kr)
Haemyeong Jung[2], Tectonophysics Laboratory, School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea
Loren A. Raymond[3], Department of Geology, Appalachian State University, Boone, NC, U. S. A.

Abstract

The microstructures and deformation mechanisms of amphibole significantly impact the overall structure and deformation processes of the crust because amphibole occupies a large volume fraction in the middle to lower crust. Amphibole is elastically very anisotropic, therefore, lattice-preferred orientation (LPO) of amphibole can largely affect the characteristics of seismic wave propagation in the crust, particularly seismic anisotropy. In this study, we collected and analyzed amphibolites from Jenner Headlands and Ring Mt. in the Franciscan Complex in Western California. LPO of amphibole was measured using scanning electron microscope (SEM) with electron back-scattered diffraction (EBSD) facility. The SEM and transmission electron microscope (TEM) were used to study microstructureal detail and deformation mechanisms of amphibole. All samples were well-foliated amphibolites which consist mainly of amphibole, plagioclase, and minor minerals such as garnet, epidote, mica, and titanite. The type-III LPOs of amphibole were observed in all samples, which is characterized as the [100] axes of amphibole aligned normal to the foliation and the [001] axes forming a girdle distribution on the foliation (refer to the classification of amphibole LPO type by Ko and Jung, 2015). The calculated grain orientation spread (GOS) of samples exhibited consistently low values for all the samples. Furthermore, observations of samples using the SEM and TEM indicate that the deformation mechanism of amphibole involves cataclastic flow with rigid body rotation and dissolution-precipitation creep. In addition to these deformation mechanisms, it is found that topotactic growth of amphibole from clinopyroxene also influenced the development of the type-III LPO of amphibole. The observed deformation mechanisms of amphibole within the Franciscan mélange in W. California provide insights into understanding the deformation processes within subduction zones.

Keyword

Amphibole, Lattice-preferred orientation (LPO), Deformation mechanism, Microstructures, California

High-temperature shear initiation of subridge mantle: A microstructural study of peridotites from the Zhongba ophiolite, SW Tibet

ZHANG ZHEN[1]*, University of Chinese Academy of Sciences (zhangzhen184@mails.ucas.ac.cn)
Liu Chuan Zhou[2], Laoshan Laboratory, Qingdao
Jung Haemyeong[3], Seoul National University
Jung Sejin[4], Seoul National University
Liu Tong[5], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Strain localization is the fundamental prerequisite for shear zone development in rheologically weak regions, such as the detachment faults at slow to ultra-slow spreading ridges. How does strain localization initiate within subridge mantle at high temperature (i.e., the sub-solidus conditions) is still poorly understood, which instead is more easily facilitated at low temperature. To understand the mechanisms for triggering this process, we analyzed mineral H2O contents and microstructures for fresh mantle harzburgites from the Zhongba ophiolite in the Yarlung-Tsangpo Suture Zone in terms of its petrological and variable-deformation advantages. Porphyroclastic peridotites and mylonites are both equilibrated at consistently high temperature (972-1185ºC), low oxygen fugacity (-0.93) conditions. Low H2O contents (48–107 wt. ppm) in orthopyroxene mainly controlled by partial melting represent the original water contents in a depleted mantle comparable to the ultraslow spreading ridges. Electron backscattered diffraction (EBSD) analysis revealed that crystal preferred orientation of olivine (Ol) and orthopyroxene (Opx) switch from mantle flow (Ol: A- and E-type; Opx: AC-type) to shear zone (Ol: D-type; Opx: CA-type) as deformation proceeds. Progressive grain size reduction causes successive decrease in fabric strength and promote strain rate for over two orders of magnitude (from ~10-14 s-1 to >10-12 s-1). Concurrently, deformation mechanisms convert dislocation creep to grain boundary sliding (GBS) and ultimately to diffusion creep from low-stress regimes (5.8-8.8 MPa) to high-stress regimes (up to 37.5 MPa). Combined with rheological modelling using olivine flow laws, we proposed a scenario depicting the petrological and textural evolution as well as mutually microstructural feedback with ongoing strain localization in detail. Our findings show that CPO transition and grain size reduction (GRS) can play a key role in shear initiation of subridge mantle at high temperature, especially for the melt-starved mid-ocean ridges.

Keyword

H2O contents, CPO, Strain localization, Zhongba ophiolite, Yarlung-Tsangpo Suture Zone

Crystallographic preferred orientation and seismic anisotropy of minerals in glaucophane schist and eclogite from the Franciscan Complex of Jenner, California

Yoonhae HA[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea (gkyoon0507@snu.ac.kr)
haemyeong JUNG[2], School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea

Abstract

Strong seismic anisotropy observed in many subduction zones is partly attributed to subducting oceanic crust. Glaucophane schist forms a major proportion of the top of the slab and commonly transforms to eclogite during subduction. Studying crystallographic preferred orientation (CPO) of glaucophane schist and eclogite forming minerals could be crucial to understand the seismic properties observed in the subducting slab and channel. We studied deformation microfabrics and seismic properties of glaucophane schist and eclogite from the Franciscan Complex of Jenner, California. Glaucophane schist samples are mainly composed of glaucophane, epidote and phengite. Eclogite samples are mostly composed of omphacite, glaucophane and garnet. CPOs of minerals were measured by using the FE-SEM/EBSD and we calculated seismic properties of major minerals and whole rocks.

In most samples, the CPO of glaucophane showed that [001] axes are aligned sub-parallel to lineation with a girdle parallel to foliation. Both (110) poles and [100] axes are aligned subnormal to foliation. Epidote showed that the [001] axes are aligned subnormal to foliation and both (110) and (010) poles subparallel to lineation. CPOs of phengite were characterized by a maximum of the [001] axes aligned normal to foliation, with the (110) and (010) poles and [100] axes aligning in a girdle parallel to foliation. CPOs of omphacite showed that the [001] axes are aligned subparallel to lineation and the [010] axes subnormal to foliation. Major minerals in glaucophane schist showed a strong seismic anisotropy. Especially, phengite showed the strongest seismic anisotropy (AVP = 15 — 52 %, max.AVS = 11 — 52 %). In contrast, omphacite and garnet showed very weak seismic anisotropy. As a result of whole rocks, glaucophane schist showed much stronger seismic anisotropy than eclogite facies rocks. Therefore, strong seismic anisotropy observed in subduction zone could be more affected by glaucophane schist, especially phengite-rich glaucophane schist, rather than eclogite.

Keyword

glaucophane schist, glaucophane, phengite, crystallographic preferred orientation, seismic anisotropy

Deep Structure of the Southeast Asian Curved Subduction System and its Dynamic Process

Weiwei Ding[1]*, Second Institute of Oceanography, MNR, China (wwding@sio.org.cn)
Jiabiao Li[2], Second Institute of Oceanography, MNR, China
Xiongwei Niu[3], Second Institute of Oceanography, MNR, China

Abstract

The main reason for the habitability of the Earth is the presence of an active interior, in which subduction zones play an important role. As linear subduction zones continue to evolve and form highly curved shape, the original plate morphology, deep structure, and convection patterns will undergo significant changes, leading to increasingly complex dynamic mechanisms and giving rise to a series of new problems that current plate tectonic theories find difficult to explain. Southeast Asia is a typical representative of an inward-curved subduction system. The deep structure, material circulation, and dynamic processes in the Southeast Asia have long been an elusive scientific puzzle due to the lack of systematic scientific observations and recognized theoretical models. Based on the deep seismic tomography using long-period natural earthquake data, this study investigates the deep structure and material circulation of the curved subduction system in Southeast Asia, and reconstructs the dynamic processes since 100 million years ago. It is pointed out that challenges still exist in the precise reconstruction of deep mantle structures in the study area, the influence of multi-stage subduction on deep material circulation and shallow magma activity, as well as the spatiotemporal evolution and coupling mechanism of multi-plate convergence. Future work should focus on high-resolution land-sea joint three-dimensional seismic tomography imaging of the curved subduction system in Southeast Asia, combined with geochemical analysis and geodynamic modelling works.

Keyword

Curved subduction system, Deep structure, flattened subducting slab, material recycling, SE Asia

Influence of Convergence Rate and Subduction Dip Angle on Island-Arc Magma Production

Yongliang BAI[1]*, China University of Petroleum (East China) (ylbai@upc.edu.cn)

Abstract

Island-arc growth is a primary outcome of the subduction system, offering valuable insights into subduction dynamics. Understanding how key factors impact island-arc growth is crucial for uncovering these dynamics. This study aims to investigate how convergence rates and slab dip angles influence the production rate of island-arc magma (MPR) using numerical models.

The simulations were conducted using ASPECT to model various processes, such as slab penetration, mantle convection, slab dehydration, water migration in the wedge, mantle partial melting, and melt extraction. The coverage rate and subduction dip angle of our numerical models varies between 2 cm/yr and 10 cm/yr, between 30° and 60°, respectively. These ranges can cover the majority subduction zones according to the variations of the convergence rates and subduction dip angles of the present subduction zones on the Earth. The findings indicate the following trends: (1) Increasing convergence rates lead to higher mean and peak MPR values. (2) As the slab dip angle increases from 30° to 45°, both mean and peak MPR values increase. However, when the dip angle continues to increase from 45° to 60°, mean and peak MPR values start to decrease. (3) The convergence rate has a more significant influence on MPR compared to the dip angle.

The influence of convergence rate and slab dip on island-arc MPR is based on their effects on mantle wedge temperature and hydration fraction. Specifically: (1) An increase in convergence rate leads to higher mantle wedge temperature and hydration fraction during both MPR increasing and decreasing periods. (2) Similarly, an increase in slab dip angle leads to higher mantle wedge temperature during both MPR increasing and decreasing periods. However, the impact on hydration fraction differs. Specifically, hydration fraction initially increases and then decreases as the slab dip angle increases from 30° to 45° and subsequently from 45° to 60°. As hydration fraction has a more significant impact on mantle melting than temperature, MPR increases as the slab dip angle increases from 30° to 45° but decreases as the slab dip angle increases from 45° to 60°.

Keyword

island-arc magmatism production rate, convergence rate, slab dip angle, mantle wedge temperature, mantle melting

How could density contrast between magmatic rocks and bedrocks affect SDR formations?

Haibin YANG[1]*, Zhejiang University (haibin.yang@zju.edu.cn)
Huixin Guan[2], Key laboratory of ocean and marginal sea geology, Chinese Academy of Sciences

Abstract

Seaward dipping reflectors (SDRs) are characteristic features to identify a volcanic passive margin. They usually form sets of wedges developing with time from the inner- to the outer-part of the necking zone . They are first identified as layered igneous sequences dipping towards the ocean from multi-channel seismic reflection profiles offshore the North and the South Atlantic margins. Two sets of SDRs, inner SDRs and outer SDRs, can be distinguished according to their location and geometry. They generally show the same seaward-developing divergent-arcuate pattern. Outer SDRs usually present smaller thickness (less than 2km) and no wedge shape , while inner SDRs are usually constitute of several seaward dipping convex-wedges and the thickness of a single inner SDR wedge commonly varies from 5 to 10 km. How these structures are developed is not yet clear. We use numerical models to show that the density contrast between surfacial magmatic rocks and bedrocks, together with hot and weak lower crust , can create similar structures as SDRs in a volcanic passive margin. It can explain different structures between SDRs and sedimentary basins. High density contrast tends to promote faults develops towards the sea and generate continent-dipping normal faults in passive volcanics margins.

Keyword

SDR, volcanic passive margin, continent-dipping fault, numerical modelling

Structure and geodynamics beneath the Indian Ocean inferred from multimode surface wave tomography

Debasis D MOHANTY[1]*, Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Sapporo, Japan (devlinkan06@yahoo.com)
Kazunori Yoshizawa[2], Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University, Sapporo, Japan

Abstract

Multimode surface wave tomography provides a robust spatial image of the Earth's upper mantle over a wide depth range, dealing with a broader frequency range of waveform records. We have created new tomographic images of multimode phase speeds of Rayleigh and Love waves in the Indian Ocean with recently enhanced seismic networks in the southern hemisphere by incorporating a large number of regional surface-wave paths for both the fundamental and higher modes, which are sensitive to the whole upper mantle structure. With a data set of 22 years, we have retrieved more than 63,000 and 26,000 ray paths for fundamental Rayleigh and Love waves, respectively, over a wide period range (30 s – 200 s), where more than 16,000 ray paths are achieved for successful analysis of higher modes. In the first stage, the multimode waveform inversion is performed to compute path-specific 1-D velocity profiles to retrieve the dispersion information. In the second stage, the information from all the ray paths is combined to produce multimode phase speed maps with an approximation of surface wave propagation along great circle paths. These phase speed maps are further updated by incorporating the ray tracing and finite frequency effects along the influence zone around the corresponding surface wave path. We have produced high-resolution phase-speed maps beneath the Indo-Australian plate, which indicate some intriguing structural features, such as the relatively faster anomaly underneath the Australian Antarctica Discordance and the relatively slower anomaly along the Ninety East Ridge. These multimode phase speed maps will be used to construct the final 3D model as the final stage of our tomography model. This three-stage inversion process, including automated multimode phase speed measurements with a fully non-linear waveform fitting, and subsequent phase speed mapping incorporating ray-bending and finite-frequency effects, has significant benefits in improving the model images in regions with tectonic complexity and significant lateral velocity gradients, such as near tectonic boundaries along continent-ocean margins and subduction zones, Indo-Eurasian collision, Indo-Burmese arc, and mid-ocean ridges in the Indian Ocean.

Keyword

Indian Ocean, Multimode phase speed, seismic Tomography, Indo-Australian Plate, Surface wave

The structure and spreading history of the South China Sea

Zhen SUN[1]*, South China Sea Institute of Oceanology (zhensun@scsio.ac.cn)
Ning Qiu[2], South China Sea Institute of Oceanology
Weiwei Ding[3], Second Institute of Oceanography, Ministry of Natural Resources,

Abstract

As one of the largest marginal seas in the Western Pacific, the South China Sea experienced an almost complete Wilson cycle. Therefore, the research on its evolution could provide an important reference to the other marginal sea basins. However, strong controversies exist in the spreading history of the South China Sea, especially on the location of the fossil ridge, and the periods as well as mechanism of ridge jump. In order to deduce the spreading history of the SCS accurately and decode the mechanism of ridge jump in marginal sea basins, we first lock down the location of the latest fossil ridge with both OBS velocity and free air gravity anomaly, at the same time the spreading direction as well as the fracture zone direction were confirmed with the macrostructure analysis from IODP drilling sites U1431 and U1433. Expanded from the latest spreading stage, we obtained the whole spreading history according to spreading fabrics based on high resolution bathymetry and magnetic anomaly lineation. The fracture zone(inactive transform fault) during spreading stage were reconstructed. We found that the spreading direction of the SCS changed frequently during the 16 Myr spreading history. Along with the spreading direction variation, the ridge may rotate or migrate accordingly. Kinematic analysis suggest that the style of ridge adjustment depends on the relative location of spreading ridges and transform fault, as well as the relationship between clockwise or counter clockwise rotation relative to the ridge. Based on these data and kinematic analysis, we realized that ridge adjustment caused by spreading direction variation was proceeded mainly by rotation or slight migration, which can’t explain the whole ridge jump at early Miocene. At the same time, the M-number of the whole South China Sea basin suggest a fundamentally difference before and after early Miocene (~23 Ma). The early Miocene ridge jump is strongly correlated with the magma supply, the later decreased greatly after ridge jump to the south. Therefore, we conclude that the early Miocene Ridge jump might be caused by magma supply event, while the other stage of ridge adjustment might be caused by spreading direction variation.

Keyword

South China Sea, spreading process, plan and profile structure, multi-geophysical methods, ridge jump

Continental breakup of Marginal Seas in SE Asia

Jean-Claude RINGENBACH[1]*, TotalEnergies (jean-claude.ringenbach@totalenergies.com)
Geoffroy Mohn[2], CY Cergy Paris University
Michael Nirrengarten[3], CY Cergy Paris University
Julie Tugend[4], Commission for the Geological Map of the World, Paris, France
Chao Lei[5], University of Geosciences, Wuhan
Anders McCarthy[6], HEAT GmbH

Abstract

Marginal Seas are extensional basins formed in a convergent setting near active subduction zones. They are characterized by a short life (<25 Ma), as well as unstable and changing directions of seafloor spreading. However, the processes related to their formation from rifting to seafloor spreading initiation remain debated (supra-subduction convection/extension, slab-pull). This problem is further compounded by the fact that our understanding of continental breakup used to be derived from the evolution of magma-poor and magma-rich Continent-Ocean Transitions (COT) of the Atlantic margins.

Here, using high-resolution seismic data we describe the tectono-magmatic processes occurring during continental breakup by investigating the COT structures of three Marginal Seas located in the Western Pacific, namely the South China Sea, the Coral Sea and the Woodlark Basin. These data are completed by drilling results of International Ocean Discovery Program (IODP) expeditions available across the South China Sea COT which provides an insight on sediment facies and thermal maturity.

All three examples record a similar pre-rift evolution characterized by an orogenic phase quickly followed by an orogenic collapse with significant influence on the pre-rift inheritance in terms of structures or thermal evolution. Opening of these basins subsequently formed under rapid extension rates and propagation of seafloor spreading. Although each marginal basin is unique, we show that the three of them show a narrow COT (typically <~20 km), where final extension is accommodated by the activity of mainly one low-angle normal fault. Extension is contemporaneous with an important magmatic activity emplaced in the distalmost part of these margins as volcanoes, dikes and sills. This interpretation is confirmed by thermal maturity of sediments showing a jump below post-rift sediments and a higher thermal maturity gradient with respect to depth in the syn-/pre- rift sediments for the SCS. Based on 1D modeling of this dataset, we show that it is necessary to invoke magmatic intrusions in the COT at the time of breakup.

As a result, and unlike in archetypal magma-poor or magma-rich margins, the COTs are characterized by a sharp juxtaposition of continental crust against ”normal” igneous oceanic crust suggesting a rapid shift from rifting to spreading.
Rapid localization of extensional deformation during continental breakup has major implications

for partial melting generation. The evolution of extensional structures is controlled by the interplay of lithospheric thinning, asthenosphere upwelling and decompression melting. High extension rate prevents conductive cooling allowing the focusing of volcanic activity in sharp COTs, quickly evolving to magmatic accretion. Fast extensions rates during the formation of Marginal Seas are likely directed by kinematic boundary conditions directly or indirectly controlled by nearby subduction zones. Such mode of continental breakup is probably not limited to Marginal Seas but only enhanced in such settings.

Keyword

Continental breakup, Low-angle normal faults, Continent-Ocean Transition, South China Sea

Detachment fault systems in the Northern South China Sea, insights into 3D tectonic segmentation of rifted margins

Shihao HAO[1]*, China University of Geosciences (haoshihao@cug.edu.cn)
Lianfu Mei[2], China University of Geosciences
César Ranero[3], Institut de Ciéncies del Mar (CSIC), Barcelona, Spain

Abstract

The 2D rifting modes interpreted in traditional “magma-poor” and “magma-rich” margins cannot explain the crustal structure and inferred rifting processes in the northern South China Sea (SCS) rifted margin. The “intermediate-type” terminology has been therefore applied to the mid-northern SCS, where a “wide-rift” model has been widely accepted. However, the tectono-magmatic processes of the SCS are still debated and at least five contrasting interpretation models exist. We present a compilation of 3-D seismic volumes and regional 2-D seismic surveys covering the entire Baiyun and Liwan Sub-basins to investigate their tectonic structure and faulting style in this “wide-rift” region. We interpret two segments with contrasting tectonic styles separated by a volcanic lineament and steep transfer faults. The Baiyun Sub-basin was controlled by a landward-dipping detachment system. The Liwan Sub-basin, however, was formed by a ~100-km-long oceanward-dipping, concave-up detachment system working at a low angle. The lateral boundaries of the detachment system were mechanically decoupled from surrounding tectonics by a volcanic lineament to the west and a >145-km-long N-S-trending left-lateral strike-slip transfer fault to the east. The planar low-angle detachment does not resemble classical metamorphic core complex domes interpreted previously. Our results indicate a 60-80-km-wavelength segmentation within a single “wide-rift” system, indicating complex 3D rifting during crustal extension. This study supports that the intermediate SCS margin had a kinematically complex deformation style locally dominated by the interaction between detachment and transfer fault systems that might be yet unrecognized in other margins.

Keyword

South China Sea, Strike-slip fault, Low-angle detachment, margin segmentation

[Keynote] Hydrothermal Feedbacks on Tectonics During Magma-Poor Rifting and Start of Oceanic Spreading

Marta PEREZ-GUSSINYE[1]*, MARUM/Bremen University (gussinye@uni-bremen.de)
Javier García-Pintado[2], MARUM/Bremen Universität

Abstract

Rifted margins display a wide variety of tectonic architectures and transitions to oceanic spreading. The influence of factors such as extension velocity, initial thermal and rheological profile of the lithosphere and surface processes has been extensively explored in the last two decades. Here, we turn our focus to the largely unknown effect of hydrothermal flow on the temperature field and tectonics during rifting and intiation of seafloor spreading at magma-poor margins. The influence of hydrothermal activity on tectonics has been generally evaluated via a parameterization of the cooling effect from hydrothermal fluid flow in the host rock, emulated by an increase in the thermal conductivity in the heat transfer equation.

Here, we evaluate the feedbacks between hydrothermal activity and tectonics by using a thermo-mechanical model fully coupled with hydrothermal flow, Rift2Ridge_Hydro. Heat release by plastic deformation at fractures and faults, exothermic serpentinization reactions, sensible and latent crystallization heat from magmatic emplacement provide different energy-source signatures promoting hydrothermal activity. We show how advective heat transfer via hydrothermal circulation results in a much higher spatio-temporal variability in the thermal field, in comparison to simulations where this is not considered. In turn, this leads to a strong feedback in the tectonic deformation, the bathymetric relief and the heterogeneity in the composition of the crust in the ocean-continent transition.

Keyword

Tectonics, Hydrothermal flow, Magmatism, Serpentinization

Characterization of fault systems and implications on structural evolution of the northern Qiongdongnan Basin, South China Sea

Yu QIU[1]*, State Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China), Qingdao, 266580, P.R.China; School of Geosciences, China University of Petroleum (East China), Qingdao, 266580, P.R.China (b22010057@s.upc.edu.cn)
Yangwen PEI[2], State Key Laboratory of Deep Oil and Gas, China University of Petroleum, Qingdao, 266580, China
Yannan DU[3], State Key Laboratory of Deep Oil and Gas, China University of Petroleum, Qingdao, 266580, China
Kongyou WU[4], State Key Laboratory of Deep Oil and Gas, China University of Petroleum, Qingdao, 266580, China

Abstract

The Qiongdongnan Basin is located in the northern continental margin of the South China Sea. Since the Cenozoic, the Qiongdongnan Basin has undergone complex tectonic evolution processes, resulting in fault systems comprising normal faults, reverse faults, and strike-slip faults. Although there has been a lot of studies focusing on the Qiongdongnan Basin, the control of fault systems evolution on the spatial and temporal geometric variation have not been well documented. In this research, by employing 3D seismic interpretation and seismic attributes analysis, the stratigraphic contacts and fault systems in Cenozoic were interpreted with high-resolution. The temporal deformation rates of three fault systems were analyzed by calculating the fault offsets versus geological time intervals. The various deformation rates along strikes suggest high level of lateral variation of faulting deformation. By integrating the fault heave/throw distribution maps, the key fault systems were then subdivided into four segments from east to west. Six representative seismic profiles were restored in 2D MOVE, with extension amounts and deformation rates calculated to reveal the Cenozoic structural evolution occurred in the Qiongdongnan Basin. The balanced profile restoration and statistics indicated that the Qiongdongnan Basin experienced a multi-staged evolution, including the Oligocene rifting stage, the Miocene rifting-depression transition stage, and the Pliocene to present depression stage. As the fault systems dominated the distribution of the paleo-highs and lows, it is critical to reconstruct the paleo-geomorphology and understand its impacts on sedimentation patterns in the Qiongdongnan Basin. The erosion amounts of the three key horizons were calculated by considering both the structural trend and thickness variation. The paleo-geomorphology maps were then constructed, indicating that the general structural framework of the Qiongdongnan Basin was generated in late Oligocene and was subsequently altered in Miocene. The characteristics and structural evolution of the fault systems may provide important hints for the petroleum exploration in the northern Qiongdongnan Basin.

Keyword

fault systems, fault characterization, lateral variation, structural evolution, paleo-geomorphology reconstruction

Development of detachment fault system associated with a mature metamorphic more complex: insight from the Kaiping Sag, northern South China Sea rifted margin

Gengbiao LI[1]*, China University of Geosciences (1076500813@qq.com)
Qing YE[2], China University of Geosciences

Abstract

The Kaiping Sag, located in the northern South China Sea (SCS) rifted margin, characterized by the development of a mature and complete metamorphic core complex (MCC), which provides an excellent location to study the development of detachment fault system associated with MCC. In this study, a newly acquired high-resolution 3-D seismic reflection volume allows detailed analysis of the development of the KP detachment fault system. The master detachment fault displays a convex-upward shape, and the fault surface and its footwall at KP9 High suffered from denudation and flattening, generating the long-distance horizontal displacement by oblique sliding. Accompanying second-order faults include synthetic faults and antithetic faults, regularly distributed in the supra-detachment basin, at right angles to the prevailing extension direction. These faults are mainly developed in the syn-rift formations, predominantly up-steep and down-sloping medium-high angle normal faults. Comprehensively analyzing the activity pattern of the fault system and the characteristics of basin evolution, it can be assumed that the differential uplift of the mid-crustal ductile layer and the rolling-hinge activity of the MCC are the main reasons leading to the uniqueness of the detachment fault system. We propose that the KP MCC went through three stages from embryonic to mature: strong detachment stage, detachment-uplift composite stage, and strong uplift stage. During the transition, the controlled depositional faults were transformed from synthetic faults to antithetic faults, the Collapse Graben migrated to the front of the rolling hinge, new high-angle normal faults were developed centrally at the top of the uplift zone, and the old faults underwent different degrees of rotation. The developmental law of detachment fault system recognised in this study supplements and completes the existing rolling-hinge models, and provides clear and reliable practical examples to demonstrate the rationality of the model.

Keyword

Detachment fault system, A mature metamorphic core complex, Collapse graben, northern South China Sea rifted matgin

Geochemistry and petrogenesis of igneous rocks from the Yap forearc in the western Pacific: Implications for forearc magmatism

Ling CHEN[1]*, Second Institute of Oceanography, Ministry of Natural Resources, China (chenling@sio.org.cn)
Limei Tang[2], Second Institute of Oceanography, Ministry of Natural Resources
Jie Zhang[3], Second Institute of Oceanography, Ministry of Natural Resources

Abstract

Herein, we analyze the elemental composition and Sr–Nd–Pb isotopic data of the gabbroic rocks (gabbros and gabbroic diorites) from the forearc of the Yap trench in the western Pacific to investigate the early arc magmatism. The gabbroic diorites, which exhibit a negative Eu anomaly and relatively flat REE patterns with slight LREE depletion, represent the evolved magma that has undergone varying degrees of fractional crystallization. In contrast, the gabbros, which exhibit a positive Eu anomaly and a significant depletion of LREE, can be further classified into two groups. The noncumulate Group 1 gabbros have composition closely resembles that of gabbroic diorites and the Group 2 gabbros represents cumulate rocks formed through melt crystallization. Most of the studied gabbroic rocks exhibit negative anomalies in high-field-strength elements, such as Nb, Zr, Hf, and Ti, accompanied by very low Ti/V and Nb/Yb ratios. Based on these features, they are suggested to originate from the partial melting of a depleted forearc mantle, which is supported by their high 143Nd/144Nd ratios that are similar to those of forearc basalts (FAB). The forearc origin of gabbroic rocks is further supported by their plagioclase composition, which exhibits a higher anorthite content (An: 86–99) compared to the plagioclase in backarc and mid-ocean ridge gabbros when coexisting with identical clinopyroxene composition. However, even though the major- and trace-element compositions of the Yap gabbroic rocks are similar to those of FAB, their large-ion lithophile element content (e.g., Cs, Rb, Ba, and Th) and 87Sr/86Sr ratios considerably exceed the values of FABs, highlighting their similarity to boninites. In addition, their Ba/Yb and Th/Yb ratios are higher than the mid-ocean ridge basalt values and plot between the FAB and boninite fields in Ba/Yb versus Th/Yb diagram. Consequently, we propose that the Yap gabbroic rocks evolved from an early arc magma, which was produced by a combination of decompression melting and fluid-flux melting. Thus, they exhibit a transitional composition that falls between FABs and boninites. The exposure of intrusive rocks related to the early arc magmatism in the Yap forearc is a consequence of the extensive tectonic erosion induced by the collision of the Caroline ridge with the trench. This collision resulted in the erosion of the volcanic crust, exposing the underlying plutonic rocks. Therefore, intrusive rocks likely hold a preserved record of the early arc magmatism in subduction zones exhibiting extensive tectonic erosion. The Yap arc system is characterized by multiple episodes of magmatism, and the collision with the Caroline ridge may prevent the Yap arc magmas from evolving into mature arc magmas.

Keyword

Subduction zone, Yap trench, Forearc magma, Early arc, Subduction initiation

The Oceanic crustal structure and the magmatic accretion history of the South China Sea

chenghui ZENG[1]*, South China Sea Institute of Oceanology, CAS (chenghzeng@163.com)
zhen SUN[2], South China Sea Institute of Oceanology, CAS

Abstract

Plate separation is accommodated by magmatic accretion and tectonic extension, it is of great significance for studying the plate dynamics based on the ratio between them. The South China Sea (SCS) is typically representative of the slow-intermediate spreading marginal sea. However, there is a lack of holistic quantitative calculation of the magmatic accretion from the perspective of spatio-temporal distribution, which limits the cognition of the seafloor spreading process of the SCS.

We calculate the spatial distribution characteristics of M number, which marks the ratio of separation accommodated by magmatic accretion, in the SCS through seismic profiles. The main conclusions are:

(1) The M number of the SCS fluctuates in the range of 0.5~0.95. For each sub-basin, the M of the main spreading area of the northwest sub-basin (NWSB) of the SCS can reach above 0.9. In the east sub-basin (ESB), the M can be above 0.9 and a few areas can be as low as 0.7~0.8 in the early spreading stage (> 23.6 Ma). In the late spreading period (< 23.6 Ma), the values of M number vary alternately between 0.5~0.8 and 0.8~0.95 along the single seismic profile or along the single magnetic anomaly lineation in the ESB and the southwest sub-basin (SWSB).

(2) When the M number attain 0.93, small offset planar faults are developed in the oceanic crust, the horizontal displacement is less than ~0.5 km. When the M value decrease to 0.66, large offset low-angle faults are developed, the horizontal displacement can reach ~3 km. The dip angle of fault plane is less than ~30°.

(3) There is hardly any fault heave exceeding 5 km in all seismic profiles, implying that the magma supply cycles (less than 0.25-0.33 Myr) are shorter than large oceans. These calculations are consistent with the observation that very few oceanic core complexes are revealed.

Keyword

South China Sea, Magmatic accretion, Oceanic crust, M number

Oceanic crustal structures and characteristics of Syn-Spread Magmatism in the Central basin of the South China Sea

Haixuan SUN[1]*, South China Sea Institute of Oceanology (2472223896@qq.com)
zhen SUN[2], South China Sea Institute of Oceanology

Abstract

The accretion process of the oceanic crust and the formed crustal structures are of great significance for understanding the dynamic mechanisms within the earth, the spreading history of ocean basins, and the interaction between magmatic and tectonic processes. Yet, the evolutionary characteristics of magmatic activity during the syn-spread period remain enigmatic due to the lack of seismically resolvable data and dredged rock samples in the central basin of the South China Sea. In this study, we present two maps of crustal thickness and sediment base depth to reveal the fluctuation of magma supply during seafloor spreading. First, we integrate publicly available seismic data with previously obtained gravity results to create an enhanced crustal thickness map. Then, the improved bathymetry and sediment thickness grids are constructed and the sediment base depth in SCS is mapped as constrained by seismic data. The results find, that the crust is thickened north of the extinct spreading center (ESC) and mostly located in the middle part of the central basin, corresponding to ages of ~29–15 Ma, while a much narrower region of thickened crust is visible for the corresponding southern part. Moreover, the width of the thickened crust region reflects a prominent increasing to decreasing change from north to ESC with the peak around the fossil ridge. Meanwhile, the sediment base uplifts in an irregular broad band of half-width ~120 km north of the ESC, mostly located between ESC and fossil ridge. The combination of these maps indicates that the magma budget firstly increases and then decreases towards the ESC, reaching the peak around the fossil ridge and the through around the ESC. The results provide insights into the dynamics of mid-ocean ridge spreading and associated crustal accretion processes. Furthermore, the implications of these findings extend to a broader understanding of oceanic crustal evolution, magmatic processes, and resource potential in the South China Sea.

Keyword

South China Sea, Central basin, Crustal structure, Magmatic budget

Possible Plume-Ridge Interactions during India-Madagascar Break-up

LACHIT SINGH NINGTHOUJAM[1]*, National Centre for Polar and Ocean Research, Goa, India (lachit@ncpor.res.in)
Dhananjai Kumar Pandey[2], Jawaharlal Nehru University, Delhi, India
Nisha Nair[3], National Centre for Polar and Ocean Research, Goa, India
Rahul Yadav[4], National Centre for Polar and Ocean Research, Goa, India
Sanjay Singh Negi[5], National Centre for Polar and Ocean Research, Goa, India
Amit Kumar[6], National Centre for Polar and Ocean Research, Goa, India
Khogenkumar Singh Shoraisham[7], CSIR-National Institute of Oceanography, Goa, India

Abstract

The Central Indian Ocean Basin (CIOB) encompasses several enigmatic tectonic features, such as the Comorin Ridge, whose origin and development remain largely obscure. These tectonic features play a major role in elucidating the genesis and evolution of the CIOB, which is closely linked to the early-mid Cretaceous Antarctica-India rifting and dispersal, followed by the late Cretaceous India-Madagascar break-up. The northward voyage of the Indian plate and its adjoining margins was accompanied by frequent interactions between concurrent mantle plumes and spreading centers. Despite its profound geodynamic significance, a comprehensive understanding of the CIOB and its adjoining regions has remained elusive due to the scarcity of deep-penetrating, high-quality seismic refraction and reflection data. A thorough comprehension of the crustal processes that have shaped this region necessitates velocity and structural information of the crust and upper mantle obtained through deep-penetrating seismic observations.

In this study, a ~420-km long wide-angle reflection and refraction seismic profile in the CIOB south of Sri Lanka is utilized to enhance our understanding of the geodynamic evolution in the area. Two-dimensional seismic travel-time tomographic inversions reveal the presence of an anomalously thick crust (~14 km) beneath the Comorin Ridge, gradually thinning out towards the east, towards the center of the geoidal low. It is observed that the crust in the east of the profile appears to be of a normal oceanic type. We attribute the lateral diversity in crustal type to possible magmatic underplating beneath the Comorin Ridge. It is interpreted that concurrent plume-ridge interaction during the late Cretaceous India-Madagascar break-up may have caused this crustal underplating. These findings hold significant implications for a better understanding of plume-ridge interaction processes along various passive margins, as well as for the precise reconstruction of India-Madagascar dispersal.

Keyword

Comorin Ridge, Central Indian Ocean Basin, Madagascar, plume-ridge interaction, wide-angle

New insights to slab interface and crustal structure in Sumatra subduction zone: constraints from novel receiver function analyses

Ling CHEN[1]*, State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences (lchen@mail.iggcas.ac.cn)
Mingye Feng[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences
Shengji Wei[3], Earth Observatory of Singapore, Nanyang Technological University
Xin Wang[4], Key Laboratory of Earth and Planetary Physics, Institute of Geology and Geophysics, Chinese Academy of Sciences
Xu Wang[5], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The Sumatra subduction zone, where the Australian plate is subducting obliquely beneath the Sunda plate, hosts the most devastating earthquake (2004 Mw9.2 event) in this century and strongest volcanic eruption (Toba eruption at 74 ka) in Quaternary, and thus has become a focus of subduction zone studies. To better understand the subduction dynamics and related geological phenomena in this region, recently we conducted detailed seismic studies based on teleseismic receiver function (RF) analysis. We first focus on the geometry and structure of the subducting plate boundary to understand slab deformation and slab-mantle wedge interaction in Sumatra. By developing a Dip Direction Searching (DDS) method of station-based RFs, we constrained the geometries of the top and bottom interfaces of a dipping Low Velocity Layer (LVL) around the subducting plate boundary beneath the forearc area of Sumatra. The LVL bottom interface, interpreted as the subducting oceanic Moho, shows lateral variations in its dip direction, indicating an along-strike bending of the slab that probably is related to the oblique oceanic subduction and could trigger large earthquakes. The top and bottom interfaces of the dipping LVL are found locally nonparallel (with a deviation up to 23˚), and the LVL appears to thicken with depth and apparently thicker than a normal oceanic crust (10-14 km versus 6-7 km). These features suggest that the LVL is composed of not only the subducting oceanic crust, but probably also a layer of slab-dehydration induced low velocity serpentinized mantle on its top, forming a diffuse plate boundary along the Sumatra subduction zone. We then investigated the crustal structure at the volcanic arc area of Aceh in northern Sumatra, to understand crustal deformation and its relationship with arc volcanism. We expanded the commonly used RF H-κ stacking to RF H-Φ stacking scheme for dense nodal array data and estimated the crustal thicknesses and melt fractions of the area. Our results show an overall thin crust (~29 km on average) with high Vp/Vs ratios (~1.98) and melt fractions (~12% on average). The crustal melt fraction increases as the crustal thickness decreases northwestward, reaching the highest value of 19% and the thinnest crust of 22 km at the northwestern edge of Sumatra. The melt fractions estimated for Aceh are comparable to other active volcanic areas in the world, and the observed melt fraction-crustal thickness correlation corroborates previous speculation that high crustal stretching associated with

the opening of the Andaman Sea facilitates melt intrusion into the crust and northward Quaternary volcanic migration in Aceh. This suggests that the arc volcanism in Sumatra may not be controlled merely by the oblique subduction process, but is possibly also modulated by continental tectonics over a broader region. To further understand the interactions and coupling between the oblique oceanic subduction and overlying continental tectonics in Sumatra requires improved constraints on the structures of various depths and scales from multidisciplinary observations.

Keyword

Sumatra, oblique subduction, subducting plate boundary, crustal melt fraction, volcanism

Constraining water flux in the Manila subduction zone with seismic data

Zhenteng WANG[1]*, South China Sea Institute of Oceanology, Chinese Academy of Sciences (wangzhenteng234@163.com)
zhen SUN[2], South China Sea Institute of Oceanology, Chinese Academy of Sciences

Abstract

Subduction zone is the major location for water on earth recycled into the deep interior of Earth, it's also the location of large submarine catastrophes such as earthquake and volcanic eruption. Numerous studies have shown that there is a positive relationship between the medium-depth earthquakes and the larger subduction water fluxes, while hydration plays an important role in subducted water fluxes. The Manila Trench is located between the South China Sea and the Western Philippine Sea, along which a narrow portion of the southern section of the Manila Trench concentrates more than 80% of the medium- and deep-source earthquakes along the entire trench, above which the notorious super large Pinatubo volcano locates. In order to decode the relationship between subducted water fluxes and catastrophic volcano eruption, we plan to calculate the variation and its controlling factors of water flux along trench first. Here we use dozens of multichannel seismic (MCS) reflection and wide-angle seismic data spanning the Manila subduction zone from south to north to establish the relationship between uplift faulting and hydration at the outer edge of the trench. We quantify the amount of South China Sea pore and structurally bound water entering the Manila subduction zone by comparing it with other subduction zones that are relatively well-studied around the world. Finally, we attempt to establish a link between the water subduction fluxes at the trench and seismic hazards and catastrophic volcanic eruptions (e.g., Mt. Pinatubo), with the ultimate goal of providing theoretical support for disaster monitoring and prediction in volcanic and seismic hazard-prone island nations.

Keyword

subduction zone, hydration, water flux, volcano

Seismic and Gravity Data Analysis of Oceanic Core Complexes in the West Philippine Basin

Jingyan Zhao[1], Second Institute of Oceanography
Yanghui Zhao[2]*, Second Institute of Oceanography (zhaoyh@sio.org.cn)

Abstract

Detachment faulting related to oceanic core complexes (OCCs) has been suggested to be a manifestation of slow seafloor spreading. Although numerical models suggest OCCs form under low magma supply, the specific interaction between magmatism and tectonic faulting remains elusive. Recently acquired seismic profiles from the spreading center of the West Philippine Basin, complemented by satellite gravity data, have shed light on the sequential emergence of distinct OCC structures along the strike of this mid-ocean ridge. The combination of geological interpretation of the seismic profiles and the inversion of gravity data has yielded the following foundlings. We identified a magma-rich spreading phase at 36 Ma, indicated by a magmatic top basement and normal oceanic crust with shallow-penetrating high-angle faults. An axial valley reveals an along-strike transition from normal to highly tectonized oceanic crust over a distance of 70 km. Two older OCCs with concave-down fault geometries and a younger OCC with steep-dipping faulting suggest sequential detachments with the same polarity. Our findings suggest: (1) slow seafloor spreading is cyclical, alternating between high-angle faulting with a relatively high magma supply and detachment faulting with limited magma supply; (2) sequential development of younger detachments in the footwall of its predecessor leads to an asymmetric split in the newly accreted crust; and (3) the life cycle of OCC ends with high-angle faults that overprint the detachment and act as magma pathways, sealing the OCC. Our study captures the dynamic interaction between high-angle and detachment faults and their concurrent and subsequent relationship to magmatic systems. This reveals that strain distribution along strike is critical to OCC formation, thus enriching our understanding beyond conventional considerations such as spreading rates and melt budgets at mid-ocean ridges.

Keyword

slow mid-ocean ridges, life cycle of oceanic core complex, tectonic-magmatism interaction

Rift architecture and evolution controlled by an exhuming and decapitating metamorphic core complex in the Kaiping Sag, northern South China Sea margin

WenDi LI[1]*, China University of Geosciences (lwd15184488553@163.com)
Qing Ye[2], China University of Geosciences

Abstract

The architecture and evolution of rift basins overlying a metamorphic core complexes (MCCs) have not yet been well reported. The northern margin of the South China Sea was the main rift period of sedimentary basins from the Late Cretaceous to the Middle Oligocene, undergoing five important tectonic movements. The basin structure was complex, and the metamorphic core complex developed and evolved during the Middle to Late Eocene significantly affected the basin structure. In this study, using high-quality 3-D seismic reflection data we study how the Cenozoic rifting structure and evolution of the KaipingSag relate to the development of an underlying metamorphic core complex, the Kaiping metamorphic core complex, in the northern South China Sea margin.

The Kaiping sag was a half-graben structure in the early stage of deposition (49Ma~43Ma). With the development and uplift of the metamorphic core complex, the original medium-high angle section bends, forms a sinusoidal shape. The sedimentary basin was strongly extended, the depth of the depocenter increased, and the top of the core complex was gradually exposed to the water surface for erosion(43Ma~39Ma). The development of metamorphic core complexes is thought to favor sediment accumulation.

The Kaiping sag suffered significant denudation, forming a large-scale stratigraphic angular unconformity inside the sag. In the Kaiping Sag, the strata deposited before the activity of the metamorphic core complex underwent significant rotation as the metamorphic core complex developed and uplifted. Evidence shows that the two areas subject to the strongest denudation in the KP Sag are the highest uplift points of the core complex. Current research shows that the impact of the metamorphic core complex on the structure of the basin overlying it is huge and complex. The reconstruction of the structure and evolution of metamorphic core complexes and the rift basins above them is crucial for evaluating and predicting the oil and gas accumulation patterns of metamorphic core complex type basins.

Keyword

The northern margin of the South China Sea, Kaiping metamorphic core complex, Basin evolution

New data on the age of the basement of the Devonian Magnitogorsk island arc (the Southern Urals) according to the results of U-Pb LA-ICP-MS dating of zircons from tuffs of the Irendyk Formation

Ivan SOBOLEV[1]*, IGEM RAS (sobolev_id@mail.ru)
Anton Latyshev[2], Institute of Physics of the Earth of the Russian Academy of Sciences
Anna Kulikova[3], Kazan Federal University
Kamil Minnebaev[4], Kazan Federal University
Ilya Vikentev[5], IGEM RAS
Denis Lapaev[6], IGEM RAS
Daria Soboleva[7], IGEM RAS

Abstract

Zircons from boninite tuffs (sample S1-16; 54°37'19.7"N, 59°43'32.2"E) belonging to the Lower-Middle Devonian (Emsian–Eifelian stages) Irendyk Formation (Zhdanov et al., 2018) were studied for the first time in the Western Magnitogorsk Zone of the Southern Urals, 1 km southeast of the Polyakovka village. Boninite tuffs are massive in thin sections, but demonstrate clear graded bedding in outcrops. The rocks are medium-grained and composed of porphyry amygdaloidal and massive basaltic andesite fragments and clinopyroxene crystalloclasts. For the first time, we determined the U-Pb (LA-ICP-MS) age of zircons from boninite tuffs. Most of zircon grains are rounded to varying degrees, and some of them are euhedral. According to CL images, zircons without zoning dominate in the sample, grains with oscillatory zoning are less common. The Th/U ratio for all grains >0.1, which is typical for zircons of magmatic origin. A total of 108 individual zircon grains were analyzed. The results for 31 grains were excluded from consideration due to high discordance (the criterion for rejection of analyses is –10>D>10). For the remaining 77 zircons, a wide age range was obtained from 236 to 3587 Ma. No age comparable to the time of deposition of the rocks of the Irendyk Formation (Zhdanov et al., 2018) was obtained for any of the zircons. There are five grains (6.5% of the total sample) of the Middle-Late Triassic, Permian and Carboniferous (Serpukhov-Gzhel) age (236–325 Ma), which may be the result of isotopic rejuvenation under the influence of superimposed processes associated with Late Paleozoic accretion-collision events in the Urals. Five zircon grains (6.5%) have Silurian-Cambrian ages – 428-534 Ma. Precambrian ages were obtained for 67 grains, among which Neoproterozoic zircons predominate (35% – 27 grains, 559–997 Ma). Zircons of Mesoproterozoic (14% – 11 grains, 1004–1564 Ma), Paleoproterozoic (23% – 18 grains, 1649–2498 Ma) and Neoarchean (12% – 9 grains, 2501–2800 Ma) age are less common. The two oldest grains (3%) have Meso- and Paleoarchean ages – 3179 and 3587 Ma.

The results of dating of zircons from boninite tuffs demonstrate a significant predominance of Precambrian xenogenic zircons over Paleozoic ones, which may indicate the presence of an ancient Precambrian basement at the base of the Magnitogorsk Devonian island arc. Similar results were previously obtained for the Paleozoic island-arc of the Polar Urals (Sobolev et al., 2017).

Keyword

Magnitogorsk Island arc, Devonian, Southern Urals, paleotectonic reconstructions, Irendyk formation

Synrift and postrift thermal evolution of margins: a re-evaluation of classic models of rifting

Marta PEREZ-GUSSINYE[1]*, MARUM/Bremen University (gussinye@uni-bremen.de)
Yanfang Xin[2], Exploration and Development Research Institute, Shengli Oil Field Company, SINOPEC, China
Tiago Cunha[3], IGI Ltd., The Granary, Hallsannery, Bideford, EX39 5HE, UK
Raghu Ram[4], MARUM/Bremen University
Miguel Andrés-Martínez[5], Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany
Dongdong Dong[6], Key Laboratory of Marine Geology and Environment, Institute of Oceanology, Chinese Academy of Sciences, Qingdao 266071, China
Javier García-Pintado[7], MARUM/Bremen University

Abstract

The thermal history of margins controls the development of hydrothermal systems during rifting, diagenetic processes in the sediments and the generation and preservation of hydrocarbons. It also affects the depth of the oceanic gateways formed during continental break-up, thereby influencing ocean circulation and ultimately climate (Brune et al., 2023, Pérez-Gussinyé et al., 2023, Peron-Pinvidic et al., 2019). However, observed heat-flow values however, do not always comply with classic rifting models. Here, we use 2D numerical models to investigate the relationship between rifting, sedimentation and thermal history of margins. We find that during the synrift, the basement heat flow and temperature are not only controlled by extension factor, but also by synrift sediment thickness and the evolution of deformation. As this progressively focuses oceanward, the proximal sectors thermally relax, while the distal sectors experience peak temperatures. This time lag is important for wide rifted margins. In the postrift, the lithosphere under the hyperextended margins does not return to its original state, at least for ~100 Myrs after breakup. Instead, it mimics that of the adjacent oceanic plate, which is thinner than that of the original continental plate. This results in heat flow values increasing oceanward at postrift stages where classic rifting theory predicts complete thermal relaxation. Our increased heat-flow estimations, may extend hydrocarbon plays into distal margin sectors and adjacent oceanic crust, previously discarded as immature. Finally, our models indicate that commonly used temperature approximations in basin analysis may strongly differ from those occurring in nature (Pérez-Gussinyé et al., 2024).

Pérez-Gussinyé et al., Synrift and postrift thermal evolution of margins: a re-evaluation of classic models of rifting, Geol. Soc. Spec. Publ. Lon., 2024

Keyword

rifted margins, heat flow, postrift, small-scale convection

USE OF MAGNETIC METHODS TO MODEL A GONDWANA SUTURE ZONE IN DEPTH: SOUTHEAST BRAZILIAN CONTINENTAL MARGIN

RAPHAELA LOPES DE ANDRADE SILVA[1]*, Coppetec (rapha.las@hotmail.com)
RENATA DA SILVA SCHMITT[2], UFRJ / CDGG
NATASHA SANTOS GOMES STANTON[3], UERJ / OCN
GUILHERME GONÇALVES MARTINS[4], UFRJ /CDGG

Abstract

Orogenic sutures are crustal/lithospheric-scale lineaments that mark the limits between terranes previously separated by tectonic plates active margins. In the SE Brazilian continental margin, a Cambrian NE-SW suture zone is marked by an expressive magnetic anomaly onshore that extends offshore to the proximal Santos basin (Rio de Janeiro). The suture is product of the last Gondwana amalgamation event, being represented by a high positive curvilinear lineament, by which the magnetic gradient decreases to NW after pass it. This lineament separates two contrasting geological terranes: a Neoproterozoic magmatic domain (Oriental Terrane - ORT), to the west, and a Paleoproterozoic gneissic terrane, to the east (Cabo Frio Tectonic Domain - CFTD). The dip direction of this suture and the vergence of the subduction that generated it is still motive of debate by researchers. The studied area comprises mainly two geological units separated by a thrust fault (suture zone): dioritic to granitic Paleoproterozoic rocks with metabasite layers (Região dos Lagos Complex, from CFTD) and Ediacaran aluminous paragneisses with calcsilicate layers (Palmital Succession, from ORT). Magnetically, the Paleoproterozoic gneisses are associated with high amplitude, long wavelength (55 km) and numerous magnetic rectilinear and curvilinear lineaments. Amplitude ranges between -100 and 452 nT, mostly higher than 150 nT. Otherwise, the Palmital paragneisses coincides with low frequencies, a long wavelength (55 km) magnetic domain and amplitudes <0 nT, resulting in a lateral contrast of more than 500 nT with Região dos Lagos Complex. The focus of the present work is to determine how this suture extends on depth and the source of the magnetic anomaly for, consequently, understand the nature of the basement that constitutes the continental margin, once the suture extends offshore to SW. For this, we built an unprecedented magnetic susceptibility database including values obtained both on field and laboratory. Based on this database, and also on standard remanence and density values, we modeled two magnetic sections made on field along the suture zone on GMSYS. We try to variate only susceptibility values. So, geophysical data was integrated with geological maps in order to build correlations so that petrological characteristics and fluids interaction during orogenic events was considered during modeling parameters adjustment. Finally, models have a better fit with the suture dipping to NW, suggesting a west vergence subduction. Also, Cabo Frio Tectonic domain is the probable source of the magnetic anomaly. The methodology and database developed in this work allows further researches modelling, including in areas were the geological information is unknown.

Keyword

MAGNETIC METHODS, SUTURE ZONE, BRAZILIAN CONTINENTAL MARGIN, GONDWANA

Intrusive mantle flow induced by thermal heterogeneity during rift propagation

Min-seok JANG[1]*, Kangwon national university (alstjr2264@kangwon.ac.kr)
Byung-dal So[2], Kangwon national university
jimin Kim[3], Kangwon national university

Abstract

Extensional forces induced by the plumes or relative motion of plates cause rifting to separate continents and form new oceanic crusts. In addition, the mantle uplifted by rifting is known to have an essential influence on lithospheric evolution through igneous activity such as magmatic underplating and LIP(Large igneous province). Recent studies from seismic wave surveys in the EARS(East African Rift System) suggest that mantle flow may also parallel the ridge. Although previous studies have shown that uplifted mantle can flow long distances from a ridge in an extensional direction, an understanding of flow in parallel directions is still not well defined. In particular, the flow of the lower mantle and its interaction with the lithosphere during rift propagation requires further investigation. We used the thermo-mechanical geodynamics code ASPECT to model rift propagation and trace lower mantle convection. Mantle flow in different lithospheric environments has also been evaluated by varying the initial and boundary temperature conditions, which is an important factor of viscosity. The model results confirm the generation of a mantle flow parallel to the ocean ridge. The mantle flow becomes more active and vigorous at higher temperatures condition in the rift zone, extending several hundred kilometers in the hottest models. Mantle intruded beyond the rift tip into the bottom of the lithosphere, and convection persisted after rift termination. These results suggest that rift propagation processes in high-temperature environments can invade the lower mantle outside the rift zone. We propose that the sub-lithospheric intrusion of the hot mantle by rift propagation has the potential to generate intraplate volcanism or magmatic underplating.

Keyword

Rifting, mantle flow, rift propagation

Earthquake rupture features in near-surface regions, Korea

Youngbeom CHEON[1]*, Active Tectonics Research Center, Korea Institute of Geoscience and Mineral Resources (cheonyb@kigam.re.kr)
Chang-Min Kim[2], Department of Geology, Division of Geology and Geophysics, Kangwon National University
Jin-Hyuck Choi[3], Active Tectonics Research Center, Korea Institute of Geoscience and Mineral Resources

Abstract

We present the structural characteristics of earthquake ruptures, which propagate and terminate at and near the ground surface, based on multi-scale observations of the paleoearthquake records distributed throughout South Korea. Paleoearthquake ruptures are mostly observed along the NNE–SSW-striking and WNW–ESE-striking pre-existing faults, which are the most dominant sets of inherited structures in Korea. Especially, some of them occurred along the boundary between the inherited fault core and damage zone. The NNE–SSW-striking and WNW–ESE-striking ruptures primarily show different movement senses; dextral and sinistral slips with small reverse components (i.e., dextral and sinistral transpressional kinematics), respectively, due to the imposed neotectonic stress (ENE–WSW maximum horizontal stress). The ruptures propagated upwards to the shallow subsurface along the <3-cm-wide specific slip zone. However, within unconsolidated sedimentary strata (below the surface), the numerous ruptures change their natures as follows. (1) The ruptures tend to branch into several narrower splays (less than a few millimeters wide). The branched splays can be grouped into those breaking ground surface and those terminating below the surface. (2) In the case of ruptures terminating in shallow subsurface, the dip angles of these branched ruptures decrease upward and their strikes change from NNE–SSW to NNW–SSE and from WNW–ESE to NNW–SSE, respectively. (3) The NNW–SSE-striking fault splays with a lower dip angle show much greater rake angles of striations, indicating reverse-dominant kinematics, unlikely the mostly strike-slip sense on high-angle fault splays in the basement rocks. (4) The deformation mechanism of the slip zone is predominantly characterized by a granular flow (i.e., rearrangement of clasts rather than fragmentation and truncation of them). Our findings suggest that the near-surface features of earthquakes in Korea are controlled by the following factors. (1) The inherited fault geometry that is unfavorable with respect to the imposed stress (ENE–WSW maximum horizontal stress) at basement depths in terms of reactivation on the fault, and lack of upward extension of the inherited fault to the shallow surface (or recent unconsolidated sediment). (2) The ratio of vertical (overburden) stress to minimum horizontal stress, which changes from deep to shallow levels (i.e., at depth of ~200 m). (3) Physical properties of unconsolidated sediments, which have low inter-granular cohesion that favors granular flow and distributed deformation.

Keyword

Earthquake rupture, Korea, Structural characteristics, Near-surface

Fault Creep Promoted by the Regional Alignment of Fault Networks

Jaeseok LEE[1]*, Brown University (jaeseok_lee@brown.edu)
Victor C Tsai[2], Brown University
Greg Hirth[3], Brown University
Avigyan Chatterjee[4], University of Nevada, Reno
Daniel T Trugman[5], University of Nevada, Reno

Abstract

While many faults are locked and capable of hosting earthquakes, some other faults creep, silently accommodating tectonic loading through slow, gradual slip. Currently, the slip behavior of faults is thought to be explained by the frictional properties of the rocks forming the fault material; yet studies suggest that the relationship between rheology and slip behavior may not be as straightforward. Here, we introduce a novel interpretation of fault creep, proposing that the geometrical complexity of fault networks primarily controls fault slip behavior. We investigate the link between fault network geometry and surface creep rates in California and observe that regions with aligned fault network geometries are prone to hosting aseismic slip while more complex regions tend to be locked. Other creeping fault systems, such as the North Anatolian Fault and the Chaman Fault, also demonstrate similar correlations, suggesting that the influence of fault network geometry on fault creep may be a universal behavior. Through correlation studies of key physical variables including subsurface shear wave velocity, surface heat flow, and fault nonplanarity, we conclude that other parameters are not significant in explaining either fault creep or fault misalignment, indicating fault misalignment as a predominant and independent factor for explaining fault creep. This finding challenges traditional notions that earthquake stability is primarily governed by rate-and-state dependent frictional properties on single fault strands, and raises many questions about how to best understand the fundamental nature of earthquakes.

Keyword

fault geometry, aseismic creep, fault locking

On the active faults around Gyeongju, Korea: a possible relationship with the 779 AD Gyeongju Earthquake and the Buddhist temples/pagodas in the Silla Dynasty (57 BC – 935 AD) as a 'Bibo Pungsu (Feng Shui theory)'

Chung-Ryul RYOO[1]*, Korea Institute of Geoscience and Mineral Resources (ryoocr@kigam.re.kr)
Taehyung KIM[2], Korea Institute of Geoscience and Mineral Resources

Abstract

In Korea, we have many historic monuments around Gyeongju, the capital city during about one thousand years long of the Silla dynasty (57 BC – 935 AD), especially many Buddhist temples and pagodas. By historical seismic records from 2 AD to 1904, there are several strong earthquakes occurred around Gyeongju, Korea. The 779 AD Gyeongju Earthquake is reported as the most disastrous earthquake in the Korean history about 100 peoples died. The 779 AD Gyeongju Earthquake is estimated as M 6.5-7.0, and is considered as strong enough to make a surface rupture around Gyeongju. Gyeongju is located in a junction area of two important faults, the Yangsan and the Ulsan faults. Several active faults are found in these fault zones around Gyeongju during last 30 years. We discovered that there are the Buddhist temples and pagodas near some active faults along the Ulsan Fault Zone. In the Korean history many temples and pagodas are reported to built mainly after 780 AD, which support a possible relationship between the 779 Gyeongju Earthquake with possible surface ruptures and the Buddhist temples with pagodas in the Silla Dynasty as a 'Bibo Pungsu (Feng Shui theory)'. The Silla peoples believed that the temples and pagodas could be control and calm the underground dragons making the big earthquakes. We suggest that some temples and pagodas are historically beautiful and tectonically useful to trace a possible surface rupture occurred during 779 Gyeongju Earthquake.

Keyword

Gyeongju, active Ulsan Fault, 779 Gyeongju Earthquake, Bibo Pungsu, Buddhist temples/pagodas

Fossil Earthquakes Preserved on Fossils: New examples from Taiwan

CHIEN-CHIA TSENG[1], Department of Geosciences, National Taiwan University
JIH-PAI LIN[2]*, National Taiwan University (alexjplin@ntu.edu.tw)
CHUNG-PAI CHANG[3], Center for Space and Remote Sensing Research, National Central University
CHI-WEN CHEN[4], Department of Geosciences, National Taiwan University

Abstract

In the structural divisions of Taiwan, the coastal plain of Miaoli belongs to the Outer Foothill of the Western Foothill. Approximately six million years ago, the Penglai Orogeny began, leading to significant tectonic activities in the Miaoli region, resulting in numerous faults and folds. These structures have concurrently influenced the occurrence and preservation of fossil echinoids in the region. Goal of this study is study and document the deformed and fractured specimens of the fossil sand dollar Scaphechinus mirabilis from the Xiangshan Member of the Toukoshan Formation in Miaoli County, Taiwan.

Unlike deformed fossils that are commonly reported from the Mesozoic and older strata, new examples of deformed fossils are recovered from the Pleistocene strata in Taiwan. Micro-CT tomographic imaging and rendering of deformed sand dollars reveals 3D geometry of fault planes in hand sample size. Under the thin sections, additional tectonic structures, such as pressure solutions, box folds and monoclines, are evident. While some ductile and brittle deformations, such as fractures along the taphonomically weak ossicle boundaries, may have sedimentary origin(s), fault features that were triggered by earthquakes are undoubtedly preserved in rare specimens. This study provides new and unique evidence to reveal key missing information to understand better the neotectonics for the collision between the Philippine Sea Plate and Eurasia Plate in Taiwan based on fossils.

Keyword

Earth History, neotectonics, fault geometry, ductile and brittle deformation, 3D microscopic computed tomographic imaging

Evidence of Surface Rupture on Inherited Fault and its Implications for Intraplate Earthquakes in the Central Yangsan Fault, South Korea.

Sangmin HA[1]*, Korea University (hsm9181@korea.ac.kr)
Hee-Cheol KANG[2], Pusan National University
Seongjun LEE[3], Korea Institute of Geoscience and Mineral Resrouces
Yeong Bae SEONG[4], Korea University
Jeong-Heon CHOI[5], Korea Basic Science Institute
Seok-Jin KIM[6], National Research Institute of Cultural Heritage
Moon SON[7], Pusan National University

Abstract

Unlike interplate, where earthquakes are periodic and frequent, predicting earthquakes in the intraplate, where they occur randomly, is challenging. Furthermore, the difficulties are compounded in regions where slow deformation and complex fault internal structures. The Korean peninsula is a prime example of a region that fits all of these cases. We used multiple methods to identify characteristics of Quaternary surface rupture and obtain paleoseismic information on the central Yangsan Fault, one of the most major tectonic lines in Korea. Topographic analysis using a high-resolution LiDAR image revealed the 2-4 m fault scarp and the 50-150 m dextral offset deflected stream, which led to the recognition of a 7.6 km lineament. Electrical resistivity surveys were conducted on 25 lines along the lineament, and low resistivity anomalies suggestive of faults were observed along most of the lines. In 5 trench surveys, N-S to NNE-striking faults cut Quaternary sediments, and OSL, IRSL, ESR, and 10Be dating were performed on the sediments. Taken together, all of our results show that the most recent earthquake in the study area was 3,000 years ago, with at least three faulting events. The displacement per event is 0.33-2.81 m, the cumulative displacement is 3.1-94 m, and the estimated maximum magnitude is 6.7-7.2. The average slip rate is 0.14 mm/yr, and the recurrence interval is estimated to exceed 10,000 years according to the quasi-periodic model. The central Yangsan fault has been continuously reactivating since the Quaternary as a dextral strike-slip with a small reverse component, with a top-to-west geometry of the pre-existing fault core under ENE-WNW compression. Our results not only provide fundamental elements for seismic hazard assessment but also contribute to the understanding of intraplate seismicity.

Keyword

Yangsan Fault, intraplate earthquake, paleoseismology, surface rupture

[Keynote] Temporal clustering of large earthquakes along the central-eastern sections of the Altyn Tagh Fault, China

Yann KLINGER[1]*, CNRS - IPGP (klinger@ipgp.fr)
Nicolas Pinzon[2], IPGP - Université de Paris Cité
Xiwei Xu[3], China University of Geosciences, Beijing, China
Jing Liu[4], Tianjin University, Tianjin, China
Jerome Van der Woerd[5], Institut Terre et environnement de Strasbourg (ITES), Strasbourg, France
Kang Li[6], National Institute of Natural Hazards, Beijing, China
Mingxing Gao[7], Xinjiang University, Urumqi, China

Abstract

The understanding of the spatial-temporal distribution of past earthquakes is essential to assess the event recurrence behavior and to estimate the size of potential earthquakes along major strike-slip fault systems. However, the scarcity of paleoseismic data remains a major hurdle in this endeavour. We document a paleoseismic record over the last 8kyr along the central-eastern Altyn Tagh Fault (ATF). First, we identify six very likely large earthquakes that potentially ruptured the Aksay section of the ATF. Employing a Bayesian model approach, we present modeled range ages of 6339 – 5220 BC, 5296 – 4563 BC, 3026 – 2677 BC, 1324 – 808 BC, 314 – 632 AD, and 916 – 1236 AD. The mean recurrence time is 1371±625 yr with a COV of ~0.46, suggesting a quasi-periodic behavior. In the same fault section, 90 horizontal offsets record an average coseismic slip of 5.1 1.4 m for the most recent event (MRE) and suggest at least four older earthquakes plausibly with a similar slip distribution.

We find that at the local scale (fault section) the earthquake recurrence is quasi-periodic along the ATF. However, at the regional scale (fault system) the tectonic strain seems to be released in bursts of seismic activity punctuated by periods of relative quiescence. Applying site-to-site correlation of rupture ages along four fault sections of the central-eastern ATF, we found that ten large earthquakes occurred in clusters during the middle (5.4 – 4.4 kyr) and late (1.6 kyr - present) Holocene. These bursty periods of seismic activity show mean interevent times of 495 ± 129 yr and are preceded by millennial long-lull periods of 1360 ± 223 yr. Based on this temporal organization we suggest that the central-eastern ATF is either at the early stage of a seismic quiescence period, or it might currently be in the late stage of an earthquake cluster. In such a scenario, given the 390-yr elapsed time since the MRE there exists a possibility of a forthcoming large earthquake occurring within the next century.

Keyword

earthquake, paleoseismology, Altyn Tagh, reccurence time, rupture scenario

A Study on Seismic Velocity Contrast along the Longitudinal Valley Fault System, Taiwan, Using Fault Zone Head Waves

Tzu-Chi Lin[1]*, Institute of Earth Sciences, Academia Sinica, Taiwan (sallylin0625@gmail.com)
Gregor Hillers[2], Institute of Seismology, University of Helsinki, Finland
Shiann-Jong Lee[3], Institute of Earth Sciences, Academia Sinica, Taiwan
Shu-Huei Hung[4], Department of Geosciences, National Taiwan University, Taiwan

Abstract

Fault zone head waves (FZHWs) offer insights into fault structures at seismogenic depths. We investigate the northern segment of the Longitudinal Valley (LV) fault system, a major suture zone between the Eurasian Plate and the Philippine Sea Plate. The analysis focuses on 22 stations within a 60 km by 28 km area along the fault, using ~8000 small-to-moderate earthquake seismograms recorded from 2012 to 2018. Employing Ross and Ben-Zion's algorithms, we detect 272 robust head waves from 149 events, primarily along the west-dipping Central Range fault, indicating a consistent velocity contrast across this segment. Validation of automatic FZHW picks confirms accuracy through particle motion, polarization, and moveout analyses despite complexities in subsurface structures and topographical changes. Our investigation reveals a constant moveout pattern from P wave to FZHW time differences, indicating a shallow bimaterial interface significantly impacting the wavefield near or beneath stations. We further fit the moveout and constant arrivals with two models to the differential P and head wave arrival times to explore possible local variations of the constant trend. The Akaike Information Criterion applied to the constant and classical moveout pattern suggests spatially complex significant results that, together with the depth distribution of the involved events, indicate a deeper-reaching bimaterial interface. This analysis yields an average velocity contrast of approximately one per cent, aligning with previous FZHW studies along major plate boundary faults. Overall, this study enhances understanding of fault structures in the LV fault system and underscores the importance of FZHWs in providing high-resolution fault information.

Keyword

seismic velocity contrast, bimaterial interface, fault zone head waves, Longitudinal Valley fault system, moveout analysis

Persistent crustal CO2 degassing following the 2022 M6.8 Chihshang earthquake sequence, eastern Taiwan

Ching-Chou FU[1]*, Institute of Earth Sciences, Academia Sinica (ccfu@earth.sinica.edu.tw)
Kuo-Hang Chen[2], Institute of Earth Sciences, Academia Sinica
Kuo-Wei Wu[3], Institute of Earth Sciences, Academia Sinica
Chung-Hsiang Mu[4], Institute of Earth Sciences, Academia Sinica
Pei-Ling Wang[5], Institute of Oceanography, National Taiwan University
Li-Hung Lin[6], Department of Geosciences, National Taiwan University
Hao Kuo-Chen[7], Department of Geosciences, National Taiwan University
Vivek Walia[8], National Center for Research on Earthquake Engineering, NARL

Abstract

On September 17, 2022, a magnitude 6.6 earthquake occurred, followed by a magnitude 6.8 mainshock in Chihshang approximately 17 hours later, along the southern Longitudinal Valley in eastern Taiwan, where the Eurasian and Philippine Sea plates meet. This seismic event caused significant damage to buildings and the surface. In order to investigate the gas-bearing properties of the Chihshang Fault (CSF) zone and gain a better understanding of the degassing behavior, soil gas surveys were conducted to examine gas species and CO2 degassing. Our findings indicate that the observed increase in CO2 flux at the surface after the CS earthquake could be attributed to the release of gases from both deep and shallow sources, with the enhanced permeability of the fault system playing a role in this process. The presence of a heavier 13C isotopic composition provides evidence of an additional contribution of CO2 gas migrating from depth to the surface, a phenomenon that persisted for at least three months after the earthquake. These observations suggest that the CSF system acts as a conduit connecting deep and surface gas reservoirs, with CO2 emissions linked to significant seismic activity. The earthquake-induced microfractures may gradually heal and return to their original state. Based on our estimates, the total natural CO2 degassing around the entire CSF zone is approximately 1200 t/d before the Chihshang earthquake and 2200 t/d after the earthquake. These findings shed light on the dynamic behavior of gas emissions associated with seismic events and provide valuable insights into the degassing processes within the study area.

Keyword

CO2 degassing, Chihshang earthquake, Chihshang Fault, Soil gas

Frictional slips on artificial fault planes implicating periodic earthquakes along active tectonic plate boundaries

Insun SONG[1]*, Korea Institute of Geoscience and Mineral Resources (isong@kigam.re.kr)
Yu Na LEE[2], Kongju National University

Abstract

Frictional slips along subduction plate boundaries are often observed as an alternative behavior between interseismic locking and coseismic rupture. The unstable slips known as stick-slip failure occur along the seismogenic zone of a convergent boundary. The seismogenic portion does not extend all the way to the trench, and the aseismic boundary is called the updip zone. We have conducted a series of double direct shear tests on saw-cut planes with three blocks of Hwangdung granite to simulate the frictional slip on the convergent boundary with increasing depths. We prepared a double direct shear apparatus with three rock blocks in parallel, where the middle one slipped against the outer blocks. The shear apparatus was placed in a pressure cell for applying the normal stress on the 3 x 4 cm contact planes with the confining fluid pressure. The planes were subjected to shear stresses by moving the middle block against the outer ones using a loading frame with a jack. For the test, we first applied the normal stress on the artificial fault planes with the confining fluid pressure and kept the pressure constant using a syringe pump. Then we pushed up the pressure cell against the loading frame bar with the jack that was actuated by fluid pressure from a syringe pump controlled with constant flow rate. Thus there exists some spring compliance between shear planes and syringe pump that we actually controlled. This experimental system was designed to imitate the convergence of tectonic boundaries where the control of plate movement takes place far from the fault planes. Our experimental result revealed that the stick-slip behavior occurred at high normal stress on the planes but clearly disappeared at low normal pressure (lower than 3 MPa replicating shallow depth). The pressure drop at coseismic slip proportionally increases with the normal stress (or depth). These results are consistent with the observation of frictional slip behaviors along subduction plate boundaries showing aseismic zone at very shallow depth and periodic coseismic ruptures accompanying with earthquakes.

Keyword

Stick-slip behavior, Periodic earthquake recurrence, Coseismic rupture mechanics, Frictional plate boundary, Aseismic sliding

Tectonic Geomorphology and Paleoseismology of the East Solsona Basin Fault in Northern Luzon, Philippines

Noelynna Tuazon Ramos[1]*, University of the Philippines (noelynna.ramos@up.edu.ph)
Jeffrey S. Perez[2], Department of Science and Technology-Philippine Institute of Volcanology and Seismology
Kathleen L. Papiona[3], Department of Science and Technology-Philippine Institute of Volcanology and Seismology
Arturo S. Daag[4], Department of Science and Technology-Philippine Institute of Volcanology and Seismology
Clod Anne V. Punzalan[5], University of the Philippines
Reynaldo M. San Jose[6], University of the Philippines
Karlo L. Queaño[7], Mines and Geosciences Bureau

Abstract

The East Solsona Basin Fault (ESBF) forms part of the northern segments (collectively named West Ilocos Fault System) of the Philippine Fault Zone (PFZ) on Luzon Island. The West Ilocos Fault System (WIFS) consists of a network of strike-slip, reverse, and normal fault segments, whose major strands have generated strong to major earthquakes in recent years, notably the Mw7.7 1990 Luzon Earthquake and the Mw7.0 2022 Northwestern Luzon Earthquake. Despite its active seismicity, several segments of the WIFS such as the ESBF remain understudied. In this study, we examine geomorphological, geophysical, and paleoseismological data to establish the rupture history and hazard potential of the fault. Offset streams, truncated spurs, and subtle elevation changes were interpreted from anaglyph images and high-resolution digital topography data. Geomorphic markers indicate a general sinistral movement of the fault, with the fault scarp trending N20-35°E and dipping northwest. Ground penetrating radar surveys conducted along and across the fault scarp reveal discontinuous reflectors, corresponding to fault strands at a depth of about 5 m. Paleoseismic trenching conducted at one site reveals at least ten (10) stratigraphic units and four (4) fault strands, with minor vertical offsets ranging from 10 to 30 cm. Radiocarbon dating of organic sediments infers that at least two surface-rupturing earthquakes occurred along this fault segment over the past 1200 years, establishing recent movement along the ESBF.

Keyword

tectonic geomorphology, paleoseismic trenching, East Solsona Basin Fault, Philippines

Neotectonic deformation and long-term behavior of Masjed-e Soleyman Dam, Iran

Arash Barjasteh[1]*, Khuzestan Water & Power Authority (KWPA) (barjasteh@hotmail.com)

Abstract

Fault movement in dam foundation and reservoir is one of the seismic hazards that can lead to extensive structural damage in the dam and appurtenant structures. In this article, neotectonics deformation in the area of Masjed-e Soleyman dam in Khuzestan province is investigated considering its location in the most active seismotectonic zone of Iran. The dam height is 177 m with an annual 3,700 million kilowatts per hour of hydroelectric power energy. The construction of the dam was completed in 2001 over the Karun River. The foundation rock of the dam is composed of Agha-Jari Formation sandstones besides conglomerates of its member called Lahbari Member. The studied area is located in the northern part of Dezful Embayment in the folded Zagros, and deformation of the Neogene Formations exposed in the studied area is related to the activity of the surrounding faults, especially the Lahbari and Andeka faults. NW-SE trending Lahbari fault with thrust mechanism is the most important fault in the region that lies in the southwest of the dam. The Andeka fault passes through the north of the right abutment of the dam while changing its strike from northwest-southeast to east-west near the dam site. The change in the trend of the fault is associated with a change in its mechanism from strike-slip in the northern sector to thrust in the southern sector. Additionally, morphotectonic features of the dam site region indicates existence of a NE-SW lineament with a left-lateral displacement upstream the dam axis. The neotectonic movements such as faulting in post-Miocene Formations, tilting in the river course, extensive rock falls and fault scarps are visible in the dam vicinity. The location of the dam between the two mentioned active faults caused heterogeneous compression, disturbed bedding and tight synclinal structure at the dam site. Dam monitoring data confirms progressive deformation of the present formations in the investigated area. The aim of this article is to explain and discuss the possible relationship between the geological setting and the observed problems.

Keyword

Neotectonic deformation, Long-term behavior, Andeka fault, Masjed-e Soleyman

Multi-disciplinary active fault mapping in the central Gyeongju, SE Kore

Jinhyun Lee[1]*, PUKYONG NATIONAL UNIVERSITY (Jinhyunlee747@gmail.com)
Young-Seog Kim[2], PUKYONG NATIONAL UNIVERSITY

Abstract

Active fault mapping is crucial for earthquake mitigation, particularly in regions with highly anthropogenic modifications and low slip rates. Records of paleo surface ruptures can be traced using multi-disciplinary methods. In the Gyeongju area of SE Korea, we utilized LiDAR/aerial photography, trench, and geophysical data to classify the faults into the Cheongun (C), Wangsan (W), Sinpyeong (S) and Galgok (G) segments. These segments are located in the merging area of the Yangsan-Ulsan fault system and exhibit a north-south trend. All four segments display reverse fault characteristics, with variations in fault movement depending on the fault geometry. Through multi-disciplinary active fault mapping, the precise distribution of four segments was identified, with deformations in the Miocene strata serving as key evidence. The segments deformed Miocene sedimentary layers and cut through Holocene alluvial/fluvial deposits. The C-S-G segments are structurally developed as step segments, and the W segment is isolated. All C-S-G segments are identified with at least three Holocene activity, with OSL dating indicating a concentration of fault movements around 40 ka. We examined the possibility of kinematic segmentation and re-evaluated the role of these segments within the Yangsan-Ulsan fault system. Furthermore, utilizing precise mapping data, we proposed safety distances in the Gyeongju area, which can serve as fundamental data for seismic hazard assessments.

Keyword

Active fault mapping, Yangsan-Ulsan Fault system, Safety distance

Aseismic, co-seismic, and post-seismic displacements on the September 2022 Guanshan and Chihshang earthquakes, in eastern Taiwan

Horng-Yue Chen[1]*, Institute of Earth Sciences (chenhy@earth.sinica.edu.tw)
Tung Hsin[2], Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan
Ya-Ju Hsu[3], Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan
Jian-Cheng Lee[4], Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan
Yu Wamg[5], Department of Geosciences, National Taiwan University, Taipei, Taiwan
Hung-Kyu Lee[6], Department of Civil Engineering, Changwon National University, South Korea

Abstract

To estimate the aseismic, co-seismic, and post-seismic displacements, we characterize the spatial pattern of ground deformation caused by the September 17 ML 6.6 Guanshan and the September 18 ML 6.8 Chihshang earthquakes in eastern Taiwan using geodetic data collected from Continuous Operating Reference Stations (CORS), corrected Single-frequency CORS (SCORS), campaign-mode GNSS/GPS survey (CMGS) stations, as well as the results from two precise leveling routes. For the ML 6.6 foreshock, our analysis from high-rate CORS data suggests ~20 cm coseismic horizontal displacements occurred between the Chihshang and Taitung area, south of the foreshock epicenter. In contrast, high-rate CORS data from the ML 6.8 Chihshang mainshock show more than 90 cm of coseismic horizontal displacements between Guanshan and Ruisui, north of the mainshock epicenter. The largest observed ground deformations roughly aligned to the western side of the Yuli fault, which is likely to be a branch of the steeply west-dipping Central Range Fault ruptured during the 2022 earthquake sequence. Altogether, the largest coseismic GPS vertical movements from the foreshock and the mainshock reach 15 cm and 85 cm on the hanging wall of the Central Range fault (i.e. Yuli Fault), and the largest observed subsidence reach 35 cm on the footwall of the Central Range Fault, and in the Coastal Range. Meanwhile, we conducted three times on CMGS and two precise leveling routes to acquire the post-seismic displacement one year after the earthquakes. The results show that post-seismic behavior is rapid along the Yuli Fault.

Keyword

Central Range Fault, Longitudinal Valley Fault, continuously recording reference GPS stations, precise leveling

The characteristics of the Chihshang segment of the Longitudinal Valley Fault System, eastern Taiwan, assessed by historical aerial photo reconstructions

Tsz Yau Amundsen LAM[1]*, Department of Geosciences, National Taiwan University, Taipei (Taiwan) (r10224115@ntu.edu.tw)
J. Bruce H. Shyu[2], Department of Geosciences, National Taiwan University, Taipei (Taiwan)

Abstract

The Longitudinal Valley Fault (LVF) System is one of the most active fault systems in Taiwan. The Chihshang segment, located from Yuli to Luyeh, has been proposed as an active creeping fault and has a high slip rate of about 2-3 cm/year. However, records of historical earthquake events show that surface ruptures of the November 1951 earthquake were only observed from Yuli to Chihshang, but not between Chihshang and Luyeh in the Guanshan area. In fact, only limited studies were focused on the fault segment in the Guanshan area, partly due to the fact that human activities have significantly modified the fault trace and geomorphic features in this area. The recent development of photogrammetry techniques enabled us to use historical aerial photos to reconstruct the old landforms that may have been obliterated by human activities. Therefore, we used historical aerial photos taken from 1968 and 1969 to obtain a historical Digital Surface Model (DSM) and orthoimages using Structure from Motion (SfM) and Multi-View Stereo (MVS) methods. With the historical DSM and orthoimages, we mapped structural scarps along the fault segment in the Guanshan area. We also measured current scarp heights using Real-Time Kinematic Global Navigation Satellite System (RTK-GNSS) in the field.

Our results show that, by comparing the river terrace riser heights in the reconstructed DSM and present-day measurements, the error of the reconstructed DSM is generally much lower than 5 m. Therefore, structural scarps that are higher than 5 m can be reliably identified with reconstructed DSM using historical aerial photos. This suggests that the reconstruction of historical aerial photos can be applied to obtain previous landforms that were significantly modified by human activities and to characterize active faults in those areas.

Keyword

Aerial photos, Longitudinal Valley Fault, Digital Surface Model (DSM), Structure from Motion (SfM), Multi-View Stereo (MVS)

Active shortening in the axial portion of the Andes in the northern end of the Chilean-Pampean flat slab triggered by sublithospheric controls

Sarah Ellen THOMAS[1]*, Instituto de Estudios Andinos (Don Pablo Groeber), Universidad de Buenos Aires - CONICET, Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Buenos Aires, Argentina (saruthomas12@gmail.com)
Carlos Costa[2], Departamento de Geología, Universidad Nacional de San Luis, San Luis, Argentina.
Lucia Sagripanti[3], Instituto de Estudios Andinos (Don Pablo Groeber), Universidad de Buenos Aires - CONICET, Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Buenos Aires, Argentina
Natalia Hauser[4], University of Brasilia, Institute of Geosciences, Laboratory of Geochronology and Isotope Geochemistry, Brasilia, DF, Brazil.
Andres Folguera[5], Instituto de Estudios Andinos (Don Pablo Groeber), Universidad de Buenos Aires - CONICET, Departamento de Ciencias Geológicas, Facultad de Ciencias Exactas y Naturales, Buenos Aires, Argentina

Abstract

The Andes are classically divided according to alternating normal and flat slab subduction segments, with contrasting shortening degrees and thermal structures. This work focuses on the northernmost section of the Chilean-Pampean Flat slab (27°–33°S), above its transition to the Central Volcanic Zone (CVZ, 15°–27°S) to the north.

The Juan Fernández aseismic ridge was subducted under the trench at the Southern Puna region (in the present CVZ), during Early Miocene times, establishing a flat slab subduction setting, evidenced by the within-plate migration of the arc front.

The elbow shape of this ridge made the collision point migrate south, leading to slab steepening in Southern Puna and the onset of the Chilean-Pampean Flat slab subduction in the Late Miocene. Nowadays, the Juan Fernández ridge subducts at the southern edge of the flat slab segment (at 33°S).

Flat slabs produce arc migration, lithospheric weakening, foreland uplift at the orogenic front, and eclogitization of the subducted lower lithosphere, becoming anomalously dense and therefore, gravitationally unstable when the subducted lithosphere steepens.

Lithospheric foundering through the Southern Puna region, visualized in seismic tomographies, is spatially associated with Miocene sedimentary basins (like Arizaro, Antofalla and Pasto Ventura) and within-plate volcanic fields, re-interpreted as drip-related depocenters with alternating contractional and extensional regimes. A southward trend in their development is observable in the last 15-8 Myrs as lithospheric delamination and steepening subduction settings have been younger in this direction during Juan Fernandez's southward subduction.

Satellite imagery and fieldwork led to the recognition of contractional active deformation in the transition zone between the Andes Precordillera, a narrow fold and thrust belt that deforms Paleozoic marine and nonmarine sequences, and the western Sierras Pampeanas, the wide broken foreland associated with the Chilean-Pampean flat subduction zone (28°20´S). Three main active structural systems were analyzed: The Los Colorados thrust, the Famatina Range front fault, and

the Catinsaco-La Ciénaga fault zones. These active structural systems affect Quaternary deposits and produce changes in the drainage system showed by geomorphological and lithological evidence such as wind gaps, and ponding facies.
This out-of-sequence quaternary contractional activity is explained by the surface expression of the delamination of the Famatina Range where inverted gravity data revealed the attenuation of the lower crust, signaling this as the southernmost growing drip of the series of delaminated drips identified in the southern Puna region.

Keyword

Active shortening, Neotectonic deformation, Lithospheric dripping

Quaternary reactivation and paleo-seismologic records along intrabasinal faults in the Miocene Janggi Basin, SE Korea

Jong-Won HAN[1]*, Department of Geological Sciences, Pusan National University (han_jongwon@pusan.ac.kr)
Min-Cheol Kim[2], Department of Earth Science Education, Pusan National University
Hyewon Lim[3], Department of Geological Sciences, Pusan National University
Seongjun Lee[4], Active Tectonics Research Center, Korea Institute of Geoscience and Mineral Resources
Sangmin Ha[5], Department of Geography Education, Korea University
Jeong-Heon Choi[6], 5Research Center for Geochronology and Isotope Analysis, Korea Basic Science Institute
Hee-Cheol Kang[7], Department of Geological Sciences, Pusan National University
Sonkap Lee[8], Department of Geological Sciences, Pusan National University
Moon Son[9], Department of Geological Sciences, Pusan National University

Abstract

The Miocene sedimentary basins located in the southeastern part of the Korean Peninsula record the Quaternary reactivation of intrabasinal faults. However, the Quaternary faulting has not been well studied due to its short extension and immaturity compared to large faults such as the Yangsan Fault. The aim of this study is to reveal structural and paleoseismic characteristics of the reactivated intrabasinal faults in the southern (HJ) and northern (GM) parts of the Miocene Janggi Basin and to correlate the reactivation timings of the intrabasinal faults with those in adjacent major fault zones. We conducted a detailed paleoseismic investigation, including geomorphic analysis, fieldwork, electric resistivity survey, trench excavation, and numerical age dating. Our geomorphic analysis shows two NW-SE to WNW-ESE-trending lineaments (one each in HJ and GM) that are presumed to have formed from Quaternary faulting, exhibiting vertical scarplet and linear valleys. Stratigraphic features, cross-cutting relationship, and numerical ages obtained from outcrop and excavation in the GM indicate that the most recent faulting event occurred between 229±19 and 80±2 ka, while two excavations in the HJ disclosed that the latest Quaternary faulting took place after 260±30 ka. We also observed fault-propagation folds within the Quaternary sediment layers in the HJ as well as the GM, which is indicative of the presence of blind faults activated during the Quaternary. Based on the results of comparative analysis by combining all the Quaternary faulting ages and spatiotemporal deformation patterns of the Miocene intrabainal faults and adjacent major faults, the Quaternary reactivations of the intrabasinal faults and the northern Yangsan Fault tend to exhibit incompatibility with each other. This spatiotemporal deformation pattern can provide an important key to understanding the seismic activity behavior in the intraplate region.

Keyword

intraplate region, Quaternary fault, intrabasinal fault, major fault, spatiotemporal deformation

pattern

Assessing Quaternary-active footwall splays in the Andean thrust front, Southern Precordillera, Argentina (32° 30’ S - 68° 49’ W)

Victoria Alvarellos[1]*, Instituto de Estudios Andinos “Don Pablo Groeber” (IDEAN), CONICET-Universidad de Buenos Aires (UBA) (vicuu-a@hotmail.com)
Carlos Costa[2], Universidad Nacional de San Luis, San Luis, Argentina
Lucía Sagripanti[3], Instituto de Estudios Andinos “Don Pablo Groeber” (IDEAN), CONICET-Universidad de Buenos Aires, Buenos Aires, Argentina.
Andres Richard[4], Universidad Nacional de San Luis-CONICET, San Luis, Argentina
Lucía Jagoe[5], Instituto de Estudios Andinos “Don Pablo Groeber” (IDEAN), CONICET-Universidad de Buenos Aires, Buenos Aires, Argentina
Soledad Morales Volosín[6], Instituto de Geociencias Básicas y Aplicadas de Buenos Aires (IGeBA), CONICET – Universidad de Buenos Aires, Facultad de Ciencias Exactas y Naturales, Buenos Aires, Argentina
Andres Folguera[7], Instituto de Estudios Andinos “Don Pablo Groeber” (IDEAN), CONICET-Universidad de Buenos Aires, Buenos Aires, Argentina

Abstract

At the southern Pampean flat-slab in the Central Andes, the Quaternary active deformation is concentrated on the easternmost thrusts of the Southern Precordillera along the Las Peñas-Las Higueras hill (32° 10’-32° 45’ S). This range is bounded by the Las Peñas Thrust System (LPTS), which emplaces Cenozoic sedimentary rocks over a suite of Quaternary alluvial deposits.

This study is focused on the La Escondida Creek, at the southern part of the Las Higueras-Las Peñas range, which represents an unusual area where neotectonic contractional structures can be documented from the main morphogenic thrust zone at range-piedmont junction to the younger propagating splays within the alluvial plain. This constitutes an outstanding opportunity to characterize and quantify the deformation of the most recent contractional structures. These data assess the shortening of the area and enable the understanding of how the active thrust front is growing. The mountain-building processes can be elucidated by understanding how the footwall splays migrated from west to east and describing the associated scarp morphology. Furthermore, the contribution of shortening rates in this section of the LPTS trace addresses the gap in shortening rates knowledge. These data presented here, together with the rates available by the bibliography could elucidate whether variations in these rates are temporally and/or spatially correlated, contributing to different approaches for addressing the characterization of fault activity. Hence, the neotectonic analysis of LPTS at the piedmont relies mostly on topographical techniques, Trishear modeling, and retrodeformation of geometric markers, such as alluvial surfaces. The field evidence so far analyzed suggests a clear propagation of the splays into the piedmont area as discontinuous branches showing the great activity of the Las Peñas Thrust System. The calculation of shortening rates for three different alluvial surfaces ranges from 0.1 mm/y to 2.0 mm/y for the last ~18, 12, and 3 thousand years.

Keyword

Active tectonics, Orogenic front, Andean thrusts, Shortening rates, Southern Precordillera Argentina

Active tectonics of the Yuli Fault in the central Longitudinal Valley area, eastern Taiwan

Siang Duan[1], Department of Geosciences, National Taiwan University
Yu WANG[2]*, Department of Geosciences, National Taiwan University (wangyu79@ntu.edu.tw)
Nai-Wun Liang[3], Department of Geosciences, National Taiwan University
Tsz Yau Amundsen Lam[4], Department of Geosciences, National Taiwan University
J. Bruce H. Shyu[5], Department of Geosciences, National Taiwan University

Abstract

Using topographic survey data, historical topographic maps, and digital elevation models (DEMs), we mapped the active tectonic features associated with the long-term activity of the Yuli Fault that ruptured during the 2022 Mw 6.4 and Mw 6.8 earthquakes in Eastern Taiwan. Although the recent co-seismic surface rupture of the Yuli fault shows a highly oblique nature of its fault slip close to the surface, and its fault trace cannot be mapped in detail prior to the earthquake, our retro-investigation results show systematic geomorphic features along its entire fault trace, suggesting the long activity of the Yuli fault within the central Longitudinal Valley. These features include the wrapped and the tilted alluvial fan surfaces, the flexure and fault scarps, springs, and dammed-lake depositional surfaces. All of these features are well aligned with the 2022 co-seismic surface ruptures. Together with pressure ridges and channel deflection found before the earthquake, our result confirms the Yuli fault is a major left-lateral and reverse fault in the central part of the Longitudinal Valley, with its slip rate yet fully constrained by the geodetic and geologic analyses. The left-lateral and reverse active behavior of the Yuli fault is very similar to the active behavior of the previously proposed Central Range Fault at the base of the mountain range, which also showed flexure scarps and uplifted terraces along its proposed fault trace. This leads us to believe both faults originated from the same structural system with the slip partitioned close to the surface. Further investigations are needed to confirm the slip rate of both faults and their structural relationship close to the surface.

Keyword

Active Fault, Taiwan, Active tectonics, Geomorphology

Wedge confinement; a brittle faulting process for the accommodation of active block movements in the interior of continents

Esmaeil SHABANIAN[1]*, Department of Earth Sciences, Institute for Advanced Studies in Basic Sciences (IASBS), Zanjan 45137-66731, Iran (shabanian@iasbs.ac.ir)

Abstract

Deep-seated strike-slip faults play significant structural rolls in the accommodation of active deformation in the interior of continental plates such as the Turkish-Iranian and Tibetan plateaus. In several cases, these crustal structures take up the oblique convergence of continental blocks through pure strike-slip faulting, with negligible internal deformation. In some cases like in Central Iran, there are pure strike-slip faults nearly perpendicular to the direction of relative motion of surrounding continental blocks, while the overall block motion is mainly transferred across these strike-slip block boundaries. This study presents the 'wedge confinement' tectonic model, which is based on geological and tectonic geomorphology observations from the Iranian plateau and explains how block-bounding strike-slip faults can accommodate active shortening caused by oblique convergence without the need for main folding processes and thrust faulting, as well as book-shelf block rotations around vertical axes. The process of wedge confinement at the corner of converging blocks allows accommodating the internal deformation not absorbed by the lithospheric scale tectonic boundaries. The block adjustment requiring for the accommodation of this internal deformation is done through conjugate to crosswise faulting along dextral and sinistral fault sets. The structural significance of these nearly orthogonal fault sets depend upon the angle between the overall shortening and the fault sets strike. However, the simultaneous activity of these fault sets is mechanically impossible; therefore, the fault sets must be operating in sequence. The wedge confinement process also leads to the development of contractional (reverse/thrust) fault zones perpendicular to the overall direction of oblique convergence accommodating both along-strike and across-strike components of the convergence. This process implies that such slow-slipping orthogonal strike-slip faults are capable to produce high seismic risk in the interior of continents despite their insignificant structural and geodynamic roles.

Keyword

Crosswise faulting, Central Iran, continental deformation, strike-slip fault, oblique convergence

A short review on geologic evidence of pre-historical large earthquakes in S. Korea

Jin-Hyuck CHOI[1]*, Korea Institute of Geoscience and Mineral Resources (cjh9521@kigam.re.kr)

Abstract

The Korean peninsula is tectonically slow-deforming yet active region, as evidenced by large earthquakes inferred by historical documents and geologic records of earthquake surface rupture in pre-historical periods. After the 2016 Mw 5.5 Gyeongju earthquake, the biggest instrumental seismicity in S. Korea, it is highlighted to investigate the records of past large earthquakes and to assess the earthquake hazards. Indeed, multidisciplinary paleoseismological investigations were conducted to understand characteristics of large earthquakes along the major fault system in S. Korea. This study introduces the major results and research trends of the paleoseismic investigations: 1) history and characteristics of paleoearthquakes along the Yangsan-Ulsan Fault System in the southeastern part of the S. Korea, 2) newly identification of geologic records of paleoearthquake along the Gongju Fault System crossing the central S. Korea, and 3) patterns of up-dip rupture terminations and their tectonic implications. Together with those observations, this study presents the on-going research on fault model and slip-rate estimation, which are essential information for seismic hazard assessments. Moreover, this study introduces the research trends and results of the remote sensing-based investigations of the large earthquakes. Based on the short review, we discuss future research directions for understanding the characteristics of large earthquakes in slow-deforming regions.

Keyword

paleoearthquake, S. Korea, fault system, slip-rate

Developing Fault Models for Seismic Hazard Assessment in Slow-Deforming Intraplate Regions: A Case Study of the Yangsan Fault, Korea

Taehyung KIM[1]*, Korea Institute of Geoscience and Mineral Resources (adrian0305@kigam.re.kr)
Jin-Hyuck CHOI[2], Korea Institute of Geoscience and Mineral Resources

Abstract

For Seismic Hazard Assessment (SHA), it is essential to present simplified fault models that can represent the complex geometry of faults. However, in slow-deforming regions such as intraplate areas, creating fault models can be challenging due to the lack of surface ruptures. This study reviews research from leading countries in fault model development, proposes methods for developing fault segment models in intraplate settings, and applies these methods to the Yangsan Fault (YF), a long-lived fault on the Korean Peninsula. The Korean Peninsula is an intraplate region with relatively stable crust, but the YF is an active fault that has undergone multiple reactivations during the Quaternary, according to paleoseismic research. Following our proposed workflow, the YF can be divided into 11 to 15 unit-segments. By integrating existing research, we aimed to enhance the fault and deformation models by adding lateral slip rate information. Most studies on the slip rate of the YF have predominantly focused on rates calculated using vertical separation and fault orientation from trench wall. Recently, the significance of lateral slip rate studies, derived from geomorphic offset, has been increasingly emphasized, leading to research efforts aimed at obtaining lateral slip rates. Additionally, attempts have been made to conduct 3D trench survey along the YF. We have reviewed these studies to incorporate slip rate information into the fault model of the YF that we propose. However, the availability of lateral slip rate data is still limited, and improving this could significantly benefit fields such as SHA in the future.

Keyword

Seismic hazard assessment, Intraplate, Fault model, Yangsan Fault, segmentation

Space and time variability of styles of continental shortening: new insights from 3D seismic interpretation in the Jura fold and thrust belt

Miller Zambrano[1]*, Geology Division, School of Science and Technology, University of Camerino, Italy (miller.zambrano@unicam.it)
Stefano Mazzoli[2], Geology Division, School of Science and Technology, University of Camerino, Italy
Jon Mosar[3], University of Fribourg, Department of Geosciences, Switzerland

Abstract

The Jura fold and thrust belt is characterised by a competition and combination of thin-skinned and thick-skinned thrusting, and represents a paradigmatic example of the switch from detachment-dominated thrusting of the sedimentary cover to crustal bulk shortening in the outer zone of collisional orogens. Recent high-quality 3D seismic data from siting of a Deep Geological Repository in Switzerland provided the opportunity to obtain insights from the easternmost termination of the Jura fold and thrust belt.

The aim of this study is to document the modes and timing of contrasting thrusting styles in this peculiar fold and thrust belt, which is located in the Alpine foreland north of the Swiss Molasse basin. The results of seismic interpretation point out that the tectonic setting of the siting region (Nördlich Lägern) is characterised by localised (0.5 to 2 km wide) fold-thrust zones involving the Triassic-Jurassic epicontinental platform succession and the stratigraphically overlying Cenozoic Molasse Basin deposits, separated by almost undeformed (at the seismic scale) rock volumes. The location of the shortening zones appears to be controlled by variable interaction between the detachment level hosted in the Triassic evaporites of the Muschelkalk Group and normal faults linked to an underlying Permo-Carboniferous half-graben. The structures interpreted in the 3D seismic data range from a ~ 2 km wide pop-up located above a step produced by a normal fault of the underlying Permo-Carboniferous half-graben, to a ~ 0.5 km wide zone of multiple thrusts and backthrusts forming a series of fishtail structures arranged in a steep belt involving the Mesozoic strata. The latter fishtail zone is located above a series of reverse faults that appear to have propagated from the underlying Permo-Carboniferous basin fill into the overlying Mesozoic succession, probably because of mild basin inversion. Salt mobility and associated salt weld development may have further contributed to a degraded quality of the detachment at this location. Different degrees of interaction between the evaporite décollement and underlying inherited faults, which produced a marked contrast in structural style (different pop-up and triangle zone geometry), appear to characterise the switch from detachment-dominated thrusting of the sedimentary cover to bulk crustal shortening ahead of the Alpine orogen.

Keyword

Alpine orogen, Thin-skinned thrusting, Basin inversion, Inherited structures, Fault reactivation

Tectonic evolution of the Eastern Central Asian Orogenic Belt

Yongjiang LIU[1]*, Ocean University of China, Qingdao 266100, China (liuyongjiang@ouc.edu.cn)
Yongfei Ma[2], College of Earth Sciences, Institute of Disaster Prevention, Sanhe 065201, China
Zhiqiang Feng[3], College of Mining Engineering, Taiyuan University of Technology, Taiyuan 030024, China
Weimin Li[4], College of Earth Sciences, Jilin University, Changchun 130061, China
Qingbin Guan[5], 1. Frontiers Science Center for Deep Ocean Multispheres and Earth System, Key Lab of Submarine Geoscience and Prospecting Techniques, College of Marine Geosciences, Ocean University of China, Qingdao 266100, China 2. Laboratory for Marine Mineral Resources, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266237, China
Boran Liu[6], 1. Frontiers Science Center for Deep Ocean Multispheres and Earth System, Key Lab of Submarine Geoscience and Prospecting Techniques, College of Marine Geosciences, Ocean University of China, Qingdao 266100, China 2. Laboratory for Marine Mineral Resources, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266237, China
Sanzhong Li[7], 1. Frontiers Science Center for Deep Ocean Multispheres and Earth System, Key Lab of Submarine Geoscience and Prospecting Techniques, College of Marine Geosciences, Ocean University of China, Qingdao 266100, China 2. Laboratory for Marine Mineral Resources, Qingdao National Laboratory for Marine Science and Technology, Qingdao 266237, China

Abstract

The eastern section of the Central Asian Orogenic Belt (CAOB), located between Siberia and the North China Craton, has undergone a complex evolution process of multi-tectonic system domain superposition and multi-cyclic ocean-land transition. Although there have been many research carried out in the Northeast China and Far East Russia, the tectonic pattern and geodynamics has still been controversial. Based on the tectonic properties of tectonic units and their formation process, combined with the evolution of regional tectonic belts, this paper redefines the basic tectonic pattern of the Northeast China and establishes a tectonic evolution model of the eastern section of the CAOB. The results show that the main tectonic units in the Northeast China during the Paleozoic period were composed of two ancient blocks with Precambrian basement, the Erguna block and the Jiamusi-Khanka block, and two Paleozoic accretionary terranes, namely the Xing'an accretionary terrane and the Songliao accretionary terrane, and the Zhangguangcailing continental margin arc, which were divided by Xinlin-Xiguitu ocean, Hegenshan-Nenjiang ocean, Longfengshan ocean and Solonker ocean. During the Early Paleozoic, the southeastern part of the western Erguna block was a western Pacific active continental margin, with the development of oceanic islands such as Gaxian-Jifeng-Huanyu inner arc and Toudaoqiao oceanic island. To ~500 Ma with the closure of Xinlin-Xiguitu ocean, these intraoceanic arcs and islands were collaged and accreted to the southeastern margin of the Erguna block. Subsequently, the subduction and retreat of the Hegenshan-Nenjiang ocean formed a series of trench-arc-basin systems, and the continuous subduction led to the collision of the arc-land and the accreted to the continental margin, forming the main body of the Xing'an accretionary terrane. At the same time, an Andean-type subduction active continental margin of the Longfeng Shan ocean is developed on the west side of the Jiamusi block, and a continental margin arc of the Zhangguangcailing is formed on the

western edge of the Jiamusi block. Along with the subduction of the oceans and the accretion of the continental margin, the Erguna and Jiamusi blocks and their continental marginal accretion zones together constitute a chain of continental blocks in the Early Paleozoic. In the Solonker ocean to the south of the block chain, the subduction accretion occurred surround continental margin of the Xilinhot-Longjiang ancient fragment, forming the prototype of the Songliao accretionary terrane. The Solonker Ocean underwent bidirectional subduction and continental margin accretion through arc-land collisions. During the Late Paleozoic, along with the subduction and final closure of the Paleo-Asian Ocean and the subduction of the Mongolian-Okhotsk Ocean and the Pan-Ocean, the block chain formed during the Early Paleozoic experienced large-scale rotation and bending, and finally formed a large-scale orocline structure with the Erguna block and the Xing'an accretionary terrane as the west flank, the Jiamusi block and the Zhangguangcailing continental margin arc as the east flank, and the Songliao accretionary terrane as the core.

Keyword

Orocline, accretion, Paleo-Asian Ocean, Central Asian Orogenic Belt, NE China

[Keynote] Subduction dynamics and overriding plate deformation

Wouter Pieter SCHELLART[1]*, Vrije Universiteit Amsterdam (w.p.schellart@vu.nl)

Abstract

Many subduction zone systems are characterized by active overriding plate deformation. Most experience extension, resulting in the formation of a backarc basin (e.g. East Scotia Sea, North Fiji Basin, Aegean Sea), while some experience shortening, sometimes associated with the formation of an orocline, resulting in a massive cordilleran mountain range (e.g. Andes). It is unclear why some overriding plates experience shortening and others extension, and why extension occurs more frequently than shortening. Numerical geodynamic simulations of subduction evolution in 3D space are presented together with global subduction zone statistical analyses, investigating the control of slab width, time and subduction depth on overriding plate deformation. The numerical models demonstrate that shortening only occurs at very large subduction zones that have subducted into the lower mantle, while overriding plate extension occurs more frequently, taking place both for small and intermediate size subduction zones throughout their evolution, and for large subduction zones in the early (upper mantle) stage of their evolution as well as near their lateral slab edges during the middle stage of their evolution. The models also demonstrate that the plate boundary curvature is dependent on slab width, with wide subduction zones forming an orocline in the centre (convex towards the overriding plate), while narrow subduction zones form a concave geometry. The model results are compared with global datasets of active subduction zones, providing an explanation for the present-day deformation style and subduction kinematics at these subduction zones. The investigation also provides explanations why parameters other than slab width, such as slab dip angle, are correlated with overriding plate deformation, and why some parameters, such as slab age, show low to negligible correlations with overriding plate deformation and subduction kinematics. Finally, the comparison between models and global datasets provides an explanation for the more frequent occurrence of extension and backarc basin formation in the overriding plate compared to shortening and cordilleran orogeny.

Keyword

subduction, deformation, overriding plate, orogen, backarc basin

Along-strike change of erosion and sedimentation in the Longmenshan FTB, SE Tibetan Plateau, evidence from analogue experiments

Bin DENG[1]*, Chengdu University of Technology (dengbin3000@163.com)
Hongbin GUO[2], Chengdu University of Technology
Zijun LIU[3], Chengdu University of Technology
Hemin Koyi[4], Uppsala University

Abstract

Tectonic–erosion–sedimentation interaction and their coupling relationships control the evolution of fold-and-thrust belt and foreland basin system at different time and space scales. In this study, we use analog experiments to investigate the influence of erosion and sedimentation of fold-and-thrust belt, in particular, the along-strike change of erosion–sedimentation in the Longmenshan fold-and-thrust belt, SE margin of the Tibetan Plateau. The along-strike change of surface processes results a strong erosion in wedge hinterland, reactivation of faults and out-of-sequences thrusting, some of faults and related pop-up structures joint together along strike, to form lateral faults (or transfer faults). Displacement and angle of boundary faults increase along-strike due to multistage reactivation of faults as a results of erosion. Furthermore, along-strike change of erosion accommodates faults in the wedge hinterland overturned, even normal faults. The stronger of erosion, the bigger change for the faults in the hinterland. Extensional deformation is found across the Longmenshan fold-and-thrust belt, which could be accounted by the along-strike change of erosion occurred in the Cretaceous to Cenozoic time. In particular, the along-strike change of erosion induces low-angle faults reactivated, and out-of-sequence thrusting in the southwestern Sichuan basin. Thus, we argue that the tectonic shortening and surface processes have significant influence on the architecture of the Longmenshan.

Keyword

Along-strike change, Erosion and sedimentation, Analog experiment, Longmenshan Mts., SE Tibetan Plateau

The formation of the Mongolian Orocline in Central Asia: slab-driven or overriding-plate-driven?

Pengfei Li[1]*, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (pengfeli@gig.ac.cn)

Abstract

Orogenic curvatures, which are also referred as to oroclines, have been widely recognized in ancient and modern orogens. The formation of such curvatures has a significant impact on orogenic architecture, paleogeography, magmatism, as well as subduction dynamics in 4D. However, how relatively linear orogenic belts become tightly curved, remains enigmatic. Alternative mechanisms, including overriding-plate-driven orogenic buckling or bending, as well as along-strike variation of slab rollback, have been proposed. Here, I investigate this issue by studying the tightly-curved Mongolian Orocline that involves oroclinal bending of ~6000 km Andean-type subduction system. The research outcome shows that the formation of the Mongolian Orocline involved a relatively low strain as demonstrated by the lack of a penetrative fabric parallel to the axial plane of the orocline. Combined with available geological and geophysical data, we conclude that oroclinal bending occurred in a period of Permian to Jurassic, and its formation can be attributed to the along-strike variation in trench retreat, which was either driven by negative buoyancy of the subducted Mongol-Okhotsk oceanic slab, or linked to relative convergence and rotation of the Siberian and North China cratons. The latter is preferred given that the crustal thickness along two limbs of the orocline progressively increased during oroclinal bending, which suggests that the absolute trench retrench associated with the formation of the Mongolian Orocline, was forced by the relative convergence and rotation of overriding plates.

Keyword

Central Asian Orogenic Belt, Mongol-Okhotsk Orogen, Orocline, Slab rollback, Crustal thickness

Slab Subduction and Pull Link Magmatism at Active and Passive Continental Margins

Li-Qun DAI[1]*, University of science and technology of China (lqdai@ustc.ustc.cn)
Zi-Fu Zhao[2], University of science and technology of China
Guo-Chao Sun[3], University of science and technology of China

Abstract

Subduction leads to voluminous arc magmatism at active continental margins; however, the potential far-field geodynamic connections with coeval magmatism along opposing passive margins, are rarely investigated. In this study, we found that large-scale alkali mafic dike swarms on the South Qinling passive continental margin are associated with a series of parallel faults. Based on the estimated pressures and temperatures of the mantle sources of these dike swarms, we found that the thick and cold subcontinental lithospheric mantle beneath the passive continental margin was gradually replaced by thin and hot one during the early Paleozoic. In addition, arc magmatism on the active margin slightly precede the dike swarms in passive continental margin. We suggest the subduction of the Proto-Tethys oceanic lithosphere led to arc magmatism along the active margin, while rift-related magmatism occurred along the passive margin of South Qinling. Subsequent continuous ridge subduction, mantle upwelling and slab rollback increased the tensional forces on the passive margin, eventually triggering large-scale rift-related magmatism and the opening of the ocean. Thus, we suggest the slab pull associated with subduction, and mantle upwelling geodynamicaly link the active and passive continental margin magmatism and leading to the opening of new ocean basins at passive margin.

Keyword

slab pull, slab subduction, passive continental margin magmatism, active continental margin magmatism

Keyword

Central Asian Orogenic Belt, paleo-Tianshan Ocean, Central Tianshan, Paleozoic

Crustal Evolution and Mantle-Crust Interaction in the Paleoarchean: Insights from the Southern São Francisco Paleocontinent

Henrique BRUNO[1]*, UERJ - TEKTOS (henriquebruno.uerj@gmail.com)
Claudio Valeriano[2], UERJ-TEKTOS
Monica Heilbron[3], UERJ-TEKTOS
Samuel Bersan[4], UERJ-TEKTOS
Mike Fowler[5], University of Portsmouth
Craig Storey[6], University of Portsmouth
Hugo Moreira[7], University of Portsmouth
Gabriel Paravidini[8], UERJ-TEKTOS
Rob Strachan[9], University of Portsmouth

Abstract

Deciphering the intricate processes underlying the formation and stabilization of continental crust during the Archean era is vital for understanding Earth's early geological history. Here, we present a comprehensive analysis integrating new geochemical, isotopic, and geochronological data from granitoid rocks within the Archean basement of the Southern São Francisco Paleocontinent, southeastern Brazil (SFP). Our study endeavors to unravel the complex evolution of continental crust in this region. We delineate a significant shift in crustal genesis mechanisms, transitioning from Archean melting of hydrous basalts to melting of enriched mantle peridotite, driven by metasomatic processes. The emplacement of sanukitoid rocks during this epoch underscores deep interactions between metasomatized mantle material and crust-derived magmas. Employing a suite of analytical techniques encompassing U-Pb dating, Lu-Hf, Sm-Nd, and Sr isotopic analyses, oxygen isotopic compositions, and Zr trace element analysis, we elucidate the temporal and compositional evolution of continental crust within the Campos Gerais Complex during the Paleoarchean era. Notably, our study identifies the oldest known sanukitoid rock, dating back to 3.3 Ga, characterized by mantle oxygen isotopic signatures and chondritic Lu-Hf and Sm-Nd isotopic compositions. Furthermore, our analyses suggest the stabilization of proto-cratonic crustal blocks during the subsequent Mesoarchean period (3.2–2.8 billion years ago), often accompanied by extensive reworking of pre-existing granitoid crust. We propose a comprehensive model for the origin of sanukitoids, implicating the opening of the mantle wedge after a period of shallow subduction, fostering interactions between metasomatized mantle material and crust-derived magmas. Our study underscores the dynamic interplay between mantle and crustal processes during the Paleoarchean era, highlighting the importance of localized geological investigations in elucidating broader geodynamic processes. Additionally, our findings shed light on the temporal relationship between subduction initiation and the establishment of modern plate tectonics, highlighting the unique nature of these processes during Earth's early history. The chronology of our results, complemented by prior data, delineates a complete orogenic cycle, featuring a 3.3 Ga sanukitoid, succeeded by High-K Granites, 2.9 Ga TTG, sanukitoid, and High-K granites.

Keyword

Archean, Sanukitoid, TTG, Isotope

The Southern Segment of the Paleoproterozoic Minas-Bahia Orogen, SE Brazil: an example of a complete orogenic cycle

Monica da Costa Pereira Lavalle Heilbron[1]*, UERJ- Rio de Janeiro State University (monica.heilbron@gmail.com)
Henrique Bruno[2], UERJ-Rio de Janeiro State University
Ciro Avila[3], UFRJ-National Museum
Claudio Heilbron Valeriano[4], UERJ-Rio de Janeiro State University
Wilson Teixeira[5], USP-São Paulo University
Samuel Bersan[6], UERJ-Rio de Janeiro State University

Abstract

The São Francisco Paleocontinent, ESE Brazil, includes Archean nuclei surrounded by Paleoproterozoic magmatic arcs systems (ca. 2.4–2.1 Ga), lately amalgamated between 2,1 to 2.05 Ga, with collapse related bimodal magmatism extending until 1.9 Ga. This complex orogenic system is known as Minas-Bahia Orogen (MBO). New data, including detailed mapping, petrology, geochemical and geochronological studies carried out at the southern segment of the MBO, revealed a diachronic history of juvenile and continental magmatic arcs accretion and collisional episodes with the Archean nuclei. From NW to SE these tectonic units are the southern SFC Meso-to Neo Archean nuclei, The Mineiro Juvenile to Evolved Magmatic Arc and related basins, the Piedade Archean Microcontinent and the Mantiqueira-Juiz de Fora Magmatic Arc System that encompass minor Archean Inliers.

The Southern SFC include Meso-to-Neo Archean TTG complexes and volcano sedimentary basins. The oldest complexes occur westwards, with ages reaching 3.9 Ga, including sanukitoid rocks. U-Pb, Sm-Nd and Hf data indicates even old episodes of crustal rock generation and contribute to discuss tectonic models for the Early Earth. The Piedade microcontinent has TTG and Sanukitoid rocks of 2.7-2.6 Ga and besides 2.5 Ga intraplate basic rocks.

The MBO display a complete Paleoproterozoic orogenic cycle, from subduction-accretion to diachronic collisions, followed by a pervasive bimodal magmatism during the collapse episode. The accretionary period has IAT rocks of 2.4 Ga and ca. 2.3 Ga sanukitoids in the so-called magmatic lull period, besides a high proportion of crustal accretion and reworking in the magmatic arc systems between 2.2 and 2.08 Ga. Diachronic colisional episodes attached the Archean nuclei and passive margin units with the magmatic arc systems between 2.1 and 2.05 Ga. All magmatic arc systems have several coeval pulses of sanukitoid, TTG and common magmatic calcalkaline series, together with IAT basic rocks generation suggestive for flare-ups episodes.

The available zircon Hf isotope data set from Archean and Paleoproterozoic magmatic and metasedimentary rocks of the southern São Francisco craton (Brazil) is interpreted as evidence of accretionary and collisional plate tectonics since at least the Archean-Proterozoic boundary. We show that the crust of the amalgamated Paleoproterozoic tectonostratigraphic terranes that make up the southern São Francisco craton were generated from different proportions of mantle and crustal isotopic reservoirs. Plate tectonic processes are implied by a consistent sequence of events

involving (1) the generation of juvenile subduction-related magmatic arc rocks, followed by (2) collisional episodes and remelting of older crust, and (3) post-collisional bimodal magmatism.

Keyword

Paleoproterozoic, Orogenic Systems, Crustal Growth, Magmatic Arcs, Plate Tectonics

The architecture of ancient collapsed orogens: an integrated magnetotelluric-structural-seismic study of Paleoproterozoic Trans-Hudson orogen and its foreland

Sally Pehrsson[1]*, Geological Survey of Canada (sally.pehrsson@nrcan-rncan.gc.ca)
Joshua Pare Laughton[2], Geological Survey of Canada
Robert Berman[3], Geological Survey of Canada
Daniele Regis[4], Geological Survey of Canada
Derek Drayson[5], University of Manitoba
Alfredo Camacho[6], University of Manitoba

Abstract

Large-scale orogenic collapse as a consequence of crustal overthickening or changes in plate boundary conditions is well documented in modern collisional systems or the classic Neoproterozoic Grenvillian orogens but is rare in earlier Paleoproterozoic orogens that have been thought to be insufficiently widely elevated in temperature to extend. We utilize data from four crustal-scale magnetotelluric, gravity and magnetic studies, the Hudson Bay Seismic experiment, and regional tectonometamorphic and structural-tectonometamorphic data to elucidate the late syn-collisional geometry and architecture of the 1.87-1.80 Ga Trans-Hudson orogen in Arctic Canada, which, owing to substantial post-collisional erosion, affords a window into geometry inaccessible in many other systems.

The Trans-Hudson Orogen formed as a result of closure of the Manikewan Ocean during assembly of the supercontinent Nuna and culminated in collision of the Superior plate with a composite, 2500 km long upper plate comprising Archean Rae and Nain cratons and accreted arcs and microcontinents including Hearne craton. Thickening of the upper plate propagated over 800 km north and formed under MP or barrovian conditions up to high pressure granulite and local eclogite. Extension focused in two domains over what was once the overthickened plateau: a preserved transtensional subaerial volcanic basin flanked by two large metamorphic core complexes, and a pair of narrow elongate extruded panels thrust back towards the foreland. Gravity and magnetic studies show the discrete, 150-400 km long core complexes have the classic arched geometry that accommodated exhumation of mid crustal rocks and enabled formation of accommodation space for the ca. 1.83-1.80 Ga Baker Lake basin, host to the world's largest ultrapotassic volcanic province. The complexes are characterized by granulites or retrograded granulites, large volumes of decompression melt and regional-scale folds of foliations, straight gneiss, mylonite, and blastomylonite, all bounded by discrete shear zones. The length of this coupled system imaged in magnetotelluric, magnetic and gravity datasets extends for 1400 kilometers between the syntaxes of the butterfly-shaped Superior collider. Contemporaneous with formation of the basin and core complexes, the minimum 12 kbar Kaminuriak and Nowyak domains were exhumed between west Hudson Bay and southwestern Nunavut. The south-vergent basal thrust localizing extrusion of these narrow, 50 km across but 450 long, mid to lower crustal panels extends to the Moho in the vicinity of the original suture between Rae craton and Hearne

microcontinent. Tens of kilometre-scale sheath-like internal folds accommodated the strongly vergent geometry of transport, with exhumation of the panels forming inverted metamorphic isograds in overthrust Hearne craton. Although the geometry of a main principal thrust and structurally higher high-grade metamorphic complex is analogous to the Main Central Thrust and Higher Himalayan Crystalline Sequence of the modern Himalaya, unlike the latter, the Trans-Hudson exhumed deeper crust is localized above the principal discontinuity well inside the upper plate: the distinct Rae-Hearne sub-continental mantle lithospheres accreted some 80 million years earlier. The combination of core complex formation and extrusion to accommodate late-synorogenic collapse presented here may be a function of ongoing indentation by Superior into the assembled upper plate during continued south and eastward growth

Keyword

extensional collapse, orogenic architecture, Paleoproterozoic

Slab segmentation, anomalous arc volcanism, and giant porphyry copper deposits in Indonesia

Jack F Ward[1], The University of Queensland
Gideon Rosenbaum[2]*, The University of Queensland (g.rosenbaum@uq.edu.au)
Teresa Ubide[3], The University of Queensland
Mike Sandiford[4], University of Melbourne

Abstract

The geochemical and geophysical properties of most Holocene volcanoes in the Sunda and Banda arcs are consistent with formation via mantle wedge metasomatism. However, the Holocene volcanoes Toba, Ungaran, Muriah, Rinjani, Tambora, Sangeang Api, and Batu Tara are (1) located above sections of slab considered too deep to induce subduction-driven metasomatic melting, (2) characterised by enriched and alkaline geochemical compositions that are atypical of arc lavas, and/or (3) responsible for producing unusually explosive eruptions during Quaternary time. Associated with these 'anomalous' volcanoes are several world-class Pliocene–recent porphyry ore deposits, whose occurrence in an island arc juxtaposes current models of porphyry genesis that favour intra-crustal garnet fractionation (which is typically restricted to thick continental arcs) as a metal-enriching mechanism. In this study, we integrate a diverse suite of geophysical and geochemical data sets to propose that slab tearing has contributed to the formation of these anomalous Indonesian volcanoes and porphyry ore deposits. Excursions to greater slab depth and discontinuities in slab seismic tomography anomalies below Toba are interpreted as expressions of a sub-vertical slab tear, formed due to the subduction of the mechanically weak Investigator Fracture Zone, that feeds volcanism via poloidal mantle flow. Ungaran, Muriah, Rinjani, Tambora, Sangeang Api, and Batu Tara are also associated with depth-to-slab excursions and/or positioned at the margins of slab seismic velocity discontinuities (located at depths of 185–400 km) that likely represent elongate slab windows created during the subduction of unusually buoyant oceanic lithosphere. Based on the geophysical and geochemical data, we propose that poloidal asthenospheric flow along slab segment boundaries has triggered deep, low-degree partial melting with varying contributions of slab melt, sediment, and fluid, ultimately producing sub-alkaline and alkaline lavas with trace element patterns enriched in incompatible elements relative to the 'normal' arc volcanoes. Considering the spatial, temporal, and geochemical relationships between slab tearing and the Pliocene–recent Indonesian porphyry ore deposits (as well as the absence of geochemical evidence for slab melting in the formation of these deposits), we also propose that slab tearing produced oxidised magmas (geochemically akin to those of thick continental arcs and areas undergoing slab melting) by facilitating mantle melting in the garnet stability field. Furthermore, we hypothesise that slab tearing locally enhanced magma flux, facilitating extremely violent Quaternary eruptions at Toba, Rinjani, and Tambora.

Keyword

Arc volcanism, Subduction, Slab tearing, Porphyry ore deposits, Indonesia

Exhumation of the Hogem Batholith, north-central British Columbia, Canada

Ruohong JIAO[1]*, University of Victoria (rjiao@uvic.ca)
Xi Wang[2], University of Victoria
Luke Ootes[3], British Columbia Geological Survey

Abstract

The Hogem Batholith is an intrusive igneous complex in the Quesnel terrane in north-central British Columbia. The batholith intruded during the Mesozoic, as four lithologic suites that contain various lithology, such as diorite, monzodiorite, syenite, clinopyroxenite, tonalite, granodiorite, and granite. Zircon U-Pb ages of rocks from the four suites suggest that the batholith had a long emplacement history, ranging from 207 to 125 Ma. We report new apatite fission-track (AFT) data from six bedrock samples, which yield apparent ages between 96 and 40 Ma. We modelled thermal histories of these samples using the AFT age data and track length distributions. The results suggest that following the initial cooling during the Jurassic and Early Cretaceous, the rock samples had remained within the AFT partial annealing zone or underwent moderate reheating until the Eocene. Since the Early Eocene, slow unroofing of the batholith occurred, and the samples have undergone continuous cooling to their present states. We infer that this period of slow exhumation reflects the uplift and denudation of the host terrane. No substantial changes in the exhumation rate over the Cenozoic imply that changes in the Pacific-North American Pate convergence regime had no significant impact on the deformation of this part of the Canadian Cordillera.

Keyword

Exhumation, Thermochronology, Canadian Cordillera

Orogenic Evolution and Plate Tectonic Significance of the East African Orogen of Turkana, N. Kenya

Morgan L. BLADES[1]*, The University of Adelaide (morgan.blades@adelaide.edu.au)
Alice McIntyre[2], The University of Adelaide
Samuel Boone[3], The University of Sydney
Laura Morrissey[4], The University of South Australia
Alexander Simpson[5], British Geological Survey
Alan S. Collins[6], The University of Adelaide

Abstract

The East African Orogen is the largest mountain belt known of the last billion years. The evolution of this orogen marks the sharpest rise in ocean water radiogenic Sr isotope testifying to the global significance of this orogen in changing Earth surface systems. The correspondence of the EAO with incredible changes to the climate and biosphere are likely linked, but it is only by much better understanding these links that any causality will be able to be modelled.

Here we present extensive new U-Pb zircon, titanite and apatite age data. These are coupled with novel laser ICP MS/MS Lu-Hf garnet dating, fieldwork and a thermobarometric study of granulite-facies metasedimentary and meta-igneous rocks that form the basement to Tukana region in northern Kenya. The data reveal a complex Neoproterozoic origin and evolution that fills in an East African orogenic ‘missing-link’.

Protoliths to the Turkana basement gneisses define an eastern metasedimentary belt that is delineated west of Lake Turkana by a broad N-S meta-igneous terrane that we call the Lodwar Arc due to the volcanic-arc nature of its protoliths and Neoproterozoic origin. A second metasedimentary belt occurs to the west of the Lodwar Arc that separates it from the Pokat suture and putative ophiolite.

High pressure granulite rocks crop out directly east of the Lodwar Arc in the Lokhone block. Phase equilibria modelling indicates that these rocks underwent peak granulite-facies metamorphism at pressures of 8.4–10.6 kbar and temperatures of 750–830°C. Peak metamorphic conditions have been directly dated by Lu–Hf isotopic analysis of garnet (625 ± 7 Ma and 621 ± 5 Ma), and by U–Pb isotopic analysis of metamorphic titanite (604 ± 8 Ma and 622 ± 16 Ma) and metamorphic zircon rims (612 ± 14 Ma). P-T conditions indicate a moderate geothermal gradient of 78 – 98°C/kbar (17-30°C/km), consistent with metamorphism during crustal thickening. U–Pb apatite geochronology yields ages between ca. 540 and ca. 560 Ma, interpreted as post-peak cooling after metamorphism. These data suggest slow cooling of 2.5 - 9.5°C/Myr, consistent with slow exhumation. U–Pb dating of detrital zircons suggest that at the time of formation, the Lokhone region was not connected to any pre-Neoproterozoic terrane.

Keyword

East African Orogen, Turkana, U-Pb zircon ages, LA-ICP-MS/MS, Lu-Hf

Cenozoic uplift of Luxi Uplift and the Qinghai-Tibet Plateau and their geological significance

Fengdi GUO[1]*, China University of Petroleum (East China) (2422863672@qq.com)
Li Li[2], China University of Petroleum (East China)

Abstract

A series of NW normal faults developed in the Luxi Uplift, East China from south to north, such as Mengshan fault, Lianhuashan fault and Taishan fault, whose activities led to the uplift of Taishan, Lianhuashan and Mengshan mountains. The uplift history of the Luxi Uplift was revealed by combining the activity time of the faults and the uplift time of the mountain. In Western China, the collision between the Indian plate and the Asian plate caused the Cenozoic uplift of the Qinghai-Tibet Plateau. Also influenced the tectonic pattern of Eastern China. Therefore, the uplifting history of the Qinghai-Tibet Plateau was further compared to explore the deep dynamic background of the extended orogenic belt in Eastern China and the collision orogenic belt in Western China.

The rock samples of Mengshan Mountain, Lianhuashan Mountain and Taishan Mountain (from the footwall of the normal fault) in Luxi Uplift were analyzed by means of fission track dating and T-t simulation. Combined with the active time of NW normal faults, the Cenozoic uplift of the Luxi Uplift was divided into the following periods: 65~60Ma, 49~40Ma, 30~24Ma and 10Ma. It revealed the time of extension orogen in Eastern China. According to previous studies, the uplift history of Qiangtang Basin in the central Tibetan Plateau was 44.4~30.8Ma, 26.1~22.6Ma, 10.3Ma. The uplift history of the southern Tibetan Plateau was 45~38Ma, 26~18Ma, 13~8Ma. It revealed the time of collision orogen in Western China. The Cenozoic extensional orogen of the Luxi Uplift was compared with the Cenozoic collision orogen of the central and southern Tibetan Plateau, it was found that the uplift of the two was quasi-simultaneous, and both had a uplift sequence from south to north. From the perspective of plate motion, the collision between the Indian plate and the Asian plate caused the uplift of the Tibetan Plateau. The remote effects of the collision affected the uplift of the Luxi Uplift through the flow upwelling of the deep mantle. And with the subduction of the Pacific plate to the Asian plate, the east-west replenishment of the mantle was accelerated. The quasi-simultaneity of the uplift history between the two reflected the possible deep tectonic dynamic response between the eastern and western orogenic activities in China.

Keyword

Extensional orogen, Collisional orogen, History of Cenozoic uplift, Luxi Uplift, Qinghai-Tibet Plateau

[Keynote] The structure and breakup mechanism of the South China Sea: the feature of subduction related rifting

Zhen SUN[1]*, South China Sea Institute of Oceanology (zhensun@scsio.ac.cn)
Fucheng Li[2], South China Sea Institute of Oceanology
Jiangyang Zhang[3], South China Sea Institute of Oceanology
Minghui Zhao[4], South China Sea Institute of Oceanology

Abstract

As one of the largest marginal seas in the Western Pacific, the structure and evolution of the South China Sea will provide important reference to the marginal sea research. In order to decode the continent-ocean transition and seafloor spreading process of the South China Sea, 3 normal and 1 extended IODP drilling expeditions were carried out from distal margin to the relict ridge of the South China Sea. However, large controversies still exist due to the lack of enough drill site-coordinated geophysical investigation to calibrate the drilling results. 30 active source OBSs were deployed along the 300 km long drilling transect and then a 3D network with ~60 OBSs were deployed in the Continent-Ocean transition zone. The velocity models deduced from the OBSs suggest that thick and widespread magmatic underplating occurred below the northern continental margin, with the thickest underplating occurred below the continental slope where the crustal thickness is over 20 km. Correlated with the sedimentary history, the strong magmatic underplating is supposed to happen at late Eocene and caused strong uplift and erosion of early syn-rift sequences. Quantitative analysis suggests that up to 10 km thick magmatic underplating below the thick crust requires a highly attenuated if not fully devastated mantle lithosphere below the continental slope during Eocene. Therefore, the breakup of South China Sea is supposed to experience an earlier mantle breakup and then a crust breakup to generate the spreading ocean. In comparison with Atlantic, the mantle below the northern continental margin might be more wet to generate such an enormous syn-rift magmatic underplating. Forward mathematical modeling suggests that a pre-rift subduction may provides the mechanism of both unsteady lithospheric and more saturated mantle. This might explain why marginal sea basin usually has much wider underplating and more magma supply than the same spreading rate passive margin and ocean.

Keyword

the structure and breakup mechanism, thick and wide magmatic underplating, mantle attenuation earlier than crusut, pre-rift subduction, marginal sea

Tectonic-controlled sedimentary basins in NE Iran

Mohammad Reza SHEIKHOLESLAMI[1]*, Research Institute for Earth Sciences
(rezasheikholeslami@yahoo.com)

Abstract

Geological studies indicate close relationship between tectonic events, related to Paleotethys evolution, and generation of different sedimentary basins in NE Iran. Several tectonic controlled sedimentary basins are recognized during Paleotethys evolution from rifting, subduction and collision stages between Central Iran and Turan plates. These basins have been developed in response to the relative movements of the of Eurasia and Gondwana supercontinents.

The main litho-stratigraphic units of the NE Iran, including eastern part of the Kopeh-Dagh and Binalud, are examined in terms of various tectonic events. The resulted tectono-stratigraphic column is composed of different units ranging from the Early Paleozoic at the base to the Quaternary deposits on the top. Each unit may include several formations or rock units formed in a similar tectonic setting.

The sedimentary basins related to different tectonic setting have been determined as follow:

1- Passive marginal basins, including post-rift passive marginal basin of Prototethys ocean, Middle Ordovician to Devonian Paleotethys rift basin and Devonian-Carboniferous platform sediments of Turan plate.

2- Subduction related basins containing trench and forearc continental shelf basin, remnant arc, arc intra-arc basin (Fariman and Darreh-Anjir complex) and Permian-Triassic back arc basin (Aghdarband Group).

3- Collisional basins and associated rocks, including collisional magmatism, Late Triassic-Early Jurassic Peripheral foreland basin and Middle Jurassic intramontane basin.

4- Post collisional basins containing Kashafrud rift basin, Upper Jurassic to Eocene Carbonate platform, Oligocene-Pliocene foreland basin and post-orogenic molasse- type basin.

Keyword

Tectonics, Sedimentary basins, NE Iran

The evolution of Eastern Paleotethys Ocean on Hainan Island, South China

Dai ZHOU[1]*, China Geological Survey; China University of Geosciences
(zhoudai@mail.cgs.gov.cn)
Niu Zhijun[2], China Geological Survey
Wang Lei[3], China Geological Survey
Song Fang[4], @mail.cgs.gov.cn

Abstract

Accompanying the closure of the Eastern Paleotethys Ocean, numerous terranes such as South China, North China, Indochina, Qiangtang, etc. were collaged together, constituting the prototype of the East Asian continent. Hainan Island is in the easternmost part of the Jinshajiang-Ailaoshan-Song Ma suture belt (also branch ocean basin) of the Eastern Paleotethys Ocean, therefore crucial to understanding the evolution of the Eastern Paleotethys Ocean. We have rebuilt the stratigraphic sequence and sedimentary environment from Silurian to Triassic on the Hainan Island, as well as investigated the clastic sources in the area by detrital zircon U-Pb dating. The Silurian stratum on Hainan Island consists only of the Lower Silurian, the Tuolie Formation at the base is a charcoal-sandy-siliceous turbidite formed on the continental slope and abyssal plain, which is overlain by a suite of littoral and neritic facies sandstone-conglomerate-graywacke dominantly. The Lower Silurian in the Sanya and Dongfang areas is dominated by clastic sources over 1.0 Ga, while the rest of the area is dominated by similar clastic sources of ~435 Ma and ~950 Ma, showing affinities with Cathaysia and Indochina terrane, and paleomagnetic evidence suggest that they are all located in the northern margin of East Gondwana. Since Devonian, there has been a significant stratigraphic difference between Hainan Island and the Cathaysia terrane, indicating the separation between them. The Lower Devonian of Hainan Island is a volcanic-clastic sedimentary assemblage with typical turbiditic features, meanwhile the volcanic component is mainly intermediate-acidic, and the volcanic eruption age (which approximates the deposition age) is ~400 Ma. This is close to the time of rifting of the South China Plate from the northern margin of the East Gondwana indicated by paleomagnetism, which may represent the formation of the continental rift and corresponds to the opening of the East Paleotethys Ocean. The lower part of the Triassic Lingwen Formation is a disorganized sandstone-conglomerate with typical molasse feature, which contains a larger proportion of Early Silurian slate gravel and Late Devonian granite gravel, and the upper part of Lingwen Formation is a mudstone-siltstone squence. The clastic rocks sources of the Lingwen Formation are mainly of ~370 Ma and share similar clastic source (most likely derived from the Late Devonian magmatic belt of Hainan Island with subduction-magmatic feature) with the Kaiping, Yong'an, and Yongning Triassic basins at the southern margin of the Cathaysia, suggesting that the Hainan Island was collapsed with the Cathaysia in Early Triassic, which corresponds to the closure of the Eastern Paleotethys Ocean. The evolution of the volcanic-sedimentary basins on Hainan Island corresponds well to the opening-subduction-closure of the Eastern Paleotethys Ocean.

Keyword

Paleotethys Ocean, Hainan Island, sedimentary basin, stratigraphic sequence, detrital zircon U-Pb dating

The Late Cretaceous tectonic evolution of the Southern Central Andes: insights from the Malargüe area (36°S)

Matias BARRIONUEVO[1]*, IANIGLA-CONICET (matbarrionuevo@yahoo.com.ar)
José Francisco Mescua[2], IANIGLA-CONICET
Julieta Suriano[3], IANIGLA-CONICET
Laura Beatriz Giambiagi[4], IANIGLA-CONICET

Abstract

The Andes are the prime example of a subduction-related orogen, located at a long-term convergent margin where oceanic plates subduct beneath the South American plate. Despite being a long-lived subduction, its main phase of construction occurred during the Cenozoic. Here, we focus on the Southern Central Andes (36°S) where the Late Cretaceous deformational phase marks the onset of orogenic processes. There is general consensus on the initiation of this contractional phase, but its magnitude and extent remain under debate. At this latitude, the Late Cretaceous synorogenic deposits are represented by the Neuquén Group. These sedimentary rocks have been interpreted as deposited in two distinct foreland basin domains. One interpretation, based on the presence of alleged growth strata, proposes a Late Cretaceous wedge-top domain located at the present-day orogenic front. The second interpretation postulates a foredeep position for these deposits, suggesting that the orogenic front for the Late Cretaceous was close to the present-day watershed. We present new structural and thermochronological data to contribute to this debate and evaluate both alternatives.

We surveyed two outcrops of the Neuquén Group strata on the eastern slope of the Cordillera, which were previously recognized as growth strata. We could not recognize either of them as growth strata. The first outcrop consists of reddish to yellowish sandstones and mudstones, dipping consistently to the NW with dips ranging from 38-44°. No systematic changes in dip or thickness nor progressive unconformities have been recognized there. The second outcrop, farther east, consists of conglomerates and sandstones, dipping consistently to the east, with values around 74-88°. As in the previous outcrop, there are no changes in dip or thickness.

Furthermore, we obtained data from apatite-fission track (AFT) in three samples along the 36°S transect. These samples show, although some dispersion, Neogene exhumation ages. Considering their location, it is unlikely that, after the proposed Late Cretaceous exhumation, these rocks were reheated again due to burial and totally reset to record just the Neogene exhumation.

Based on these results, we cannot account for the proposed evidence of synorogenic growth strata as indicative of the location of the Late Cretaceous orogenic front at 36°S. Although preliminary, the thermochronological data do not show exhumation supporting this wide orogen, reaching nowadays orogenic front. Thus, the hypothesis that the Late Cretaceous shortening phase was restricted to the present-day watershed at this latitude is more plausible.

Keyword

subduction-related orogen, growth strata, thermochronology

Degree of coupling in 3D multilayer lithospheric buckling: Implications for tectonic environments

Seok-Hyeon DO[1]*, Kangwon National University (tvdo@kangwon.ac.kr)
Byung-Dal So[2], Kangwon National University
Young Hong Shin[3], Korea Institute of Geosciences and Mineral Resource

Abstract

The interaction between the lithospheric strength gradient and tectonic compression induced by relative plate motion is a significant driver of buckling instability. Examining lithospheric buckling alongside plate tectonic history is crucial for deducing lithospheric strength. Through extensive 3D viscoelastic numerical simulations, we delved into the morphology, symmetry, and interplay of layers subjected to intricate stress regimes, varying according to distinct strength configurations within multilayer models. Our simulations encompassed two robust layers sandwiching weaker layers within a matrix of low strength, mimicking simplified lithospheric strength profiles. We applied additional extension or compression boundary conditions perpendicular to the primary compression direction. We observed that boundary conditions predominantly dictate the overall geometry and symmetry. Conversely, the strength and thickness of the layers dictate the extent of layer coupling. Boundary conditions inducing extension resulted in smaller cylindrical buckling structures compared to models subjected solely to uniaxial compression. In models of biaxial compression, the proportion of shortening along each axis dictates the axis of symmetry. The presence of a thicker, weaker layer sandwiched between stronger layers led to decoupling of buckling structures in terms of wavelengths and amplitudes, shedding light on the detached lithospheric buckling beneath the Tibetan Plateau. Simultaneous deformation of the two robust layers generated a spatially dynamic pressure gradient within the weak layer, potentially triggering buckling-induced intraplate volcanism.

Keyword

3D numerical model, buckling, lithosphere, crust, mantle

Sedimentation and subsidence history of the Gosau Group, Austria: Implications of Late Cretaceous subduction and sea level fluctuations

xinxuan Xiang[1]*, University of Vienna (xiangxxcumtb@hotmail.com)
Eun Young Lee[2], University of Vienna
Wagreich Michael[3], University of Vienna

Abstract

At a subduction zone, the geodynamic mechanisms are responsible for the deformation and movements of the overriding plate. The near-surface evolution, including the uplift, subsidence, and paleoenvironment, can be recorded in the sedimentary deposits on the overriding plate. The Gosau Group is such deposits formed on top of the Northern Calcareous Alps during the Late Cretaceous to Eocene, which is closely associated with the subduction of the South Penninic Ocean below the Austroalpine units. This study investigates the sedimentation profiles and subsidence curves of the Gosau Group at different sites, which provide insights into the subduction process and the complex history of the Eastern Alps. The Gosau Group exhibits the evolution of the depositional environment from fluvial-lacustrine, nearshore and shallow marine (Lower Subgroup) to deep marine (Upper Subgroup) setting, which corresponds to the continuous tectonic subsidence of the plate margin. During the Santonian to Campanian, inconsistencies in the onset of the deep marine environments as well as the trends of subsidence rates are likely associated with the differential structural deformation and vertical movements of the northern margin of the Ausroalpine units along the subduction zone. In the Lower Gosau Group, variations of the depositional system and waterdepth indicate relatively short-term topographic changes, which can be attributed to structural deformation and sea level fluctuations.

Keyword

Gosau group, subsidence, paleoenvironment

Late Cretaceous Tectonic and Paleogeographic Evolution of the Southern Central Andes: Insights from the Diamante Formation at 34°40’S

Federico Exequiel Martos[1]*, University of Buenos Aires (martos.fede@gmail.com)
Lucas Martin Fennell[2], CONICET-UBA
Maximiliano Naipauer[3], CONICET-UBA
Andres Folguera[4], CONICET-UBA

Abstract

The Andes represent the most extensive orogenic system associated with an active subduction margin. While this mountain range has been the focus of study for over a century, its genesis and evolution remain subjects of debate. Some authors propose that during the Cretaceous, there was an increase in the absolute velocity of the South American plate towards the west in response to the opening of the Atlantic Ocean, which would have generated the necessary convergence conditions for the development of a mountain chain. Within the Southern Central Andes, the initial stage of contraction capable of generating an orogenic system and an associated foreland basin took place during the Late Cretaceous.

In this work, we present a detailed investigation into the tectonic and paleogeographic evolution during the Late Cretaceous of the Southern Central Andes at 34°40'S. A multidisciplinary approach integrating sedimentological, geochronological, structural, and provenance analyses was employed to reconstruct the architecture of the first Andean foreland basin. The results provide new evidence of the early uplift history of the Andean orogen.

We focused on an Upper Cretaceous sedimentary succession, the Diamante Formation, which represents the first synorogenic deposits of the foreland basin at theses latitudes. We studied outcrops previously unrecognized, located in a western position of the foreland basin, making it a strategic locality for understanding sedimentary processes near the topographic front of the Cretaceous orogen.

Field surveys allowed the recognition of growth strata associated with bivergent contractional structures (east and west verging). Additionally, progressive unconformities with offlap relationships between discontinuity surfaces were analyzed, which indicates an uplift rate greater than the sedimentation rate at the time of deposition.

Two samples for U-Pb ages on detrital zircons of the Diamante Formation allowed us to determine that this unit has a maximum depositional age of 98.4 ± 2.1 Ma in the basal section and ca. 95 Ma in the upper section. Furthermore, from the provenance age patterns, a primary source area derived from the recycling of Mesozoic sedimentary and volcanic units, likely exposed in the incipient orogen and volcanic arc located to the west, was recognized. Subordinately, a contribution of Permian-Triassic zircons from basement rocks possibly exhumed towards the east was observed.

Integration of the results with previous works allowed for a detailed reconstruction of the basin architecture along an orogenic transect at 34°40’S, showing the evolution of the Andean foreland

basin during the Late Cretaceous, where the main depozones and sediment source areas were delineated. Particularly, the study region represents a wedge-top depozone of the Cretaceous foreland basin, where sedimentation was synchronous with the deformation and advance of the orogenic front towards the east.

Keyword

Foreland basin, Andes, Late Cretaceous, Synorogenic, Geochronology

Structural evolution of Mud-intrusive and -extrusive System: Insights from 2D seismic reflection data of Makran Accretionary Wedge

SYED AHSAN HUSSAIN GARDEZI[1]*, Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China (gardezisah@scsio.ac.cn)
Xiwu Luan[2], College of Earth Science and Engineering, Shandong University of Science and Technology, Qingdao, 266590, China
Zhen Sun[3], Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou 510301, China

Abstract

The Mud-intrusive and -extrusive system (MIES) serves as a significant mechanism for the exchange of matter and energy between deep and shallow sequences, making it a key medium for the accumulation and migration of hydrocarbons. The convergence of the Arabian plate beneath the Eurasian plate gave rise to the Makran accretionary wedge (MAW), which hosts a typical MIES spanning kilometers within the offshore and coastal regions. This offers a unique opportunity to study the structural evolution of MIES within the ultra-slow subducting system on earth. In order to define the structures associated with whole edifice (mud-volcano) and its feeder network that links the volcano to its source rock unit, we utilized two-dimensional seismic reflection profiles, bathymetric and satellite data to analyze MIES in MAW. The main results include: i) the MIES is primarily sourced from hemipelagic muds originating from the Oligocene to Early-Miocene Himalayan turbidite deposits (HTDs) overlain by thick Makran sands (middle-Miocene to Pliocene), ii) during the renewed subduction in the middle-Miocene, the MAW was primarily comprised of overpressured shales, which diapirically move upward along weak zones and syn-depositional accumulation of mud initiated within the Makran sands, followed by subsequent phases of mud volcanism, iii) Some mud-volcanoes are characterized by deep source and high energy, erupting directly from HTDs, while others with shallow sources and low energy initially accumulated in mud-chambers within Middle-Miocene to Pleistocene rocks before resurfacing in multiple episodes, iv) Up-pulling of sediments along mud-volcanos and mud-diapirs collaborated in the formation of mini basins within Makran sands, which further exacerbated gravity collapse/ normal faulting in the coastal region, and v) mud pipes/ fluid escape conduits extend to the seafloor, exhibiting conical and bifurcating geometries tapering upwards like Christmas-tree structures, with widths narrowing from a significant base and inclination angles ranging approximately between 75° to 105° relative to horizontal plane. The MIES varies from east to west, primarily due to the convergence rate of the Arabian plate, underplating and high sedimentation rates. The extensive mud flows indicating significant gas generation within the accretionary deposits, fueling the occurrence of MIES.

Keyword

Makran Accretionary Wedge, Mud-volcanos, Mud-diapirs, Fluid escape structures, Formation mechanism

Long-range effects of mid-ocean ridge dynamics on earthquakes, magmatic activities, and mineralization events in plate subduction zones

Qiuming Cheng Cheng[1]*, IUGS/China University of Geosciences (Beijing)/Sun Yat-sen University (qiuming.cheng@iugs.org)

Abstract

The deep processes of plate subduction zones are closely related to extreme geological events in continental magmatic arcs. The processes of plate subduction and mountain building can lead to events such as earthquakes, magmatic activity, and mineralization. The occurrence of these extreme events is closely related to factors such as crust-mantle interaction, mantle wedge formation, partial melting of the lithosphere, and tectonic magmatism during subduction. However, little is known about the long-term and long-range effects of heterogeneities or innate defects in the newly formed crust at mid-ocean ridges on the extreme events described above. During the formation of new crust at mid-ocean ridges, due to plate expansion, pressure reduction, and asthenospheric material upwelling, the temperature of the new crust increases, pores and cracks develop, the density decreases, and the structure is complex. Therefore, the newly formed crust has heterogeneities in density, strength, temperature, thickness, etc. These crustal differences will influence and determine the behavior of plates during expansion and subduction, with long-term effects on events such as earthquakes, volcanoes, and mineralization caused by plate subduction. Analysis of the Pacific subduction and the Andes orogen has found that sudden changes in plate movement speed, plate subduction angle, plate tearing, lithospheric thickness, Moho depth, etc., have long-range effects on the spatiotemporal distribution of earthquakes, volcanoes, and porphyry copper mineral deposits. These understandings are of great significance for predicting the spatiotemporal distribution of extreme geological events in plate subduction and collision zones.

Keyword

Mid-ocean ridge, ocean lithosphere, subduction, extreme Xevemts, long distance effect

Unveiling the Evolution of the West Philippine Basin with Massive High-Resolution Seafloor Mapping Data

HANJIN CHOE[1]*, Pusan National University (explorist@pusan.ac.kr)
Hyeonuk Shin[2], Pusan National University

Abstract

The West Philippine Basin, an oceanic basin half the size of the Philippine Sea Plate, lies in the western part of the plate. It subducts beneath the Eurasian Plate and the Philippine Islands bordering the Ryukyu Trench and the Philippine Trench with 25-50% of this basin already consumed. However, the opening history of the basin's southern region is still ambiguous due to insufficient marine geophysical data. we collected the open-source multibeam bathymetry data from various data centers(JAMSTEC-DARWIN, NOAA-NCEI, IFREMER-SISMER) and obtained a new dataset by R/V Isabu in September 2022. By analyzing high-resolution multi-beam echo-sounding data, we confirmed that the non-transform discontinuity due to the propagating rift dynamically evolved in the entire basin. In the early stage of basin extension, the Amami-Sankaku Basin was rotated 90 degrees clockwise from its current orientation. This result is contradictory to the previous paleomagnetic analysis that the basin rotated 90 degrees counter-clockwise using sediment cores obtained from the Amami-Sankaku basin. As a result of reconstructing the basin evolution process based on these two conflicting results, the dynamic evolution process of the West Philippine Basin was confirmed. In the beginning stage of the opening, the Amami-Sankaku Basin separated from the Palau Basin while the spreading of the West Philippine Basin began with a counter-clockwise rotation. This indicates that the non-transform discontinuities formed by a sudden change in magma supply due to the drift of the Philippine Sea Plate and simultaneously with the rapid changes in the spreading direction from ENE–WSW to N–S. We performed a combined analysis using high-resolution multi-beam bathymetry and satellite gravity data to uncover new insights into the evolution of the West Philippine Basin. This study illuminates the complex plate interactions and provides a crucial contribution toward understanding the opening history of the basin and the Philippine Sea Plate.

Keyword

West Philippine Basin, Multibeam, seafloor spreading, Non Transform Discontinuity, basin evolution

World Digital Magnetic Anomaly Map (WDMAM) version 2.2 released

Jerome DYMENT[1]*, CNRS - IPGP - UPC (jdy@ipgp.fr)
Yujin CHOI[2], CNRS - IPGP - UPC
Vincent LESUR[3], CNRS - IPGP - UPC
Andreina GARCIA-REYES[4], CNRS - IPGP - UPC
Takemi ISHIHARA[5], Geological Survey of Japan - AIST
Tamara LITVINOVA[6], VSEGEI
Mohamed HAMOUDI[7], USTHB

Abstract

The last version of the World Digital Magnetic Anomaly Map (WDMAM v. 2.0) endorsed by IAGA and CGMW was released in 2015 (Dyment et al., EPSL, 2015; Lesur et al., EPS, 2016) with the mandate to update it using the same methodology when new data become available. After a provisional version 2.1 that was including a minor error released in 2023, the new version 2.2, compiled at 5 km interval, at 5 km altitude above the continents and at sea-level over the oceans, includes new datasets: (1) the complete digital aeromagnetic map of Brasil made available by ANP; (2) an improved version of the aeromagnetic map of Russia prepared by V-SEGEI; (3) the second version of the Antarctic Digital Magnetic Anomaly maP (ADMAP; Golynsky et al., GRL, 2018) which results from a remarkable international effort during and after the Second International Polar Year; (4) a new map of the Caribbean Plate and Gulf of Mexico (Garcia and Dyment, EPSL, 2021, 2022); (5) the updated Magnetic Anomaly Map of Eastern Asia prepared by the CCOP (MAMEA; Ishihara and Uchida, 2021); and (6) a new marine magnetic anomaly data compilation prepared by T. Ishihara and coworkers. The remaining data gaps are filled with a satellite anomaly model (Thebault et al., GRL, 2021). Long wavelengths of degree and order lower than 120 are filtered and replaced by those computed between order and degree 16 and 120 using the same satellite magnetic anomaly model from CHAMP and Swarm data. The new map is presented and its significant improvements over the previous version are discussed, with examples of how the map can be used to address geological questions. The version 2.2 of the WDMAM will be available at wdmam.org. This presentation is dedicated to the memory of Manuel (Manen) Catalan who co-chaired the WDMAM task force for the last 10 years and passed away in December 2023.

Keyword

Magnetiic Anomaly, World, International effort

Can an extraterrestrial body impact affect plate tectonics? The case of Chicxulub and the Yucatan Basin

Jerome DYMENT[1]*, CNRS - IPGP - UPC (jdy@ipgp.fr)
Andreina GARCIA-REYES[2], CNRS - IPGP - UPC

Abstract

The Yucatan Basin is a triangular basin located between Yucatan, Cuba, and the Cayman Trough. Its age and origin remain unsolved so far. The Cayman Trough is an narrow basin formed by ultraslow seafloor spreading between two long transform faults that define the northern boundary of the Caribbean Plate since 50 Ma (Leroy et al., GJI, 2000). This basin cuts across the Yucatan Basin and is therefore younger. Further North, seafloor spreading opened the Gulf of Mexico between 150 and 140 Ma (Garcia-Reyes and Dyment, EPSL, 2022); further South, the Caribbean Large Igneous Province formed by seafloor spreading between ~120 and 73 Ma in the Pacific before being drifted eastward (Garcia-Reyes and Dyment, EPSL, 2021). We therefore expect that the Yucatan Basin formed between 73 and 50 Ma.

Marine magnetic profiles in this area have been collected in the 1970s and are poorly navigated. Only a few profiles are conveniently oriented. We identify anomalies 29r to 28 off southern Cuba. A set of complex short-wavelength anomalies observed off Yucatan do not fit the wide anomalies expected between 73 and 50 Ma. We interpret them as "tiny wiggles" generated by geomagnetic intensity fluctuations usually depicted on fast-spreading spreading centers. This area is underlain by a strong regional gravity anomaly typical of magmatic crust formed at fast spreading centers. A fossil ridge is clearly identified on the gravity. By comparison with "tiny wiggles" recognized globally (Bouligand et al., EPSL, 2006), we date this area to Chron 26r. The Yucatan Basin was therefore formed by seafloor spreading between Chrons 29r and 26r (65-59 Ma) in two stages, first at an intermediate rate of ~40 km/My, then at a fast rate of ~100 km/My. The collision of Cuba with the Bahamas platform at 59 Ma resulted in a plate reorganization, with Cuba being attached to the North-American plate and the remaining Caribbean Plate moving due east.

The Greater Antilles Arc, ahead of the Caribbean Plate in its northeastward motion between the North and South American plates, was split by the opening of the Yucatan Basin between Jamaica-Hispaniola and Cuba at Chron 29r (~66 Ma). The coincidence in time and location with the Chicxulub impact is striking and suggests that sometimes regional plate tectonic events may result from major impacts with extraterrestrial bodies.

Keyword

Extrraterrestrial body impact, plate tectonics trigger, Chicxulub

Investigating the Chemical Mechanism for Magnetization Reduction in Subducting Oceanic Crust through Hydrothermal Alteration of Magnetic Minerals

Sunhwa HONG[1]*, Pusan National University (ovooo41@pusan.ac.kr)
Hoon young JEONG[2], Pusan National University
Hanjin CHOE[3], Pusan National University

Abstract

The subduction zones are the area where tectonic movements with related natural disasters such as volcanic eruptions, earthquakes and tsunamis actively occur. The extreme conditions in subduction zones induce the changes in physical and chemical characteristics in the subducting oceanic crust (i.e. the hydrothermal alterations of magnetic minerals). In the initial stage of its formation, the oceanic crust exhibits strong magnetization due to the formation of titanomagnetites when the magnetic mineral meets seawater. The hydrothermal circulation alters the magnetic minerals as a result of significantly decrease of the strength of magnetic intensities. Over time, the formation of anhydrous minerals block the seawater circulation in the oceanic crust and finally the weakening magnetizations are stabilized. Subsequently, in the subduction zone, it was observed that magnetization of oceanic crust gradually decreases up to 20% from the top of the outer rise to the trench by rejuvenated hydrothermal circulations from bending related re-opening faults. However, the quantitative impact of chemical alteration on magnetic minerals within the oceanic crust, associated with the reactivation of hydrothermal circulation, remains unquantified. Therefore, we conducted hydrothermal experiments to investigate the extent of alteration in major magnetic minerals, namely magnetite and titanomagnetite, prevalent in the oceanic crust. These experiments involved subjecting these minerals to reactions with artificial seawater at varying particle sizes and temperature conditions. Additionally, Gas Chromatography analyses were performed at regular intervals to monitor gas generation and observe mineral alteration, while X-ray diffraction (XRD) was utilized to examine resultant mineral samples for any mineralogical changes. Furthermore, we assessed the magnetic susceptibility of these minerals before and after the experiments using a magnetometer. These results, obtained through quantitative measurement of chemical alteration in magnetic minerals within the oceanic crust, are anticipated to advance our understanding of the interaction between hydrothermal circulation and magnetic minerals in subduction zones, thereby providing fresh insights into the formation and evolution of subduction zone environments.

Keyword

magnetization reduction, subduction zone, magnetic mineral, alteration, hydrothermal circulation

Inside the Central Cordillera of Colombia: La Línea Tunnel

Jorge GÓMEZ TAPIAS[1]*, Servicio Geológico Colombiano (mapageo@sgc.gov.co)
Carolina MORALES FERNANDEZ[2], Servicio Geológico Colombiano
Daniela MATEUS ZABALA[3], Servicio Geológico Colombiano

Abstract

The La Línea tunnel crosses the axis of the Colombian Central Cordillera at approximately 4.5° north latitude and is part of the road corridor that connects Bogotá with Buenaventura, the main harbor of Colombia in the Pacific Ocean. The tunnel was constructed at an altitude of 2400 meters above sea level, has a length of 8.6 kilometers, a width of 12.5 meters, and reaches a maximum depth of 900 meters below the highest point, the summit of La Línea. The importance of the tunnel lies in its ability to provide a comprehensive geological record of the Central Cordillera, which is otherwise concealed beneath surface vegetation and the volcanic ash deposits of the Cerro Machín Volcano.

The geological map of the La Línea tunnel was carried out at a scale of 1:10000 and covered an area of 42 km2. It was developed based on the description of 8595.3 linear meters of exploratory cores from the tunnel, the geological characterization of areas without tunnel wall coverings, and the description of approximately 300 outcrops in the vicinity.

To the east of the San Jerónimo Fault, La Línea Diorite was identified. La Línea Diorite is in faulted contact with the Cajamarca Complex. The Cajamarca Complex consists of intercalations of quartz muscovite schists with varying amounts of graphite, chlorite and amphibole schists, and amphibolites in greenschist to amphibolite facies.

To the west, the Cajamarca Complex is in contact with the Quebradagrande Complex along the San Jerónimo Fault. The most representative lithologies of the Quebradagrande Complex in this region consist of interbedding of crystal and volcanic lithics tuffs, hornblendic andesites, with fewer occurrences of agglomerates and volcanic breccias. Additionally, there are deformed sedimentary rocks characterized by interbedding of conglomerates with granules, sandstones with convolute stratification, load structures, and gradation, and mudstones exhibiting plane–parallel stratification structures. The tuffs have undergone metamorphism into greenschist facies with the formation of talc, chlorite, and tremolite–actinolite. Various new porphyritic bodies were mainly recognized to the east of the San Jerónimo Fault in intrusive contact with rocks of the Cajamarca Complex.

New U–Pb dating of detrital zircons from rocks of the Cajamarca Complex indicates maximum depositional ages ranging from the Middle to Late Jurassic, with populations showing inherited characteristics from the Paleozoic era. Geochemical analysis of the greenschists reveals a

predominant oceanic affinity, characterized by intermediate Th/Yb and Nb/Yb ratios falling between N–MORB and E–MORB type basalts. In the tuffs of the Quebradagrande Complex, geochemistry suggests a magmatic arc affinity, while the zircons display Early Cretaceous ages and inherited Triassic characteristics, indicating a continental contribution. The La Línea Diorite exhibits a crystallization age from the Jurassic period, the porphyries have a Miocene age, and a newly discovered volcano at the summit of the tunnel shows a Pleistocene age.

Keyword

U–Pb geocronology, metamorphism, Cajamarca Complex, Quebradagrande Complex, San Jerónimo Fault

Understanding postseismic deformation patterns in the Korean Peninsula following the 2011 Tohoku-Oki earthquake: Insights from viscoelastic numerical simulations

Sungho LEE[1]*, KIGAM (slee29@memphis.edu)
Eunseo Choi[2], University of Memphis
Minkyung Son[3], KIGAM
Seok Goo Song[4], KIGAM
Demian D. Gomez[5], Ohio State University

Abstract

The 2011 Tohoku-Oki earthquake caused geodetically detectable co- and post-seismic surface deformations across Northeast Asia and might be responsible for the enhanced seismic activity reported for the southern part of the Korean Peninsula (SKP). Here, we conducted a series of viscoelastic numerical simulations to explain the complex spatial and temporal distribution of the postseismic deformations in the SKP captured by the Global Navigation Satellite System (GNSS). We used the GNSS data published by a previous study but newly calculated yearly velocity gradient tensors for five years since the Tohoku earthquake using the extended linear trajectory modeling method. Our numerical models were composed of two layers, lithosphere and asthenosphere. The lithospheric thickness and elastic properties were taken from LITHO1.0; and those of the crust, embedded within the lithosphere, from CRUST1.0. For simplicity, each layer's viscosity was assumed to be uniform and constant. The lithospheric viscosity was set to be 10^23 Pa s. Based on the root mean square error with respect to the low-pass filtered GNSS-derived strain rate fields, we found that 5 x 10^18 Pa s is the best-fitting asthenospheric viscosity. In the GNSS data, three regions of the SKP—northwest, southwest, and southeast areas—exhibited particularly large maximum shear strain rates relative to the best-fitting model. Noting the spatial coincidence of those regions with the low-velocity anomalies at depths of 60-120 km in two regional seismic tomography models, we modified the best-fitting model by introducing a low (10^19 Pa s) viscosity at the locations of the low-velocity anomalies and found the difference from the GNSS data significantly reduced. Finally, we show that the magnitudes of maximum shear strain rate for the first year since the Tohoku earthquake in a numerical model could approach those from the GNSS data only with an asthenospheric viscosity as low as 2-3×10^18 Pa s while 5×10^18 Pa s is the best-fitting value for years 2-5. This result suggests that post-seismic stress relaxation in the region's asthenosphere is strain rate-dependent.

Keyword

the 2011 Tohoku-Oki earthquake, postseismic deformation, GNSS, viscoelastic modeling, rheology

The critically stressed state of the earth's crust and the associated response to anthropogenic impact

Andrian Sergeevich Batugin[1]*, NUST MISIS (batugin.as@misis.ru)

Abstract

An industrial large-scale impact on the subsoil and the earth's surface is accompanied by such hazardous technogenic geodynamic phenomena as induced earthquakes, rock bursts, gas migration to the surface in mining areas and reactivation of tectonic faults. In some cases, the induced nature of geodynamic phenomena cast no doubt, as, for example, in the extraction of minerals in mines. At the other extreme are geodynamic phenomena, the technogenic nature of which is being questioned. This mainly concerns strong earthquakes with magnitude M> 5 and with a large depth of the hypocenter. The main argument against the technogenic nature of such earthquakes is insignificant stress changes at the depth of the hypocenter and the overly strong response of the earth's crust to the technogenic impact. Based on several examples from the author's experience and published data, this presentation considers the hypothesis of the occurrence of strong induced earthquakes with a major depth of the hypocenter. Among the examples are earthquakes with magnitudes of 5 to 8, the nature of which is under discussion. The hypothesis is based on the concept of the critically stressed state of the earth's crust, which occurs in a layer located at a certain depth from the earth's surface. During the study, it was found that the occurrence of induced earthquakes with a magnitude of more than 5 and the fault reactivation can be explained through the concept of critically stressed state of the earth's crust. The results obtained comply with understanding of the nature of technogenic geodynamic phenomena and can be used to develop recommendations for zoning of the induced geohazards. This study was supported by grant № 22-27-00728 from the Russian Science Foundation (RSF), https://rscf.ru/en/project/22-27-00728/

Keyword

Earth crust, Stress state, Fault Reactivation, Induced Earthquake

[Keynote] Properties, nature and outlook of intraplate earthquakes in the eastern margin of Eurasian plate around the Korean Peninsula

Tae-Kyung HONG[1]*, Yonsei University (tkhong@yonsei.ac.kr)
Junhyung Lee[2], Yonsei University
Seongjun Park[3], Yonsei University
Byeongwoo Kim[4], Yonsei University
Jeongin Lee[5], Yonsei University
Dong Geon Kim [6], Yonsei University

Abstract

The tectonic loading rate in stable continental regions is low, which causing low earthquake occurrence frequency in intracontinental regions compared to interplate regions. However, large earthquakes may still occur within geological structures in stable continental regions. The Korean Peninsula and its neighboring regions belong to a stable intracontinental regime located in the eastern Eurasian plate. A series of major earthquakes occurred over time in the Korean Peninsula after the 2011 Mw 9.0 Tohoku-Oki megathrust earthquake. There is increasing concern regarding the possible occurrence of major events that may cause fatal damage to large cities. Historical seismicity may provide valuable information on the seismic hazard potentials for earthquakes with long recurrence intervals. There are historical literatures that describe seismic damage and earthquakes during the Joseon dynasty in 1392–1910, presenting moderate and large earthquakes of long recurrence intervals. Most earthquakes in the continental lithosphere occur in the upper crust, while mid- to lower crustal earthquakes rarely occur in intraplate regions due to ductile deformation. The rate of seismicity is low, and the seismicity is spatially diffuse. The focal depths of these events are 4–20 km, mostly within ~4–8 km in the peninsula and Yellow Sea and 2–30 km (mostly 12–20 km) in the East Sea (Sea of Japan). The seismicity appeared to increase after a megathrust earthquake. Episodic earthquake swarms occur in low seismicity regions. After a megathrust earthquake, mid to lower crustal earthquakes increased. The midcrustal and lower crustal events occurred in regions where the seismicity was low before the events. On the other hand, the earthquake occurrence is relatively low in the usual high seismicity regions. The feature may happen due to the stress balancing in the crust after the megathrust earthquake. Also, changes in the properties of the medium caused major earthquakes to occur at relatively early times. Successive ML5 earthquakes occurred on the outskirts of high-seismicity regions. The identification of potential earthquake locations is important for seismic hazard mitigation. Paleo-tectonic structures develop as earthquake-inducing faults, which may be important for seismic hazard mitigation in intraplate regions.

Keyword

intraplate, seismicity, tectonic, Korean Peninsula, fault

Effect of postseismic deformation following Tohoku-Oki earthquake on the East Asian intraplate due to the strength of the East-Sea (Japan Sea).

Hyeon-Seob KIM[1]*, Kangwon National University (hskim_knu@kangwon.ac.kr)
Byung-Dal So[2], Kangwon National University

Abstract

Stress transfer between faults caused by seismic events has triggered or induced aftershocks and subsequent earthquakes. Following Mw 9.0 Tohoku-Oki great earthquake on March 11, 2011, near the coast of Eastern Japan, led to increased seismic activity within intraplate faults of the Eurasian plate. The Korean Peninsula, located more than 1200 km from the epicenter, occured microearthquakes and the >Mw 5 middle earthquakes since 2011. Geodetic, seismological, and geophysical investigations have demonstrated that the great earthquake induced static, dynamic, and quasi-static stress changes in faults within the peninsula.

Viscoelastic relaxation of the rheological structure, in response to earthquake stress, causes disturbance in the stress field over a wide upper plate, a long duration, and identified as a primary factor in the stress change of intraplate faults from previous numerical modeling. However, the laterally homogeneous layered structure model representing the Eurasian plate may overlook the effects of viscoelastic behavior due to the rheological contrast between the 1000 km wide back-arc and the continent. The East Sea (Japan Sea) back mantle, where undergone expansion, showed a thickness difference of more than 30 km with the Korean pennisula., even rheological strength weakening through the interaction of the uplifted mantle. We compare the effects reflecting the heterogeneity of the back mantle using a three-dimensional numerical model incorporating the Japanese subduction zone and the vast Eurasian plate. Our study discusses the remote stress stransfer between interplate and intraplate faults due to the extended back mantle in the subduction zone.

Keyword

Postseismic deformation, Back-arc mantle, Stress transfer, Intraplate seismicity

Permian magmatism and Triassic and Jurassic metamorphism recorded at the western margin of Gondwana, Colombia

Jorge GÓMEZ TAPIAS[1]*, Servicio Geológico Colombiano (mapageo@sgc.gov.co)
Carolina MORALES FERNÁNDEZ[2], Servicio Geológico Colombiano
Daniela MATEUS–ZABALA[3], Servicio Geológico Colombiano

Abstract

New detrital U–Pb LA–ICP–MS ages carried out in Colombia in recent years have allowed us to separate the Cajamarca Complex, previously assigned to the Paleozoic, composed of quartzites, schists, and amphibolites that make up a large part of the basement of the Central Cordillera, into two geological units. The first one has a Triassic metamorphism as indicated by Ar–Ar ages. The second one has an age range from Late Jurassic to Early Cretaceous? This age is assigned based on detrital ages ranging from 167 to 138 Ma and the fact that these rocks are intruded by the Mariquita Stock with an age of 130 to 143 Ma. The second unit is in the middle of two blocks of the first unit and its boundaries are the Palestina and Ibagué Faults. These boundaries are interpretative because no new geological mapping has been carried out in this region.

Similarly, new U–Pb ages on the eastern flank of the Central Cordillera and the Sierra Nevada de Santa Marta have enabled the split up of several Permian igneous bodies that define a non–continuous, north–south–oriented arc. The Ortega Batholith stands out, which was previously considered part of the Jurassic Ibagué Batholith.

Various xenoliths of medium to high–grade metamorphic rocks in the Jurassic Ibagué Batholith were dated by U–Pb LA–ICP–MS. These xenoliths, previously lacking data, have been assigned to be of Stenian–Tonian age, related to the Putumayo Orogeny. These rocks consist of granulites, orthogneisses, paragneisses, migmatites, and amphibolites. Our results show that these orthogneisses contain igneous zircons with a Permian crystallization age and a Middle Triassic metamorphic overprint.

These new data suggest that the western margin of Gondwana experienced a Permian magmatism and a Middle Triassic metamorphic event associated with the assembly and breakup of Pangea. Additionally, a Late Jurassic or Early Cretaceous metamorphic event is reported, which may be allochthonous and raises new questions about the evolution of this part of the northwestern corner of South America.

Keyword

Central Cordillera, Cajamarca Complex, Ibagué Batholith

A review of the retroarc foreland metasediments associated with the Devonian-Mississipian west Patagonian magmatic arc, Argentina

Carlos Jorge Chernicoff[1]*, CONICET-SEGEMAR (Council for Scientific Research, Argentina)
(cc_jorge@yahoo.com.ar)
Eduardo O. Zappettini[2], Servicio Geològico-Minero Argentino

Abstract

37 IGC , Republic of Korea. 2024. T4: Tectonophysics, Session 13: General Topics.
Abstract #142

In the central segment of the North Patagonian Massif, Argentina, where limited outcrops of Paleozoic metasediments of the Colo Niyeu Formation are exposed, new zircon U-Pb SHRIMP dating has been carried out, yielding a Devonian age; notably, this unit was formerly regarded as Cambrian.

The rock analyzed is a low-grade metasandstone sampled at 40°43´51´´ S / 68°36´56´´ W, from which 27 detrital zircons have been analyzed. Most of the grains are late Neoproterozoic (n=11) and late Mesoproterozoic (n=9) in age, followed by Cambrian (n=3) and Ordovician (n=2); the oldest grain is Rhyacian. The age of the youngest detrital zircon grain is Silurian (430 ± 6 Ma; Wenlock Epoch), indicating the maximum age for the onset of sedimentation of the protolith of the Colo Niyeu Formation.

In the context of the Colo Niyeu Formation occurring ca. 120 km to the east of the NNW-trending late Devonian-Mississipian, Western Patagonian Magmatic Arc, it is likely that this unit could pertain to a retroarc foreland basin associated with the latter arc, subjected to deformation and low-grade metamorphism during the Middle Carboniferous collisional event occurred in that region. The partly coeval and relatively nearby metasediments of the Cushamen and Colohuincul Formations are comparable to the Colo Niyeu Formation, though located in a forearc position.

Keyword

retroarc, foreland, Devonian, metasediments, Patagonia

Newly dated Neoproterozoic-Cambrian Las Pacas Complex at the boundary between the Cuyania and Chilenia terranes, southern Mendoza province, Argentina

Carlos Jorge Chernicoff[1]*, CONICET-SEGEMAR (Council for Scientific Research, Argentina) (cc_jorge@yahoo.com.ar)
Eduardo O. Zappettini[2], Servicio Geològico-Minero Argentino

Abstract

37 IGC, Republic of Korea. 2024. T4: Tectonophysics, Session 13: General Topics. Abstract #150

The Las Pacas Complex is formed mostly by metasediments poorly exposed at the southern Mendoza province of Argentina (ca. 35° 45´S / 68º 19`W). They have been dated using the U-Pb SHRIMP method, yielding the following results.

The main rock unit studied is a low-grade metapelite/metasandstone, from which 22 detrital zircons have been analyzed, representing the main populations, i.e. 27.2 % Paleoproterozoic (13.6 % Statherian, 13.6 % Orosirian) and 72.7 % Mesoproterozoic (4.5 % Ectasian, 68.2 % Calymmian).

The youngest zircón is ca. 1235 Ma (Late Ectasian; Tdm-Hf 1.42 Ga –Late Calymmian-, épsilon Hf +9.73). In spite of the latter Late Ectasian age, the regional context strongly suggests that the maximum age for the onset of sedimentation of the protolith of the Las Pacas metasediments is Late Neoproterozoic-Cambrian, probably representing the southern continuation of the likely equivalent Guarguaraz Complex, also exposed at the boundary between the Chilenia and Cuyania terranes, ca. 200 km to the south. If correct, the Las Pacas Complex would also represent a segment of the same collisional accretionary prism as proposed e.g. by Willner et al. (2008; Chemical Geology 253:114–129) for the Guarguaraz Complex.

In addition, in the same area of poor exposures, although with field relationships still undetermined, there are sparsely distributed metabasites which have been dated at 1424 Ma. In the geological context, both local and regional, these scarce metabasites are herein regarded to probably pertain to upthrust basement slivers, tectonically imbricated with the Las Pacas metasediments.

Keyword

Cuyania, Chilenia, Las Pacas Complex, metasediments, Neoproterozoic-Cambrian

A study on magnetization vector inversion modeling of Dokdo submarine volcanic body

SoonYoung CHOI[1]*, Korea Institute of Ocean Science and Technology, Kangwon National University (sychoi@kiost.ac.kr)
ChangHwan KIM[2], Korea Institute of Ocean Science and Technology
WonHyuck KIM[3], Korea Institute of Ocean Science and Technology
ChanHong PARK[4], Korea Institute of Ocean Science and Technology

Abstract

To understand the formation and evolution processes in Dokdo submarine volcanic body, we studied a magnetic model around the study area using bathymetry and magnetic data. Volcanic body regions have complex structures due to magma eruption and intrusion during the formation process. We performed modeling using the magnetization vector inversion (MVI) method, which can consider both remanent magnetization and induced magnetization, to determine the accurate three-dimensional spatial magnetic distribution and magnetic structure of the volcanic body region. The Dokdo submarine volcanic body is a flat seamount measuring approximately 26(N-S)x21(E-W)km and is divided into the summit, slope, and base. There are two small islands at the center of the summit of the Dokdo submarine volcano (Dongdo and Seodo). About four small craters that are inferred to be parasitic volcanoes appear. The magnetic characteristics of Dokdo submarine volcanic body, derived from the total magnetic intensity, show that the low anomaly zone is distributed in the central part of the submarine volcanic body and a high anomaly zone surrounds it. The boundary area between the summit and slope is almost matched with the boundary area between the high-anomaly zone and the low-anomaly zone. At the summit, a low anomaly zone appears in most areas east and south of Dokdo, including around Dokdo, while a relatively high anomaly zone appears in the north and northwest areas of Dokdo. The slope area, with a different pattern from the summit area, shows that all areas except the eastern area are distributed in a high anomaly zone. The magnetic modeling range of this study is 21x18x10km, and the modeling results are expressed as magnetic susceptibility and magnetization vector. As a result of analyzing the magnetic susceptibility and magnetization vector, It is expected that strong magnetic material that affected the Dokdo submarine volcanic body was moved from the deep seafloor layer to the shallow layer in the central area of the summit and the south-southeast area of the slope. Meanwhile, small anomalous zones appear dispersed in the west-southwest-south near the base, which is considered to be a possible influence of strong residual magnetization created by lava flows at the time of volcanic body formation. The result of the magnetic intensity and magnetization vector by clip (>0.02) indicates the overall high-abnormality patterns of the shallow and deep layers. In addition, the expected movement path of strong magnetic materials is more clearly visible in two regions (the central region of the summit and the southeast-southeast region of the slope). The opposite magnetization vector directions of the two regions suggest that the source location and eruption time of the magnetic material in the two regions might be different.

Keyword

Dokdo, submarine volcano, magnetic susceptibility, magnetic modeling, magnetization vector inversion

Deciphering Fissure Dynamics: Magnetic Fabric Insights into Cretaceous Deccan's Volcanic Phenomena from N-S-T Dyke Swarms

GARIMA SHUKLA[1]*, Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research Bhopal, Madhya Pradesh 462066, India (garimashukla003@gmail.com)
AYANANGSHU DAS[2], Basin and Crustal Deformation Research Laboratory, Pusan National University, South Korea
JYOTIRMOY MALLIK[3], Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research Bhopal, Madhya Pradesh 462066, India
SAYANDEEP BANERJEE[4], Department of Geology, Banaras Hindu University, Varanasi 221005, India

Abstract

The emplacement mechanism of the Deccan Continental Flood Basalt (DCFB) in India has been extensively debated among researchers, with proposed models including the Plume model, Mantle convection theory, and fissure eruption theory. The DCFB comprises three major dyke swarms i.e., the Western Coastal dyke swarm (N-S trending), the Narmada-Satpura-Tapi (N-S-T) dyke swarm (E-W trending), and the Nasik-Pune dyke swarm (randomly oriented). This research focuses on the Pachmarhi and Nandurbar-Dhule (N-D) dyke swarms, located on the Eastern and Western sides of the N-S-T dyke swarm, respectively. The primary objectives are to develop a comprehensive geodynamical model of the N-S-T dykes, explain flow dynamics within these dykes, and identify the locations of magma chambers that feed them.

The Pachmarhi and N-D dykes have maximum lengths of 22 km and 79 km, respectively, with both having mean lengths of ~5 km. These dyke swarms are emplaced within preexisting fractures, exhibiting a discernible preferred orientation along an ~E-W trending trajectory. This alignment corresponds to the general trend of the Narmada-Son lineament (NSL) and is perpendicular to the direction of the minimum horizontal stress ($\sigma 3$). This $\sigma 3$ direction aligns with the ~N-S trending paleoextension during the period of dyke emplacement. Anisotropy of magnetic Susceptibility (AMS) and rock magnetic analysis have been deployed for the dyke swarms which aims to determine the direction and sense of magma flow, providing insights into the depth, number, and spatial distribution of magma chambers. The rock magnetic studies conducted on the dykes have revealed the presence of high-titanium magnetite particles, primarily of Pseudo-Single Domain (PSD) nature. However, in the case of the N-D dykes, low-titanium magnetite particles with Multi-Domain (MD) grains were observed.

To determine magma flow direction and sense in dyke margins with different fabric shapes, magnetic foliation plane imbrication (dip and strike of the K1-K2 plane) is used for oblate fabric, and magnetic lineation (plunge of the K1 axis) imbrication is used for prolate fabric. When one dyke margin has an oblate shape and the other has a prolate shape, magnetic foliation is used for the former and magnetic lineation for the latter. This analysis reveals various magma flow trends, mostly vertical or inclined, suggesting proximity to magma sources. Few dykes show a sub-

horizontal flow pattern. The intersection of imbrication within the margins of each dyke provides valuable information about the flow geometry, suggesting the presence of multiple shallow subcrustal magma chambers. This finding aligns with earlier conclusions based on structural attributes, such as the length and thickness of dykes, quantifying magmatic overpressure and the depth of the magma chamber. The multiple trends of flow indicate a polycentric flow pattern for both the Pachmarhi and N-D dykes. Thus, it can be inferred that dyke emplacement in the NSL region was primarily facilitated by a "polycentric flow" mechanism through sub-crustal magma chambers, where magma was injected through crustal fissures, leading to a significant volume of magma being generated in the DCFB.

Keyword

Dykes, Magma Chamber, Magnetic Fabric, Imbrication, Polycentric flow

Cenozoic crustal thickness variations and surface uplift in the southeastern Tibetan Plateau: Insights from detrital zircon U-Pb geochronology and trace elements in the Gongga Shan region

Yanglin ZHAO[1], National Institute of Natural Hazards, Ministry of Emergency Management of China
Xiaoming SHEN[2]*, National Institute of Natural Hazards, Ministry of Emergency Management of China (xiaoming_shen@163.com)
Zhiyuan HE[3], Ghent University
Xiaoping YUAN[4], China University of Geosciences
Xiong WU[5], National Institute of Natural Hazards, Ministry of Emergency Management of China
Yukui GE[6], Institute of Geology, China Earthquake Administration
Shiguang WANG[7], Institute of Geophysics, China Earthquake Administration
Lin WU[8], Institute of Geology and Geophysics, Chinese Academy of Sciences
Yingying JIA[9], National Institute of Natural Hazards, Ministry of Emergency Management of China
Xiudang TANG[10], National Institute of Natural Hazards, Ministry of Emergency Management of China

Abstract

The timing and mechanism of uplift in the southeastern Tibet Plateau have long been subjects of debate. The Gongga Shan region, positioned at the convergence of the Songpan-Ganzi, Chuandian, and Yangtze blocks, serves as a crucial vantage point for unraveling the evolutionary history of the southeastern Tibet Plateau. Nevertheless, the uplift history of the Gongga Shan region remains shrouded in uncertainty. By employing multivariate trace element ratios and reconstructing crustal thickness using zircon Eu/Eu* based on the timeline established by detrital zircon U-Pb, our research has unveiled distinct periods of crustal thickening and thinning events. Within the time span of ~240–160 Ma, a discernible thickening trend emerged from ~35 to ~45 km between ~240 and ~ 215 Ma, followed by a relatively stable phase from ~215 to ~170 Ma, and subsequently a decline from ~170 to ~160 Ma, reducing the thickness from ~45 to ~30 km. In the period from ~55 to ~5 Ma, an initial increase in thickness occurred from ~30 to ~60 km between ~55 and ~ 30 Ma, succeeded by an overall thinning from ~60 to ~35 km between ~30 and ~ 10 Ma. Moreover, based on our reconstructed crustal thickness data, we have traced the paleo-elevation changes in the Gongga Shan region from the Cenozoic to the present, revealing a fluctuation from ~0.5 to ~4.5 km. We attribute the Triassic-Jurassic crustal thickening and subsequent thinning to the Triassic orogeny and post-collision extension following the closure of the Paleo-Tethys Ocean. Our findings further suggest that during the Eocene-Oligocene period, the Gongga Shan region experienced significant crustal thickening and surface uplift, indicative of intense compression. This phenomenon likely resulted from the northeast-directed compression of the Indian- Eurasian plate, causing substantial crustal shortening and thickening in specific areas of the southeastern Tibet Plateau, leading to rapid surface uplift. Subsequently, during the Oligocene-Miocene, the detachment and subsidence of the lithospheric mantle triggered rapid crustal thinning in the Gongga Shan region. This phase was accompanied by relatively stable and

slight surface uplift, signifying a shift in the plateau uplift mode of the southeastern Tibet Plateau from compression to lateral extrusion.

Keyword

Southeastern Tibetan Plateau, Gongga Shan, Detrital zircon, Crustal thickness, Uplift

Evidence of crustal scale fracture system in Central Indian Precambrian (Bastar) Craton, India: Inference from airborne magnetic data analysis and modelling.

AJIT SINGH[1]*, GEOLOGICAL SURVEY OF INDIA (ajit.singh4@gsi.gov.in)
RAJESH KUMAR[2], GEOLOGICAL SURVEY OF INDIA

Abstract

The Central Indian Precambrian Craton (Bastar) holds a unique position in Indian plate tectonics evolution owing to its complex crustal architecture, poly deformational history and spatial proximity to mega scale tectonic features viz. Godavari Graben, Mahanadi Graben, Eastern Ghat Mobile Belt (EGMB) and Central Indian Tectonic Zone (CITZ), bounding it from all sides. This study utilizes high resolution airborne magnetic data to comprehend the subsurface geology, structural trends and overprinting relationships through magnetic data interpretation.

The processing of high-resolution aeromagnetic data has enabled delineation of a number of parallel, E-W trending Trans Central Indian Craton Airborne Magnetic Lineaments (TCIMLs) extending for a strike length of 250-300 km, traversing through varied litho-structural domains encompassing Archean Tonalite-Trondhjemite-Granodiorite (TTG) suite of Amgaon and Bengpal Gneisses, supracrustal rocks sequences of Bailadila Group of Neo-Archean to Paleoproterozoic age, Paleo-Mesoproterozoic Dongargarh Supergroup, Bimodal volcanics of Nandgaon Group, 2.5 Ga Malanjkhand and Dongargarh granitoids, Kotri-Dongargarh Belt, Sakoli Group and Meso-Proterozoic Chhattisgarh basin. Filtering techniques viz. horizontal derivative of magnetic field (THDR) and Tilt derivative (TDR) have revealed edges and systematic E-W orientation of these TCIMLs. First vertical derivative (FVD) map revealed a large number of NW-SE, NE-SW and N-S trending, subtle magnetic anomalies cross cut by the TCIMLs which are relatable with small scale dykes, brittle ductile shear zones, faults, etc. A substantial depth persistency up to 3000 - 4000 m is recorded for most of these mega linears in matched filtered radially averaged power spectrum maps. Source Parameter Imaging (SPI) and Euler deconvolution method using dyke parameters reveal a maximum depth in a range of 500 m with gradual increase in depth of solutions from west to east, indicating a general eastward dip. The inverse modelling using profile data at few locations across these TCIMLs have depicted the slope, height, width, strike, dip, plunge and magnetic susceptibility of these lineaments.

Field evaluation of TCIMLs in and around Kotri-Dongargarh belt, where the anomalies are most prominent, reveals negligible surface manifestation of the TCIMLs substantiating their deep seated nature. To create such a huge magnetic susceptibility contrast, the TCIMLs must accommodate a huge volume of Fe and Mg rich materials. It is further reasoned by the presence of positive gravity anomalies caused by high density material in most parts of the CIPC except for the south eastern part, revealed during regional gravity data studies in the past. Creation of such large scale fracture system require a major tectonic impetus which is present in the form of suturing of two continental blocks along Central Indian Tectonic Zone (CITZ) during the

Precambrian. A close spatial proximity as well as a comparable trend of these TCIMLs with CITZ suggest a possible association between them. The fracture system, so created might have been impregnated with mafic magma during later phases of basaltic magmatism as mega dykes.

Keyword

Central Indian Precambrian Craton (Bastar Craton), Trans Central Indian Craton Airborne Magnetic Lineaments (TCIMLs), Inverse modelling, Central Indian Tectonic Zone (CITZ), Basaltic magmatism

ML-based volumetric conversion of 2D seismic sections for comprehensive seismic interpretation

Min Je LEE[1], Seoul National University
Jun-Woo Lee[2]*, Seoul National University (crusaider0614@snu.ac.kr)
Yongchae Cho[3], Seoul National University

Abstract

A conventional two-dimensional (2D) seismic survey is often more economical than a three-dimensional (3D) seismic survey and therefore employed in regional initial subsurface structure characterization. In contrast, a 3D seismic survey is employed in a specific region selected based on the potential reservoir characterization due to its costly nature (up to several million USD). These lead to 2D seismic sections distributed throughout the region while 3D seismic volume only occupies a minuscule, limited portion of the survey site compared to 2D seismic sections.

Rather than performing an additional 3D seismic survey, which can cost a substantial amount of resources, image-training- and machine-learning-based volumetric conversion of 2D data into 3D data volume can significantly reduce the monetary and computational cost. Furthermore, the obtained 3D data volume can be used to analyze the potential sites and to structurally interpret the subsurface geology. If an additional seismic survey were to be performed, such supplementary information can aid in decision-making processes.

The conventional volumetric conversion method has several limitations. The result of the converted volume heavily depends on the prior interpretation, which may vary based on the interpreter. This may pose a problem in analyzing large-scale seismic data. Each seismic vintage has a different seismic source waveform and a migration velocity model. These lead to misties which refer to misfits between 2D seismic data. By utilizing image-training- and machine-learning-based volumetric conversion, a seismic data volume that is 1) independent of prior interpretation, 2) robust to the misties, and 3) computationally effective can be obtained.

By training the correlation between the volume and line data in the same location, the region without seismic volume data can be estimated. This additional information can help interpreters in the decision-making process in hydrocarbon reservoir exploration. In this study, an extrapolation technique estimating the external region of the seismic volume by incorporating line and volume data is proposed. Here, methods used in image outpainting are utilized since an extrapolation of seismic volume is similar to image outpainting since the objective of both methods is to generate an image outside of the original image.

The applicability of the proposed method is tested in two cases: 1) a regular grid where data points of line data are in perfect alignment with data points of volume data, and 2) an irregular grid with random 2D section position. In both cases, the extrapolation performance was plausible near the original volume data. However, after repetitive estimation and expansion of the extrapolation area, a performance degradation was observed. Nonetheless, the final extrapolated result on the entire region provided sufficient information for improved subsurface structure interpretation. The

extrapolation technique in an irregular grid showed degraded performance compared to that of the regular grid.

Keyword

3D Seismic, neural network, machine learning

Hyper-extended basins controlled by low-angle normal faults in Marginal Seas: 3D structure and tectono-sedimentary evolution

Geoffroy MOHN[1]*, CY Cergy Paris Université (geoffroy.mohn@u-cergy.fr)
Jean-Claude Ringenbach[2], Totalenergies, CSTJF
Etienne Legeay[3], CY Cergy Paris Université
Nick Kusznir[4], University of Liverpool
William Vetel[5], Totalenergies
François Sapin[6], Totalenergies, CSTJF
Julie Tugend[7], Commission for the Geological Map of the World

Abstract

This contribution explores the formation and evolution of hyper-extended basins controlled by low-angle normal faults active at <30°. Based on high-resolution industrial 2D and 3D seismic reflection surveys along the southern margin of the South China Sea (Dangerous Ground), we mapped and analyzed the 3D geometry of low-angle normal fault systems and the related stratigraphy. A series of hyper-extended basins were documented, filled locally by up to 6 km of sediments including pre- to post-rift sequences. The observed normal faults on depth migrated seismic sections show an average dip angle of 30° and appear planar, characterized by continuous reflections with no clear steepening at depth and sole-out on distinct decollement levels. Detailed fault surface mapping reveals the occurrence of corrugation together with large wavelength undulation. The geometry of intra-basement reflectors is compatible with occurrence of Mesozoic nappe stacks in agreement with the inferred geodynamic setting during this period. Reactivation of former thrust faults is interpreted as enhancing the formation and development of low-angle normal faults as reported in others SE Asia rift basins.

The stratigraphic infill of the hyper-extended rift basins is characterized by several syn-rift sequences controlled by development of the low-angle normal faults. The first syn-rift sequence appears as chaotic and discontinuous packages that has been dismembered and fragmented during the activity of low-angle normal faults. The second syn-rift package shows unexpected sedimentary wedges developing successively towards the footwall and the hangingwall. This geometry results from the interplay between the main low-angle normal fault and antithetic faults defining a so-called extensional fishtail. Our structural interpretations are tested using kinematic forward lithosphere deformation model allowing the production of flexural isostatically compensated as well as balanced cross-sections. Such models enable us to validate our structural interpretations but also test several kinematic scenarios.

Our study brings new observations and constraints on the development of hyper-extended basins controlled by faults initiated and active at low-angle that are common in SE Asia marginal Seas.

Keyword

Rifting, Hyper-extended basins, Low-angle normal faults, Extensional tectonics, South China Sea

Cenozoic tectonic history of SE Korea during the evolution of the East Sea (Japan Sea)

Min-Cheol KIM[1]*, Pusan National University (igumany@pusan.ac.kr)
Moon Son[2], Pusan National University
Cheol Woo Song[3], Busan Metropolitan City
Youngbeom Cheon[4], Korea Institute of Geoscience and Mineral Resources
Hong Gyun Kim[5], National Forestry Cooperative Federation
Hee-Cheol Kang[6], Pusan National University

Abstract

The geology of SE Korea offers an exceptional opportunity to study the Western Pacific Cenozoic tectonic events, preserving diverse evidence for interpreting the evolution of the East Sea (Japan Sea). The sea is a semi-enclosed marginal back-arc basin separated from the Pacific Ocean by the Japanese Islands. The southeastern margin of the Korean Peninsula was subject to dextral shear stress due to the NNW-SSE opening of the sea during the late Oligocene to Middle Miocene. A number of Miocene sedimentary basins were formed by pull-apart openings with a series of NNW-trending dextral strike-slip (PDZs: Principal Displacement Zones) and NE-trending normal faults. Although these basins occur close to one another, they are mostly bordered by faults and show different lithologies, ages, and sedimentary processes of basin fills. The basin fills consist of the Early Miocene dacitic and basaltic volcanogenic rocks and the intercalated terrestrial sediments (ca. 23-18 Ma) and the Middle Miocene (non-volcanic) terrestrial to marine sediments (ca. 17-10 Ma). The Early Miocene volcanic rocks are primarily sub-alkaline, whereas a series of Middle Miocene basalt (ca. 15-13 Ma) is sodic alkaline phono-tephrites. Since at least 23 Ma, parallelogram-shaped Early Miocene onshore basins formed between the NNW-trending PDZs, accompanied by southwestward propagation rifting, northwestward block tilting, and clockwise horizontal block rotation. At about 17 Ma, wedge-shaped Middle Miocene basins were produced by the NNW-trending strike-slip activation of the Yeonil Tectonic Line (YTL) and NNE-trending normal reactivation of the northern extension of the Yangsan Fault zone. These vigorous basin extensions in SE Korea continued until the collision of the Philippine Sea Plate and SW Japan at around 15 Ma. This tectonic inversion from a tensional to a compressive stress regime in East Asia resulted in the cessation of the East Sea opening and the subsequent gradual uplift of the crust in SE Korea, with a compositional change of magmas from sub-alkaline to alkaline. The basin fill sedimentation finally ceased at about 10 Ma. Meanwhile, the region has been undergoing continuous E-W to ENE-WSW compression since around 5-3.5 Ma, due to the eastward movement of the Amurian Plate (ca. 1-1.5 cm/y) and the westward low-angle subduction of the Pacific Plate.

Keyword

Cenozoic, Miocene basin, crustal deformation, East Sea (Japan Sea), Western Pacific

Morphodynamic interaction between canyons and fans in a Basin and Range setting: the roles of tectonics, bedrock incision and alluviation

Gary PARKER[1]*, University of Illinois Urbana-Champaign USA (parkerg@illinois.edu)
Li Zhang[2], North China Electric Power University, China
Jeffrey Nittrouer[3], Texas Tech University, USA

Abstract

Basin and Range provinces consist of subparallel mountain ranges and valleys undergoing alternate relative uplift and subsidence. Canyons are incised into the uplifting mountains. The canyons deliver sediment to adjacent subsiding fans (bajadas) that occupy the valleys, where it deposits. We use the example of Rainbow Canyon and the adjacent Panamint Valley, Death Valley National Park, USA as a motivator for a study of general canyon-fan interaction. We use a morphodynamic model for this purpose. Tectonics is imposed externally. Incisional processes are modeled with the MRSAA saltation-abrasion-alluviation formulation, according to which moving sediment can act as tools to erode bedrock under conditions of partial alluvial cover. Depositional processes are modelled using a standard Exner formulation for sediment conservation and a sediment transport relation. The model illustrates the following. Canyon uplift can enhance the upstream migration of a bedrock-alluvial transition, rather than push it out toward the subsiding receiving basin. If the rate of accommodation space creation by subsidence in the receiving basin is large enough, a scarp (waterfall) is exposed at the canyon-fan transition. If the basin is open at a set outflow elevation, the long profile of the fan stabilizes in just such a way that the bedrock of the canyon is shaved off so as to balance uplift there. We also illustrate incipient conditions for inselberg formation.

Keyword

basin, range, canyon, fan, incision

Tectonic evolution and depositional environments of the southernmost continental shelf basins of Korea, the northern East China Sea

Seok Hoon YOON[1]*, Jeju National University (shyoon@jejunu.ac.kr)
Gi Bom KIM[2], Pusan National University
Jae Hyuk LEE[3], Pusan National University
Chang Seong KOH[4], Jeju Research Institute

Abstract

This study focuses on the seismic stratigraphy, tectonic evolution, and depositional environments of Jeju and Socotra basins in the southern continental shelf of Korea, based on the analyses of seismic stratigraphy, geologic structures, and seismic facies on the multi-channel seismic profiles. The basins commonly occur as the local basement lows surrounded by large-scale basement highs. The basin-filling sedimentary sequences are divided into 4 megasequences (MS1 to MS4) by regional unconformities and their correlated conformities. Chronostratigraphy of the megasequences from Eocene to Plio-Pleistocene is established based on biostratigraphic data from the existing hydrocarbon exploration wells. Geologic structures in the Socotra Basin are characterized by rift-stage normal faults involved with basement rotation, and subsequent folds and local normal faults in Oligocene sequence interval, The Jeju Basin, by contrast, shows predominant occurrence of reverse faults and folds within Eocene to Miocene sequences.

Based on the acoustic characters and reflection geometries, 6 types of seismic facies are classified, and interpreted as geologic basements (B1), volcanic-sedimentary complexes (B2), inner-shelf deposits (S1), fluvio-lacustrine deposits (S2), coastal deposits (S3), and volcanic sills or volcanic edifices (S4), respectively. Interpretation of these sedimentary facies and the correlation with biozones in drilling wells are suggestive of diverse depositional environments including terrestrial lowland (Eocene), lower coastal and oceanic environments (Oligocene), open lowland and middle coastal environments (Miocene), and shoreface and marine settings (Plio-Pleistocene). By integrating all these results, we present the reconstructions of tectonic evolution in the basins as follows. Initial rifting began in the Late Cretaceous building a series of grabens and half-grabens in the Socotra Basin, whereas basement subsidence without significant structural deformation occurred in Jeju Basin at the same time. Regional uplift and folding (e.g. Yuquan movement) in Late Eocene to Early Oligocene terminated the initial rifting in Socotra Basin and subsidence in Jeju Basin regions. In the Early Oligocene, the rifting and subsidence started again in the Socotra Basin and Jeju Basin respectively, which interrupted by uplift and folding in Early Miocene, marking the transition to the post-rift phase. Regional subsidence continued in Early to Late Miocene period. In the Late Miocene, a tectonic inversion (e.g. Longjing movement) occurred interrupting the subsidence in Jeju Basin region. At the end of the Late Miocene, the entire area entered a stage of regional subsidence again.

Keyword

East China Sea, sedimentary basin, tectonic evolution, sedimentary environment

A novel coupled model for rift basin evolution: Integrating tectonics, sea-level cycles, and multiple sediment sources

Wonsuck KIM[1]*, Yonsei University (delta@yonsei.ac.kr)
Jaehyung Lee[2], Yonsei University
Bitna Park[3], Yonsei University
Yujin Kim[4], Yonsei University

Abstract

Sequence stratigraphy has been used to identify and interpret patterns in stratal records and understand how sea levels and environmental conditions have changed over time, providing valuable insights for paleo-environmental changes and resource exploration. For rift basins, the focus typically revolves around understanding tectonic controls such as faulting, crustal extension, and subsidence on sedimentary facies, but the sea-level controls are often ignored, or the ExxonMobil's traditional stratigraphic model was simply applied in the rift-basin stratal interpretation. In rift basins, however, the coupling of axial and transverse systems plays significant roles in controlling sedimentation patterns, basin architecture, and evolution, which was not thoroughly considered in the traditional stratigraphic model. Understanding the spatial distribution and activity of these systems along with tectonic and sea-level controls is crucial for interpreting the depositional history of rift basins, and thus identifying potential hydrocarbon reservoirs. Here, we present a basin model that integrates both axial and transverse systems under rift basin tectonics and sea-level cycles to provide a new stratigraphic model for rift basins. Modeling results under sediment sources from multiple directions, and different tectonic and sea-level conditions indicate timing and distribution of key horizons, such as sequence boundaries and maximum flooding surfaces are distinguished from the traditional model and provide valuable insights into the complex interactions between tectonics and sedimentation in rift basin settings.

Keyword

Rift basin, Tectonics, Sea level, Model, Stratigraphy

Depositional Age and Provenance of the Jeju Basin Sediments Inferred by Detrital Zircon U-Pb Geochronology

Taejin CHOI[1]*, Korea National University of Education (tchoi@knue.ac.kr)

Abstract

This study investigates the depositional ages and provenance of sediments in the Jeju Basin on the northeastern margin of the East China Sea Basin by detrital zircon U-Pb dating. The East China Sea Basin was formed as a back-arc basin in the Cretaceous due to the tectonics between the Eurasian and paleo-Pacific plates. The Jeju Basin was formed by rifting in the Oligocene and received sediments in changing depositional environments from terrestrial to shallow marine. Detrital zircons were separated from 10 cutting samples obtained from three boreholes in the Jeju Basin, and U-Pb isotopic compositions of 1100 zircon grains were analyzed.

The analytical results show that the detrital zircons in the Jeju Basin have a wide age range from 3561 Ma to 7 Ma, covering the Archean to Cenozoic. Most samples are dominated by Neogene, Paleogene, Mesozoic, Paleozoic, Neoproterozoic, and Paleoproterozoic zircons. Paleoproterozoic zircons are the most abundant, accounting for at least 15% of all samples. However, the proportions of zircon age groups show spatial variance and temporal changes. The maximum depositional ages of the Jeju Basin sediments estimated from the youngest zircon age groups range from 28 to 8 Ma, depending on the depth. This is mostly consistent with the previous report based on fossils. However, the uppermost sample of the Okdom-1 core shows a younger maximum depositional age than the fossil age. These results provide essential data for the stratigraphy and depositional environment of the Jeju Basin sediments.

Keyword

depositional age, provenance, detrital zircon, Jeju Basin

Subduction Initiation under the Neotectonic Regime of the Western East Sea (Sea of Japan) Margin

Jae-Hyuk LEE[1]*, BK21 School of Earth and Environmental Systems, Pusan National University, Busan 46241, Republic of Korea (dooi3232@gmail.com)
Seok-Hoon YOON[2], Department of Earth and Marine Sciences, Jeju National University, Jeju 63243, Republic of Korea
Yoon-Mi KIM[3], Marine Geology & Energy Research Division, Korea Institute of Geoscience and Mineral Resources, Daejeon 34132, Republic of Korea
Byung-Dal SO[4], Department of Geophysics, Kangwon National University, Chuncheon 24341, Republic of Korea
Gi-Bom KIM[5], Department of Geological Sciences, Pusan National University, Busan 46241, Republic of Korea

Abstract

The East Sea (Sea of Japan) is one of the marginal seas on the western Pacific region, surrounded by eastern Eurasia and Japanese islands. The sea has been under regional E–W compressional stress regime since the Early Pliocene (c. 4 Ma). Under this neotectonic stress regime, compressional deformation is concentrated on the western (Korean side) and eastern (Japanese side) margins of the East Sea, and induced subduction initiation along the both margins. Here, we introduce a case of earliest stage of subduction initiation on the western East Sea margin in detail, and estimate the possibility to evlove into self-sustained stage of this case. Stratigraphic and structural analyzes using multi-channel seismic reflection data obtained from the eastern Korean margin and the Ulleung Basin regions revealed three key juxtaposed neotectonic components: 1) the Ulleung Major Thrust, 2) the Ulleung Syncline, and 3) the East Korean Thrust Belt. The Ulleung Major Thrust, marked by the NS-elongated west-dipping reverse tri-shear zone along the back-arc–continent transitional zone, is considered as an embryonic subduction interface that guides subductive movement of the Ulleung back-arc crust and obductive movement of Korean continental crust. As the Ulleug Major Thrust nucleated, the westernmost downbuckle in the Ulleung Basin became asymmetric and formed the Ulleung Syncline, regarded as a proto-trench. Thrusting down of the Ulleung back-arc crust gave rise to regional uplift of the overriding eastern Koran margin, which were accommodated by an array of east-dipping thrust faults, named the East Korean Thrust Belt. The east-dipping thrusts of the East Korean Thrust Belt elevated thrust sheets, by which numerous post-Miocene neotectonic piggyback basins were formed.

Although there is no evidence indicating that the lithosphere of the western East Sea margin is failed, the apparent asymmetry of the Ulleung Syncline and the tri-shear deformation in the Ullueng Major Thrust imply that the compressional deformation on this margin started to be localized into the back-arc–continent transitional zone. This means that the western East Sea margin is under the earliest stage of subduction initiation after already passed through simple crustal buckling stage.

The subduction initiation on the western East Sea margin appears destined to fail, because a more

mature case of subduction initiation exists on its opposing side (Japanese side of the sea). However, lines of evidence, such as uplifting marine terraces and compressional earthquakes by Quaternary faulting, imply that the subduction initiation on this margin has the fate to be failed soon but has not yet failed.

Keyword

Subduction initiation, Korean neotectonics, East Sea, Sea of Japan, Piggyback basin

Characterization of Igneous Bodies around the Jeju Basin, the East China Sea: Igneous Stratigraphy and Tecto-Magmatic Implications

Yun-Hui JE[1]*, Division of Earth Environmental System, Pusan National University (yhje1@pusan.ac.kr)
Gi-Bom KIM[2], Department of Geological Sciences, Pusan National University, Busan 46241, Repulic of Korea

Abstract

The East China Sea Shelf Basin (ECSSB), which has a high hydrocarbon potential, has evolved with repetitive volcanic activities since the Late Cretaceous in association with multi-phase tectonic evolution. In this study, we investigated variable types of igneous bodies found in the northern ECSSB using multi-channel seismic reflection data and drill cores. The igneous bodies were primarily classified into extrusive and intrusive types and sub-categorized into nine facies groups (i.e., E.cone, E.sheet/E.flood, E.comp, E.rift for extrusives and I.con, I.sau, I.step, I.stock, I.lac for intrusives) depending on their emplacement styles. The nine facies groups of igneous bodies were mapped using PETREL™ (Schlumberger, Ltd., France) software to visualize their spatio-temporal distribution and fundamentally understand their relationship with the evolution of the ECSSB. Based on the biostratigraphic correlation and isotope ages of volcanic rocks, we categorized the igneous bodies into four stratigraphic groups (IG).

Igneous bodies of IG-1 (Igneous Group 1), recognized as discontinuous/high-amplitude reflectors, are distributed near the acoustic basement of subbasins throughout the ECSSB region. The IG-1 is interpreted as basaltic lava/sill-sediment complexes formed by fissure eruption alongside with the boundary faults at the time of early stage of the ECSSB opening. IG-2 comprises sheeted (or flooded) lava flows and complex of sills and dikes emplaced during the early Miocene, when the tectonic inversion, so-called Huagang Movement, caused local compressional uplift. IG-3 consists of a variety of monogenetic volcanic edifices, showing linear NNE–SSW distribution, parallel with the Taiwan-Sinzi Tectonic Belt. Stratigraphic correlation with the existing chronostratigraphic framework may imply that the IG-3 is related to the paleo-Ryukyu Arc volcanisms, terminated in association with the formation of Okinawa Trough around 5 Ma. IG-4 comprises complex of sills, dikes and extrusives, distributed locally on the south of Jejudo volcanic island. Apparent seafloor deformation, caused by the igneous bodies of IG-4, indicates that IG-4 volcanism is still active. This further implies that the IG-4 volcanism has an identical tecto-magmatic origin to Jejudo.

Keyword

Jeju Basin, Igneous stratigraphy, East China Sea Shelf Basin, Tecto-magmatic evolution

The Distinctive History of the Attu region of the Western Aleutian Arc in the Western Pacific Region

Suzanne Mahlburg KAY[1]*, Cornell University (smk16@cornell.edu)
Suzanne Mahlburg Kay[2], Cornell University

Abstract

A distinctive part of the Aleutian arc is the Attu region in the western Pacific section of the arc, where the oldest known ages (~42.5 Ma) are from Eocene to early Oligocene volcanic and plutonic rocks with Marianas arc-style trace element features (La/Sm=1.6-1.9; La/Ta=100-120) and depleted MORB-like pillow lavas, breccias and dikes (La/Sm < 1.8; La/Ta=10-40) in the backarc. These sequences are followed by early Miocene mafic flows with depleted light REEs, ~16 Ma rhyolites and granites and light REE enriched mafic rocks and ~7-5 Ma calc-alkaline andesites. Epsilon Nd 9.5 to +10 in the arc-like rocks as high as +10.6-11.7 show the backarc lavas are isotopically depleted relative to Aleutian magmatic rocks to the east where maximum values rarely reach ~+9.5. The arc further east also differs in lacking backarc lavas and in exclusively having light REE enriched arc-like magmatic rocks that include late Eocene to Recent calc-alkaline units. Xenoliths in Kanaga Island arc basalts show that at least part of the central Aleutians is underlain by a metamorphic plutonic basement that could be as old as Eocene. Overall, the distinctive western Attu region is best explained as evolving in a distinctive depleted part of the Aleutian arc with a distinct history from the central and eastern Aleutians in contrast to some structural and tectonic models that suggest the Attu region has been translated up to 1000 km to the west. The older evolution of the Attu region is generally consistent with the plate evolution scheme in Vraes et al. (2019) in which Eocene to Oligocene Attu magmas formed as a westward moving Kronotsky arc reached the Aleutian trench at ~ 40 Ma and broke apart to block the Aleutian trench and create the Bowers Ridge arc.

Keyword

Aleutians, Alaska, arc magmatism, crustal evolution

[Keynote] Trench kinematics and the opening of backarc basin

claudio faccenna[1]*, GFZ Potsdam UniRoma TRE (claudio.faccenna@uniroma3.it)
Adam Holt[2], University Florida
Thorsten Becker[3], UT Texas
Serge lallemand[4], University Montpellier

Abstract

Trench motions represent the surface expression of the interaction between subducting plates and the underlying mantle, but the inherent dynamics are not fully understood. Here, we will revise first the main process leading to trench migration, revising the trench migration in the western Pacific. We will then focus on the case of the migration of the Izu- Bonin-Marianas trench (IBM) that accommodates the subduction of the Pacific beneath the Philippine Sea Plate (PSP), which is in turn subducting beneath the Eurasian plate along the Ryukyu trench. The history of the IBM trench is dominated by fast, episodic retreat from 40 to 15 Ma. However, around 10–5 Ma, the IBM trench reversed its motion from retreat to advance. Here we run 2-D numerical experiments to test the influence of the Ryukyu slab on the established IBM subduction zone. The results from our geodynamic model compare favourably with the reconstructed trend, indicating that the switch in trench motion along the IBM trench may indeed be related to the onset of a new subduction zone along the Ryukyu trench. Our analysis substantiates the idea that advancing trench motions in the western Pacific are due to the establishment of a double subduction system. Further analysis of such dynamics provides insights for the mechanisms controlling subducting plate and trench motions and mantle force transmission.

Keyword

subduction, trench migration, backarc basin, pacific

Subduction Initiation process of a young marginal sea: a case study of the North Sulawesi subduction Zone

Tianyao HAO[1]*, Institute of Geology and Geophysics, CAS (tyhao@mail.iggcas.ac.cn)
Jian ZHANG[2], University of Chinese Academy of Sciences
Miao DONG[3], Institute of Geology and Geophysics, CAS

Abstract

marginal sea: a case study of the North Sulawesi subduction Zone

The transition of a passive continental margin into a subduction zone remains a hypothesis because few geological cases have been reported. The North Sulawesi subduction zone (NSS) is a 5-9 myr system in Southeast Asia that has evolved from a passive continental margin and has long been overlooked by studies of passive to active margin transitions. Interestingly, no Quaternary arc volcanoes have been found to be associated with the NSS.

We conducted a comprehensive survey, collecting original geophysical data from the southern South China Sea to the North Sulawesi subduction zone. Utilizing various modeling techniques and joint inversion, we obtained insights into the deep structures of subduction zones in North Borneo and the Celebes Sea. Additionally, the subduction process in the study area was reconstructed through dynamic numerical simulations.

Our investigation reveals two main insights:

1The NSS is characterized by "induced" subduction initiation and "spontaneous" trench retreat. At the initial stage of subduction, the young Celebes sea plate must be driven down by external forces in the horizontal direction. As the oceanic crust descends to approximately 60 km, it undergoes gradual eclogization, with the principal stress governing subduction transitioning to the negative buoyancy of the subducting plate. Subsequently, the self-sustained subduction of the plate, trench retreat, and continental crust extension are primarily controlled by the negative buoyancy of the subducting plate itself.

2The absence of arc magma in the NSS could be explained by the little water influx and the shallow water dehydration of the subducting slab. Our findings also suggest that, when the angle between a young slab and the overriding plate is small, a long arc magma history will not be observed during the early subduction stage. We speculate that the "hot" and "light" nature of the overriding plate contributes to this small initial subduction angle.

Keyword

Subduction initiation, Young marginal sea, slab hydration and dehydration, arc volcano, numerical modelling

Geothermal characterization of the Western Pacific marginal seas

Shaowen LIU[1]*, Nanjing University, School of Geography and Ocean Science (shaowliu@nju.edu.cn)
Wenjing ZHU[2], Nanjing University, School of Geography and Ocean Science, Nanjing 210023, China
Makoto YAMANO[3], Atmosphere and Ocean Research Institute, The University of Tokyo, Chiba 277-8564, Japan

Abstract

Marginal seas are widespread along the western Pacific region, with various evolutionary stages and associated geological characteristics. Geothermal field could provide important clues for understanding regional tectonics, thus revisiting the geothermal regime of the marginal seas in western Pacific region is in demand, and is also available with the increasing heat flow data. Combing the updated global heat flow dataset of International Heat Flow Commission (IHFC) and other geological and geophysical observations, heat flow and thermal structure of the western Pacific marginal seas are analyzed. Our results demonstrate that heat flow varies much among the marginal seas, and the average values for the Okhotsk Sea, Sea of Japan, Okinawa Trough and South China Sea are 80 mW/m2, 93 mW/m2, 210 mW/m2 and 75 mW/m2, respectively, indicating their different ages. In addition, high heat flow anomalies are also observed within the marginal seas, as a result of fluid circulation and recent volcanic activities. While the subduction zones exhibit similar geothermal patterns, with relatively low heat flow in the fore-arc regions, extremely high but variable heat flow in the volcanic arcs, and generally high heat flow in the back-arc regions. High temperature and large heat flow in the back-arc regions can be attributed to the heat contributions from the mantle. In general, the heat flow verse crustal age relation for the western Pacific marginal seas can be roughly expressed by Q(t)=585.8 t-1/2. It seems that this Q-t relation for marginal seas does not significantly differ from that for oceanic basins. Given the uneven coverage in heat flow data and vagueness in crustal age of some marginal seas, this expression needs confirmation with more observations in further study.

Keyword

Heat flow, Thermal Structure, Marginal Seas, Western Pacific

An Analysis of Karst Model and its Controlling Factors of Carbonate Buried Hill: A Case Study from the Weixinan Sag, Beibuwan Basin, South China Sea

Yanying LI[1]*, China University of Petroleum (East China) (b18010016@s.upc.edu.cn)
Kongyou WU[2], China University of Petroleum (East China)
Yannan DU[3], China University of Petroleum (East China)

Abstract

Paleokarst is a modification effect of water on soluble rocks, which is widely developed in soluble rocks such as carbonates. With the discovery of paleokarst-related oil and gas reservoirs in a series of large carbonate oil and gas fields, the relationship between paleokarst and carbonate oil and gas reservoirs has attracted extensive attention from petrologists. The previous research on paleokarst oil and gas reservoirs mainly focused on two aspects, paleogeomorphic restoration and vertical zoning. Carbonate buried hills are developed in the Weixinan Sag of the Beibuwan Basin in the western South China Sea, and multiple buried hills have been discovered as oilfields or oil-bearing formations. This study analyzed the characteristics and the main controlling factors of karst development in carbonate buried hills by combining drilling core, thin section, logging and seismic data. This study is of great significance to the exploration work of finding new types and strata of oil and gas reservoirs. The research has three outcomes. (1) The karst processes of carbonate buried hills have multi-phase cyclicity, and each cyclicity can be subdivided into surface karst zone, vertical seepage zone and horizontal underflow zone. (2) The exposed-phase karst was developed in the No. 1 fault zone, while the exposed-phase karst and buried-phase karst were developed in the No. 2 fault zone. (3) The karst in the carbonate buried hills is influenced and constrained by multiple factors such as sedimentation, diagenesis, tectonics, karst, and paleogeomorphology, etc, and the karst development model of the carbonate buried hills in the study area has been established.

Keyword

Weixinan Sag, Carbonate buried hills, Karst model, Carboniferous, Controlling factors

The Formation and Evolution of the Central Uplift in the South Yellow Sea Basin and Its Geological Significance for Oil and Gas

zhangjin CHEN[1]*, CNOOC China Limited, Tianjin Branch (hellochenzhj@163.com)
qinxun WU[2], CNOOC China Limited, Tianjin Branch
yongqiang YAO[3], CNOOC China Limited, Tianjin Branch
zhiqiang LI[4], CNOOC China Limited, Tianjin Branch
shaowei CHEN[5], CNOOC China Limited, Tianjin Branch

Abstract

The South Yellow Sea basin, located in the northeast of Yangtze plate, it is a typical sea land superimposed basin with four primary tectonic units of two depressions and two uplifts. As one of the positive units, the central uplift is characterized by shallow burial and relatively complete preservation of marine strata, which has great exploration potential. According to statistics, the distribution of large and extra large gas fields in the marine craton basin is closely related to the paleo-uplift in the craton. The so-called "paleo uplift" refers to the uplift structure formed in the evolution stage of craton basin. So is the central uplift a paleo-uplift?

Based on the research approach of combining the macroscopic laws with the local characteristics of the Yangtze Plate, by combining the macroscopic laws of the development of paleo-uplift in the cratonic basin of the Yangtze Plate with the local structural characteristics of the South Yellow Sea Basin, it is proved that the central uplift of the South Yellow Sea basin is an inherited paleo-uplift. The formation and evolution of the central uplift can be divided into three stagesFormation period, Strengthening period and Renovation period. From Sinian to Middle Ordovician, the whole Yangtze basin had a tectonic pattern of two basins and one platform, the central uplift is located on the platform, and the seismic profile shows typical reflection characteristics of platform margin facies. During the late Ordovician to Middle Triassic, under the influence of Caledonian and Hercynian movements, the amplitude of the central uplift has been further strengthened, and the thickness of Silurian system was thin in the middle of the central uplift, thickened in the north and south sides, with upward displacement observed. Drilling reveals biogenic algal tuff limestone of the Carboniferous platform margin facies. Since the Late Triassic, the paleo uplift ended the marine deposition and underwent the compression and extension transformation stages, forming the present structural pattern of two depressions and two uplifts in the South Yellow Sea basin.

As an inherited paleo-uplift, the central uplift is the direction area for long-term migration of oil and gas. Firstly, large traps developed in the central uplift before the reservoir forming stage. Secondly, the unconformity formed during the formation of the central uplift is an important pathway for oil and gas migration. Thirdly, the reflection characteristics of platform margin reef beach facies can be seen in multiple sections of the central uplift, and three periods of unconformity can be identified, it can be seen that the reservoirs of the central uplift reef shoal facies and karst reservoirs are developed.

Keyword

inherited paleo-uplift, platform margin facies, Yangtze Plate, South Yellow Sea Basin

Differential deformation characteristics and genetic mechanisms of the central uplift in the South Yellow Sea Basin,China

Qingxun WU[1]*, CNOOC China Limited, Tianjin Branch, (wuqx@cnooc.com.cn)
Bo YANG[2], CNOOC China Limited, Tianjin Branch
Rucai ZHANG[3], CNOOC China Limited, Tianjin Branch
Yongqiang YAO[4], CNOOC China Limited, Tianjin Branch
Shaowei CHEN[5], CNOOC China Limited, Tianjin Branch

Abstract

The Mesozoic-Paleozoic structures in the central uplift of the South Yellow Sea Basin are very complex, and the overall quality of seismic data is poor. The understanding of the structural deformation laws of the central uplift since the Indosinian period is unclear, which restricts the exploration process. By means of geochemical analysis, structural analysis, and numerical simulation, the deformation laws of the central uplift structure have been clarified, and a differential deformation structural model of "obstruction of ancient uplifts and detachment of double detachment layers" has been innovatively established. (1) Differential deformation under the obstruction of ancient uplifts: Strong thrust phenomena such as limited extension of the front fault, pushing out of the surface, and huge repetition of strata are observed above the ancient uplifts; The back front of the ancient uplift is constrained and obstructed by compression deformation, and the structural deformation is relatively weak and stable;Double detachment layer detachment differential deformation: There are two sets of detachment layer systems, Cambrian gypsum rock and Silurian thick mudstone. The decoupling effect of upper and lower structural deformation of the detachment layer is obvious, showing a differential deformation characteristic of "strong compression deformation above the detachment layer and relatively stable below the detachment layer". Considering the different distances from the orogenic belt and the varying levels of stress, stratigraphic compression analysis was conducted to ultimately clarify that the three factors of "orogenic belt ancient uplift detachment layer" jointly control the differential deformation of the central uplift structure in the South Yellow Sea Basin.

Keyword

Ancient uplift, Detachment layer, Indochinese period, Structural deformation, South Yellow Sea Basin

Geochemistry and U-Pb chronology of Silurian clastic rocks from boreholes in the Yellow Sea, Western Pacific Marginal Seas: Geological data evidence that the Yellow Sea belongs to the Yangtze Block

LI ZHIQIANG[1]*, China National Offshore Oil Group (zhiqiangligeo@163.com)
ZHANG RUCAI[2], China National Offshore Oil Group
GAO XILONG[3], China National Offshore Oil Group
CHEN XINYI[4], China National Offshore Oil Group

Abstract

It seems that the Yellow Sea belongs to the Yangtze block only some seismic data support, there is no actual geological data to support the above conjecture. Silurian clastic rocks from ultra-deep boreholes in the Yellow Sea provide a possibility for understanding the tectonic evolution in this area. To understand the provenance and tectonic evolution of the Early Paleozoic foreland basin, the Silurian clastic rocks have been analyzed by means of major, trace and rare earth elements and zircon U-Pb chronology. The results show that the Silurian clastic rocks are mainly composed of mudstone and argillaceous siltstone, with high content of feldspar and quartz minerals in mudstone, linear contact of siltstone particles, chemical alteration index (CIA) range of 70.04-77.4, index of compositional variation (ICA) range of 0.72-1.03, indicating high compositional maturity in the source rocks. The trace and rare earth element indicator source area is mainly feldspar igneous rock with island arc tectonic background, suggesting source area may be an accretionary orogenic belt. The Th/U ratio of 526 zircons is greater than 0.1, indicating magmatic origin. These zircons exist in three age ranges: 2500-1800 Ma, 980-820 Ma and 580-430 Ma, with the peak of 980-820 Ma. The three age peaks coincide with the three major geological units of the Yangtze block, namely the craton basement, the Neoproterozoic Jiangnan Orogenic belt and the early Paleozoic Wuyi-Yunkai orogenic belt. Longitudinally, the zircons of synorogenic age (460-430 Ma) are only found at the top of Silurian stratum. These geochemical characteristics and chronological data are consistent with the geological data published earlier in the Lower Yangtze Block, indicating that a Neoproterozoic (980-820 Ma) accretionary orogenic belt like Jiangnan orogenic belt was the main provenance of the early Paleozoic foreland basin. Our data confirm the existence of an accretionary orogenic belt in the Yellow Sea formed by the Neoproterozoic (980-820 Ma) collision of the Cathaysian Block and the Yangtze Block, combined with the published geophysical data of the surrounding area, confirm that the Yellow Sea and the Lower Yangtze Block have similar tectonic evolution processes, indicating that the Yellow Sea should belong to the Yangtze Block. Our study provides a substantiality geological archive to reveal the attribution of the Yellow Sea.

Keyword

Yellow Sea, Yangtze Block, Jiangnan orogenic belt, Foreland basin, U-Pb chronology

Thick-skinned tectonics in southern Ulleung Basin (East Sea) through gravity data analyses

Yoon-Mi KIM[1]*, Korea Institute of Geoscience and Mineral Resources (ymkim1@kigam.re.kr)
Gi-Bum KIM[2], Busan National University

Abstract

The Ulleung Basin (UB), located in the southwestern corner of the East Sea, served as a key locus that accommodated the Miocene back-arc extension and subsequent tectonic inversion between Korean Peninsula and southwestern Japanese Island. A pull-apart-style opening of the UB began with the subduction of the old and thick Pacific Plate during the Early Miocene. Subsequently, during the Middle Miocene, as the young Philippine Sea Plate converged along the Ryukyu trench, a tectonic inversion from extension to contraction occurred. Since the Pliocene, compressional forces acting in the E-W direction have prevailed in the UB. Notably, the southern UB exhibits significant compressional geological features, including the Dolgorae Thrust-Fold Belt, the Tsushima and Goto islands, and the Gorae anticlines. This study examines the gravity anomalies of the southern UB, a distinctive geological site, to better understand crustal deformations induced by such inversional forces. Our analysis shows that the Bouguer gravity anomaly highs correlate well with the compressional structures in the San'in Folded Zone in the southern UB. After calculating the Moho depth from the Bouguer anomalies corrected for bathymetry and sediment thickness, the variations in the Moho depth closely mirrors those of sediment basement in the cross section across the fold-and-thrust belts of the southern UB. This suggests that in the southern UB, thick-skinned tectonics involves thrust faults reaching down into the crust. Also, we interpret the sedimentary structures to analyze shallow to deep structure deformation caused by tectonic inversion at multiple scales. The integrated analysis of sedimentary layers and crustal structure offers crucial implications for understanding how the UB has undergone tectonic deformation processes involving tectonic development.

Keyword

Southern Ulleung Basin, Gravity anomalies, Tectonic inversion, Thick-skinned deformation

Phanerozoic tectonic evolution and mineral system formation in East Asia

Xuanhua CHEN[1]*, Chinese Academy of Geological Sciences (xhchen@cags.ac.cn)
Shuwen Dong[2], Chinese Academy of Geological Sciences
Qi Zhou[3], Chinese Academy of Geological Sciences
Yan Ma[4], Chinese Academy of Geological Sciences

Abstract

Mineral system is always tectonics related, which could be called tectono-metallogenic system. In eastern Asia, the mineral systems are always related to the tectonic evolution and plate convergence in this area. They are important relics of tectono-metallogenic systems preserved in the continental Asia. Most of them have experienced the whole life Wilson cycle of plate tectonics. Especially, they could be identified as mineral systems which are related to plate subduction, collision orogeny, post orogenic extension, and stable cratons. Based on temporospatial analyses of deep structure, tectonic events and mineralization of the East Asia continent in Phanerozoic, plate convergent-related mineral systems are preliminarily constructed in East Asia. Due to continuous interactions of the three tectono-metallogenic regimes such as the Paleo Asian Ocean (Central Asia), Tethys-Himalaya and West Pacific tectono-metallogenic regimes, a unique tectonic system, which is named as the East Asia plate convergence tectonic system, and several tectonic-related mineral systems, such as the collisional orogenic Qinghai-Tibet Plateau, accretionary orogenic western north China, and composite orogenic northeastern China mineral systems, have formed in the continental China in Phanerozoic. Meanwhile, craton-related tectono-metallogenic systems, such as the North China craton destructional and South China intracontinental mineral systems, have formed in eastern China. Several mantle plume mineral systems, such as the Emei, Tarim, and Songliao-Bohai Bay ones, have formed due to the superposition of multiple mantle plumes on plate convergence-related mineral systems. Temporospatial transition of tectonic dynamic systems may result in significant mineralization, and the craton margins is always the most favorable locations for mineralization. Porphyry copper and orogenic gold deposits may form in multiple stages of the plate tectonics, especially in the post-orogenic extensional stages.

Keyword

Phanerozoic, Tectonics, Mineral system, Plate convergence, East Asia

Adaptive mesh-free approach for gravity inversion

Yan LIU[1]*, 010-68999481 (liuy@cags.ac.cn)
Qingtian Lü[2], 010-88333292
Yao Huang[3], 14708294710
Jiayong Yan[4], 13552350590

Abstract

We proposes a method of gravity inversion based on an adaptive mesh-free approach by using a modified radial basis function (RBF). Traditional mesh-based methods discretized partial differential equations (PDEs) based on tessellated meshes. The subsurface space is generally discretized into regular grid cells, where mesh-free methods can avoid the expensive mesh generation and manipulation required in those traditional approaches. In most mesh-free methods a cloud of unconnected nodal points that do not coincide at any time is introduced. Our adaptive mesh-free method is an unstructured method of inversion that mitigates ill-conditioned inversion by reducing the number of model parameters. The nodes are adaptively refined during the inversion process to better recover the abnormal bodies. To deal with the unstructured nodal discretization of problems, we uses a mesh-free discretization strategy to establish a mapping of subsurface grid cells to a cloud of discrete points. The radial basis functions is modified by the distance reweighting method so that they are similar to the orebodies in terms of shape, inclination, and dip. In addition, to solve RBF's ill-conditioned system of equations in case of the interpolation of large datasets, we propose a hybrid kernel based on multi-quadric and cubic kernels. The results of tests on 2-D and 3-D synthetic models showed this mesh-free inversion can be used to accurately reconstruct anomalous bodies and its results of inversion are stable. The proposed method was applied in the Nihe iron ore deposit (eastern China), and its results agreed well with the geological information.

Keyword

Gravity inversion, Radial basis function, mesh-free method, adaptive strategy

Heterogeneous lithospheric mantle: A geophysical perspective

Irina M. ARTEMIEVA[1]*, SinoProbe Lab, China; GEOMAR, Germany (iartemieva@gmail.com)

Abstract

The lithosphere makes both a thermal boundary layer atop mantle convection and a chemical boundary layer formed by mantle differentiation. The thicknesses of thermal and chemical boundary layers vary significantly both globally and regionally, reflecting thermal and compositional heterogeneity of the lithospheric mantle both in continents and oceans. Thermal anomalies are usually thought to have stronger effect than compositional anomalies on rock seismic, electric, and density properties, especially at near-solidus temperatures; however physical parameters determined by geophysical sensing are sensitive to both thermal and compositional heterogeneity. Thus, geophysical constraints on mantle compositional heterogeneity require subtracting the lithosphere thermal signal.

Here I present examples for lithosphere thermal and compositional heterogeneity in continental and oceanic regions, with highlights from North Atlantics, the Arctic shelf, Iceland, Europe, Arabia, Asia and southern Africa. Joint interpretation of various geophysical data indicates a number of conventionally unexpected features, such as possible formation of ocean spreading below the Arabian Shield, an extremely high-density (possibly eclogite-bearing) lithospheric mantle below deep sedimentary basins in Europe and Siberia, strong correlation between diamondiferous regions in the southern Africa and high-density mantle anomalies, and strong thermos-chemical heterogeneity of the lithosphere of Tibet and the North China craton, inconsistent with models of lithosphere destruction in the NCC.

DOI: 10.1016/j.gr.2016.03.002; 10.1016/j.gr.2016.05.002;
10.1029/2018JB017025;
10.1016/j.earscirev.2018.11.004;
10.1016/j.epsl.2018.09.034;
10.1029/2020JB020296;
10.1029/2019TC005594;
10.1029/2022JB026213;
10.1016/j.earscirev.2022.103955

Keyword

lithosphere, mantle density, cratons, xenoliths, LAB

Cratons are not all that stable!

Hans THYBO[1]*, SinoProbe Laboratory, CAGS (h.thybo@gmail.com)

Abstract

Exciting geoscientific transects have contributed significantly to our understanding of geodynamic processes in active tectonic regions. Cratons have received much less attention because their tectonic significance is not evident from surface observation, being old and stable parts of the interior of the continents. However, abundant evidence shows that 'stable' cratons are modified substantially during their existence. I will present several examples where integrated geoscientific interpretation around seismological models shows significant modification of cratonic lithosphere:

1. The Baltic Shield formed during the Svecofennian orogeny c. 1.7 Ga with later reworking of its western parts. Recent geophysical interpretations show a large eclogitic body of crustal material beneath the Moho in the central shield. This body probably formed after the initial cratonization (Buntin et al., 2021).
2. The isopycnicity hypothesis proposes that a trade-off between composition and temperature of the lithospheric mantle maintains constant topography in cratons (Jordan, 1978). However, gravity data from Siberia shows that kimberlite pipes solely modify cratons in isostatic equilibrium (Artemieva et al., 2019). Therefore, kimberlite sampling is non-representative, and the real composition of most cratonic mantle lithosphere is unknown.
3. Strong seismic anisotropy is observed in many cratons and is commonly attributed to the mantle due to frozen-in lithospheric features or asthenospheric flow. Recently it was demonstrated that a major part of the anisotropy resides in the crust of the Kalahara craton and that the fast axes are parallel to the strike of young major dyke swarms and orogenic fabric (Thybo et al., 2019). This finding indicates significant craton modification by magmatic intrusion.
4. Modification by external stresses and induced magmatism may even split existing cratons. Integrated interpretation of existing data and geodynamic modelling show that a linear sequence of volcanic harrats in the Arabian craton potentially represents the formation of a new plate boundary (Artemieva et al., 2022). It is probable that the extension in the northern Red Sea rift will jump to the volcanic lineament, which eventually will develop into new ocean spreading and effectively split the existing craton.

References:

Buntin, S., Artemieva, I.M., Malehmir, A., Thybo, H. et al., 2021, Long-lived Paleoproterozoic eclogitic lower crust. Nature Comm. doi: 10.1038/s41467-021-26878-5.

Artemieva, I.M., Thybo, H., Cherepanova, Y., 2019. Isopycnicity of cratonic mantle restricted to kimberlite provinces. Earth Plan. Sci. Lett.,doi: 10.1016/j.epsl.2018.09.034.

Thybo, H., Youssof, M., Artemieva, I.M., 2019. Southern Africa crustal anisotropy reveals

coupled crust-mantle evolution for over 2 billion years. Nature Comm., doi: 10.1038/s41467-019-13267-2.
Artemieva, Irina M., Yang, Haibin and Thybo, Hans, 2022, Incipient ocean spreading beneath the Arabian shield, Earth-Science Reviews, doi: 10.1016/j.earscirev.2022.103955

Keyword

cratons, seismics, transects, integration

Multi-scale velocity structures of crustal-mantle beneath South China and its constraint on deep mineralization mechanism

Guoming JIANG[1]*, China University of Geosciences, Beijing (jiang_guoming@cugb.edu.cn)
Guibin Zhang[2], China University of Geosciences, Beijing

Abstract

South China is one of the most rich regions of polymetallic mineral resources in China, and has become a rare world-class metal province in the world, especially in the Middle and Lower Yangtze River metallogenic belt dominated by Fe and Cu, and the Nanling metallogenic belt dominated by W, Sn, Mo, Bi, Pb, Zi, Rare earth and U. The geological background and mineralization of the Mesozoic granitic system, the large-scale Mesozoic low temperature metallogenic system and the late Paleozoic continental mantle plume metallogenic system in the South China have been studied by previous researchers, and a relatively common theoretical framework and metallogenic model of regional mineralization has been established. However, the deep mechanism and geodynamics of the large-scale Mesozoic mineralization in South China is still not clear.

In this study, the seismic tomography method and the teleseismic full waveform inversion method were used to study the crust-mantle velocity structure at large, medium and small scales in South China. The spatial resolutions were divided into 1°, 0.5° and 0.3°, respectively. The three scales of crust-mantle velocity structures reveal the characteristics of the overall tectonic background and material migration channels under the metallogenic belt in South China. The large-scale velocity structure results show that there are obvious low-velocity anomalies in the upper mantle beneath the Cathaysia block, while the lower middle and upper Yangtze block is dominated by high-velocity anomalies, which may represent mantle-derived hot materials and lithospheric roots respectively. There is a low-velocity anomaly in the crust beneath the Jiangshao fault between the Cathaysia and Yangtze blocks. There are obvious low-velocity anomalies in the upper mantle below the metallogenic belt in the middle and lower Yangtze River. The middle and small-scale velocity structures show that there is an obvious high-velocity anomaly at a shallow depth of 70 km in the land of the Cathaysia block, while there is a thicker high-velocity body below the coastal area. There are obvious low-velocity anomalies in the upper mantle. These low-velocity anomalies match well with the surface metallogenic belt and might represent the upwelling channels of mantle hot material. The velocity characteristics obtained in this project are related not only to the subduction of the paleo-Pacific plate in the Mesozoic , but also to the westward subduction of the Cenozoic Philippine Sea plate, and even to the Hainan mantle plume. In addition, hot material from deep upper mantle underplates into the lithosphere, which may cause the thinning of the eastern lithosphere and provide material and heat sources for deep mineralization.

Keyword

South China, Seismic tomography, Multi-scale velocity model of crust-mantle, Deep geodynamics, Deep metallogenic mechanism

New insights into asthenospheric flow beneath the Qinling Orogenic Belt and adjacent areas revealed by a three-dimensional Magnetotelluric study

Gaofeng YE[1]*, China University of Geosciences, Beijing (ygf@cugb.edu.cn)
Cheng Liu[2], China University of Geosciences, Beijing
Sheng Jin[3], China University of Geosciences, Beijing
Ji'en Dong[4], China University of Geosciences, Beijing

Abstract

The Qinling Orogenic Belt, formed by the convergence of the North China Craton and the Yangtze Craton, is located in the middle part of mainland China. It is a critical window to clarify the formation and evolution of the composite collision orogenic belt and to observe the northeastward extrusion and escape of material caused by the collision of Indian and Eurasian plates. Using 872 magnetotelluric sounding stations, we obtained for the first time a high-resolution three-dimensional resistivity model of the lithosphere of the Qinling Orogenic Belt and its surrounding areas. The model shows that the near EW direction anomalies dominate the electrical structure of the middle-upper crust of the Qinling Orogenic Belt, and high-resistivity anomalies are arranged at intervals along regional faults and plate suture zones, which show obvious low resistivity. The lower crust and upper mantle show electrical structural characteristics mainly in the near SN direction. Based on these, we propose that the "overpass-structured" electrical structure indicating the crust-mantle decoupling of the Qinling Orogenic Belt was formed under the influence of the asthenospheric flow escaping from the northeast of the Tibetan Plateau. The three-dimensional lithospheric resistivity model also shows that the high-conductivity anomaly in the middle and lower crust of the northeastern margin of the Tibetan Plateau terminates in the West Qinling Orogenic Belt at about 106.5°E and continues to migrate eastward in the form of asthenospheric flow. High conductors penetrating the crust and mantle are also found in the Weihe Graben, the East Qinling Orogenic Belt, the circular rift zone around the Ordos Basin, and even the northern Ordos Block, which was considered to be a stable craton. This may represent upwelling of northeastward escaping asthenospheric flow along rift zones and areas of structural weakness. We propose that this asthenospheric flow and upwelling transformed the lithospheric mantle in the Qinling Mountains and the central and western parts of the North China Craton through thermal erosion.

Keyword

Lithospheric resistivity model, Tibetan Plateau, Channel flow, Qinling Orogenic Belt, Mantle upwelling

Deep Researches of the North Eastern Eurasia: Russian geotransects – results and perspectives

Ivan KUDRIAVTCEV[1]*, VSEGEI (ivan_kudryavtsev@yahoo.com)
Evgeniia Milshtein[2], VSEGEI
Sergey Kashubin[3], VSEGEI
Viktor Tatarinov[4], IMGRE
Roman Serzhantov[5], VNIGNI

Abstract

Russian Geotransects Program of the Deep Researches has seventy-years history and includes more than 150 thousand kilometers of the seismic profiles. Three stages were carried out within this period in Russia but only the results of the last stage (since 1995) are most significant today. Researches of this stage is aimed mainly to the Earth crust.

The important feature of the modern stage is multidiscipline field experiments within geotransects. It provides three types of field data acquisition along onshore profiles – two seismics (deep seismic sounding and near-vertical reflection) and magnetotelluric. Along offshore profiles, field experiments comprise of two types of seismic survey. The unity of the frame network is ensured by the spatial intersections of geotransects. The state geotransects network is the basis for the geophysical surveys within the local profiles and networks.

Within the North Eastern Eurasia there is the most extensive and representative frame network, which crosses tectonic structures from Eastern Siberia to Chukotka and the south of the Russian Far East. These transects could be used as the elements of the global Earth crosssections which aimed to the whole Eurasian continent researches.

Reflection seismic data provide the most detail information about the deep structures and processing of this data requires special methods, oriented to the highly heterogeneous crystalline crust. Since 2021 we use new stand-alone equipment for three-component registration of seismic signals during deep seismic soundings, which has made it possible to reduce the spacing of receivers and significantly increase the reliability of new data. For magnetotelluric data processing the constraint inversion is used and the other geophysical data play important role in this process.

Density sections which provided by 3D modelling technology are based on gravity surveys data and represents the important part of the geophysical dataset. These sections are crucial for studying horizontal heterogeneity of crust. All geophysical sections are used for complex analyses and represents the basis for the geological interpretation.

For the geological interpretation magnetic anomalies and gravimetric maps, including detail aeromagnetic surveys materials, are used, as the geological maps of different scales. Theoretical models of the earth's crust developed within the tectonophysics, as well as the principles of structural geology, are also considered for the correct interpretation. This approach leads to the need to consider deep structures in three-dimensional models using data over a large area, not limited to a narrow strip along each transect.

The crustal thickness, crust types and sedimentary cover thickness maps, which are the result of a

synthesis of all geophysical data, including regional seismic profiles, are used for areal interpretation. These materials are very important for the complex geological interpretation and demonstrates relationships between the structures of fold belts and the configuration of blocks of the crystalline crust. So three-dimensional models of large tectonic provinces have to be the main result of deep researches. Such a systematic approach seems to be the most perspective in the Earth's crust studying.

Keyword

North Eastern Eurasia, Geotransects, Deep Researches

The geodynamic process of the eastern Tibetan plateau revealed by a 3D structure extracted by the Wavegradiometry Method

Chuntao LIANG[1]*, Chengdu University of Technology (liangct@cdut.edu.cn)
Feihuang Cao[2], Chengdu University of Technology

Abstract

The Wave Gradiometry (WG) method measures the spatial gradients of the wavefield within a subarray to extract phase velocity, wave propagation direction, geometrical spreading and radiation pattern within a subarray (Langston 2007). An azimuth-dependent dispersion curve inversion (ADDCI, Liang et al. 2020) is used together with the WG method to extract both 3D velocity and 3D azimuthal anisotropy. Additionally, the geometrical spreading extracted by the WG method is used to find the attenuation of the materials.

The method is applied to the three phases of Chinarray programs (including the Western Sichuan Array, Himalayan Arrays I and II) conducted in the eastern Tibetan plateau. The arrays have an average station spacing of 30km. The phase velocity and azimuthal anisotropy maps for periods 5-20s are inverted using ambient noise tomography, while that for periods 20-80s are obtained from WG method (Cao et al. 2020). The phase velocity dispersion curves for different azimuths with periods 5-100s are then constructed to obtain a 3D velocity and anisotropy model.

Our results show large variations in fast propagation directions (FPD) and magnitude of anisotropy (MOAs) with depth and blocks. The FPDs are positively correlated with plate directions measured by GPS, and are also positively correlated with strikes of regional faults for the South Chuandian block. The low-velocity zones (LVZs) in middle to lower crust are widely distributed in the Songpan Ganze Terrence, the north Chuan-Dian block. But the LVZs are not well present across the Kunlun fault to the NE Tibetan plateau, and across the Lijiang-XIaojinghe fault to the SE Tibetan plateau. The coexistence of LVZs in middle-lower crust and uppermost mantle surrounding the Sichuan basin is dramatic and it may suggest that large-scale deformation is coupled vertically from surface to uppermost mantle. Meanwhile, the FPDs in the lower crust are not aligned well with the assumed flow directions as required by the lower crust flow model. This observation may further suggest that the pure shearing crust shortening model, which involves the thrusting and folding of the upper crust and the lateral extrusion of blocks, may be the major mechanism causing the growth of the eastern Tibetan Plateau.

References

Cao, F., C.Liang*, Yihai Yang, Lu Zhou, Zhiqiang Liu, Zhen Liu, 2022, 3D velocity and anisotropy of the southeastern Tibetan plateau extracted by joint inversion of wave gradiometry, ambient noise, and receiver function, Tectonophysics, https://doi.org/10.1016/j.tecto.2022.229690

Cao, F., Liang, C., Zhou, L., & Zhu, J. (2020). Seismic azimuthal anisotropy for the southeastern Tibetan Plateau extracted by Wave Gradiometry analysis. Journal of Geophysical Research: Solid Earth, 124, e2019JB018395. https://doi.org/10.1029/2019JB018395

Liang, C., Liu, Z., Hua, Q., Wang, L., Jiang, N., & Wu, J. (2020). The 3D seismic azimuthal anisotropies and velocities in the eastern Tibetan Plateau extracted by an azimuth-dependent dispersion curve inversion method. Tectonics, 39, e2019TC005747. https://doi.org/10.1029/2019TC005747

Keyword

Tibetan Plateau, Anisotropy, Geodynamics

Intraplate thrust orogeny of the Altai Mountains revealed by deep seismic reflection

Lei Zhang[1], IGGCAS
Lian-Feng Zhao[2]*, IGGCAS (zhaolf@mail.iggcas.ac.cn)
Liang Zhao[3], IGGCAS
Xiao-Bi Xie[4], UCSC
Xiaobo Tian[5], IGGCAS
Wenjiao Xiao[6], XIEGCAS
Zhen-Xing Yao[7], IGGCAS

Abstract

The Altai orogen is a typical intracontinental orogen in Central Asia that experienced far-field deformation associated with Indian-Eurasian plate convergence. This region is characterized by an uplift comparable to that of the Tianshan Mountains but has a distinct strain rate. Half of the Indo-Asia strain is accommodated by the Tianshan Mountains, whereas the Altai Mountains accommodate only 10%. To elucidate how the Altai Mountains produced such a large amount of uplift with only one-fifth of the strain rate of the Tianshan Mountains, we constructed a detailed crustal image of the Altai Mountains based on a new 166.8-km deep seismic reflection profile. The prestack migration images reveal an antiform within the Erqis crust, an ~10 km Moho offset between the Altai arc and the East Junggar area, and a major south-dipping (30° dip) thrust in the lower crust beneath the Altai Mountains, which is connected to the Moho offset. The south-dipping thrust not only records the southward subduction of the Ob-Zaisan Ocean in the Paleozoic but also controlled the Altai deformation pattern in the Cenozoic with the Erqis antiform. The Erqis antiform prevented the extension of deformation to the Junggar crust. The south-dipping thrust in the lower crust of the Altai area caused extrusion of the lower crust, generating uplift at the surface, thickening of the crust, and steep (~10 km) Moho deepening in the Altai Mountains. This process significantly widened the deformation zone of the Altai Mountains. These findings provide a new geodynamic model for describing how inherited crustal structure controls intraplate deformation without strong horizontal stress.

Keyword

Altai Mountains, deep seismic reflection profile, subduction-accretion process, intraplate deformation pattern

Study on the deep geological structure of the southern section of the Kyushu-Palau Ridge based on the combined gravity, magnetic and seismic inversion method

KE QIN[1]*, qinke_003@126.com (qinke_003@126.com)
Qizhen Du[2], multicomponent@163.com

Abstract

The investigation of the deep structure and dynamic mechanism of the Kyushu-Palau Ridge is crucial for comprehending the dynamic evolution of the Philippine Sea plate, and holds significant importance in resolving the scientific inquiry regarding how subduction occurred and developed from the paleo-Pacific plate to the West Philippine Sea plate. In this study, a comprehensive analysis and examination of the deep geological structure in the southern section of the Kyushu-Palau Ridge is conducted using a combined approach involving gravity, magnetic, and seismic inversion methods. This approach aims to address challenges related to multiple solutions derived from single geophysical data as well as limitations associated with each technical method. Furthermore, it seeks to overcome difficulties arising from multiple inferred geological solutions caused by insufficient clear imaging of rugged submarine oceanic crust structures within the Kyushu-Palau Ridge due to seismic events. Establishment of a fine crust-mantle geological-geophysical model for the study area. The findings presented in this paper unveil distinctive characteristics pertaining to crustal structure within the Kyushu-Palau Ridge, thereby establishing a foundation for understanding initial subduction mechanisms and dynamic processes involved in paleo-Pacific plate interaction with Philippine Sea plate. Additionally, these findings contribute towards reconstructing formation and evolutionary processes associated with the Kyushu-Palau Ridge.

Keyword

Kyushu-Palau Ridge, joint inversion, integrated geophysics interpretation, deep geological structure

Three-Dimensional Tomography: Unveiling the Tectonic and Mantle Dynamics Beneath the Mendocino Triple Junction

Ziqiang YANG[1]*, Chang'an University (yangzq@chd.edu.cn)

Abstract

The Mendocino Triple Junction (MTJ) is a geologically significant area situated on the coast of Northern California. It represents the intersection of three tectonic plates: the North American, Pacific, and Gorda-Juan de Fuca (G-JdF) plates. These geological features play a crucial role in shaping the seismic and tectonic activity in the region, which records the latest tectonic deformation patterns resulting from the interaction between the Pacific, Gorda, and North American plates, making it an ideal area for understanding plate interactions and deep dynamic processes. Utilizing a substantial dataset of high-quality P-wave travel times from local and teleseismic events, we have constructed a detailed three-dimensional model of P-wave anisotropic tomography for the crust and upper mantle beneath the Mendocino Triple Junction. Our findings reveal the existence of a slab window, where upwelling asthenospheric material directly interfaces with the surrounding tectonic plates. A high-velocity anomaly, indicative of a fragment of the Monterey microplate associated with the detachment of the Farallon plate, is discernible at depths of approximately 300-400 *km beneath the triple junction. The upper mantle displays seismic anisotropy that varies with depth and exhibits a circular pattern, primarily attributed to the three-dimensional mantle flow around the southern edge of the Gorda plate. The mantle wedge presents a subduction-driven corner flow. Following the initial contact between the Farallon and North American plates, the fragmentation of the Farallon plate led to the formation of a slab window. Subsequently, the Pacific plate captured the remnant of the plate and moved northwestward in unison. The Monterey plate then fractured, descended into the mantle, and under the influence of shearing forces from both the Pacific and North American plates, relocated to its present position.*

Keyword

Tomography, Mendocino Triple Junction, P-wave Anisotropy, Deep structure

Earth CT: Intergrating Deep Earth Profiles to Make Global Transections via Wide Open Collaboration

Qi ZHOU[1]*, SinoProbe Lab CAGS (1437922567@qq.com)
Shuwen DONG[2], SinoProbe Lab, Chinese Academy of Geological Sciences
Larry BROWN[3], Cornell University
Hans THYBO[4], SinoProbe Lab, Chinese Academy of Geological Sciences
Xuanhua CHEN[5], SinoProbe Lab, Chinese Academy of Geological Sciences

Abstract

The Earth CT initiative originates from initial discussions during the International Symposium, DEEP-2018. Earth CT Program- the 3D Global Probe International Program is a new big scientific collaboration program of deep earth exploration and practice in global scale after Global Geo-Transects (GGT) program led by ILP in last 80th. Deep Earth processes control the geological evolution, including the formation of natural resources, natural disasters, and large-scale environmental changes at the surface of the Earth. The Earth CT programme aims to globally construct long range profiles in wide corridors to image the lithosphere by integrative interpretation of geoscientific data. The programme will integrate data from structural geology and tectonic interpretation at global and continental scales, geochemical surveys in geotransect corridors to define their crustal and lithospheric composition, deep seismic I reflection and refraction/wide -angle reflection profiling to identify I crustal and upper mantle structure and composition, magnetotelluric(MT) sounding for the electrical structure, broadband passive seismic tomography techniques for global and regional velocity structure and receiver functions for crustalupper mantle structure, as well as gravity and magnetic regional and global interpretation. Scientific dilling for deep earth sampling and detection of anomalous features in key tectonic belts will be based on the interpretation of the I above data and will add substantially to the uniqueness of the global and regional interpretation. The aims of the propject are to reveal the deep structure of the lithosphere, recognize the deep processes of plate movement and their control and influence on the surface system, explore energy and mineral resources at depth, and provide insight into geoscience frontier issues, such as the mechanisms controlling natural disasters and their intrinsic dynamics. This program would play a leading role in the development of the world geosciences.

At the DEEP-2018, DEEP-2021, 2019–2023 AGU FMs, and EGUs as particular sessions, there has been much discussion of the Earth CT initiative. The following approach has been supported by lots of international scientists, several societies, academic institutions and research facilities specializing in contouries, as well as proposed by Shuwen Dong, Larry Brown, Hans Thybo, Oleg Petrov, and many worldwide leading scientists. SinoProbe-Ⅱ, the new deep earth exploration program will be one of the important funder to contribute this Global Probe Program.
(1) To construct global "Big Cross" of the lithosphere by integration of intercontinental and regional geoscience transects based on reflection,frofiles.
(2) Lithosphere geotransect and geoscience corridor in Critical Zones.

(3) Global Array of BBS

Keyword

3D Geotransect, Lithosphere, Earth Exploration, Tectonophysics, Intnerational Cooperation

Seismic discontinuities in the Australian upper mantle: a Bayesian approach using receiver functions and multimode dispersion of surface waves

Kotaro TARUMI[1]*, Hokkaido University (tarumi.kotaro.x5@elms.hokudai.ac.jp)
Kazunori Yoshizawa[2], Hokkaido University

Abstract

The Australian continent is composed of the western cratonic region formed in the Archean and Proterozoic eras and the eastern Phanerozoic orogen, drifting rapidly to the north with a speed of about 6-7 cm/year, which is a key to understanding the evolution of the continental lithosphere. The past formation and deformation process can be reflected in the upper mantle structures, such as anisotropic properties and seismic discontinuities (e.g., LAB: Lithosphere-Asthenosphere Boundary; L-D: Lehmann discontinuity). In this study, we aim to map the spatial distribution of LAB and L-D from the joint analysis of body and surface waves using permanent seismic stations in Australia.

We have performed the joint Bayesian inversions of multimode surface-wave phase speeds and azimuth-dependent receiver functions for permanent seismic stations in Australia. The LAB and L-D under the Australian continent are identified clearly in our retrieved models beneath each station. In eastern Phanerozoic Australia, significant S-wave speed drops, suggesting the LAB, are generally observed at shallow depths (70-80 km). In contrast, the estimated LAB becomes deeper (130-140 km) at the north and west of a station located near the margin with the western cratonic region, where the lithospheric thickness becomes thicker. Below the LAB, we could detect seismic discontinuities accompanied by an S-wave velocity increase, which can be interpreted as L-D. Compared with LAB, L-Ds are generally flat but appear in multiple interfaces. On the other hand, in the western cratonic region, LAB is distributed at deeper depths (110-180 km) than in eastern Australia, although S-velocity drops are not very clear. In addition, L-D can be detected as a single interface at around 300km depth in these regions.

As expected from the previous research, the radial anisotropy (xi=(Vsh/Vsv)^2) increases underneath LAB, indicating the effects of horizontal flow in the asthenosphere. On the contrary, radial anisotropy becomes weaker below the L-Ds, suggesting the transition from dislocation to diffusion creep across the L-D, as suggested in mineral physics. Thus, the L-Ds may be related to the base of the ductile asthenosphere under the continental plate.

Keyword

Lithosphere, Asthenosphere, Anisotropy, Receiver Function, Surface wave

Three-dimensional thermal-rheological structure of East Asian continental lithosphere

Yujun SUN[1]*, SinoProbe Laboratory, Chinese Academy of Geological Sciences (sunyujunabc@163.com)
Shuwen Dong[2], SinoProbe Laboratory, Chinese Academy of Geological Sciences
Xueqiu Wang[3], Key Laboratory of Geochemical Exploration of MNR, Institute of Geophysical and Geochemical Exploration, Chinese Academy of Geological Sciences, China
Mian Liu[4], Department of Geological Sciences, University of Missouri, Columbia, MO, USA
Huai Zhang[5], Key Laboratory of Computational Geodynamics, University of Chinese Academy of Sciences, China
Yaolin Shi[6], Key Laboratory of Computational Geodynamics, University of Chinese Academy of Sciences, China

Abstract

The thermal-rheological structure of East Asian continental lithosphere is critical for understanding its diffuse and variable intracontinental deformation in the Cenozoic. Here, we present a three-dimensional thermal-rheological of the lithosphere in East Asia, using the latest thermal parameters, strain rate measurements in mainland China. The results show great lateral heterogeneity of lithospheric temperature and rheology. The crust of orogenic belts such as the Tibetan Plateau, the Mongolia Plateau, and the Tian Shan orogeny is generally characterized by high temperature and low viscosity. The cratons, including Tarim, North China craton, Yangtze craton, have low temperature and high viscosity. The heat sources for the crust also vary. In the Tibetan Plateau, high crustal temperature results from radiogenic heat production within the thick crust, indicting the influence of continental collision. However, high heat flow from the upper mantle is the main cause of high surface heat flow in the eastern part of East Asia, suggesting the role of the Pacific-Eurasian Plate convergence. The rheological structure show that a weak lower crust with low effective viscosity is ubiquitous in East Asian continent. The complicated rheology is helpful to understand the broad and diffuse deformation in the interior of continents, which is a challenge to the theory of plate tectonics.

Keyword

East Asia, continental lithosphere, temperature, viscosity

Upper-mantle velocity and anisotropy under the Mongol-Baikal region

Hanting WU[1]*, Nanjing University (whting@smail.nju.edu.cn)
Zhouchuan Huang[2], Nanjing University

Abstract

The Mongol-Baikal region is located in the western segment of the Central Asian Orogenic Belt. This area experienced multiple periods of extensive compression starting from the Proterozoic. In the Cenozoic, the study region was modified by neotectonics, featuring large extensional rifting (the Baikal rift zone) and plateau uplift (the Hangai Dome). However, the deep mechanisms of the onset of rifting and doming are still debated. We performed high-resolution 3-D P-wave tomography under the southwestern Baikal and western Mongolia. The images show distinct low-velocity anomalies under the Baikal Rift at ~60 km depth, the Hangai Dome at ~200 km depth, and beneath the Siberian craton. This may indicate that potential mantle flows ascended from the deep Siberian MTZ to shallower levels, influencing the rifting of the Baikal rift zone and the lithospheric process of the Hangai Dome. We then further determined the seismic anisotropy of the upper mantle under western Mongolia using SKS splitting measurements. The study region is dominated by NW-SE trending fast polarization directions (FPD), which indicates consistent compressional and transitional stress among the whole study area. Small delay times in the Hangai Dome spatially coincide with the low-velocity anomalies, supporting remarkable asthenosphere upwelling. However, the local Hangai upwelling did not affect the general anisotropic structures significantly, indicating that the lithospheric process only occurred in a limited area.

Keyword

Central Mongolia, Baikal rift zone, mantle upwelling, tomography, anisotropy

Determining three-dimensional Vp/Vs model for the Longmenshan fault system and adjacent areas, Sichuan, China

Junjie HAO[1]*, University of Science and Technology of China (Lydia_Hao@mail.ustc.edu.cn)
Haijiang Zhang[2], University of Science and Technology of China
Ying Liu[3], University of Science and Technology of China

Abstract

It is known that 2008 Wenchuan Mw7.9 earthquake and 2013 Ms7.0 Lushan earthquake occurred along the Longmenshan fault system in Sichuan, China, both of which caused great casualties. Although detailed Vp and Vs models have been developed around the Longmenshan fault system, reliable Vp/Vs model is still lacking. Compared to separate Vp and Vs models, Vp/Vs is more sensitive to the distribution of fluids and partial melting in the crust and upper mantle. Although Vp/Vs could be derived directly from dividing Vp by Vs, it may contain some artifacts due to different Vp and Vs uncertainties.

In this study, we aim at using the Vp /Vs model consistency-constrained double-difference tomography method of Guo et al. (2018) to determine reliable three-dimensional Vp/Vs model for the Longmenshan fault system and adjacent areas in Sichuan, China. This method uses P, S and S-P arrival times to simultaneously determine earthquake locations, Vp, Vs and Vp/Vs models. The advantage of this method is to not only determine a reliable Vp/Vs model, but also has a comparable resolution to Vp and Vs models. Here we assembled high-quality seismic body wave arrival time data on permanent and temporary seismic stations to ensure a good data coverage for the region.

The result shows that the middle and lower crust of the eastern margin of the Tibet Plateau is associated with low Vp, low Vs and high Vp/Vs, indicating the existence of partial melting or fluids. Along the Longmenshan fault system, it shows clear velocity segmentations, with large coseismic slip areas correlating with high velocity anomalies. In general, the seismicity in this region is located in low Vp/Vs anomalies. This study will be useful for better undertanding structural changes in the crust and their correlations with seismic behaviours.

Keyword

the Longmenshan fault system, Vp/Vs model, double-difference tomography method

Lithospheric structure beneath the Hoh Xil block in the northern Tibetan Plateau revealed by deep seismic reflection profile

Zhanwu LU[1]*, SinoProbe LabInstitute of Geology, Chinese Academy of Geological Sciences (luzhanwu78@163.com)
Wenhui LI[2], SinoProbe LabInstitute of Geology, Chinese Academy of Geological Sciences
Xiaoyu GUO[3], School of Earth Sciences and Engineering, Sun Yat-sen University
Rui Gao[4], School of Earth Sciences and Engineering, Sun Yat-sen University

Abstract

The Hoh Xil block in the hinterland of the Tibetan Plateau is viewed as a window into lithospheric connections between the Indian and Eurasian plates (Ding et al., 2013; Wang et al., 2016). The Hoh Xil block has attracted wide interest among geologists who focus their attention on identification of its crustal architecture and therefore the deep lithospheric interactions between the Indian and Eurasian plates. However, the crustal-scale structures at depths beneath the Hoh Xil block remains unknown, partly owing to its typically high elevation and therefore difficult logistics. In this study, we conducted a 170km-long deep reflection profile and high resolution crustal-scale architecture was obtained beneath the Hoh Xil block.

Seismic reflection profile clearly shows the mid-to-lower crustal structures (6-22 s, t.w.t) beneath the Hoh Xil block. One of the prominent reflections appears beneath the northern Qiangtang terrane, where are presented with a sequence of north-dipping reflections in the lower crust and a sequence of top-to-the south overthrusting reflections in the middle crust. These overthrusting reflections can be traced upward to the surface, where are coincident with the Tanggula Mountain. Meanwhile, in the lower crust beneath the Hoh Xil block, there is presented with a sequence of south-dipping reflections, which is in sharp contrast to the reflections beneath the Qiangtang terrane. The overall reflections for a “funnel-shaped” Moho geometry constitute a deformation pattern calling upon face-to-face convergence between the Qiangtang terrane and the Hoh Xil block. A similar convergence pattern has been ever identified in the western Kunlun orogenic belt (Gao et al., 2000) but has never been recognized yet within the plateau’s interior before. Therefore, this newly obtained seismic reflections shown has captured the deep geodynamics for an opposite convergence of the lithosphere (handshake) between the Indian and Eurasian plates.

This study was supported by the Second Tibetan Plateau Scientific Expedition and Research Program2019QZKK0701-02National Natural Science Foundation of China91962109,4157409141590863.

Keyword

Lithospheric structure, northern Tibetan Plateau, deep seismic reflection profile

Film formation behavior of a hybrid silicate and its anti-hydration performance under a high-temperature environment

Mingyi Guo[1]*, Jilin University (gmyjlu@gmail.com)
Ying Li[2], College of Construction Engineering, Jilin University
Maosen Wang[3], College of Construction Engineering, Jilin University
Yinghui An[4], College of Construction Engineering, Jilin University

Abstract

Forming a protective layer on shale surfaces is a promising method to maintain wellbore stability in oil and gas drilling operations. In this study, we explored a novel hybrid silicate, consisting of potassium methylsilicate (PMS) and inorganic silicates (R2SiO3, R= K, Na, Li), as a shale stabilizer to inhibit shale hydration. Comprehensive tests are performed to evaluate the film-forming performance of the hybrid silicate system. The testing results show that, compared to the inorganic silicates, the hybrid silicate system yields a 58-68% reduction in the linear swelling rate of sodium bentonite (Na-Bt). Moreover, the hybrid silicate demonstrates a higher shale cutting recovery rate of 103% at 180°C due to the film formation on shale surfaces. The hybrid silicate system can spontaneously in-situ crystallize to form a quartz film on shale surfaces. The film was identified as crystalline silica (quartz) composed of reticulate nanofibers with alignment controllable morphology, and the size depended on the alkali cations in the hybrid silicate. Hybrid silicates have superior shale inhibition properties than inorganic silicates only, which can be ascribed to the chemical synergy effect between the potassium ions and the methyl group, and the formation of a unique film on shale surfaces at elevated temperatures higher than 150°C.

Keyword

hybrid silicate, shale inhibition, crystalline silica film, biomimetic mineralization

Double-difference Seismic Tomography Using Variational Inference Method and its Application

Hao YANG[1]*, University of Science and Technology of China (youngh_geo@mail.ustc.edu.cn)
Xin ZHANG[2], China University of GeosciencesBeijing
Haijiang ZHANG[3], University of Science and Technology of China

Abstract

Seismic tomography is an important method for determining subsurface structures at different scales. However, in practice it often faces challenges of high nonlinearity and non-uniqueness. Therefore, quantifying the velocity model uncertainties is crucial for a more accurate interpretation of seismic tomography results. However, the travel time seismic tomography method generally cannot provide reliable velocity model uncertainties. Monte Carlo sampling methods can be used to determine reliable velocity model uncertainties, but they need high computational costs when dealing with large datasets or high-dimensional spaces. In comparison, Bayesian variational inference is an effective method for approximating posterior probability distributions and has been applied to 2D travel-time tomography problems.

This study incorporates the variational inference method with the double-difference seismic tomography method (tomoDD). Synthetic tests demonstrate that the newly developed inversion method based on variational inference can achieve solutions comparable to tomoDD but without regularization constraints, thereby avoiding the generation of artifacts. This approach can rapidly and approximately provide velocity models with reliable uncertainty estimates. Compared to traditional checkerboard resolution tests, the resulting uncertainty estimates can more accurately measure the stability of the solution.

We have also applied the new method to local dense seismic array datasets around the SAFOD site along the San Andreas Fault at Parkfield. Similar to tomoDD, the velocity models show significant velocity contrasts across the fault. More importantly, the new method also produces velocity uncertainties, which are on the order of 0.2-0.4 km/s(Vp) and 0.1-0.3 km/s(Vs). Overall, double-difference seismic tomography based on variational inference method provides a powerful and efficient tool for determining seismic velocity structure with reliable uncertainty estimates.

Keyword

Double-difference, Variational inference, Uncertainty estimation, Tomography

Structure, rheology, and evolution of the Martian lithosphere across the crustal dichotomy in and around the Tharsis-Valles Marineris provinces

Ratheesh Kumar RT[1]*, Cochin University of Science and Technology (ratheesh@cusat.ac.in)
Dhananjay Ravat[2], Department of Earth and Environmental Sciences, University of Kentucky, Lexington, 40506, USA
Paul Morgan[3], Colorado Geological Survey, Colorado School of Mines, 1801 Moly Rd. Golden, CO 80401, USA.
Zhang H.L.[4], Hubei Subsurface Multi-scale Imaging Key Laboratory, Institute of Geophysics and Geomatics, China University of Geosciences, Wuhan, China.

Abstract

We have analysed flexural rigidity of the Martian lithosphere using a space-domain convolution method and mapped high-resolution spatial variation of elastic thickness (Te) and crust-mantle interface (CMI) in and around the Tharsis-Valles Marineris provinces. We tested the convolution method using Bouguer and free-air gravity anomaly-based computations and obtained consistent results. Also, we studied the variability of Te by testing with different parameters, including CMI models, density variations, and window sizes that gave rise to optimal results. These models mainly suggest a bimodal lithospheric setting across the highlands-lowlands boundary which we attribute to rheological differences with the aid of lithospheric strength envelope models. The predominantly large-Te (>150 km) and CMI depth (~ 65 – 88 km) characteristic of the major volcanoes in the Tharsis province are attributed to a significantly strong lithosphere having a coupled crust-mantle rheology that supports relatively recent volcanic loads. In contrast, significantly low-Te (< 5 km) and thin crust (CMI ~ 25 – 27 km) of the northern lowlands correspond to a decoupled crust-mantle rheology that was flexurally frozen into the lithosphere during its ancient formation under the influence of a high-thermal gradient. A relatively small-Te and thinned crustal structure in the central part of Valles Marineris, with inferred layered plutons, flood basalts, and mafic dikes are suggestive of a rift-like evolution. We find that Te correlates well to the first-order published geological and geophysical constraints (e.g., age, lithology, and crustal magnetic signatures) that characterize unmodified, magmatism-modified, and impact-altered lithosphere.

Keyword

Lithosphere, Elastic thickness, crust-mantle interface, Rheology, crustal dichotomy

Far-IR spectrometer, MIRORES, for orbital ore prospecting on the Moon

Jakub CIAZELA[1]*, Instytut Nauk Geologicznych PAN (j.ciazela@twarda.pan.pl)
Jaroslaw Bakala[2], Centrum Badań Kosmicznych PAN
Miroslaw Kowalinski[3], Centrum Badań Kosmicznych PAN
Marta Ciazela[4], Instytut Nauk Geologicznych PAN
Weronika Patalas[5], Instytut Nauk Geologicznych PAN
Natalia Zalewska[6], Centrum Badań Kosmicznych PAN
Ireneusz Badura[7], Warsaw University
Marek Steslicki[8], Centrum Badań Kosmicznych PAN

Abstract

Lunar ore minerals host noble and base metals crucial for the self-sustainability of future human colonies on the Moon. Pyrite and troilite, which are sulfide minerals, have various technological applications and use cases. They can be used as a raw material source for producing new solar panels, which are readily available on the Lunar surface. Ilmenite is the primary source of iron and titanium ore on the Moon, which can provide helium-3 for nuclear fusion and oxygen for rocket fuel.

The most important ore minerals have prominent absorption peaks in a narrow far-infrared (FIR) wavelength range of 20–40 μm. This is much stronger than the spectral features of other common minerals, including significant silicates, sulfates, and carbonates. Simulations based on both the linear mixing and the single-scattering albedo/Hapke modeling of ore minerals with the silicates mentioned above indicate that areas containing at least 10–20 vol.% pyrite or ilmenite could be detected from orbit in the FIR range.

The MIRORES (Multiplanetary far-IR ORE Spectrometer) instrument proposed here would operate with a resolution down to <5 m, making it possible to detect areas covered by 2-3 m2 of pyrite (or ilmenite) on a surface of ~17 m2 from an altitude of 50 km. This creates possibilities for detecting large and local smaller orebodies along with their stockworks. The Cassegrain optical system enables this capability. MIRORES will measure radiation in eight narrow bands (0.3 μm in width) that can include up to five bands centered on the ore mineral absorption bands. For instance, MIRORES can measure 24.3, 24.9, 27.6, 34.2, and 38.8 μm for pyrite, marcasite, chalcopyrite, ilmenite, and troilite, respectively. The instrument's size is 32 x 32 x 42 cm, and the mass is <10 kg, which fits the standard microsatellite requirements. The instrument has been selected as the priority payload for the Polish Lunar Mission and will be integrated into a satellite launched to the Moon by the Polish Space Agency between 2028 and 2029. The prototype construction for Earth-based tests started in 2021, and its laboratory testing began in 2022. The Earth test of the prototype from the drone started in December 2023 in Warsaw.

Keyword

ilmenite, ore deposts, Moon, far-IR spectroscopy, MIRORES

Foundations for Lunar Landing Sites: Estimating the Bulk Density of Near-surface Lunar Regolith Through Cone Penetrometer Testing of Simulants

Michael P LUCAS[1]*, Notre Dame (mlucas9@alum.utk.edu)
Clive R Neal[2], University of Notre Dame
Jared Long-Fox[3], University of Central Florida
Daniel Britt[4], University of Central Florida

Abstract

Purpose: Future exploration and infrastructure development on the lunar surface will demand a firm understanding of the geotechnical properties, structure, and stratigraphy of the near-surface regolith. Long duration stays on surface of the Moon will require the use of regolith as construction material and as the unrefined material for resource extraction during in situ resource utilization (ISRU) activities. To prepare for these activities it will be essential to perform geotechnical testing using regolith simulants in Earth-based laboratories, which will help identify: the most applicable regolith analogue(s) for a particular landing region; laboratory measurements that are able to predict and replicate the structure and stratigraphy of near-surface regolith, and methods to calibrate the in situ geotechnical testing necessary to guide future excavation, construction, and ISRU activities.

Introduction: Soil mechanics experiments conducted during the Apollo 14-17 missions revealed that regolith density significantly increases with depth. These experiments also indicated that although near-surface regolith stratigraphy varies locally at Apollo landing regions, regolith stratigraphic layers display a general similarity in that the top several cm consists of a fluffy, unconsolidated layer (e.g., think astronaut boot prints); a firm layer at ~5-10 cm below the surface; then a denser, stronger layer is encountered at depths of 20-40 cm. Therefore, to understand how regolith can enable, but must withstand, surface activities, it will be critical to understand the geotechnical properties and the density profile of the regolith while performing Earth-based testing. Here, we use Exolith Lab regolith simulants to develop correlations between cone penetrometer testing (CPT) measurements and bulk density (ρB); correlations essential for replicating the near-surface regolith conditions of the Moon in Earth-based test beds.

Methods - Cone Penetrometer Measurements: We used a Rimik CP40II penetrometer to obtain Cone Index (CI) penetration resistance values (stress in kPa) vs. depth for regolith simulants packed at various ρB in clear, acrylic test bins. We used an ASAE standard cone area of 1.29 cm2. We measured CI values at 10 mm intervals to depths of ~150-200 mm to estimate the slope parameter (G), which is the slope of CI values vs. depth measured from the surface to 100 mm depth.

Results - G Derivation for Lunar Simulants: We measured CI values of simulants packed at

specific ρB to determine their range of strength in terms of G. At present, we have developed correlations for three variations of lunar highland simulant: LHS-1 Dried (dried at ~110±5°C for 4 hr), LHS-1 Undried, and LHS-1E Engineering Grade Undried. LHS-1E is a “simplified”, lower-cost simulant (i.e., high-fidelity LHS-1 minus trace minerals). We also developed correlations for lunar mare simulants LMS-1 Dried and LMS-1 Undried. All data sets yield strong exponential relationships (R2 values of 0.91 to 0.98); fitted using the least squares method (Equations 1-5; solved for ρB):

LHS-1 Dried: $\rho B = (\ln G + 16.6)/10.524$ (Eq. 1)
LHS-1 Undried: $\rho B = (\ln G + 13.2)/8.451$ (Eq. 2)
LHS-1E Undried: $\rho B = (\ln G + 15.8)/9.934$ (Eq. 3)
LMS-1 Dried: $\rho B = (\ln G + 18.3)/10.18$ (Eq. 4)
LMS-1 Undried: $\rho B = (\ln G + 15.9)/8.978$ (Eq.

Keyword

Lunar Regolith, Regolith Simulants, Cone Penetrometer, Geotechnical Properties, Bulk Density

Lunar Dust Removal using a Gecko Roller

Charles T Pett[1]*, University of Maryland at College Park (pett@umd.edu)
Colby C Merrill[2], University of Maryland at College Park
Christine M Hartzell[3], University of Maryland at College Park

Abstract

Humans and robotic assets landing, exploring, and living on the Moon during the Artemis era will be immersed in a hazardously dusty environment. Lunar dust is notoriously abrasive and creates challenges for almost every lunar surface procedure, including negative optical and thermal effects. The hazard of charged dust in situ was captured by Apollo 16 astronaut, John Young, who remarked, “Dust is the number one concern in returning to the moon” (Gaier, 2007). Mitigation technologies that quickly and effectively remove dust particles (down to microns in size) with minimal consumables, as well as meet tight mass, volume, and power constraints, are needed for future long-term lunar and martian exploration and habitability. We present a novel technology to remove lunar dust from spacesuit, optical, and solar panel surfaces. The Gecko Roller is a handheld device that functions in the same way as a common terrestrial lint roller, but with an elastomeric gecko skin-inspired membrane replacing the adhesive sheet. The synthetic gecko skin membrane is a silicone elastomer with micron-scale molded hair-like structures that increase the adhesion between the dust and the elastomer. The gecko roller requires no power when operated by an astronaut, but can become reusable via electrostatic cleaning if power is available. Preliminary work has demonstrated that the gecko roller is able to effectively remove dust from hard surfaces as well as a spacesuit fabric swatch at lab temperature and pressure. The clean gecko roller was able to consistently remove over 90% of the lunar dust simulant from flat surfaces and spacesuit material at 1 atm. The gecko roller is currently at TRL 4. A recently awarded Lunar Surface Technology Research (LuSTR) 2023 grant aims to raise the technology to TRL 5 after testing in a lunar relevant environment in ultra-high vacuum at subzero temperatures.

Keyword

Dust Mitigation, Astronaut Tooling, Enabling Sustainable Exploration, Enabling Habitability

Gale crater Mars – 3.7 billion years of Mars history from the Curiosity Mars Rover mission

Horton E Newsom[1]*, University of New Mexico (newsom@unm.edu)

Abstract

For almost 12 years Curiosity has been roving across the Gale Crater on Mars. The data from Curiosity, along with orbital data has revealed amazing results from the formation of the crater to literally the daily weather on Mars. Perseverance has also been roving Jezero crater and studying Martian environments for several years, with the intent to eventually return important samples to the Earth. Key discoveries by Curiosity and recent studies of Gale Crater, Mars include evidence of aqueous processes spanning a long duration of Mars history, with evidence for alluvial fans and lakes that may be as young as 500 M.Y. Along the rover traverse evidence of lake deposits and even mud cracks have been found. The Mt. Sharp group rocks have also been altered by circulation of groundwater and deposition of abundant veins of Ca-sulfate and other mineralization. Rippled shallow lake deposits are even found at the Marker Band. Further evidence for water includes the possible role of glaciation, including rock glaciers. Aeolian processes have led to substantial erosion of the Mount Sharp group along the rover traverse up Gediz Vallis, as seen through the presence of ventifacts, and tilted block fields.

Keyword

Mars, Curiosity, Lakes, Glaciers, Aeolian erosion

Spectrally Feldspathic Detections on Mars: A Review and New Discoveries

Michael Steven PHILLIPS[1]*, The University of Arizona (phillipsm@arizona.edu)

Abstract

Over the past decade, several studies have reported detections of visible to short wavelength infrared (VSWIR) spectra dominated by the ~1.25-μm absorption feature of Fe2+-bearing plagioclase on Mars. These “spectrally feldspathic” detections are intriguing because: i) Mars has long been considered a basalt-covered world with little petrologic diversity and these detections may represent rock types that are more evolved than basalt; and ii) these detections occur primarily in ancient rocks (pre- and early Noachian, > 4.1 Ga) suggesting a connection to early crust forming processes on Mars.

Mars is large enough to have experienced mantle overturn processes during differentiation and yet still preserves a record of its earliest crustal products on the surface. Thus, Mars is the best, and perhaps only, planetary body in the Solar System that experienced Earth-like differentiation and where observations can be compared to models of primary crust formation processes (i.e., a magma ocean, cumulate mantle overturn, and post-overturn melting). Understanding the composition of ancient spectrally feldspathic outcrops is key for constraining models of planetary differentiation on Mars, and by extension planetary bodies that underwent mantle overturn.

In 2013, Wray et al. and Carter and Poulet first reported spectrally feldspathic outcrops on Mars north of Hellas basin, which were interpreted as granitic and anorthositic, respectively. Since 2013, six more publications have reported similar VSWIR spectral detections across the southern highlands of Mars: in the walls of Valles Marineris (Viviano et al., 2017, Flahaut et al., 2023), in western Arcadia Planitia domes (Farrand et al,. 2021), across many massifs north of Hellas basin (Phillips et al., 2022), in Nili Patera caldera and Terra Sabaea (Rogers and Farrand, 2022), and in Terra Sirenum/Cimmeria (Payre et al., 2022). The geologic contexts of spectrally feldspathic materials reported in the abovementioned publications are different from one another and different interpretations for the rock type and mechanisms of emplacement were given in all cases.

In this presentation I will review the different examples of spectrally feldspathic regions on Mars, discuss the possibility that they are related or represent distinct processes and compositions, as well as present new detections in massifs north of Argyre basin.

Keyword

Mars, plagioclase, CRISM

Estimation of Lunar Rock Strength: Integrating Regression Analysis and Machine Learning with Apollo Mission Data

Tae Young KO[1]*, Kangwon National University (tyko@kangwon.ac.kr)
Se Jin PARK[2], Kangwon National University
Ji Hye HWANG[3], Kangwon National University
Yun Seong KANG[4], Kangwon National University
Jeong In KWON[5], Kangwon National University

Abstract

This paper introduces an innovative approach for the estimation of lunar rock strength, utilizing the dataset of density and P-wave velocity values obtained from lunar samples collected during the Apollo missions. The primary objective of this study is to develop a predictive model that can accurately estimate the mechanical strength of lunar rocks, leveraging the advanced capabilities of machine learning-based regression analysis. To achieve this, we have meticulously compiled a comprehensive dataset, which includes the physical properties of lunar rocks as well as analogous terrestrial rock data, to serve as a foundation for our analytical models.

The methodology encompasses a two-pronged approach: first, conducting a detailed regression analysis to understand the fundamental relationships between the physical properties of the rocks and their mechanical strength; second, employing sophisticated machine learning algorithms to refine these relationships and enhance the predictive accuracy of our model. The machine learning component particularly focuses on exploring various algorithms, including linear regression, decision trees, and symbolic regression, to determine the most effective model for predicting lunar rock strength based on the identified physical properties.

Furthermore, this study delves into the validation and testing of the developed model using a subset of the dataset, ensuring its reliability and accuracy in estimating the strength of lunar materials. The implications of this research are manifold, offering not only a deeper understanding of the geomechanical behavior of extraterrestrial materials but also paving the way for the practical application of these findings in the planning and construction of future lunar habitats and infrastructure. By providing a robust and accurate tool for assessing the strength of lunar rocks, this research significantly contributes to the field of space exploration and in-situ resource utilization, marking a pivotal step towards sustainable human presence on the Moon.

Keyword

Lunar Rock Strength, Machine Learning, Regression Analysis, Apollo Missions, In-Situ Resource Utilization (ISRU)

Volume estimation of specific types of Martian glaciers which may be related to the paleo-environment of Mars

AKIRA SAWADA[1]*, Waseda University (sukatea2022@gmail.com)
HIROTO NAGAI[2], Department of geography, Faculty of Geo-environmental Science, Rissho University (1700 Magechi, Kumagaya, Saitama, Japan 360-0194)

Abstract

It is widely accepted that an ocean existed on ancient Mars. Also, a lot of explorations and research show that, the water remains as a subterranean ice on Martian surface until now. According to some reports, over 10000 ice-related terrains called viscous flow-features, were already found around the mid-latitude of Mars. One of the type is glacier-like forms, which looks like debris-covered glacier on Earth.

Research for the ice is extremely important for understanding the evolution and water cycle on Mars, as well as exploring the possibility of extraterrestrial life and for the smooth progress of human migration projects in the future. Especially, knowing the total quantity of water ice on Mars is important for reconstructing the initial water level related to paleo-environment of Mars.

However, scientific data of Martian surface is almost satellite images. This make estimation of total ice volume on Mars so difficult. Even there were some research done this recent years, they had difficulty on gaining more precise value.

So, we tried the new method for estimating Martian ice volume, especially terrain shaped like valley glacier, using the symmetry between flow direction and width direction of the glaciers due to mostly or absolutely not flowing over several million years, correlation between glacier area and volume called volume-area scaling, and theorized two-dimensional perfect plastic ice sheet model. This method can be useful for Martian glaciers which, only single low-resolution image data exists.

We selected over 50 terrains look like valley glacier, and then obtained parameters for volume-area correlation. The images were taken by NASA's MRO (Mars Reconnaissance Orbiter). The theory of glacier model is based on perfect plastic theory. Also, some of data quoted from the studies done by other researchers before.

The results show that, the estimated total volume of the ice obtained by the method was within acceptable order and range around 400 to 2000 square km including possible 20% error, similar to the value reported by another researcher. Additionally, this result might mean that some of previous study may have overestimated the total volume of the Martian glaciers between 45 to 70%. Also, this may support the theory espouses the possibility that the origin of these subsurface ice was not directly supplied from the ancient ocean existed on low lands of northern hemisphere but from snow, mostly water once dissipated into atmosphere and redeposited as ice and carbon dioxide mixture.

However, there are no on-site measurement data, and the specific properties or physical quantities such as heat flux around ice-rich terrain and ice-debris ratio remain unknown. Also, we used

simplified model and data not considering possible complex underground structure and recession of them. In addition, some of latest research reported the existence of ice-related terrains on low and high latitude of Mars. Thus, we must wait for global terrain survey on Mars, direct close observations and sample returns in future exploration mission for more updates. Also, we want to discuss more about this field with sedimentology and rover data after entering doctoral course.

Keyword

Mars, glacier, terrain

The >3700 km long Great Dyke of Atla Regio, Venus: the longest traced individual dyke in the solar system

Hafida EL BILALI[1]*, Carleton University, Canada (hafidaelbilali@cunet.carleton.ca)
Richard Everett ERNST[2], Carleton University, Canada

Abstract

The Great Dyke of Atla Regio (GDAR) is traced for ~3700 km on Venus, as surface graben (narrow troughs) interpreted to overlie a continuous laterally-emplaced underlying mafic dyke (vertical magma-filled crack). The GDAR is part of a giant radiating graben/fissure/fracture system (dyke swarm) associated with the Ozza Mons volcano of the Atla Regio plume centre. On the basis of this dyke interpretation the GDAR is the longest individually traced dyke so far recognized on Venus (and also in the Solar System). The GDAR is traced from an interpreted magma reservoir located ~600 km south of the Ozza Mons plume centre, which may have been fed initially from closer to the plume centre. A 50-degree counter-clockwise swing of the GDAR trend at 1200 km from the centre is consistent with 1200 km radius for the underlying Ozza Mons mantle plume head, and a stress link to the 10,000 km long Parga Chasmata rift system. Our discovery of the >3500 km long Great Dyke of Atla Regio, should spur the search for additional long continuous single dykes on Venus (and Earth), with implications for estimating plume head size, locating buffered magma reservoirs, mapping regional stress variation across a large region of Venus (and Earth) at a geological instant, and revealing relative ages (through cross-cutting relationships) over regional-scale distances.

Keyword

Dykes, plumes, Venus, rifting, Graben

A role for iron hydrogenation in the layered redox processes of the post-giant impact Earth

Jinhyuk CHOI[1]*, Yonsei University (jinhyukchoi@yonsei.ac.kr)
Rachel J. Husband[2], Deutsches Elektronen-Synchrotron (DESY)
Huijeong Hwang[3], Gwangju Institute of Science and Technology (GIST)
Seohee Yun[4], Yonsei University
Jeongmin Lee[5], Yonsei University
Heehyeon Sim[6], Yonsei University
Yeonhak Jung[7], Yonsei University
Taehyun Kim[8], Arizona State University
Yoonah Bang[9], Korea Atomic Energy Research Institute (KAERI)
Xinyang Li[10], Deutsches Elektronen-Synchrotron (DESY)
Cornelius Strohm[11], Deutsches Elektronen-Synchrotron (DESY)
Stephan Stern[12], Deutsches Elektronen-Synchrotron (DESY)
Torsten Laurus[13], Deutsches Elektronen-Synchrotron (DESY)
Anand Dwivedi[14], European XFEL
Karen Appel[15], European XFEL
Ulf Zastrau[16], European XFEL
Zuzana Konopkova[17], European XFEL
Edward J. Pace[18], University of Edinburgh
James D. McHardy[19], University of Edinburgh
Orianna B. Ball[20], University of Edinburgh
Richard J. Briggs[21], Lawrence Livermore National Laboratory (LLNL)
Amy L. Coleman[22], Lawrence Livermore National Laboratory (LLNL)
Hyunchae Cynn[23], Lawrence Livermore National Laboratory (LLNL)
Jon Eggert[24], Lawrence Livermore National Laboratory (LLNL)
Stefan Hau-Riege[25], Lawrence Livermore National Laboratory (LLNL)
Trevor Hutchinson[26], Lawrence Livermore National Laboratory (LLNL)
Raymond Smith[27], Lawrence Livermore National Laboratory (LLNL)
Nenad Velisavljevic[28], Lawrence Livermore National Laboratory (LLNL)
Leon M. Andriambariarijaona[29], Sorbonne Université
Sandra Ninet[30], Sorbonne Université
Guillaume Fiquet[31], Sorbonne Université
Marzena Anna Baron[32], Sorbonne Université
Johannes Buchen[33], University of Bayreuth
Egor Koemets[34], University of Oxford
Hauke Marquardt[35], University of Oxford
Carmen Sanchez-Valle[36], Westfälische Wilhelms-Universität (WWU) Münster
Anshuman Mondal[37], Westfälische Wilhelms-Universität (WWU) Münster
Minseob Kim[38], Washington State University
Choong-Shik Yoo[39], Washington State University
Mungo Frost[40], SLAC National Accelerator Laboratory
Jaeyong Kim[41], Hanyang University
Charles Pépin[42], CEA-DAM Ile-de-France
Alexander F. Goncharov[43], Carnegie Institution for Science
Clemens Prescher[44], Albert-Ludwigs University of Freiburg
Valerio Cerantola[45], European XFEL
Eric Edmund[46], Carnegie Institution for Science

Emma McBride[47], Queen's University Belfast
Stella Chariton[48], The University of Chicago
Vitali B. Prakapenka[49], The University of Chicago
Sangsoo Kim[50], Pohang University of Science and Technology (POSTECH)
Daewoong Nam[51], Pohang University of Science and Technology (POSTECH)
Malcolm I. McMahon[52], University of Edinburgh
R. Stewart McWilliams[53], University of Edinburgh
Hanns-Peter Liermann[54], Deutsches Elektronen-Synchrotron (DESY)
Carsten BAEHTZ[55], European XFEL
Madison ANAE[56], Stony Brook University
Motoaki NAKATSUTSUMI[57], European XFEL
Yongjae Lee[58], Yonsei University

Abstract

The Moon-forming impact (MFI) and subsequent formation of the global magma ocean would have set the last major constraints in the chemical and physical co-evolution of the mantle and the core. Based on the scenario that the core of the impactor merged into the proto-Earth, we have investigated depth-dependent partitioning of hydrogen into iron under impact-driven reaction environment between the metallic core of the impactor, e.g., iron, and the volatile component in the post-giant impact Earth, e.g., H2O. Iron compressed with H2O at pressures of 8, 12, 24 and 53 GPa, corresponding to depths of ca. 200, 300, 750 and 1200 km, respectively, was irradiated by high-brilliance X-ray free electron laser (XFEL) pulses to pump and probe the chemical reactions at 2.2 MHz and 30 Hz repetitions. Through fast heating process in pico-to-nanosecond range, we have observed depth-dependent formations of iron oxides (FeO and Fe3O4), hydrides (γ-FeHx, ε'-FeHx and FeH2) and hydroxides (γ-FeOOH and hydrohematite) in partially-quenched states. We find that the molar ratio of H with respect to Fe in all the reaction products shows ~5 fold decrease in the depth range between from 300 and 750 km. This suggests significant modulation in hydrogen partitioning into the iron compounds in the region including the present-day mantle transition zone (MTZ). The resulting abundance of hydrogen in this region would have enabled the formation of hydrous silicates such as wadsleyite and ringwoodite to explain ca. 34.4% of the water storage capacity in the present MTZ. On the other hand, the H/Fe molar ratio shows over 50% hydrogen partitioning into the iron compounds at depths below 1200 km, which would have migrated downwards to form the early core to explain ca. 3.51% of its present light element budget.

Keyword

Giant impact, X-ray free electron laser, Hydrogen content, Mantle transition zone, Core

Formation and evolution of the protolunar disk

Razvan CARACAS[1]*, CNRS, IPGP (caracas@ipgp.fr)

Abstract

Giant and large-scale impacts are ubiquitous features of early solar systems that dominate the end of the accretion stage. The last major accretion event in Earth's history was the Moon-forming giant impact. Depending on the impact parameters, the outcome of this impact was the formation of such a protolunar disk. During cooling, liquids and gases separate according to the liquid-vapor stability dome. The liquid droplets rain toward the center, forming the planet as a magma ocean (MO). The leftover gas forms the hot dense disk atmosphere.

We study the formation and condensation of the disk and the evolution of the MO using molecular dynamics simulations based on ab initio calculations. We work on a multicomponent silicate fluid with bulk silicate Earth composition. From the pressure-density variation and the Maxwell construction, we determine the limits of stability of the molten silicate and the position of the critical point. We find that the Earth's protolunar disk reached the supercritical state of the silicate mantle. Then we follow the chemical evolution of the disk during its cooling.

We characterize the structure and behavior of the MO. The onset of a mushy layer rich in bridgmanite crystals profoundly marks its evolution. This layer exhibits neutral buoyancy and effectively separates the MO at middle depths into a shallow MO and a basal MO that evolve separately.

We also compute the composition of the disk atmosphere and find that it is extremely rich in molecular species. Oxidized phases like SiO, O, O2, MgO, and cations like Na and Mg dominate the gas phase. But a plethora of other phases are present in the system, with lifetimes that allow them to play a role in the chemical and isotopic exchanges. Many of the gas molecules that we find in our simulations are not present in databases like JANAF. This suggests that a huge field of investigation lies bare ahead of us.

Keyword

giant impacts, shock, extreme conditions, supercritical

Dyke swarm history and associated plume centres of Anala and Irnini Montes in Central Eistla Regio, Venus

AASTHA MISHRA[1]*, Indian Institute of Technology Bhubaneshwar, Odisha, India (22gg05007@iitbbs.ac.in)
Richard Ernst[2], Carleton University, Ottawa, Canada
Hafida El Bilali[3], Carleton University, Ottawa, Canada
Rajesh Kumar Srivastava[4], Banaras Hindu University, Varanasi, India

Abstract

Dyke swarm history and associated plume centres of Anala and Irnini Montes in Central Eistla Regio, Venus

Mishra, Ernst, El Bilali, Srivastava

Venus provides a unique opportunity for mapping dyke swarms and their relationship with mantle plumes because of the absence of plate tectonics and any significant erosion. Dyke swarms are recognized by their surface expression as grabens. Central Eistla Regio is an important mantle plume region on Venus with multiple magmatic centres. Here we focus on two important volcanic centres, Anala and Irnini Montes. Previous geological mapping of our study area in Quadrangle V-20 was done at reconnaissance scale (1:5,000,000). In the present study we focus on detailed mapping of Anala and Irnini Montes grabens (interpreted to overlie dykes) 10x more detailed than in previous studies. We have so far mapped about 10,000 grabens, which have been provisionally grouped into radiating, circumferential and linear dyke swarms.

Anala Mons (11.0°N 14.1°E, 525 km in size) is a complex volcanic centre with multiple radiating and circumferential swarms. About 300 km to the east, there is a broad circular feature (170 km in diameter) interpreted as an older corona which has been filled by younger lava flows emanating from Anala Mons. These flows mostly cover the swarms radiating to the east, but some Anala Mons grabens were apparently large enough that they were not completely filled by the younger flows and remain visible. One particular graben can be traced for >550 km, initially trending radially to the NE from Anala Mons; at a distance of about 350 km this dyke swings clockwise 45 degrees towards an ESE trend. A second partially flooded radial graben trends east from the Anala Mons centre and at approximately the same 350 km distance also swings to an ESE trend. Additional smaller graben segments also support this pattern of a radial swarm swinging into a linear trend. Such a pattern can be used to estimate the extent of the domal uplift which proxies the size of the underlying plume head. In this case the graben (dyke swarm) pattern indicates a plume head radius of about 350 km. The recognition of a linear ESE dyke trend beyond this distance indicates a regional ESE-trending maximum compressive stress in the region east of Anala Mons.

Some grabens (dykes) in the interior of the other major centre, Irnini Mons, also show a similar swing in trend at about the same 350 km distance away from Anala Mons, and we are investigating whether these could belong to a north-trending sector of the main Anala Mons radiating swarm.

Irnini Mons (14.6°N 16.0°E, 475 km in diameter) is characterized following our detailed mapping by radiating and circumferential swarms. However, major linear sets of grabens on the western side and on the northern sides of Irnini Mons are not linked to this Mons, but instead these dyke swarms are provisionally interpreted to be part of a huge radiating swarm associated with Belet-ili Corona located more than 1000 km to the south.

Keyword

Venus geological mapping, Dyke swarm, Irnini Mons, Anala Mons, Mantle Plume

Crustal extension due to dyke swarm emplacement: Influence on Venusian surface topography including the formation of annular rims/troughs characteristic of coronae

Richard E. ERNST[1]*, Carleton University, Canada (richardernst@cunet.carleton.ca)
Hafida El Bilali[2], Carleton University, Canada
Kenneth L. Buchan[3], 273 Fifth Ave., Ottawa, Ontario, Canada
James W. Head[4], Brown University, Providence, USA

Abstract

Graben systems are extensive on Venus and have been interpreted both as purely structural features, and alternatively as underlain by mafic dykes. In many cases a dyke origin can be clearly demonstrated based on the eruption of lava flows from the grabens. Here we consider the implications of crustal extension (mostly 1-5%, but ranging up to 10%) under the dyke swarm interpretation. A key reason that dyke emplacement can cause such a major crustal extension is that the majority of dyke swarms on Venus (and Earth) have vertical extents estimated between 10 and 60 km (linked to lateral emplacement) and widths ranging from 20 to 200 m.

We base our study on field observation of dyke swarms on Earth, theoretical treatments of radial dike swarms, and the mapping of graben patterns on Venus. Our analysis benefits from the unique opportunity that Venus offers to compare the primary surface topography (preserved in the absence of erosion) with crustal extension inferred from dyke swarm emplacement.

We consider the effect on surface topography of crustal extension due to dyke emplacement in five scenarios. These examples are associated with all three types of major dyke swarms: radiating, circumferential and linear.

1) Formation of annular rims and troughs characteristic of coronae: Crustal extension associated with circumferential dyke swarms that encircle most coronae may be sufficient to explain the annular folding of corona rims and troughs, and complement other folding mechanisms based on modelling of plume dynamics.

2) Preservation of domal uplift above plumes/diapirs: Crustal extension associated with emplacement of a radiating swarm above a plume/diapir contributes to preservation of the plume-generated domal uplift. On the other hand, in the absence of dyke emplacement, once the thermal anomaly fades the original topography could be restored.

3) Formation of arachnoids: Some magmatic centres are associated with radiating ridge systems (termed arachnoids). Such radial compressional features could develop from collapse of dyke-extended domal uplift, with thrust faults partly utilizing the preexisting radiating dykes as zones of weakness.

4) Elevation of fracture belts (lineae, groove belts): Fracture belts are interpreted as older failed rifts, but often have an elevated topography. Emplacement of rift-parallel dykes and the resulting crustal extension within a failed rift zone could represent a mechanism for linear uplift.

5) Formation of km-scale undulations in topography: Many areas on Venus display multiple cross-

cutting graben sets, which appear analogous to regions of terrestrial Precambrian shields that exhibit multiple crosscutting dyke swarms of different ages. The superimposition of crustal extension from each of the multiple crosscutting trends is predicted to cause complicated patterns of km scale undulations in the surface topography. We are investigating possible examples on Venus.

Keyword

dyke swarm, crustal extension, mantle plume, rifting, Venus

Keyword

Earth's interior, Subduction, Water cycle, Hydration, Early Earth

In-situ high-pressure and high-temperature study of the Fe-S-O-H system: An implication for the thermal evolution of the Martian core

Jeongmin LEE[1]*, Yonsei University (jmlee777@yonsei.ac.kr)
Taehyun Kim[2], Arizona State University
Stella Chariton[3], The University of Chicago
Vitali Prakapenka[4], The University of Chicago
Nico Giordano[5], Deutsches Elektronen-Synchrotron (DESY)
Huijeong Hwang[6], Gwangju Institute of Science and Technology
Yongjae Lee[7], Yonsei University

Abstract

The cores of Earth and other rocky planets are believed to be composed of light elements, including silicon, oxygen, sulfur, hydrogen, and carbon, constituting approximately 5 to 22 wt.% of their overall composition. Notably, sulfur emerges as a dominant element in the cores of smaller terrestrial bodies like Mars, Ganymede, and Vesta. To gain insight into the evolutionary processes of sulfur-rich cores amid the presence of other light elements, we conducted extensive in-situ high-temperature and high-pressure experiments on the Fe-S-O-H system. These experiments spanned a broad range of conditions, encompassing pressures from 18 to 44 GPa and temperatures from 1258 to 2981 K, aiming to simulate the pressure-temperature (P-T) conditions characteristic of the Martian core. Employing ferrous sulfide (FeS) and brucite (Mg(OH)2) as proxies, our investigations unveiled the formation of distinct phases including FeSHx(IV), FeS2, and Fe(Mg)O, suggesting a preferential incorporation of hydrogen into the FeS structure within sulfur-rich environments. Moreover, our analyses revealed a segregation of the Fe-S-H and Fe(-Mg)-O phases, driven by temperature gradients and characterized by a density contrast of approximately 3.1%. Building upon these findings, we propose a crystallization pathway for the Martian core, positing a scenario where the lighter Fe-S-H layer gradually supersedes the denser Fe-O layer during the core's cooling process. This study contributes valuable insights into the complex dynamics governing planetary core formation and evolution.

Keyword

FeS, laser-heated diamond anvil cell (LHDAC), core, light element, Mars

Experimental seismic velocity measurements of chlorite and antigorite using the PE press

Nicholas Backhouse[1]*, UCL (nicholas.backhouse.20@ucl.ac.uk)
Andrew Thomson[2], UCL
John Brodholt[3], UCL
Craig Wilson[4], AWE

Abstract

Chlorite (ideal formula (Mg,Fe)5Al(Si3Al)O10(OH)8) and antigorite (ideal formula (Mg,Fe)3Si2O5(OH)4) are both hydrous silicate minerals believed to exist in downwelling subducting slabs. In hot slabs these minerals will decompose and release their water into the overlying mantle wedge, leading to arc volcanism and/or ore formation. Alternatively, if temperatures are sufficiently cold they can deliver water directly to the asthenosphere, ultimately reducing mantle viscosity and facilitating deep focus earthquakes (1). Detailed seismic studies of subduction settings (2) appear to be consistent with the presence of hydrous minerals, however, this interpretation is uncertain due to the scarcity of available data on the seismic velocity of chlorite and antigorite. Prior to these experiments, published high-pressure velocity measurements of antigorite were limited to room temperature (3), while similar measurements of chlorite are all from a single study performed at pressures of 1.8 and 3.8 GPa (4).

Seismic velocity and X-ray diffraction measurements of natural chlorite and antigorite were collected up to ~6 GPa and 700 °C in a Paris-Edinburgh press at HPCAT, APS, Chicago. The antigorite sample was a randomly oriented polycrystalline sample from Syros, while the chlorite measurements were taken on schists, both perpendicular and parallel to the lattice-preferred orientation (LPO). This allows for some evaluation of the acoustic anisotropy and the effect of chlorite composition on the seismic velocity. At each PT step, velocities were measured using pulse-echo ultrasonics at 16-60 MHz frequency, with sample lengths determined from X-ray radiography. Energy dispersive X-ray diffraction was used to measure sample density and monitor pressure via volume of an MgO sleeve surrounding the sample. Temperature was determined using power curves established at HPCAT for this assembly. These data were used to fit a 3rd-order Birch-Murnaghan equation of state and determine the bulk modulus of the samples. This allows us to reevaluate seismic observations from the Lesser Antilles, and the evidence for hydrous phases in downwelling assemblages.

1. Peacock SM. (1990) Science. 248, 329–37
2. Cooper G. et al. (2020) Nature, 582, 525-529.
3. Wang D. et al. (2019) GRL, 46, 5153–5160.
4. Mantilake G. et al. (2021) Minerals, 11, 70.

Keyword

antigorite, chlorite, velocity, high-pressure, experiments

Numerical simulation of planetary core formation using FEniCS Project for extending 3D modeling

Kyeong-Min LEE[1]*, Kangwon National University (euntm97@kangwon.ac.kr)
Hyo-Im Kim[2], Gyeongsang National University
Deok-Kyu Jang[3], Kangwon National University
Byung-Dal So[4], Kangwon National University

Abstract

Heat sources such as impact heating cause the partial melting of rocky planet interior, rendering a rheological multiphase system. This is due to the difference in phase stability between metals and silicates. Since the melting temperature of metals (i.e., iron-nickel alloys and Fe-FeS system) is typically lower than that of silicates, the metals are initially segregated into liquid phases from solid silicate-metal mixtures. Due to the higher density of fluid metal compared to solid phases, the segregated liquid metals descend towards the center of the planetary bodies. In this study, we propose several numerical simulations to understand the process of core formation. We created a model implemented in FEniCS project via scripting the weak forms of governing equations. The differentiation of silicate and iron metal has been simulated by solving the two-dimensional Stokes and Darcy equations. Case 1 corresponds to planetary evolution triggered by impact heating in early terrestrial bodies with a homogeneous metal fraction. In Case 2, the model mimicked a scenario depicting post-evolutionary impact heating by assuming heterogeneous metal fractions. The results of Case 2 simultaneously represent the behavior of the solid mixture based on the density contrast and multiphase flow of the solid matrix and metallic pores. The checkerboard test (Case 3) was used to evaluate the resolution of the numerical model, indicating consistent spatial resolution for the mesh sizes we employed. Time-dependent model was developed by simulating the multiphase advection scheme, demonstrating the rapid descent of metal phases and the relatively slower movement of silicate phases. Finally, we expanded the 2D FEM model to compute the velocity fields of silicate, Darcy, and iron metal in a 3D model featuring an impact heating case.

Keyword

Numerical simulations, core formation, finite element method, planetary evolution

Collisional erosion of planets recorded by lithium isotopes

Yingkui XU[1]*, Institute of Geochemistry, CAS (xuyingkui@vip.gyig.ac.cn)
Zhi Li[2], Institute of Geochemistry, CAS
Shuijiong Wang[3], State Key Laboratory of Geological Processes and Minerals Resources, China University of Geosciences
Dan Zhu[4], Institute of Geochemistry, CAS
Shijie Li[5], Institute of Geochemistry, CAS
Dehan Shen[6], Institute of Geochemistry, CAS
Deliang Wang[7], Institute of Geochemistry, CAS
Maoyong He[8], State Key Laboratory of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences
Xiongyao Li[9], Institute of Geochemistry, CAS
Jianzhong Liu[10], Institute of Geochemistry, CAS
Tomas Magna[11], Czech Geological Survey, Czech Republic

Abstract

Impact-induced isotopic variation provide insights into the accretion processes of terrestrial planets. One observational fact is that average lithium isotopic values of all terrestrial planets are higher than those of chondrites. This is perplexing since chondrites are thought to be the building blocks of planets and Li isotopes are less fractionated during the accretion evaporation or core-mantle differentiation. One alternative process is that isotopically light Li was partially lost during collisional erosion, defined as the mass loss of melting material of planetesimals during accretion. The key, but still not understood point for this scenario is whether Li isotope fractionation occurs during impact melting.

Here, Li isotope systematics of six suites of heavily shocked ordinary chondrites were investigated. Shock melt pockets (SMP) show resolvedly light Li isotope compositions relative to the adjacent unmelted portions of chondrites. The results strongly suggest that Li isotopic fractionation occurs during impact melting and that isotopically light Li migrates into melts. This finding is consistent with the theory of collision erosion, which predicts a partial loss of a melted material with light Li isotope compositions. The Li isotopic bias of ~2‰ between chondrites and terrestrial planets can thus be reconciled by a mass loss of 15~25% crust of planetesimals.

Keyword

Li isotope, collisional erosion, meteorites, diffusion

Petrochemical and shock heterogeneity in Shergotty achondrite

ARINDAM DUTTA[1]*, GEOLOGICAL SURVEY OF INDIA (arindam.dutta@gsi.gov.in)
Anindya Bhattacharya[2], Geological Survey of India

Abstract

Shergotty achondrite was a meteorite fall near Shergotty town ($24^0 33' 00'' N$; $84^0 50' 00'' E$), Gaya district, Bihar, India on 25th August 1865 (09:00:00 Hrs.). In the scope of present study detailed petrochemical observation and shock calibration of Shergotty achondrite has been attempted to identify chemical and structural inhomogeneity at micro domain level. Shergotty achondrite consists of clinopyroxene + maskelynite + Fe – Ti oxides (titanomagnetite, ilmenite and magnetite), phosphates (apatite and merrillite) ± K-feldspar ± quartz (melt or glass). Clinopyroxene is the most abundant mineral in the Martian Shergotty meteorite with subequal content of maskelynite. Clinopyroxene consists grains of pigeonite and sub-calcic augite, both are strongly zoned. The core compositions of clinopyroxene (Wo11.2 - 36 En44.3 – 59.6 Fs19 – 29) differ significantly from Fe-rich rims (Wo13 - 23.6 En24 – 40.6 Fs46 – 58.7). The clinopyroxene in Shergotty contains K-feldspar inclusions, mostly sanidine in composition. The elemental distribution patterns (Ca, Fe, Mg and Si) within a single clinopyroxene grain show strong compositional zoning for Ca and Mg (gradually increase towards core), whereas Fe increases towards rim compared to core. The preservation of extreme chemical zoning in clinopyroxene indicates rapid cooling from basaltic magma as evident in X-ray mapping. Maskelynite formed after plagioclase varies in composition (labradorite to andesine) within the range of Ab44 – 52 An43.5 – 54 Or1 – 4.5. Preferential orientation of clinopyroxene and maskelynite is observed in Shergotty resembling an igneous texture. Numerous K-feldspar inclusions within clinopyroxene and titanomagnetite, and presence of silica grain (Si metal) at the interface of maskelynite – ilmenite suggest magmatic origin for Shergotty achondrite. Intense fracturing, undulose extinction and mosaicism in clinopyroxene suggest this achondrite is heavily shocked (S4-S5 Stage, $Stöffler\ et\ al.$ 1991), but not brecciated as evident from microstructure. For Shergotty achondrite, the clinopyroxene peak near 670 cm-1 varies from 658 – 669 cm-1, whereas the strong asymmetric peak near 1000 cm-1 shows considerable peak shifts from 990 – 1013 cm-1, resulted from characteristic compositional zoning of clinopyroxene coupled with structural disordering. Plagioclase itself is a sensitive indicator of shock and thermal history. Transformation of plagioclase into maskelynite and diaplectic glass with complete isotropization can testify peak shock pressures at ~ 25 – 34 GPa ($Stöffler\ et\ al.$ 1991).

Keyword

SNC achondrite, shock pressure, chemical inhomogeneity

Aluminium-Magnesium Ages of Evolved Achondrites

Zoltan VACI[1]*, Washington University in St. Louis (zoltanvaci@gmail.com)
Clive M. Jones[2], Washington University in St. Louis
David A. Fike[3], Washington University in St. Louis

Abstract

The oldest igneous rocks in the Solar System are evolved achondrites which originate from the crusts of unknown planetesimals. While on Earth, the formation of evolved rocks such as andesites, trachyandesites, and dacites requires plate tectonic processes and the interaction of volatiles such as water and CO2, it is unclear how such rocks form on small bodies in the early Solar System. While primary melting and differentiation of chondritic material by the decay of aluminium-26 can produce basaltic to andesitic compositions, the diversity of igneous material in the achondrite record, especially in trace element composition, precludes simple melting models and likely involves core formation and multiple melting episodes. The crystallization ages of evolved achondrites are important pieces of evidence for understanding the magmatic histories of early planetesimals.

The oldest igneous rock in the Solar System is currently Erg Chech 002, which has been dated using multiple radiochronometers. However, several other evolved meteorites such as Northwest Africa (NWA) 6698, NWA 11119, NWA 11575, Erg Atouila 001, and the Almahata Sitta trachyandesite clast ALM-A, have either not been dated or have only been dated using one method. As several different labs have been involved in dating these meteorites, generally using 26Al-26Mg, the possibility for age discrepancies exists between different samples. We have applied the 26Al-26Mg chronometer to many of these achondrites using a single instrument in order to find the crystallization ages for the undated samples and to resolve any discrepancies in crystallization ages due to any analytical heterogeneities between different laboratories.

To determine the crystallization ages of ungrouped evolved achondrites, we used a CAMECA 7f GEO ion microprobe to measure 27Al, 24Mg, 25Mg, and 26Mg. Linear isochrons were constructed by plotting 26Mg/24Mg against 27Al/24Mg, and ages were determined relative to the formation of calcium-aluminium inclusions (CAI) using the canonical initial Solar System value of $5.23 \pm 0.13 \times 10\text{-}5$. Instrumental mass fractionation effects were corrected in feldspar using a Miyake-Jima plagioclase standard and in pyroxene using a Norton County enstatite standard. Microprobe measurements adjacent to SIMS spots on standards were used to determine a relative sensitivity factor for 27Al/24Mg fractionation. All SIMS spots were pre-sputtered using a spot size of 20 μm to remove surface contamination and gold coating, after which analyses were performed using a spot size of 15 μm.

Our analyses confirm that Erg Chech 002 is the oldest igneous rock in the Solar System, with an age that falls in between a previous SIMS analysis and a measurement done by mineral separation and ICP-MS. We also find significant radiogenic 26Mg excesses in NWA 6698, 11119, and 11575, indicating that they all crystallized within the first few Ma of Solar System history. We

continue to measure the Al-Mg isotopic systematics of Erg Atouila 001 and additional ungrouped achondrites that represent the evolved crusts of planetesimals.

Keyword

Achondrite, Planetesimal, Andesite, Magma

Maximizing the Value of Meteorite Data for Future Science

Kerstin Lehnert[1]*, Columbia University (lehnert@ldeo.columbia.edu)
Jennifer Mays[2], Columbia University, USA
Dominik Hezel[3], University of Frankfurt, Germany
Lucia Profeta[4], Columbia University, USA
Annika Johansson[5], Columbia University, USA
Peng Ji[6], Columbia University, USA
Griffin Danninger[7], Columbia University, USA
Juan David Figueroa[8], Columbia University, USA

Abstract

Meteorite specimens are among the most precious specimens we study in our labs, but the data generated by laboratory analysis of meteorites has not always been shared openly and remains difficult to access and reuse. Rigorous curation, archiving, and open dissemination of these data will be vital to maximize their utility and impact on science and society now and in the future, supporting new scientific inquiry and providing learning opportunities beyond the immediate research community working on meteorites for researchers, students, and instructors from other disciplines and the general public.

The Astromaterials Data System (Astromat) has been developed with funding from NASA since 2018 to preserve and provide access to data from astromaterials, including meteorites, and was recently designated as NASA's primary archive for laboratory analyses of astromaterials samples. Over the past 5 years, data for meteorites curated at the NASA Johnson Space Center, for lunar samples from the Apollo missions, and other astromaterials such as cosmic dust have been compiled into a searchable synthesis database that now contains over 1.3 million chemical measurements, including major and trace elements, and radiogenic and stable isotope ratios measured on bulk samples, minerals, and other components of astromaterials samples such as premolar grains and chondrules. The MetBase database of meteorite compositions merged with Astromat in 2023 and all MetBase data will become available as part of the Astromat synthesis in summer 2024. Currently underway are enhancements to Astromat's cloud infrastructure, data curation procedures and policies, and organizational structure to ensure standards-compliant, scalable, and adaptable archiving services for the widest range of lab analytical data including image data and spectra, and to fully support NASA's Scientific Information policy SPD-41A. Community engagement is a high priority to establish and promote best practices for FAIR lab analytical data of astromaterials samples. Beyond FAIR, Astromat will offer end-users access to FAIR-AR data through the Astromat Synthesis, a comprehensive, fully integrated, machine-readable, and analysis-ready (AR) data store allowing advanced data exploration and computational analysis (e.g. Machine Learning, Neural Network Analysis).

Keyword

meteorites, astromaterials, FAIR data, databases

Chemical evidence for the melting of alkali feldspar in a lunar meteorite DEW 12007

Hyeong Gyu KIM[1]*, Department of Geoenvironmental Sciences, Kongju National University (kimhyeonggyu@kongju.ac.kr)
Changkun Park[2], Division of Earth Sciences, Korea Polar Research Institute
Hwayoung Kim[3], Division of Earth Sciences, Korea Polar Research Institute
Sun Young Park[4], Petroleum Energy Research Center, Korea Institute of Geoscience and Mineral Resources
Hyun Na Kim[5], Department of Geoenvironmental Sciences, Kongju National University

Abstract

Understanding the high-pressure shock events on lunar crustal materials is critical for interpreting the lunar geological history. Feldspar, which contains traces of impact metamorphism, is an abundant mineral in the lunar crustal igneous rocks. Amorphous feldspar in meteorite can be formed as a diaplectic glass by solid phase transitions under high-pressure, and also as a glass by melt-quenched process under high-temperature. The distinction between these two glass types has generally been based on the textural observations. However, as demonstrated by Kim et al. (2019), it can be resolved by chemical differences between the crystalline and glass phases of partially amorphized plagioclase grains. In this study, we investigated whether these chemical differences can also be applied to the formation of amorphous alkali feldspars in meteorite.

Using backscattered electron (BSE) imaging and Raman spectroscopy, we distinguish between crystalline and amorphous phases of alkali feldspar, providing insight into the amorphization mechanisms under shock metamorphism. The crystalline region contains the pronounced cracks, however, these are confined to the interior and do not lead into amorphous region, except for the large-scale fracture. The amorphous region has no fracture, which has a relatively dark gray with glassy surface. For detailed observation of changes in crystallinity and chemical composition, line analysis was performed using 2D mapping of Raman and WDS. In crystalline, which has a high Raman 283 cm-1 peak intensity, the content of Ca and Na is low and the content of K is high, while in amorphous region, which has a low 283 cm-1 peak intensity, the content of Ca and Na is relatively high and the content of K is low compared to crystalline. Quantitative analysis using EPMA shows that alkali feldspars have sanidine composition, with a wide range from Or81.7Ab17.6An0.7 (crystalline) to Or57.2Ab38.3An4.5 (amorphous). The crystalline region has a high Or and a low Ab component, and as we move into the amorphous region, the Or component decreases and the Ab component increases. These results confirm the causal relationship between crystallinity and chemical composition of shocked alkali feldspar, and the presence of amorphous phase feldspar formed by impact-induced partial melting in DEW12007.

Our study highlights the importance of integrating textural and compositional analyses to distinguish the formation processes of shocked feldspar in lunar meteorites. We envisage that the crystalline and amorphous alkali feldspar in lunar meteorites will be vital for estimating the detailed P-T conditions during shock metamorphism.

Keyword

Impact melting, amorphization, chemical composition, alkali feldspar, Lunar meteorite

Experimental Method for Measuring Cohesion of Regolith via Electrostatic Lofting

Charles T Pett[1]*, University of Maryland at College Park (pett@umd.edu)
Christine M Hartzell[2], University of Maryland at College Park

Abstract

The hypothesized electrostatic lofting of individual regolith grains on the Moon and asteroids has been investigated extensively in laboratory studies. Cohesion may dominate how regolith behaves on these small, airless bodies, yet the magnitude of this force remains uncertain. We induce the electrostatic detachment of dust as a mechanism to break cohesive bonds between individual zirconia-silica microspheres in order to measure the interparticle cohesive force between them. A high-speed camera imaged centroid positions of the lofted microspheres over time. Using the centroids from the initial detachment, we numerically calculated initial accelerations to solve for the cohesion that had been restraining the microspheres. Unexpectedly, the electrostatic lofting of clumps of particles was observed and experimental results showed that clumps were a non-negligible portion of the lofted object population. We have demonstrated a new method for measuring interparticle cohesion by eliminating aeolian effects in vacuum and using electrostatic forces to break cohesive bonds. This experiment also quantified the electrostatic lofting of dust clumps formed from 200−300μm spherical particles in vacuum for the first time. Clumps comprised at least 8% and as much as 35% of the lofted objects, which included individual grains, in our six experimental runs. Within the lofted clump population, we observed that 2-grain clumps form most frequently. The average cohesive force and tensile strength for individual grains was 0.5 μN (STD = 0.2 μN) and 5.3 Pa (STD = 2.1 Pa). Similarly, cohesion and tensile strength for clumps was 1.1 μN (STD = 0.8 μN) and 10.7 Pa (STD = 8.1 Pa), respectively. The analysis of two independent methods for calculating cohesion based on cleanliness and particle weight yielded similar cohesion values. If electrostatic lofting does in fact occur in the low gravity fields on small, airless bodies and if cohesion is indeed a non-negligible force, then clumps may likely be a non-negligible component of the lofted object population. If clump lofting does in fact occur in situ, it could have significant implications for the evolution of small body surfaces. Should clump lofting occur, then electrostatic lofting events may remove more material than previously estimated. If clumps loft from asteroids, it could give insight into how cohesion scales with other forces on rubble pile asteroids. Moreover, quantifying cohesion may inform the conditions required for preferential formation and lofting of clumps rather than individual grains on asteroids. We have shown that a bulk structure will remain intact despite active surface movement, which agrees with current assessments of granular flows on asteroids. For future missions that may observe clump lofting in situ, we have shown that if the trajectory of these lofted objects can be resolved, then we can solve for interparticle cohesion as well as estimate the bulk cohesive properties of the parent body.

Keyword

Regolith Cohesion, Intergranular Cohesion, Granular Clumps, Electrostatic Lofting, Laboratory Studies

Ore prospecting in planetary analog using remote sensing data

Marta CIAZELA[1]*, Polish Academy of Sciences (marta.ciazela@twada.pan.pl)
Jakub Ciazela[2], Institute of Geological Sciences, Polish Academy of Sciences

Abstract

Large-scale ore exploration around the world is becoming more and more accessible thanks to high-quality satellite images. The aim of this research was a geological mapping in-situ and comparison with the results of the satellite images analysis of the Sierra Gorda open-pit mine located in the Atacama Desert in Chile. Sierra Gorda belongs to KGHM Polska Miedź S.A., and is one of the largest copper mines in the world. Geological mapping and remote sensing analyses were possible thanks to the lack of vegetation, the arid climate, and the rock outcrops in the mine and adjacent areas. The research focused on satellite images from the Sentinel-2A satellite due to their excellent spatial (10 m/pixel) and time resolution. Due to the lack of vegetation, arid climate, and diversified terrain, Sierra Gorda is treated as an analog for the Moon and Mars research.

In August 2023, we mapped a ~50 x 30 m test area adjacent to the Sierra Gorda mine in Chile, which is rich in rock outcrops with ore mineralization and its weathering products. Geological mapping was performed at regular points grid spaced 3 meters apart. The content of ore minerals in five randomly selected samples was assessed at 64 points. Among the minerals, sulfides (chalcocite, chalcopyrite, pyrite, sphalerite, and galena), oxides (hematite or magnetite), as well as other hydrothermal minerals such as goethite, jarosite, natrojarosite, alunite, copiapite, chrysocolla, atacamite, and nitrate were observed. The location of each measurement was recorded by GPS device with a measurement accuracy of 1–3 m and transformed into a digital map, to compare with remote-sensing data. This research allowed us to verify the remote spectral detection threshold of ore minerals in the field. Bands ratio (mathematical operations on the satellite channels) methods have been used to highlight the interesting geological features remotely: 1) B11/B4 – gossan; 2) B6/B8A – jarosite and hematite; 3) B11/B8A – ferric oxide rich rocks; 4) RGB Composition: R12 G11 B2; 5) Principal component analysis (PCA) –RGB: R1 G2 B3 and R6 G5 B4; 6) Fe silicate. On all resulting maps, the analyzed research area adjacent to the mine (without active mining) coincides in color with the area of the mine itself with active mining. Therefore, the presented method can be used at the stage of preliminary searching for ore minerals of large regions with sparse vegetation on Earth, as well as on the Moon, Mars and perhaps large asteroids, which are characterized by similar conditions.

Keyword

planetary analog, remote sensing, ore deposits

Geological evidence reveals a staircase pattern in Earth’s rotational deceleration evolution

He HUANG[1]*, Chengdu University of Technology (huanghe@cudt.edu.cn)
Chao Ma[2], Chengdu University of Technology

Abstract

Astronomically forced climate change can be recorded in the sedimentary record. Conversely, such paleorecords can inform past dynamics of solar system and the related history of Earth rotation. Due to tidal dissipation, the Earth’s rotation has been decelerating, but the rates of this process are an ongoing subject of debate. Here we conduct a comprehensive cyclostratigraphic analysis of eight geological datasets to constrain the Earth's rotation history from the late Ediacaran to the early middle Triassic. Our results allow us to test theoretical physical tidal models, and support a suggested staircase pattern in the Earth’s rotation deceleration from 650-280 million-year-ago, thereby increasing the Earth-Moon distance by approximately 20,000 km and the length of solar day by approximately 2.2 hours. A high rate of Earth’s rotation deceleration from 650 to 500 million-year-ago can be attributed to an enhanced tidal resonance. By contrast, unusually low tidal dissipation from 500 to 350 million-year-ago led to a flatter trend in Earth’s rotation deceleration, this was followed by another high rate of Earth’s rotation deceleration from 350 to 280 million-year-ago. These changes in Earth’s rotation are linked to global tectonics and ocean tidal resonance. We speculate on the possible relationship between Earth's rotation and geological processes.

Keyword

Earth-Moon system, Earth’s rotation, cyclostratigraphy, tidal resonances, geological processes

Astrochronology and cyclostratigraphic analysis of Ordovician-Silurian transition —— Case study from JY11-4 borehole in Yangtze Block, Southern China

Shang YUE[1]*, China University of Geosciences, Wuhan (yes@cug.egu.cn)
Chunju Huang[2], China University of Geosciences, Wuhan
Xuebin Du[3], China University of Geosciences, Wuhan
Ke Zhao[4], China University of Geosciences, Wuhan

Abstract

Ordovician-Silurian transition (OST) was an important period in the geological history where many global events happened. Precise astronomical timescale (ATS) provides a foundation for identifying and understanding the key Earth system processes during that period. The cyclostratigraphic analysis for establishing astronomical timescale and improving geological timescale (e.g., GTS2020) has been widely used especially in Cenozoic sedimentation. However, there is a lack of a complete and continuous time scale for the Late Ordovician Early Silurian, despite some scattered studies. Here, we provided a high-resolution grayscale data and gamma-ray logging data from JY11-4 borehole with complete stratigraphic records in Yangtze Block (Sichuan Basin, Southern China) to establish an 8.5 Myr floating ATS from the Late Ordovician to Early Silurian based on the 405-kyr long eccentricity cycle tuning. The results show that the duration of late Katian Wufeng Formation to Aeronian Lower Longmaxi Formation is 8.19 Myr. We further calculated the duration of the Hirnantian glaciation (0.141 Myr, Guanyinqiao Bed) and volcanic activity during OST (5.66 Myr from Wufeng Formation to Lower Longmaxi Formation) in Southern China, and found that the deposition of 42 volcanic ash beds were obviously constrained by orbital cycle. Our result is of great important for improving the timescale of Late Ordovician to Early Silurian and constraining the durations and rates for key geological events during OST.

Keyword

Cyclostratigraphy, Astronomical timescale, Time series analysis, Volcanic activity, Ordovician-Silurian transition

Iron's Role in Astrobiology: The Significance of Ferrihydrite in Martian Habitability

Adomas VALANTINAS[1]*, Brown University (adomas_valantinas@brown.edu)
John F Mustard[2], Brown University

Abstract

Ferrihydrite, a poorly crystalline iron oxyhydroxide mineral, is found in several types of environments, from freshwater to marine systems, cool aquifers to hydrothermal springs, temperate soils, areas affected by mining, and in iron storage proteins of all living organisms. Multiple lines of evidence as well as our observations suggest that ferrihydrite is also abundant on Mars. This hints to a prevalence of wet and low-temperature weathering environment on ancient Mars.

Beyond the geological implications, the presence of ferrihydrite may be significant due to its potential role as a microbial energy source. During the formation of ferrihydrite from iron chloride salts free hydrogen is released, which could serve as an energy source for microbial life. The redox reactions associated with reduction of iron may also be used by microbes.

Moreover, on Earth ferrihydrite's interaction with microbial life is evidenced by its role in iron permineralization. Studies have shown that microbial mats containing cyanobacteria and other phototrophs can become encrusted and permineralized by ferrihydrite, leading to the preservation of cellular and morphological features. This process not only provides insights into ancient microbial life but also suggests a protective mechanism against harsh surface conditions, such as UV radiation, due to iron's UV-absorbing properties.

In addition, ferrihydrite's irregular structure and nanometer-scale crystal size creates a high surface area, which may be important for prebiotic chemistry. This property makes ferrihydrite a strong adsorbent of organic compounds, potentially concentrating biomolecules crucial for the emergence of life. The presence of adsorbed organics also has been shown to inhibit the transformation of ferrihydrite to more crystalline iron oxides phases, making it metastable.

In conclusion, the identification of ferrihydrite on Mars opens up new avenues for understanding the planet's astrobiological potential. Its potential role as an energy source, its participation in iron biogeochemical cycling, and its possible significance in prebiotic chemistry the necessity of studying iron oxides, alongside clays, to assess Martian habitability. The dust samples to be returned by NASA's Mars Sample Return (MSR) mission may contain ferrihydrite, which could illuminate past environmental conditions conducive to life, offering a deeper understanding of the prerequisites for habitability on rocky planets.

Keyword

Mars, Ferrihydrite, Mineralogy, Redox, Habitability

Development of Early Microbial Communities within Newly Emplaced Lava in Iceland: A 3-Year Fixed-site Time-series Study

Nathan Kelly Hadland[1]*, Lunar and Planetary Laboratory, University of Arizona (nkhadland@arizona.edu)
Solange Duhamel[2], Department of Molecular and Cellular Biology, University of Arizona
Christopher W Hamilton[3], Lunar and Planetary Laboratory, University of Arizona

Abstract

Newly emplaced lava flows are initially sterile because of their high temperature upon emplacement. Once cooled, they present microbial colonizers with significant challenges such as low nutrient availability, variable temperatures, oxidative stress, and ultraviolet radiation. Consequently, these lava rocks harbor extremely low biomass, and microorganisms likely require specialized adaptations to survive these environmental conditions.

Mars has abundant evidence of both volcanic and hydrological activity in the past, raising the question if volcanic terrains on Mars were habitable in the past. To explore the potential habitability of Mars-analog systems and life detection in low biomass systems, we investigated ecological dynamics of the 2021 Fagradalsfjall eruption site in Iceland. This site represents a young, low biomass terrain situated within an active aeolian environment. The event was a 6-month subaerial, effusive, basaltic eruption, followed by subsequent episodes in 2022 and 2023. Prior to and during the 2021 Fagradalsfall eruption, we collected soil and (later) lava samples on a ~weekly basis. Additionally, we collected bioaerosol, rain, and hot spring samples to identify microorganisms associated with the newly formed lava flow-field. We also sampled older lava flows nearby (e.g., <8000 years) to compare taxonomic diversity between young and older volcanic substrates.

Samples were fixed for cell counts or frozen at –80oC. Slurries of crushed lava and soil samples were incubated in nutrient-rich and nutrient-poor broths to isolate microorganisms in culture. DNA was extracted from lava using a modified method for low-biomass rock samples and then sequenced. Processing of the sequencing data included the calculation of relative amplicon sequence variant (ASV) abundance, estimates of alpha and beta diversity, dissimilarity patterns, and significance testing. We used the algorithm SourceTracker2 to search for common ASVs between potential source environments (e.g., soil, bioaerosol, rain, hot spring, old lava) and the new lava.

Fourteen strains were isolated in culture, including oligotrophic (Sphingomonas sp.) and thermophilic (Brevibacillus borstelensis) spore formers. Cell counts increased as a function of lava age, except in fumarole sites on the flow, which remained below the detection limit. Alpha diversity generally decreased as a function of lava age. On a Bray–Curtis dissimilarity matrix, lava clustered with aerosols. This trend was confirmed quantitatively with SourceTracker2, with aerosols sourcing up to 73% of sequences. One-year old samples comparatively had more ASVs sourced from old lava samples (up to 97%).

This study reports the establishment of a community, starting from a sterile material and evolving into an inhabited ecosystem. Microbial bioaerosols have been shown to have adaptations such as endospore formation and tolerance to oligotrophic conditions. These selection pressures are also faced by microorganisms in volcanic terrains and may explain why the isolates were endospore formers and could grow on nutrient poor broth. Furthermore, a large proportion of ASVs were sourced from the atmosphere, highlighting the importance of airborne microorganisms in colonizing volcanic substrates. Understanding the succession dynamics in low biomass basaltic rocks is a critical task in astrobiology to constrain the local habitability of such systems on other planets and to optimize life detection strategies.

Keyword

Biosignatures, Habitability, Lava flows, Volcanic terrains, Extremophiles

Profiling the lipidome of microbial communities in Icelandic and Azorean lava tubes

Joleen M CSUKA[1]*, Columbia University (jmc2330@columbia.edu)
Nina Kopacz[2], Utrecht University
Oddur Vilhelmsson[3], University of Akureyri
Brent R Stockwell[4], Columbia University

Abstract

Reliable biosignatures and extra-terrestrial analogue environments on Earth are important in our search for life elsewhere in the universe. Often, however, these environments and the life that thrives in them are not fully understood. One such environment are lava tubes, typical of basaltic pahoehoe volcanic eruptions. Low-lying shield volcanoes can form lava tubes–hollow, cave-like structures that form as the surface of a basaltic lava flow cools and hardens and the lava inside continues to flow. The insides of lava tubes are isolated from the surface environment, leading to light deprived and oligotrophic conditions. Despite this, we find microbial life colonizing these caves.

Images taken by Mars Orbiters show features indicative of lava tubes across Mars. Collapsed lava tube roofs appear on the flanks of Elysium Mons, a shield volcano thought to have formed when Mars had a milder climate and was more hospitable to life. The surface of Mars, now harshly bombarded with ionizing radiation and frigid temperatures, has not yet offered evidence of organic life; however, the subsurface remains a protected environment in which signs of past or extant life may be found. Thus, lava tube environments hold strong potential as a vestige for any life that might exist on Mars.

We hypothesize that lipids may serve as a biosignature for life on other planets, as lipid biosynthesis is generally energetically demanding and lipids are not commonly formed through abiotic processes. Lipids often resist non-biological degradation, provide compartmentalization, and are important regulatory components required for extremophile survival in terrestrial environments. More specifically, we hypothesize that carotenoids are a class of stable lipids that confer protective functions to microbial life and could serve as useful and stable biosignatures.

We have determined the abundance of carotenoids, pigmented lipids, in Martian analog lava tube samples that have been carefully collected from several locations with lava tubes on Earth in effort to elucidate its potential role as a biosignature. Carotenoids are useful reactive oxygen species (ROS) scavengers, help maintain redox homeostasis under extreme conditions, and have been previously demonstrated to be found in a number of extremophiles. In our recently published paper, “A Study in Blue: Secondary Copper-Rich Minerals and Their Associated Bacterial Diversity in Icelandic Lava Tubes”, we measured carotenoid signals using Raman spectroscopy in a blue colored microbial sample. DNA analysis of that sample revealed many bacteria known for high metal resistance, which was expected for a sample containing such high copper concentrations, as well as known metabolic pathways leading to the synthesis of terpenoids and

carotenoids. Here we investigate new lava tube bacterial mat samples from the Azores, Portugal using liquid chromatography mass spectrometry to identify specific lipids and lipid metabolisms present in these extremophile environments.

Keyword

lava tubes, lipids, lcms, biosignatures, mars analogue

GEOLOGIC MAPPING OF LUNAR PYROCLASTIC DEPOSITS IN SINUS AESTUUM, RIMA BODE, AND MARE VAPORUM

Catherine Weitz[1]*, Planetary Science Institute (weitz@psi.edu)
Daniel Berman[2], Planetary Science Institute
Scott Mest[3], Planetary Science Institute
Gareth Morgan[4], Planetary Science Institute
Lisa Gaddis[5], Lunar and Planetary Institute

Abstract

Lunar features classified as “dark mantle deposits" (DMDs) were initially identified based on their relatively low albedos, surface smoothness, mantling relationship to underlying terrain, and spectral absorption bands due to the presence of iron- and titanium-bearing volcanic glasses (herein called “pyroclastics”) produced from explosive volcanic eruptions. These pyroclastics vary in color and reflectance owing in part to differences in Fe and Ti content, and to differences in physical properties. Because all pyroclastic glasses were emplaced by volatile-rich explosive eruptions, they provide clues to the nature of the lunar interior and volcanism on the Moon.

To further understand the geologic context and distribution of pyroclastics within the larger DMDs, we are producing a USGS geologic map of the Moon at 1:1M scale from 18.5° W to 9.5° E and 0° N to 16° N on a WAC basemap, which includes the DMDs in Sinus Aestuum, Rima Bode, and Mare Vaporum. Multiple data sets were used to better refine the extent of pyroclastics for these three DMDs, identify and characterize plausible source vents for the DMDs, map and determine the compositions of the mare and highlands within the study region, perform crater counting to establish ages, explore the geologic setting and history of the mapping region, and attempt to characterize the eruption(s) that emplaced each DMD. An improved understanding of the distribution, composition, and eruption conditions that produced the pyroclastic deposits gained through stratigraphic, morphologic and mineralogic characterization has the potential to reveal important information about the thermal and volcanic history of the Moon.

We mapped forty-one different geologic units and divided them into four groups: (1) Crater Units, (2) Dark Mantle Deposit Units, (3) Mare Units, and (4) Highlands Units. All craters >5 km in diameter have been mapped and are identified in age as either Copernican (Cc), Eratosthenian (Ec), Imbrian (Ic), and Nectarian (Nc) based upon the characterization and extent of their rim and ejecta. Larger craters have been mapped into distinct units including their central peaks, smooth floors, rough floors, and crater rims. Crater statistics were used to establish absolute modeled ages of geologic units.

Eleven mare units were mapped based upon location and brightness, which is related to variations in TiO2 and FeO abundance. Units include several smaller dark mare, basin mare, highland mare, intermediate and disrupted mare, bright mare, and mixed brightness mare. Several previously unmapped/unknown small mare units were mapped in the highlands.

Fourteen highlands units were mapped based on roughness, topography, relative brightness, and presence or absence of lineations.

Five DMD units were mapped, including a localized DMD unit at Hyginus crater, a higlands mare DMD unit, a diffuse DMD unit, a thick DMD unit, and a thin DMD unit.
Surface features mapped include secondary craters and crater rays marked by bright ejecta predominantly from Copernicus crater, light-colored ejecta, high Ti+Fe ejecta, high Ti+Fe lavas, high Ti+Fe pyroclastics, and high Ti+Fe+spinel pyroclastics. Many linear features were mapped, such as sinuous volcanic rilles, wrinkle ridges, faults, scarps, volcanic cones, and grabens.

Keyword

Moon, Map, Pyroclastics, Mare

Late Drainage Along Samara Valles, West of Jones Crater, Margaritifer Terra, Mars

John A GRANT[1]*, Smithsonian Institution (grantj@si.edu)
Roodra Manogaran[2], Louisiana State University
Sharon Wilson[3], Smithsonian Institution

Abstract

Relatively pristine valley segments along medial-to-distal Samara Valles in Margaritifer Terra likely originate within the continuous ejecta west of the Late-Hesperian Jones impact crater. Valley expression between a ~46 km3 upper basin and a ~7 km3 lower basin is typically well-incised with smooth walls and a relatively uniform width-to-depth, but elsewhere varies from well-incised to diffuse and some segments appear anastomosing or truncate one another. Many are more than a kilometer across and 100s of meters deep and display interior terraces and depositional forms. More pristine segments continue north and are associated with finely layered, alternating dark- and light-toned deposits well beyond Jones ejecta. Basins are approximately bound by the -1275 m MOLA contour and the upper basin displays benches and partially filled craters near and below that elevation. Lower interior surfaces of the upper basin are not incised, expose relatively light-toned discontinuous deposits, include polygonal fractures, and are locally Mg/Fe phyllosilicate-bearing. We interpret the formation of the relatively pristine segments as the result of water from impact-melted ice in and under the Jones ejecta draining westward, with some filling the upper basin. Water accumulated over a period of months to years before overtopping the divide and draining at rates perhaps on order of 104 m3s-1 before filling and overwhelming the lower basin and breaching two additional local divides. Drainage persisted for a period of years at most and then ceased. If correct, our model indicates a geologically brief interval of transient potentially habitable environments relatively late in Mars history that was likely unrelated to global climate.

Keyword

Mars, Valleys, Late

Enhanced bedrock weathering on Martian hillslopes with Recurring Slope Lineae (RSL)

Amit MUSHKIN[1]*, University of Washington (mushkin@uw.edu)
Aharon Adam[2], Geological Survey of Israel
Itai Haviv[3], Ben-Gurion University
Shimrit Maman[4], Ben-Gurion University
Dan G Blumberg[5], Ben-Gurion University

Abstract

Recurring Slope Lineae (RSL) are dynamic, low-albedo, slope-parallel surface features on Mars that typically occur on steep (>25°) slopes. RSL often display seasonal dynamics as they appear during late Martian spring, progressively grow during summer, and subsequently fade as summer ends. RSL formation mechanisms remain under debate with proposed mechanisms involving either water/brines ('wet theories') vs. dry granular flows within a surficial dust layer ('dry theories'). In an attempt to distinguish between plausible RSL mechanisms, this study examined morphologic and topographic proxies for rock weathering intensity on adjacent RSL vs. non-RSL hillslopes within three craters: Corozal (39°S, 159°E), Garni (12°S, 290°E) and Rauna (35°N, 328°E). We hypothesize that increased rock weathering intensity on RSL hillslopes would argue against the 'dry' RSL mechanisms as RSL dynamics within a thin dust layer are not expected to significantly impact bedrock weathering. In contrast, the presence of water or brines on RSL hillslopes could conceivably contribute to increased rock weathering rates. To test for variability in rock weathering intensity between RSL vs. non-RSL hillslopes we used HiRISE images to map the fracture characteristics of bedrock outcrops and HiRISE-CTX Digital Elevation Models (DEMs) to measure hillslope-scale variability in topographic attributes, such as slope distribution and curvature commonly examined in terrestrial settings. Our results revealed increased rock weathering intensity for RSL hillslopes at Corozal and Garni and no detectable differences in weathering intensity between RSL and non-RSL hillslopes at Rauna crater. Thus, slope morphologies on Mars appears to support a 'wet' formation mechanism for at least some of the RSL occurrences.

Keyword

Mars, Recurring Slope Lineae, Weathering, Hillslope

Open mineral identification from CRISM hyperspectral data using an ensemble of Support Vector Machines and Extreme Value Theory

Sandeepan DHOUNDIYAL[1]*, Indian Institute of Technology Bombay (sdhoundiyal@iitb.ac.in)
Alok Porwal[2], Indian Institute of Technology Bombay
Pattathal V. Arun[3], Indian Institute of Information Technology Sri City
Guneshwar Thangjam[4], National Institute of Science Technology and Education, NISER

Abstract

Hyperspectral data from the Compact Reconnaissance Imaging Spectrometer for Mars (CRISM) onboard the Mars Reconnaissance Orbiter (MRO) have been instrumental in advancing our understanding of Mars' geological history and habitability by enabling the identification and mapping of a wide variety of aqueous minerals. However, despite their utility, the CRISM image database (containing over 10,000 images) remains underutilized due to the significant manual intervention necessary in traditional methods of analysis.

Recently, machine learning-based methods have been developed to map minerals from CRISM data. However, these methods are limited by the need for complex pre-processing or manual feature selection. Furthermore, these algorithms are designed for closed-set mineral identification, which assumes that only the classes seen during training would be encountered during testing/mapping. This is a significant limitation, as a classifier needs to accurately detect samples from previously unseen classes ('outliers') to both mitigate false positives and facilitate the detection of previously unreported minerals on a planetary body.

Therefore, a novel method for identifying minerals from publicly available CRISM data under an open-set classification regime is proposed.

The proposed algorithm then uses an ensemble of Support Vector Machine (SVM) classifiers, each trained over a random subset of fifteen CRISM bands, to identify minerals under a closes-set regime. Thereafter, class-wise Weibull distributions (fitted over true positives from the validation set for which the ensemble had the least confidence) are used to predict the probability of an unknown spectrum belonging to an unknown class based on its average distance from the separating hyperplane (the decision boundary learnt by the SVMs).

This algorithm is tested over ~470,000 labelled spectra from the CRISM machine learning toolkit's mineral dataset where it returns an overall accuracy of 0.89, while effectively identifying outliers (F-score=0.74) when combined with a simple pre-processing pipeline.

The pre-processing consists of (i) denoising; (ii) continuum removal; and (iii) l2-normalization. It facilitates mineral identification by eliminating variance in the data due to illumination conditions and physical factors (such as abundance and grain size) while enhancing compositional information.

In its current iteration, the trained model can identify 22 minerals (including but not limited to olivine, pyroxenes, phyllosilicates, carbonates, and sulfates), and can be used to accurately map minerals from CRISM data. It may also be used to classify other hyperspectral datasets.

Keyword

Mars, CRISM, Hyperspectral remote sensing, Mineral mapping

Terrestrial hot spring systems as repositories for biosignatures on Earth and Mars

Federica BARILARO[1]*, CNR-IGAG (federicabarilaro@gmail.com)
Andrea Di Capua[2], CNR-IGAG

Abstract

Whilst most of the research on the origins of life has essentially focused on submarine hydrothermal vents, terrestrial hot springs have recently designated as the cradle of life on Earth. Terrestrial hot spring water and environments are known for their ability to harbour microbial mat and biofilm of different morphology and pigmentation and fossilized microbial communities. Thus, due to the complex interaction existing between microbes and the environment, hot spring systems represent locations of planetary exploration and exobiological interests. The interpretation of Mars' early history reveals numerous parallels with the early stages of Earth. The Red Planet, in fact, retain clear evidence of terrestrial hydrothermal systems that provide a potential record of microbial life. It has been postulated that during the Noachian and Hesperian time hydrothermal systems on Mars were most massive and attained their maximum hospitable conditions. Therefore, understanding the mechanisms of mineral formation and diagenesis in these fascinating systems will provide important insight concerning the role of microbes in mineral nucleation and growth and their preservation potential in the fossil records. An interdisciplinary investigation on modern hot spring systems (Italy) have been performed. The unique occurrence of authigenic minerals in association with living microbial communities (including viruses) in the study areas, acted as classical natural laboratories providing the opportunity to evaluate bio-geochemical and physicochemical factors that have direct influence in mineral precipitation. Using traditional and new tools from a sedimentary, petrographic, geochemical, mineralogical and geomicrobiological perspective integrated with high resolution techniques, it was possible to unequivocally identify biotic and abiotic components, document the nucleation processes and growth of authigenic precipitates and define their morphological and textural features linked to biotic compounds. This investigation sheds light on a direct correlation between biological activities, the degradation of organic matter, and the precipitation of authigenic minerals within geological systems. Indeed, filamentous bacteria, virus-like particles and extracellular polymeric substances are the main sites where minerals nucleate and grow. The findings of this study have significant implications for the search for biosignatures on early Earth and Mars.

Keyword

terrestrial hot spring, microbes, early life, Mars, biosignature

From Jezero Crater to Nili Planum: Tracing the Subsurface Life Potential on Mars

Adomas VALANTINAS[1]*, Brown University (adomas_valantinas@brown.edu)
John F. Mustard[2], Brown University
Valentin T. Bickel[3], University of Bern

Abstract

Jezero Crater, the landing site of the NASA Mars 2020 Perseverance rover, is a promising location for astrobiology research. It contains both a sedimentary record of a past lake and delta system, and its surrounding terrains a potential subsurface record of early Mars. The rover will collect and cache samples from the delta system, which may be returned to Earth in the future. However, these lacustrine samples may not capture the full diversity of possible life forms on Mars, especially if they were anaerobic and subsurface-dwelling. Subsurface life could have originated and survived on Mars before it became a frozen desert, and may have left traces in ancient rocks that are better preserved on Mars than on Earth. To complement the existing sedimentary rock samples and expand the habitable environments sampled, the rover must also explore geologic units in the rim of Jezero and outside the crater in Nili Planum. Fracture zones mineralized in the subsurface are one such promising habitat.

We used a deep learning method to map exhumed ridges on Mars, thought to be mineralized fracture zones, that have analogs on Earth and may indicate ancient hydrothermal activity and biosphere traces. Similar ridges are also found in Nili Planum, a region of old rocks that Perseverance could explore after leaving Jezero crater. We are investigating the mineralogy of the ridges with orbital data to evaluate their astrobiological relevance.

We used a public object detection model (Yolov5x CNN, PyTorch 1.7) to identify polygonal ridges on Mars from various CTX images. We ran the model on the CTX global mosaic, i.e., 86,546 images, using a reliable processing infrastructure and one NVIDIA RTX 3090 GPU (processing time of ~two months). Each detection was checked by a human, in context with the CTX mosaic. Multispectral CaSSIS data in the ridge sites were analyzed using ENVI software.

We detected more than 1,200 ridge clusters on Mars using global mapping, creating the first global and consistent catalog of polygonal ridges. We found several ridge hotspots in Gordii Dorsum, Arsia Mons, Meridiani Planum, Hellas Planitia, Nili Fossae and Nepenthes Mensae. Our detections in Nili Fossae agree with previous studies. The ridges in Nili Planum may be representative of a global process involving subsurface hydrothermal reactions that could have provided hydrogen for anaerobic bacteria.

The boxwork ridges in 3.5 Ga old rocks in the Pilbara Craton (Australia) have been suggested to

have formed in anoxic hot spring settings and may be a good analog for Mars. These ridges inside them include black chert veins that preserve microbialites and isotopic signatures consistent with the presence of life. Silica, the principal component of chert is a good preserver of biosignatures and therefore its presence (if confirmed) in the ridges in Nili Planum would raise significantly the astrobiological potential of the extended mission of Perseverance.

We plan to enhance mineralogical and morphological analyses by integrating CaSSIS, CRISM, and HiRISE data, and obtaining spectral measurements of terrestrial analogs using NASA's RELAB facility.

Keyword

Mars, Hydrothermal environments, Pilbara, Jezero Crater, Deep biosphere

(MAPCIS) Massive Australian Precambrian-Cambrian Impact Structure: evidences supporting confirmation for impact designation

Daniel Patrick CONNELLY[1]*, MAPCIS Research Project 4815 Covered Bridge Rd. Millville, NJ 08332 USA (danielconnelly@comcast.net)
Arif Sikder[2], Center for Environmental Studies (CES), Virginia Commonwealth University (VCU) 1000 West Cary Street, Richmond, Virginia 23284-3050
Jaime Presser[3], JP-Exploraciones, Asunción, , Paraguay
Dmitry Pestov[4], Nanomaterials Core Characterization Facility (NCC), Virginia Commonwealth University (VCU)
Carl Mayer[5], Nanomaterials Core Characterization Facility (NCC), Virginia Commonwealth University (VCU)
Mohammad Alauddin, [6], Department of Chemistry, Wagner College, Staten Island
Joseph B. Turner[7], Virginia Commonwealth University (VCU), Department of Chemistry

Abstract

Unraveling the true origin of an impact crater demands meticulous investigation and rigorous verification processes. This summary presentation of a remarkable 17 year journey undertaken by dedicated researchers who embarked on a quest to verify a suspected impact crater known as the Massive Australian Precambrian-Cambrian Impact Structure (MAPCIS), unraveling the fascinating complexities involved in the identification and confirmation of such geologic features. Utilizing a comprehensive approach, combining geological, geophysical, and remote sensing techniques, the research team meticulously examined the purported impact site along with the rigorous laboratory analysis of the rock collected samples. This presentation highlights the diverse methodologies and cutting-edge technologies employed during this extensive investigation. The researchers punctiliously analyzed shock metamorphism related mineralization, and geochemical and petrographic features that are characteristic of large comparable impact events such as Vredefort, Sudbury and Chicxulub. This presentation also discusses the challenges and setbacks faced during the verification process, such as distinguishing impact signatures from common terrestrial geological anomalies. Ultimately, the cumulative efforts of this multi-disciplinary team culminated in a conclusive determination regarding the authenticity of the suspected impact crater known as MAPCIS. Insights gained from this 17 year odyssey provide invaluable guidance to future researchers endeavoring to verify impact events and contribute to our understanding of Earth's history and the broader impact processes shaping the celestial bodies.

Keyword

Impact, crater, planetary, shock, pseudotachylite

Mineralogy and chronology of Ca-phosphates in the lunar meteorite SaU_169

Xiaochao CHE[1]*, Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences (cxc@bjshrimp.cn)
Alexander Nemchin[2], Department of Applied Geology, Curtin University
Tao Long[3], Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences
Dunyi Liu[4], Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences
Wenxiao Peng[5], Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences
Yiyi Ban[6], Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences

Abstract

Introduction: Lunar meteorite SaU_169 is an extremely KREEP-rich sample, containing high concentrations of Th in impact melt breccia (32.7ppm) and regolith breccia (8.44ppm), and rich in U-rich minerals such as Zircons and Ca-phosphate. Previous Zircon U-Pb studies have shown identical main age peak, 3909±13, 3920±13 and 3921±3Ma, which can represent Imbrium basin-forming event. This study aims to discuss the Mineralogy and Chronology of the Ca-phosphate grains in SaU_169 to explore its more complex impact event information compared with zircons.
Analytical Methods: Ca-phosphates of SaU_169 were identified in the polished mount by SEM (Zeiss Merlin Compact) and EDS (Oxford X-MaxN150) in Beijing SHRIMP Center (SHRIMP Center), Institute of Geology, Chinese Academy of Geological Sciences, Beijing, with a beam current of 3.0nA and an accelerating voltage of 15kV. Ca-phosphate chemical compositions were analyzed using the Jeol JXA-8230 electron microprobe at the Shandong Institute of Geological Sciences, Jinan, with a beam size of 1-5μm and a current of 10-20nA, The measured elements include Si, Ca, P, Na, Mg, Fe, La, Ce, Pr, Nd, Sm, Gd, Y, S, F, Cl. Raman was analyzed using the Horiba LabRAM HR Evolution Raman spectrometer at the SHRIMP, with a 532 nm laser excitation system (Nd: YAG), ~1 μm laser spot size. The laser power was ~5mW. The spectra were obtained in the 200-1500 cm-1 range, with 1800 grooves/mm and 40 s counting times. The U-Pb ratios of Ca-phosphates were analyzed by the SHRIMP II at the SHRIMP Center. The primary beam spot size was 12-14μm with a current of 1.0-1.5nA. 175Ca2PO4+, 204Pb+, 204.3Background, 206Pb+, 207Pb+, 208Pb+, 238U+, 232ThO+, and 238UO+ were measured sequentially using an electron multiplier positioned on the axis. In this study, we also used the Leap 5000 XR Atom probe at the SHRIMP Center to analyze the element and isotope distribution in the nanoscale of the Ca-Phosphates.
Results: The Ca-phosphates in SaU_169 are composed of apatite and merrillite, ranging in size from 1 to 150 microns. The Raman spectra of apatite and merrillite indicate that their crystal structure was not significantly affected by impact events after 3.92 Ga, as the grains are well-crystallized. The merrillite has a high REE content compared with apatite, up to 1.17wt% La2O3, 2.48wt%, Ce2O3, 0.71wt% Pr2O3, 1.74wt% Nd2O3, 0.60wt% Sm2O3, and 0.74wt% Gd2O3,

3.0wt% Y2O3. The change of content of Fe in both apatite(0.27-2.78wt%) and merrillite(0.62-1.88wt%) is relatively significant, and the results of Atom probe tomography indicate the presence of Fe nano-inclusions in those minerals. Three types of Ca-phosphates exist poikilitic grains, independent mineral clasts, and intergrowths with Fe-Ni metal. Four different age groups can be distinguished, with a weighted mean age of 4010.0Ma from the intergrowths with Fe-Ni for the first group, 3951.1Ma for the second group, and the third and fourth age groups from poikilitic grains coinciding with the majority of data from the previous study. The upper intercept age of 3921.0Ma represents the age of the Imbrium basin, and the lower intercept age of 589±110Ma is associated with the L-type asteroid parent body breakup event.

Keyword

lunar meteorite SaU_169, Mineralogy, Chronology, Ca-Phosphate, Late heavy bombardment

Light noble gases characteristics in Chang'E-5 lunar soil

Junjie LI[1]*, Beijing Research Institute of Uranium Geology (564484480@163.com)
Ziying Li[2], Beijing Research Institute of Uranium Geology
Zhixin Huang[3], Beijing Research Institute of Uranium Geology
Ting Li[4], Beijing Research Institute of Uranium Geology
Dongfa Guo[5], Beijing Research Institute of Uranium Geology

Abstract

Noble gases in lunar soil have unique advantages to study the solar and cosmic ray interactions with the lunar surface and intensity, as well as the frequency history of impact events affecting regolith turnover and material transport processes. We reported the characteristics of the light noble gases He, Ne, and Ar in Chang'E-5 lunar soil. The relatively high 4He/36Ar and 20Ne/36Ar values not only showed that Chang'E-5 had typical mare terrain characteristics, but also indicated that the soil may not be mixed with the ejecta from highland rocks severely. The integrated exposure times to solar wind of the soil on the lunar surface were close to the upper limit of those of Apollo soils, proving that the Chang'E-5 soil was only minimally contaminated by sputtered material from nearby rocks. Trapped (40Ar/36Ar) tr values of the soil indicated that the soil was likely irradiated by the solar wind relatively late in lunar history, perhaps as late as 10 Ma ago.Trapped (3He/4He) tr and (20Ne/22Ne) tr values were less fractionated than those of Apollo soils, especially for ilmenite mineral which could well preserve He and Ne, the values were very close to those of solar wind, indicating the secondary process endured by the Chang'E-5 soil was not strong.

Keyword

noble gases, lunar soil, solar wind, secondary process

Mapping the Geology of Venus as an Engagement Tool for Undergraduate Planetary Science Research

Katherine Janet Boggs[1]*, Mount Royal University; Country Committee for IUGS (kboggs@mtroyal.ca)
Melvin Spear Chief[2], Mount Royal University
Jerry Demorcy[3], Mount Royal University
Ember Varga[4], Mount Royal University
Jess Hall[5], Mount Royal University
Holly Bley[6], Mount Royal University
Lara Trnski[7], Mount Royal University
Mercedes Rego[8], Mount Royal University
Lovleen Dhami[9], Mount Royal University
Richard Ernst[10], Carleton University
Hafida El Bilali[11], Carleton University
Jim Head[12], Brown University

Abstract

Mount Royal University (MRU) in Calgary, Canada is an undergraduate university with a Bachelor in Science Geology Major and no planetary geology courses. In Alberta, our geology programs need to include 29 courses from four groups, for students to obtain their professional geologist designation after graduation. There are 7 geology faculty with a maximum of 25 geology major students per year. We are restricted in the number of courses that we can deliver. Yet the MRU Venus Geological Mapping team has 25 undergraduate students (geology, general science, anthropology, environmental sciences majors) actively mapping quadrants within the Henie (V-58) Quadrangle in Southern Venus. This team was formed in response to student interest in planetary geology (e.g. Hall, Rego, Trnski) and thrives today because of our affiliation with the International Venus Research Group (IVRG) led by Ernst, El Bilali, and Head. The MRU team is very grateful for access to the incredibly valuable resources that have been compiled by the IVRG (webinars, papers, conference presentations). Collectively the MRU team has mapped one half of the Henie Quadrangle. Student projects nearing publication include studying the characteristics of lava canali (Demorcy), and confirming if Artemis (bordering the nw corner of Henie) is the largest tectonomagmatic feature in the Solar System (Bley). Projects in progress are constraining the dynamics of wrinkle ridges (Varga), characterizing tesserae (Hall, Tnski) and constraining the dynamics of coronae (Rego). Many students are recruited out of 1st and 2nd year geology courses. During year one (Y1) they learn about the geological features of Venus while mapping their first quadrant using ArcGIS and the NASA Magellan Mission data (e.g. Spear Chief, Rego, Trinka). During Y2/Y3 students refine hypothesis and present a poster usually at the MRU Faculty of Science and Technology research day. By Y3/Y4 the plan is for students to publish a peer-reviewed journal article (which is a work in progress). We plan to expand this to include local junior and high school students. “I (Boggs) find this program incredibly inspirational to coordinate as it brings great pleasure to witness the students learning and applying their skills as they unravel

the geological features in their quadrants." Demorcy joined the team because he is "passionate about planetary geology and believes in the power of education and outreach to inspire other students." Varga sees the importance of mapping the geology of Venus because "other planets provide a pathway towards understanding our own planet better." Five students (Bley, Demorcy, Dhami, Hall, Varga) went to the June 2023 Large Igneous Province Conference in Marrakesh, where Bley, Demorcy, Hall and Varga presented posters and talks. As the only undergraduate students at the conference they did exceptionally well. Bley and Hall mentioned that the Morocco trip was important for building their international networks of "not only colleagues, but friends that share the same passions." Bley also described the importance of these undergraduate research experiences for building confidence, while others spoke of enjoying the mentorship available within the MRU Venus geological mapping team (Trnski).

Keyword

Venus, Education, Motivation, Mentoring, Passion

Platinum Group Element abundances and Re-Os isotopic composition of melt rock/breccia support the impact origin of the Simlipal structure, Singhbhum Craton, India

AJAY Kumar SINGH[1]*, CSIR-National Geophysical Research Institute, Hyderabad -500007 (India) (ajay23india@gmail.com)
Sung Hi Choi[2], Department of Geological Sciences, Chungnam National University, Daejeon 34134, South Korea
Dewashish Upadhyay[3], Department of Geology and Geophysics, Indian Institute of Technology (IIT) Kharagpur, 721302, India

Abstract

The Simlipal complex is a circular/semi-circular structure having a diameter of ca. 50 km at the eastern margin of the Singhbhum Craton in India. The structure coincides with an elliptical region of high gravity. The major rock types in the complex include quartzites, shale/phyllite, basalt/meta-basalt, and ultramafic rocks (dunite, harzburgite, picrite, gabbro). The complex is flanked by several granite-granophyre (Mayurbhanj granite) and ultramafic/gabbro/anorthosite along its periphery. In an earlier study, Singh et al. (2021) identified shock metamorphic features such as two/three sets of decorated/annealed planar deformation features (PDFs), crystallographically-controlled melting/amorphization along two or three planar directions, spall and concussion micro-fractures in quartz clasts, and the presence of coesite in melt breccia/melt rocks which suggests that the Simlipal structure maybe the remnant of an impact crater. In this study, we used highly siderophile element (HSE) and Re-Os isotope systematics to search for meteoritic component in breccia (SMP-77, 95A, 111) and melt rock (SMP-86B) of the complex. The concentration of moderately siderophile elements like Cr (9 ppm), Co (89 ppm), and Ni (2.6 ppm) in the melt rock is lower than those in the breccia (Cr = 610-1350 ppm, Co = 58-70 ppm, and Ni = 300-537 ppm). The Cr/Ni ratio of the impact melt rock (2.0-3.6) is higher than that of CI-chondrite (~0.26) and similar to the Upper Continental Crust (UCC ~2.0). The CI-chondrite-normalized HSE patterns show higher abundance of Ir, Os, Ru, Pt, and Pd in breccia and melt rock compared to the Mayurbhanj granophyre/gabbro and the UCC. The 187Os/188Os ratio of the breccia samples range from 0.3245 to 0.6670, while the melt rock has 187Os/188Os of 0.7647. The Mayurbhanj granophyre has comparatively radiogenic 187Os/188Os ratio of 1.4632, whereas an associated gabbro has exceptionally elevated 187Os/188Os ratio of 57.19. The lower 187Os/188Os ratios, coupled with elevated Os concentrations in the breccia and melt rock samples vis-à-vis the UCC or mafic and felsic lithologies in and around the Simlipal complex is strongly suggestive of the presence of a meteoritic component in these rocks. Two-component mixing calculations using 187Os/188Os composition of CI-chondrite and UCC shows the potential presence of up to 0.02 % impactor component in the breccia.

Reference: Singh, A. K., Upadhyay, D., Pruseth, K. L., Mezger, K., Nanda, J. K., Maiti, S., & Saha, D. (2021). Shock metamorphic features in the Archean Simlipal Complex, Singhbhum Craton, Eastern India: Possible remnant of a large impact structure. Journal of the Geological

Society of India, 97, 35-47.

Keyword

Simlipal Complex, Impact structure, PGE, Re-Os isotopes, Singhbhum Craton

The application of ilmenite Crystal Size Distributions in experimental charges to understand the cooling rates of Apollo 11 basalts

Vanesa Mary MUÑIZ LLORÉNS[1]*, University of Notre Dame (vmunizll@nd.edu)
Clive R. Neal[2], University of Notre Dame
Cordula Haupt[3], Universität Münster
Stephan Klemme[4], Universität Münster

Abstract

In an attempt to quantify the cooling rates of Apollo 11 high-Ti basalts, we have combined experimental petrology and Crystal Size Distribution (CSD) methods. Based upon whole-rock analyses of the returned basalts, an equivalent Apollo 11 bulk composition was created and melted, then cooled at controlled temperatures (5°C/h, 10°C/h, 20°C/h & 30° C/h). These samples were created in the University of Munster's experimental petrology laboratory, where they were also photographed using a Back Scatter Electron (BSE). Ilmenite CSDs were constructed for each experimental charge. The steeper the slope of the CSD the faster the cooling rate is. The y-intercept of the CSD gives an indication of nucleation density, which depends on bulk composition.

The experimental charges had opposite sides cut and polished and BSE images of both sides were exported to Paintshop Pro, where each ilmenite crystal was traced and filled in. The crystal fills and the outline of the area studied were then exported to ImageJ that counts the number of crystals and that area. The minimum requirement for a statistically relevant ilmenite CSD is 250 crystals; our research far exceeds that with an average of 1000 crystals per charge. The resulting data were then exported to CSDSlice, which gave information about the crystal shape and 3-D habit. Finally, CSDCorrections was employed to convert 3-D data into 2-D graphs of the CSD profiles that contain crystal size (x-axis) and population density (y-axis).

The processing of BSE images results in one CSD profile for each cooling rate. Preliminary results show that CSDs at 5°C/h and 10°C/h exhibit the presence of crystals bigger than 1 mm and a concave up or slightly kinked graph. Charges at 20°C/h and 30°C/h show a high population density of crystals smaller than 0.5 mm and steep concave up graph. According to Marsh (1998), CSDs with concave up profiles indicate a non-linear cooling rate or textural coarsening. Kinked profiles indicate cooling at two distinct rates. Because the charges were cooled in a controlled environment, the steeper part of the profile is a result of the quench-cooling of any residual liquid after the experiment was concluded. As such, the quench-cooled parts of the CSD were omitted from determining CSD slopes and intercepts. These were obtained using >0.5 mm crystals for 5°C/h and 10°C/h and >0.1mm for 20°C/h and 30°C/h. The resulting slopes range from -1.39 to -17.49, while the intercept is less variable ranging from 3.34 to 11.07. As cooling rate increases, the ilmenite CSD profiles become progressively steeper. Comparison with the actual Apollo 11 basalt ilmenite CSDs show four samples cooled at rates of between 10˚C/h and 20˚C/h (cooled in the interior of thin flows or just beneath the top of thicker flows), and three samples cooled at

>30˚C/h indicating these samples were quenched cooled at the top of a lava flow.

Keyword

lunar petrology, crystal size distribution, CSD, cooling rates, ilmenite

Bridging Disciplines: A Feasibility Study on Integrating Mathematics and Geology in Education

Lujia PAN[1]*, Hebei Normal University (peter205834@hebtu.edu.cn)
Lujia PAN[2], Hebei Normal University

Abstract

This paper presents a comprehensive feasibility study on the integration of mathematics and geology within educational frameworks, aiming to explore the interdisciplinary teaching and learning opportunities that such a blend offers. The research is grounded in a multidisciplinary approach, combining qualitative and quantitative methodologies to assess the potential benefits, challenges, and strategies for effective curriculum development that synergizes mathematical theories with geological concepts. Through a systematic literature review, curriculum analysis, and case studies, this study identifies key areas where mathematical skills are essential for understanding and solving geological problems, such as in geochronology, sedimentology, and structural geology. Furthermore, it evaluates existing educational practices and student outcomes to propose a model curriculum that incorporates mathematical modeling, statistical analysis, and computational simulations within geology courses. The study also addresses pedagogical considerations, including teaching methodologies, learning materials development, and assessment techniques tailored to foster an interdisciplinary learning environment. By showcasing successful examples of interdisciplinary education from various institutions and providing guidelines for overcoming common barriers, this paper argues for the viability and necessity of integrating mathematics into geology education. It concludes that such integration not only enhances students' understanding and application of both disciplines but also prepares them for the challenges of modern scientific research and professional practice in geosciences. This work contributes to the ongoing dialogue on interdisciplinary education and offers a blueprint for educators and policymakers aiming to cultivate a more holistic and interconnected scientific curriculum.

Moreover, the research delves into the psychological and educational aspects of learning, examining how students perceive the relevance of mathematics to their geological studies and identifying factors that influence their engagement and motivation. Through surveys and interviews with students and educators, the study highlights the importance of contextual learning and the application of mathematics in real-world geological scenarios to enhance student comprehension and interest. It also considers the implications of such an interdisciplinary approach for educator training, emphasizing the need for professional development programs that equip teachers with the necessary skills to integrate these subjects effectively.

The feasibility study further explores technological advancements and digital tools that can facilitate the integration of mathematics and geology, including virtual reality simulations of geological formations, online databases for mathematical geoscience modeling, and interactive software for data analysis and visualization. These tools not only make the interdisciplinary

learning process more engaging and accessible but also reflect the evolving nature of both disciplines in the digital age.

In conclusion, the integration of mathematics and geology in education is not only feasible but also imperative for advancing our understanding of the Earth and its processes. This study provides a foundation for developing interdisciplinary curricula that bridge the gap between these disciplines, offering students a more comprehensive and applicable education. As the demands of scientific research and industry evolve, fostering such interdisciplinary approaches in education will be crucial for preparing the next generation of geoscientists and mathematicians to tackle the complex challenges of the future.

Keyword

Interdisciplinary Education, Mathematics and Geology Integration, Curriculum Development, Educational Technology, Student Engagement and Motivation

Magnetic Susceptibility Instrument for Magnetically Inhomogeneous Granular Mixtures

Charles T Pett[1]*, University of Maryland at College Park (pett@umd.edu)
Alexandra Pick-Aluas[2], University of Maryland at College Park
Meyer Taffel[3], University of Maryland at College Park
Cecily M Sunday[4], University of Maryland at College Park
Daniel P Lathrop[5], University of Maryland at College Park
Christine M Hartzell[6], University of Maryland at College Park

Abstract

A plethora of apparatus exist for measuring the magnetic susceptibility of solid, monolithic materials. However, most naturally-occurring terrestrial and extraterrestrial granular samples are polydisperse mixtures composed of different elements with different magnetic properties. Variations in magnetic permeability across granular mixtures make it challenging to understand their bulk magnetic properties, so the range of magnetic susceptibility values for such mixtures are poorly constrained. Inspired by recent asteroid sample return missions, a future close exploration of the metallic asteroid Psyche in 2029, and rejuvenated interest in lunar science, we designed a susceptibility instrument that could accurately probe a diverse catalog of magnetically, geometrically, and elementally irregular granular mixtures. Characterizing the magnetic susceptibility of samples on the Moon will help scientists understand the formation history of and space weathering effects on lunar regolith. Additionally, susceptibility measurements of lunar regolith will aid in the design of granular transport systems for future sample collection, excavation, and ISRU techniques since lunar regolith is magnetic (Oder, 1991; Liu et al., 2007; Kawamoto & Egawa, 2021). In this work, we introduce an electronically simple, affordable, and portable susceptibility instrument that can be made in-house with a lathe and commercial off-the-shelf electronics (Pett et al., Submitted Feb. 2024). The inductor coil (currently at TRL 4) can be submerged in a variety of granular mixtures in the lab or in-situ to quantify bulk inhomogeneous magnetic effects. The relative magnetic permeability of a sample affects the inductance of a coil. To exploit this phenomenon, we relate the permeability of the medium to the inductance of a solenoid coil of a specific radius and length, composed of N turns (Wheeler, 1942). Neither the inductance nor the permeability were known a priori so we obtain a separate value for the coil inductance experimentally. The measured angular frequency at which resonance occurs in the coil is a feature of the inductance and capacitance in an LRC circuit, which varies with material and volume fraction of mixture. We substitute the measured inductance into the equation for a solenoid to solve for the permeability of the medium relative to air. It follows that the permeability of the mixture relative to air less one gives the magnetic susceptibility. To make the coil, we wound motor winding wire on a lathe into a solenoid. We recorded values for the magnetic susceptibility of monodisperse mm-sized steel-brass (51200 Alloy Steel and 260 Brass) mixtures by submerging the coil in mixture. Then we compared our coil measurements to commercial Terraplus Inc. KT-10 meter readings and theoretical approximations (Bai et al., 2018) and report

similar trends, but interesting differences. Our instrument was validated by a measurement of the permeability of air to within 0.045% of the theoretical value and a susceptibility measurement of brass mixture equal to the Terraplus Inc. KT-10 reading. Our coil was then used in experiments by Sunday et al. (Submitted Feb. 2024) to describe the avalanching behavior of magnetic grains. The aim of future work will be to measure the susceptibility of lunar simulants inside a vacuum chamber.

Keyword

Magnetic Susceptibility, Regolith Physical Properties, Geological Instruments, Resource Utilization

COMPLEX MAGMA CHAMBER PROCESSES IN THE MOROKWENG IMPACT MELT SHEET, SOUTH AFRICA

SUMAN MONDAL[1]*, University of the Witwatersrand, Johannesburg (suman.mondal@wits.ac.za)
ROGER GIBSON[2], University of the Witwatersrand, Johannesburg
GRANT BYBEE[3], University of the Witwatersrand, Johannesburg

Abstract

The ~80 km diameter, 146 Ma, Morokweng Impact Structure (MIS) in northwest South Africa occurs in a region almost entirely covered by post-Cretaceous Kalahari sediments. Current models based on geophysical and borehole core data suggest that the central region of the MIS ~ 15 km from the center of the structure, is underlain by one of the largest impact melt sheets preserved on Earth that is also the only one known to preserve fragments of the original meteorite impactor. The M3 drill core, located approximately 14 km from the center of the structure, intersects 800 m of impact melt rock overlying Neoarchaean granitoid and amphibolitic gneisses. The melt sheet has an overall noritic composition and granophyric texture, with local complexity related to partially digested mineral and lithic clasts derived from granitoid, mafic (amphibolite, dolerite), ultramafic, clastic, and chemical sedimentary rocks, as well as the meteorite. It displays a fine-grained basal chill margin and clast-rich lower zone between 700 m and 872 m depth. The absence of an upper chill margin is attributed to post-impact erosion. Above 700 m depth, previous workers have noted a broad upward coarsening and decrease in mafic mineral content, which has been interpreted as evidence of fractionation processes in the melt sheet; however, apart from basic petrographic and major element geochemical analysis, specific details about the magma chamber processes have not been explored.

In this study, reconnaissance petrographic analysis of 10 samples from the melt sheet spanning depths of between 88 and 587 m have been combined with EPMA and LA-ICP-MS analysis of plagioclase and clinopyroxene crystals to explore crystallization processes in the upper parts of the melt sheet. Plagioclase shows normal zoning from An50-An10 at a depth of 465 meters. However, above 407 meters, plagioclase in all the samples shows oscillatory zoning, with cores from An50-An10 and overgrowth from An22-An2. As a result, simple geochemical modelling by Rayleigh fractionation cannot explain the geochemical variation, even though the core of the analysed grain may retain its primary composition. We incorporate incompatible trace elements in plagioclase and whole-rock geochemical data to understand the geochemical changes in the Morokweng melt sheet by using the trapped liquid shift effect model. By using this model, we can also explain the unusual Cr content in the clinopyroxenes, which shows an initial decrease of 200 meters, then a sharp and gradual increase of 500 meters, and finally, a sudden decrease below 500 meters.

Keyword

IMPACT MELT SHEET, MOROKWENG, MAGMA CHAMBER, IMPACT CRATER, Rayleigh

fractionation

The temperature distribution in the mantle of the Moon based on geophysical data and evolutionary model

Ekaterina KRONROD[1]*, Institute of Geochemistry and Analytical Chemistry (GEOKHI)
(e.kronrod@gmail.com)
Victor Kronrod[2], Institute of Geochemistry and Analytical Chemistry (GEOKHI)
Oleg Kuskov[3], Institute of Geochemistry and Analytical Chemistry (GEOKHI)

Abstract

Temperature distribution is a crucial factor in constructing models of the Moon's composition and internal structure. However, the temperature distribution within the lunar interior remains uncertain.

In this study thermal evolution of the Moon has been computed in this study from 500 million years to the present time. The Moon model is divided into layers according to geophysical constraints: crust, upper and lower mantle, low-velocity/viscosity zone (LVZ), and core. We numerically solved a one-dimensional non-stationary heat conduction equation, accounting for both conductive and convective heat transfer, as well as mantle heating due to radioactive decay. The physical properties of the mantle (density, thermal conductivity, heat generation) were determined using the chondritic model, taking into account the heat generation obtained for the magma ocean model. To enable partial melting within the LVZ, supplementary radioactive heat sources have been introduced, whereas there are no heat sources within the core.

The calculated temperature distribution results are in agreement with geophysical data and previous constraints on lunar temperature [Kuskov, Kronrod, 2009]. The obtained temperature profile is consistent with geophysical data and previous estimations of temperature distribution in the Moon, calculated from seismic data [Kuskov, Kronrod, 2009]. The viscosity value within the LVZ layer is 1.6 × 10^17 Pa s, which corresponds to the conditions of the existence of a low-viscosity layer at the mantle-core boundary, although it slightly exceeds the value of 3 × 10^16 determined by [Tan, Harada, 2021].

References

1. Kuskov O.L., Kronrod V.A. (2009) Geochemical constraints on the model of the composition and thermal conditions of the Moon according to seismic data. Izv. Phys. Solid Earth 45, 753–768.
2. Tan Y., Harada Y. (2021) Tidal constraints on the low-viscosity zone of the Moon, Icarus, V. 365, 114361, https://doi.org/10.1016/j.icarus.2021.114361.

Keyword

Moon, Numerical modeling, Geophysical constraints, LVZ, thermal evolution

Decoding a complex geological record of the Yilgarn Craton using laterite iron crusts enriched with scandium

Daria LONGLEY[1]*, LMC (dasha@longleymining.com)

Abstract

Scandium deposits in lateritic weathering profiles represent an important potential source of scandium. Understanding the geological processes of its formation is crucial. Lateritic duricrusts occupy large areas of the Yilgarn Craton and reflect the global events associated with their occurrence.

It is traditionally believed that scandium deposits within lateritic weathering profiles occur as secondary minerals formed by the weathering of primary scandium-bearing minerals from ultramafic rocks. This implies that the duricrust is an integral part of the weathering profile. However, some scientific facts contradict the established opinion regarding the genetic connection of ferruginous crusts with the saprolite material of the weathering profiles. Firstly, the ages of ancient weathering profiles and ferruginous duricrusts are strikingly different. In Africa, the ages of ancient weathering profiles are Paleogene or Upper Cretaceous, and the ages of ferruginous duricrust are Miocene. Secondly, there are multiple instances of territorial discrepancy between ferruginous duricrusts and saprolites, when cuirasses lie directly on hard rocks and have unconformable relationships to the underlying materials. Thus, ferruginous duricrusts are not constituting the upper zone of the weathering profile, but rather represent later superimposed formations and must be considered as independent geological entities.

It has been observed that the epochs of formation of the iron crusts coincide with the moments when the solar system was in the spiral galactic arms, which also corresponds to the epochs of extinctions and bombardment of the Earth by cometary matter. Iron crusts in Africa appeared 22 million years ago, which coincides with the time of passage through the galactic arm. Iron crusts of the Yilgarn Craton were formed 66 million years ago (palaeomagnetic dating), which also coincides with the time of passage through the arm, and the Cretaceous-Paleogene big mass extinction.

During cometary bombardments a large amount of cosmic matter, enriched with chemical elements synthesized inside of stars, arrived on Earth. The cause of the Cretaceous-Paleogene crisis was most likely the result of a “shower” from cometary asteroids, which caused the initial influx of water, and subsequently, as a result of surface heating due to collision energy, local complete drying of water bodies and the formation of ferro-scandium crusts in their places. In the Yilgarn Craton Sentinel-2 imagery has proved to be a highly effective regolith mapping tool. Sentinel data, when spectrally enhanced, allowed the identification of crater-like structures and iron crusts.

Based on the galactocentric paradigm, a new hypothesis for the origin of iron-scandium crusts has been proposed. Iron-containing sediments (economically viable deposits) are mainly deposited during the epochs when the Sun enters the jet streams of the Galaxy. In addition to its scientific significance in understanding the formation of iron-scandium crusts, this study has a practical value for the methods of exploration and identification of scandium deposits in iron-scandium laterite crusts.

Keyword

Scandium, Yilgarn Craton, Comet, Laterite, Galactocentric Paradigm

Paleoproterozoic (2.01 Ga) high-pressure granulite facies metamorphism in the Central Zone of the Limpopo Belt (Eastern Botswana/South Africa): geodynamic implications

Reiner KLEMD[1]*, GeoZentrum, University of Erlangen (FAU), Schlossgarten 5, Erlangen, Germany (reiner.klemd@fau.de)
Sönke Brandt[2], GeoZentrum , University of Erlangen (FAU), Schlossgarten 5, Erlangen, Germany
Kirsten Drueppel[3], Institut für Angewandte Geowissenschaften, Karlsruher Institut für Technologie (KIT), Adenauerring 20b, 76131 Karlsruhe, Germany
Hanqiang Xie[4], Beijing SHRIMP Centre, Institute of Geology, Chinese Academy of Geological Sciences, 26 Baiwanzhuang Road, 100037 Beijing, China
Joshua Ramos[5], GeoZentrum , University of Erlangen (FAU), Schlossgarten 5, Erlangen, Germany

Abstract

The Central Zone (CZ) of the Limpopo Belt in southern Africa is a complex high-grade metamorphic zone, which comprises three major high-grade metamorphic complexes with apparently distinct tectono-metamorphic evolutions: (1) The Beit Bridge Complex, (2) the Phikwe Complex, and (3) the Mahalapye Complex. Three metamorphic events, at 3.22 Ga (M1), 2.72–2.56 Ga (M2), and 2.02 Ga (M3) are recognized in the Beit Bridge Complex, whereby the long-lasting granulite-facies M2 event was interpreted by most authors to reflect the Neoarchean continental collision orogeny. The subsequent granulite-facies M3 event is interpreted to record either an intracontinental Paleoproterozoic transpressional orogeny or just a thermal overprint unrelated to regional deformation.

To better understand the geological evolution and poly-metamorphic history of the Paleoproterozoic Limpopo orogeny we present geological, petrological, and SHRIMP U-Pb zircon age data of high-grade metamorphic rocks from the Baines Drift and Phikwe Complexes. The narrow Baines Drift Complex occurs between the Phikwe and Beit Bridge Complexes. The Baines Drift and Phikwe Complexes constitute the north-western segments of the CZ for which the geology and P-T-t evolution are poorly understood. Detailed geological mapping (1:10.000) of the exposed transitional areas of the Beit Bridge, Phikwe, and Baines Drift Complexes in the area around Baines Drift revealed a N-NE-trending planar fabric and well-developed mineral lineations dipping moderately to the S-SE or N. The dominant deformation displays a large broadly NE-SW striking fold structure, reflecting NW-SE directed shortening, typical of the CZ. Locally NE-SW striking shear zones occur.

High-pressure (HP) granulite facies metamorphism and a clockwise P-T evolution for feldspar-free Grt-Opx-Crd-Oam gneisses of the Baines Drift Complex are constrained by pseudosection modelling, Grt-Opx thermometry, and quartz-in-garnet (QuiG) elastic barometry. The peak-metamorphic garnet-orthopyroxene-rutile-ilmenite-quartz assemblage formed at HP granulite-facies conditions of > 900°C and 14 kbar, followed by significant decompression still under granulite-facies conditions as recorded by conspicuous orthopyroxene-cordierite coronas around garnet. The widespread formation of orthoamphibole documents subsequent near-isobaric cooling

into the amphibolite-facies. Metamorphic zircon in the Grt-Opx-Crd-Oam gneiss yielded a precise SHRIMP U–Pb age of 2014 ± 8 Ma for the HP granulite-facies metamorphism in the Baines Drift Complex. The clockwise P-T path of the Baines Drift Complex resembles the similarly aged granulite-facies 2.02 Ga metamorphism in the Beit Bridge Complex that forms the main segment of the CZ. Thus, based on the zircon data we precisely determined crustal thickening reflected by the HP granulite-facies metamorphism during NW-SE-directed compression at ca. 2.02 Ma, interpreted to reflect the intracontinental Paleoproterozoic transpressional orogeny within the consolidated Kaapvaal-Zimbabwe Craton. SHRIMP U-Pb zircon data further indicate that the granitic magma of a charnockite sample from the Phikwe Complex intruded at 2586 ± 27 Ma, broadly synchronous with major granitoid emplacement in the Beit Bridge Complex. The similar structural-geological characteristics and the P-T evolution of the ca. 2.02 Ga metamorphism, and the comparable voluminous granitoid emplacement at ca. 2.6 Ga indicate a common evolution of the Baines Drift, Phikwe, and Beit Bridge Complexes in the CZ of the Limpopo Belt.

Keyword

High-pressure granulite-facies metamorphism, pseudosection modelling, U-Pb zircon dating, Limpopo Belt

Kyanite trace element zoning as a tool for gaining insights into the petrological evolution of migmatites

Sara Nerone[1]*, University of Torino (sara.nerone@unito.it)
Chiara Groppo[2], University of Torino
Mónica Ágreda-López[3], University of Perugia
Maurizio Petrelli[4], University of Perugia
Franco Rolfo[5], University of Torino

Abstract

The variation in trace element concentration in kyanite has been recently investigated by several studies, highlighting its potentiality as a petrogenetic indicator in metapelites. Kyanite can contain significant amounts of Fe (thousands of ppm), Cr, Ti, V (hundreds of ppm) and other elements, displaying chemical zoning observable under cathodoluminescence (CL) microscopy. Changes in the CL colour intensity are visual indicators of chemical variability and textures that can be related to multiple episodes of growth and/or consumption of kyanite during metamorphism.

The role of kyanite as a petrogenetic indicator is especially important for constraining the evolution of anatectic metapelites, where kyanite can grow through: (i) metamorphic reactions at sub-solidus conditions (i.e., subsolidus Ky1), (ii) muscovite dehydration melting reaction (i.e., peritectic Ky2), and (iii) during cooling and melt crystallisation either through back-reactions between melt and solid phases (e.g., garnet, K-feldspar) or crystallising directly from the melt (i.e., back-reaction overgrowth or magmatic Ky3). A petrochemical study combined with phase equilibrium modelling performed on biotite + kyanite + garnet migmatites from the Lower-Greater Himalayan Sequence exposed in eastern Nepal Himalaya highlights a link between the trace elements chemical zoning of kyanite and the consumption vs. growth of the main minerals acting as reservoirs/sinks for those elements (e.g., muscovite, biotite, garnet), and ultimately to specific growth stages of kyanite (i.e., Ky1, Ky2, Ky3). The combination of petrochemical investigations (CL imaging + trace elements spot analyses and maps) and forward thermodynamic modelling is an indispensable tool for a reliable interpretation of the kyanite behaviour in anatectic rocks from collisional orogens. The complexity of kyanite porphyroblasts textures and their relation to its growth history can shed light on: (i) the prograde sub-solidus evolution of high-grade metamorphic terranes that could be otherwise obscured by partial melting; (ii) the anatectic processes, e.g. melt-producing reactions, melt segregation and extraction, chemical differentiation between melt and restite, melt crystallisation, and (iii) the behaviour of trace elements during anatexis.

Keyword

anatexis, CL zoning, thermodynamic modelling

H2O content variation in the metamorphic evolution of shear zones: a case from the Dora-Maira Massif (Western Alps)

Sara Nerone[1]*, University of Torino (sara.nerone@unito.it)
Alessandro Petroccia[2], University of Bologna
Fabiola Caso[3], Università degli Studi di Milano
Davide Dana[4], University of Torino
Andrea Maffeis[5], Università degli Studi di Milano-Bicocca

Abstract

When applying thermodynamic modelling to the investigation of metamorphic rocks, the choice between the modelling using H2O-saturated conditions or a fixed amount of H2O. During the prograde path of terranes, rocks are thought to experience only fluid loss, as dehydration reactions occur at increasing temperatures. In contrast, forward thermodynamic modelling of shear zones often considers fluid-present metamorphism to account for fluid availability. In these settings, the interplay between deformation and metamorphism is, in fact, mainly influenced by the access of fluids and fluid/rock interactions.

Here, we discuss the necessity of investigating the H2O evolution within shear zones, as H2O-saturated and -undersaturated conditions may be present at different times during the shear zone development. A thermodynamic modelling approach has been used in a case study, the Mt. Bracco Shear Zone (MBSZ). The MBSZ is an Alpine ductile tectonic contact that marks the boundary between two HP units, the polymetamorphic Ricordone Unit and the monometamorphic Sanfront-Pinerolo Unit, in the Dora-Maira Massif (Western Alps, Italy). The high strain zone of the shear zones displays a polyphase pressure (P) – temperature (T) history related to exhumation and a complex fluid regime evolution and its influence on the shear zone behaviour. After the eclogite-facies peak consistent with previous works, the subsequent mylonitic event is constrained at amphibolite-facies conditions, continuing its evolution at decreasing P and T during rock exhumation. The investigation of H2O content variation using forward thermodynamic modelling highlights the attainment of both H2O-saturated and -undersaturated conditions. After reaching a maximum H2O content during decompression with increasing temperature, a significant fluid gain is modelled before the mylonitic event. Then, the MBSZ evolves toward H2O-undersaturated conditions in a closed system. Furthermore, the difference in behaviour between the considered lithologies suggests that fluid evolution within shear zones could result from both externally and internally derived fluid flux. The MBSZ can be considered as a preferential pathway for fluid fluxes during exhumation but also determines a redistribution of the fluid.

Keyword

mylonites, phase equilibrium modelling, fluid content

Pre-Himalayan Metamorphism in the Lesser Himachal Himalaya: Insights from P-T pseudosection, U-Pb dating of zircon and monazite, and Sm-Nd garnet isochron

HIFZURRAHMAN -[1]*, WADIA INSTITUTE OF HIMALAYAN GEOLOGY (khan.hifz@gmail.com)
PRITAM NASIPURI[2], INDIAN INSTITUTE OF SCIENCE EDUCATION AND RESEARCH BHOPAL

Abstract

There is substantial evidence for post-collisional geological records associated with the India-Asia collision during the Cenozoic Era. The findings we made from the Wangtu gneissic complex (WGC) in Lesser Himachal Himalaya have revived the discussion over the existence of pre-Himalayan metamorphism. We studied the mineral chemistry and monazite geochronology of two metamorphic gneisses close to the Karcham granite intrusion, as well as the thermal effects of these granites on the adjacent Wangtu gneisses. The dating of zircon by the ID-TIMS method in two granite samples yields ages of 1872 ± 3 Ma and 1861 ± 13 Ma. Karcham granites exhibit similarities to porphyry-type granite, characterized by the presence of feldspar and quartz clasts, which are wrapped around by biotite and mica minerals. Monazite from the two metamorphic gneisses defines U-Th-Pb total chemical ages of 1900–1800 Ma, with partly more reset values down to 1400 Ma. The partial discordance of both zircon and monazite reflects the Cenozoic tectonics affecting the region.

The other pre-Himalayan metamorphic event is from the Jutogh Group of metasediments in WGC, where chlorite-mica schist, garnet-staurolite schist, and sillimanite-schist develop successively. The formation of chemically zoned garnet at 550 °C to 650 °C and 0.8 to 0.9 GPa, which destabilizes low-temperature assemblages, was predicted by phase equilibria modelling. The retrograde segment consists of exhumation and cooling, which results in a clockwise P-T route. Furthermore, textural observations and in-situ U-Th-Pb total chemical ages show that metasedimentary rocks contain Cambrian monazites. These monazites are around 500 Ma old. The ƐNd[1.8Ga] of Jutogh rocks ranges from -1.97 to -8.14, with depleted mantle-model periods between 3.07 and 2.25 Ga. The age of 472 Ma is determined by combining the isotopic composition of the garnet core and its leachates. A combined isotopic analysis of biotite, garnet rim, and garnet rim leachate yields an isochron age of 454 Ma. Phase equilibria modelling, garnet Sm-Nd isochron, U-Th-Pb monazite and zircon dating, and other evidences suggest that the WGC experienced metamorphism during Proterozoic Columbia assembly and Cambro-Ordovician accretion along the northeast margin of Gondwanaland.

Keyword

Columbia, Gondwanalanad, Lesser-Himalaya, P-T pseudosection, Geochronology

Petrogenesis of Maneswar Complex, Rengali Province, India: Implications for tectono-metamorphic evolution along craton-mobile belt margin

PRIYA PACHAURI[1]*, Geological Survey of India (priyapachauri2610@gmail.com)
ABHINAV OM KINKER[2], Geological Survey of India
ASUTOSH KUMAR TRIPATHY[3], Geological Survey of India
FREDRICK RONALD KISPOTTA[4], Geological Survey of India

Abstract

The Rengali Province is a Neoarchean metamorphic terrane in eastern India sandwiched between Singhbhum Craton (SC) in the north, Bastar Craton (BC) in the west and Eastern Ghat Province (EGP) of Eastern Ghats Belt in the east. Maneswar Complex forms a structurally rigid gneiss-granulite complex exposed in the south-west trending arm of Rengali Province sandwiched between BC and EGP. It comprises charnockite, mafic granulite, and intrusive leucogneiss. Charnockite shows acidic to intermediate nature with opdalite-enderbitic composition. Mineralogically, it is composed of orthopyroxene (Wo1.17-3.35 En41.92-42.85 Fs53.81-56.70) ± clinopyroxene (Wo45.96-47.42 En28.66-31.45 Fs21.93-24.41), k-feldspar (Ab8.3-27.2 An0.1-0.6 Or72.1-91.6), plagioclase (Ab19.4-47.9 An50.9-80.1 Or0.3-1.1), ± garnet, ± biotite, hornblende, quartz, opaque, and zircon. It is metaluminous with calc-alkaline affinity. It shows ferron-magnesian character indicative of rift related environment setting. Coronal garnet formed at the interface between plagioclase and pyroxene denotes isobaric cooling after attainment of peak metamorphism. Mafic granulite is metaluminous and conforms to gabbroic composition. Mineralogically, it is composed of clinopyroxene (Wo31.217-47.68 En29.067-37.35 Fs15.86-32.39) + orthopyroxene (Wo0.814-1.5 En36.02-55.72 Fs43.46-62.91) + hornblende (XMg: 0.33-0.54) + plagioclase (Ab41.9-61.1 An36.8-57.1 Or1-1.8) + garnet (Alm60.35-67.71 Grs18.30-23.43 Py8.68-9.76) + biotite and quartz with apatite, zircon, and ilmenite as accessory mineral constituents. On field, mafic granulite show evidence of incipient melt generation in the form of small, irregular and disconnected patches and anastomosing veinlets of quartzo-feldspathic composition. In tectonic discrimination diagrams, it shows alkali basalt affinity and plot in Ocean Island Arc Tholeiites field. Leucogneiss is intrusive into both charnockite and mafic granulite. It comprises quartz, k-feldspar, and plagioclase with occasional biotite and garnet. It is sheared forming protomylonite to mylonite with strong down dip stretching lineations. It is acidic in composition and conforms to true granitic composition. It is metaluminous with calc-alkaline affinity. In tectonic discrimination diagrams, leucogneiss indicates emplacement in a syn-collision to post orogenic tectonic setting.

The high grade rocks comprising Maneswar Complex suggest a counter clockwise P-T path in metamorphic evolution of the terrain. This is depicted by peak granulite facies metamorphism followed by isobaric cooling. The rocks were then re-equilibrated to amphibolite facies of metamorphism represented by retrogradation of pyroxene to hornblende and biotite. The presence of garnet corona in mafic granulite and charnockite along with presence of decompression related

melt generation forming quartzo-feldspathic bands in mafic granulite suggest rapid upliftment/ exhumation of lower crustal portion. Our field, geochemical and petrological findings will thus help in understanding geo-dynamic processes occurring along craton-mobile belt margin and in comprehending tectonic evolution of Bastar craton.

Keyword

Rengali Province, Bastar Craton, Mafic Granulite, Charnockite, P-T path

Indian Scientific Expedition to Bharati research base for constraining Metamorphic Evolution of Larsemann Hills, East Antarctica

ROSAN KUMAR MALLIK[1]*, GEOLOGICAL SURVEY OF INDIA (rosan.mallik@gsi.gov.in)
ASHISH KUMAR NATH[2], Geological Survey of India, UT: J & K and Ladakh, NR: Jammu, India
AMIT MANDAL[3], Geological Survey of India, SU: WB & AN, ER: Kolkata, India
MOHD YUNUS SHAH[4], Geological Survey of India, UT: J & K and Ladakh, NR: Srinagar, India

Abstract

The ice free Larsemann Hills and adjacent areas in southern Prydz Bay have been recognized as an important juncture of the early Palaeozoic Pan-African (550–500 *Ma*) *high-grade tectonic mobile belt* (*the Prydz Belt*) *in East Antarctica. The geological expedition carried out for constraining tectono-metamorphic evolution of major Peninsulas from Larsemann Hills were mainly Grovnes Peninsula, Brattnevet Peninsula, Fisher island and Stinear Peninsula which represents signature of both Grenvillian and Pan-African orogeny. Grovnes Peninsula preserves low to medium pressure high temperature granulite facies metamorphism during early Palaeozoic* (~515 *Ma to* 530 *Ma*) *exposed in a* 900-490 *Ma deep crustal section. Prograde dehydration melting reactions inferred by inclusion assemblage of sillimanite in garnet and cordierite*; *amphibole in pyroxene, coronal orthopyroxene and clinopyroxene around amphibole and biotite which indicates prograde condition was well within sillimanite stability field. Peak condition estimated to be* 830±25*oC at* ~6.5 *kb for garnet pyroxene granulite and relatively lower P-T range of* 730±25*oC at* 5.5*kb for sillimanite-garnet-cordierite-spinel bearing gneiss. Retrogression defined by isothermal decompression* (*ITD*) *due to exhumation* (*uplift*) *after reaching peak* (*granulite facies*) *followed by isobaric cooling* (*IBC*) *to lower amphibolite facies conditions. Clock-wise evolution path is constrained. CHIME dating reveals prograde isobaric heating might have triggered at waning stage of Grenvillian Orogeny* (~850-900*Ma*), *where heat budget provided by process of crustal thinning. Process might continue up to* 600-550 *Ma to reach peak condition with high P-T sustained by crustal rejuvenation related to collision tectonics during Pan-African Orogeny. Post peak retrogression represented by ITD commenced at* 550 *Ma culminate at* ~490 *Ma through IBC. North* & *South Grovnes belongs to single cratonic block forming two limbs of plunging non-cylindrical fold. Adjacent Brattenevet Peninsula experienced M*1 *metamorphism* (*which is associated with D*1-*D*2) *around* 920 *Ma whereas M*2-*M*3 *occurred between* 530-480 *Ma. In Brattenevet M*2 *event represents peak metamorphism and M*3 *event is a decompression episode of Pan African orogeny* (*rapid uplift and development of*

decompression textures) and a clockwise a P-T path is inferred. There are only Pan-African ages which is obtained from Monazites from orthogneiss and that represents melt from the earlier granulite event (Grenvillian) then metamorphosed and deformed during Pan-African orogeny. The relict ages/older ages estimated in the inclusion monazite indicate Grenvillian metamorphic event. The older (637 Ma) core in monazite present in matrix indicate reset of older event (probably Grenvillian or ca.750 Ma). Similarly, adjascent Fisher island, experiences peak M2 metamorphism in garnetiferous gneiss is 835oC with a reference pressure of 6.5 Kb. For the pyroxene granulites peak P-T condition at M2 can be estimated as 870oC at reference 6.2 Kb whereas Opx-granite attained 865oC at 6.5 Kb and comparatively lower P-T range for the metapelite is estimated as 727oC at 6.0 Kb. The retrograde path is defined by the isothermal decompression due to exhumation (uplift) after reaching the peak (granulite facies) followed by isobaric cooling to lower amphibolite facies metamorphic conditions. Preliminarily, it can be assessed that evidences of Grenvillian and Pan-African ages obtained from in-situ monazites of Larsemann Hills can be constrained

Keyword

East Antarctica, P-T-t evolution, Monazite, Grenvillian, Pan-African orogeny

[Keynote] Phase equilibria computations in Metamorphic Petrology- Applications and limitations

Somnath Dasgupta[1]*, Indian Statistical Institute Kolkata (somnathdasg@gmail.com)

Abstract

Readily available software packages for computing phase diagrams have been extensively used in Metamorphic Petrology for the last three decades. These software packages are regularly updated and have a robust scientific basis. They address major problems related to the stability of mineral assemblages, thermobaric computations, pressure-temperature (P-T) trajectory, prograde and retrograde paths of evolution, change in bulk composition due to fractionation of phases, mass transport, and others. P-T pseudosections are perhaps the most commonly used technique to decipher the P-T evolution of a specific bulk composition. All other properties of the system, such as equilibrium compositions and modal abundance of the phases at different P-T conditions and stability limits of varying mineral phases, are computed from the pseudosection. Therefore, the pseudosection calculation must be robust, and it is necessary to understand the uncertainty limits of the various inferences drawn from it. Several factors contribute to the uncertainties. These are:(a) choice of representative sample volume to compute bulk composition ;(b) estimation of volatile content if volatile-bearing phases are considered; (c¬) choice of thermodynamic database; and, (d) activity-compositional relationships for both the solid and fluid phases. All these factors should be carefully evaluated before constructing a pseudosection. We will demonstrate how these uncertainties may change the interpretations derived from pseudosection analysis. It is suggested that careful petrographic analysis, mineral chemical data, and conventional thermobarometry calculations should precede pseudosection analysis to obtain the relevant boundary conditions.

Keyword

Phase Equilibria, Application, Limitation

Comparing qualitative and quantitative isopleth thermobarometry based on garnet composition

Sara Nerone[1]*, University of Torino (sara.nerone@unito.it)
Pierre Lanari[2], University of Bern
Jacob Benedict Forshaw[3], University of Bern
Chiara Groppo[4], University of Torino
Franco Rolfo[5], University of Torino

Abstract

In modern metamorphic petrology, forward thermodynamic modelling is a common tool for determining the pressure (P) and temperature (T) conditions of mineral formations based on a given bulk composition (X). Mineral compositional isopleths can be used to further refine P–T conditions, known as isopleth thermobarometry. For example, the molar amount of Fe, Mg, Mn, and Ca in garnet is P–T–X dependent; therefore, the observed composition of garnet can be compared to modelled garnet compositional isopleths in order to aid P–T determination. Traditionally, isopleth thermobarometry involves manually tracing the field of maximum isopleth overlap, which can be considered a qualitative method. However, in the last decade, several software solutions have provided more quantitative approaches to calculate the 'optimal' P–T conditions from a statistical point of view, resulting in a more accurate interpretation of forward model results.

This study compares the P–T conditions of garnet formation constrained by the traditional qualitative isopleth thermobarometry approach with those obtained by quantitative methods. Garnet-bearing two-mica schists from the Lesser Himalayan Sequence (LHS) of the Nepal Himalaya are used as a case study. Three different quantitative approaches were tested: (i) a least squares approach, which minimises the difference between the observed and modelled values, referred to as the residue; (ii) a weighted least squares approach, which adds a weighting factor based on the analytical uncertainty; and (iii) a quality factor approach, which assesses the quality of fit between the modelled and the observed compositions. The contents of Fe, Mg, Mn, and Ca in garnet were all considered in the calculation. The results show that using quantitative techniques allows the relative uncertainties in P–T estimates to be considered, especially when the uncertainties in mineral compositions are propagated. Further investigation tests the influence of variations in the calculated bulk rock composition on the model prediction and, hence, on both qualitatively and quantitatively determined P–T conditions.

Keyword

optimal P–T estimations, statistical thermobarometry, quality factor

Phase equilibria and advanced thermobarometric modellings of Paleoproterozoic metapelites of NW Himalaya, India: Implication for its linkage with the Aravalli Supergroup

BIRAJA PRASAD DAS[1]*, DHARANIDHAR UNIVERSITY (birajageology@gmail.com)
Mallickarjun Joshi[2], Banaras Hindu University
Shubham Patel[3], Banaras Hindu University

Abstract

We present here the outputs of petrochemistry, conventional thermobarometry along with Perple_X phase section modelling, and advanced MATLAB based High-resolution garnet P-T path results to the metapelites of Askot Klippe particularly to look for their textural and mineralogical characteristics along with P-T conditions of metamorphism. Askot Klippe in the northwestern Himalaya is one among many detached erosional remnants of an extensive thrust sheet that was extruded from the Higher Himalaya in response to the Cenozoic continental collision. The klippe comprises granitic gneisses of the Ramgarh Group overlain by the metapelitic Almora Group. The Almora Group comprises garnet-cordierite- sillimanite-K-feldspar bearing metapelitic gneisses that are exposed in central parts of the Klippe in a south-verging overturned antiform flanked by successively lower grade schists. We employ multiple pressure-temperature (P-T) path modellings to deduce the tectono-thermal conditions of the klippe. High resolution garnet-based PT path modelling using Theriak-Domino and classical conventional thermobarometric approach are used for the metapelitic schists and gneisses to compare the results. Our results suggest that the metamorphism in rocks of the Askot Klippe exceeded upper amphibolite facies conditions (770oC/6.5 kbar). Comparable litho-tectonic set up, metamorphism, structure, and available dates of ~1830 Ma for the metapelitic gneisses of the Askot Klippe and Almora Nappe suggest that both are Paleoproterozoic and overstepped amphibolite facies P-T conditions. Similarities in metamorphic grades and the dates of metamorphic rocks of Kumaun to the Aravalli rocks together with the relict Aravalli trends in Kumaun Himalaya indicate the metamorphic rocks of Kumaun to be the possible reworked northernmost extensions of the Aravalli rocks.

Keyword

Himalaya, Askot Klippe, High-resolution PT path, Aravalli Supergroup, Phase section modelling

PHASE EQUILIBRIA MODELLING AND PETROLOGY OF PELITIC GRANULITES IN SOUTHEASTERN NIGERIAN BASEMENT COMPLEX: INSIGHTS INTO THE EVOLUTION OF THE TRANS SAHARAN OROGENIC BELT.

Ifeoma Chinwendu AGHAEBITA[1]*, University of Napoli, Federico II, Italy
(aghaebitaifeoma@gmail.com)
Chinedu Uduma IBE[2], University of Nigeria, Nsukka
Smart Chika Obiora[3], University of Nigeria, Nsukka

Abstract

The study area is in the eastern segment of the Benin-Nigerian Shield and underlain by the Nigerian Precambrian basement complex rocks. This metamorphic basement serves as the eastern demarcation of the Trans-Saharan Orogenic Belt (TSOB) within the broader Benin-Nigerian Shield. It consist of migmatitic gneisses and schists, granitoids, metagabbros, metadolerites, meta ultramafic rocks and meta quartz diorites. We present new petrological data and P-T conditions of regional metamorphism in the framework of the evolution of the Trans Saharan Orogenic belt. The migmatized pelitic schist exhibits prominent peak mineral assemblage, comprising plagioclase + quartz + K-feldpar + biotite + garnet + sillimanite + rutile and liquid. Through geochemistry and phase equilibria modelling, the peak metamorphic conditions have been constrained between 900 and 940 °C at a pressure of 7–10 kbar. Furthermore, retrograde conditions have been deduced based on an assemblage of plagioclase, quartz, muscovite, biotite, cordierite, rutile, and sillimanite, with pressure-temperature estimates ranging from 2.2 kbar/642 °C to 3.8 kbar/800 °C. The findings of this research represent the initial substantiation of granulite-facies metamorphism in the southeastern part of the Benin-Nigerian Shield. The identified P-T path implies a geological context characterized by continent-continent collision, indicative of the region's evolution in connection with the subsequent development of the Trans-Saharan Orogenic Belt.

Keyword

P-T condition, metamorphism, phase equilibria, modelling, Trans Saharan Orogenic belt

Metamorphic P-T paths and timing of garnet-mica schists from the Mianlüe Tectonic Zone: Insight into the early Mesozoic collisional thickening of the South Qinling orogen, Central China

Sang Wan PAK[1]*, Northwest University (flyingwing44@icloud.com)
Xiao Ying Liao[2], Northwest University
liang liu[3], Northwest University

Abstract

The Mianlüe Tectonic Zone (MTZ), marking the boundary between the South and North Qinling, is a pivotal area for understanding the tectonic evolution of the Qinling orogenic belt. This study, through detailed petrography, mineral chemistry, phase equilibria modeling, and zircon U-Pb dating, aims to investigate the metamorphic P-T-t path of two metapelites within the MTZ. Results show that, before reaching the peak stage, temperatures ranged from 510°C to 530°C with pressures between 4.0 and 6.1 kbar, displaying a peak pressure metamorphic mineral assemblage indicative of amphibolite facies conditions with temperatures from 580°C to 595°C and pressures from 9.2 kbar to over 10.1 kbar. Peak temperature conditions ranged from 625°C to 660°C with pressures between 6.0 and 6.8 kbar. Retrograde metamorphism was observed, with temperatures and pressures measured at 575°C to 600°C and 2.0 kbar to 5.0 kbar, respectively. These stages form a clockwise P-T evolutionary trajectory, reflecting an initial increase in temperature followed by a subsequent decrease in both temperature and pressure. Zircon U-Pb ages indicate that the protolith ages fall between 700~950 Ma and 1051 ± 120 Ma, with peak metamorphism occurring at 236 ± 20 Ma and retrograde metamorphism at 208 ± 18 Ma and 208 ± 5.3 Ma, aligning with the late Triassic continental collision processes in the MTZ. Furthermore, the discovery of Neoproterozoic ages for the protoliths of high-pressure rocks challenges previous interpretations that the Mianlüe tectonic belt was primarily associated with oceanic crust subduction, suggesting instead a complex zone of plate-shaped ophiolite and tectonic mixed rocks. It has been determined that the Mianlüe Ocean opened in the Middle Devonian, reached its expansion peak during the Carboniferous-Permian period, and finally closed in the early to middle Triassic. However, recent years have yielded a significant amount of Neoproterozoic age data from representative ophiolite sections in this structural belt, indicating earlier subduction events and underscoring the role of the MTZ in the broader tectonic evolution of the South Qinling belt. This study offers critical insights into the formation and evolution of collisional orogens, emphasizing the significance of high-grade metamorphism as a record of orogenic processes.

Keyword

early Mesozoic, collisional, garnet-mica schists, P-T-t path, Mianlüe Tectonic Zone

P-T pseudosection and garnet diffusion modeling of phengite eclogite from Yuka terrane, North Qaidam

Rong-Guo Hu[1]*, College of Earth Sciences,Guilin University of Technology (hurongguo@glut.edu.cn)
Zhong-Tian Hu[2], College of Earth Sciences,Guilin University of Technology
Xi-Jun Liu[3], College of Earth Sciences, Guilin University of Technology

Abstract

Eclogitic facies meta-mafic and -pelitic rocks are widespread crop out in the Yuka terrane, the north Qaidam Orogen, NW China. In order to evaluate their P–T metamorphic evolution and uplift/exhumation rates and mechanisms, detailed petrographic observation, mineral chemistry, P–T pseudosections and garnet diffusion modeling are performed on a phengite eclogite from this terrane. The phengite eclogite consists mainly of garnet, clinopyroxene, amphibole, phengite, quartz, and minor rutile, titanite, apatite, epidote, plagioclase and biotite. Based on microstructural observations, mineral relationships and different garnet domains, five metamorphic stages and related mineral assemblages have been recognized: M0) GrtC + Omp0 + Amp0 + Ph0 + Rt + Qz; M1) GrtM + Omp0 + Amp0 + Ph0 +Ttn + Qz; M2) GrtIR + Omp1 + Ph1-1 + Rt + Qz/Ceo; M3) GrtOR + Omp2 + Ph1-2 + Rt + Qz; M4) Cpx1/2 + Pl1/2 ± Amp1/2 ± Qz. The prograde stages of M0 and M1 conditions are recorded by garnet core and mantle domains, as well as minerals inclusions preserved in these domains, which are constrained at P–T conditions of ~575°C and 24.6~25.4 kbar, ~585°C and 22.5~23.1 kbar, respectively. The peak eclogite-facies metamorphic condition (M2) is represented by garnet inner rim domain and phengite core domain, which can be constrained at P–T conditions of ~600°C and ~28.6 kbar. The initial retrograde metamorphic condition (M3) at ~615°C and 25.1~25.5 kbar is marked by garnet outer rim domain and phengite mantle domain. During the subsequent exhumation, the eclogite underwent variable developed amphibolite-facies retrogression and experienced significant cooling to nearly 580°C, recorded by the breakdown of garnet and omphacite and the appearance of Cpx1/2 + Pl1/2 ± Amp1/2 ± Qz (M4) symplectite. The P-T path suggests that the phengite eclogite underwent at least two burial-exhumation cycles. The forward diffusion modeling further reveals the second exhumation process from ca. 92 km to ca. 81 km lasted only ca. 3 Myr, revealing an exhumation rate of ca. 4 mm/yr. We posit that the convective flow in the subduction channel is probably the most reasonable incentive for the first pressure reversal and uplift scenario. In contrast, the second pressure decompression and relatively fast exhumation process after the peak metamorphism could most likely be triggered by buoyancy forces with the assistance of channel flow due to slab rollback or oceanic crust breakdown.

Keyword

Eclogite, phase equilibrium modeling, garnet diffusion modeling, subduction channel, Yuka

terrane

The contribution of serpentinite to crust-mantle interaction and arc magma formation in subduction zones

Yi-Xiang CHEN[1]*, School of Earth and Space Sciences, University of Science and Technology of China, Hefei, 230026, China (yxchen07@ustc.edu.cn)

Abstract

Serpentinites play an important role in crust-mantle interaction and arc magma formation in subduction zones. However, it is usually difficult to trace the serpentinite signature in deeply subducted crustal rocks or in arc magmas. Therefore, we need to develop effective geochemical tracers to address this issue. Boron and Mg isotope compositions have increasingly used to track the effect of serpentinite derived fluids in crust-mantle interaction. This is because serpentinite derived fluids have been documented to show high Mg-B contents and heavy Mg-B isotope compositions even at subarc depths, which are distinct from fluids released from AOC and sediments. In this talk, I will introduce our work on Mg-B isotope studies of fluid-metasomatized rocks from the western and eastern Alps, as well as the South Sandwich island arc magmas. We show that the greatly elevated Mg and B isotope compositions in the fluid metasomatized rocks formed at forearc to subarc depths of Alps can be unambiguously ascribed to the infiltration of fluids derived from serpentinites. In addition, by integrated Mg-B isotope analyses of South Sandwich island arc magmas, we find that they show the heaviest Mg and B isotope compositions among worldwide arc magmas. This unique signature can be attributed to a serpentinite component. However, by combined Mg-B isotope compositions, we propose that the traditional model, i.e., fluid-flux melting of mantle wedge cannot explain simultaneously the Mg and B isotope composition of the arc magma. Instead, the origin of the unique geochemical composition of the arc magma can be explained well by partial melting of serpentinite mélange in subduction zones.

Keyword

subduction zone fluids, serpentinite, crust-mantle interaction, arc magma, Mg-B isotope compositions

Magnesium isotope constraints on the role of recycled carbonate-rich sediments in the formation of ultrapotassic magmatic rocks at a continental arc setting

chen yu[1]*, University of Science and Technology of China (chenyu123@mail.ustc.edu.cn)
Chen yi xiang[2], University of Science and Technology of China

Abstract

The formation process of orogenic ultrapotassic magmatic rocks, especially the role of carbonate metasomatism in the mantle source at an oceanic subduction setting, is still unclear. To address this problem, whole-rock Mg-Sr-Nd isotope compositions were measured for ultrapotassic magmatic rocks from the Central Pontides arc, northern Turkey. These ultrapotassic rocks have relatively low (87Sr/86Sr)i of 0.70461-0.70687 and εNd(t) values mostly of 0.3 to 2.6. Such rocks display δ26Mg values, much lower than the normal mantle values. The petrological and geochemical results indicate that the low δ26Mg values do not result from surficial weathering, diffusion or magmatic differentiation, but instead reflect the distinct Mg isotope compositions of the mantle source. The geochemistry features suggest that the low δ26Mg values cannot originate from the recycled carbonated eclogites. Instead, such a signature is probably induced by the contribution of carbonate-rich sediments to the mantle source. Using two end-member mixing of Mg-Sr isotope compositions, the mantle source of the ultrapotassic rocks is constrained to contain various proportions of carbonates, mostly dolomite. Based on the carbonate stability field and trace element compositions, the ultrapotassic rocks were possibly produced at depths of 100~150 km. In this regard, the enrichment of K and other large ion lithophile elements in the ultrapotassic rocks can be induced by the contribution of silicic sediments. Meanwhile, carbonatitic melts can be formed through partial melting of carbonate-rich sediments in the subducting oceanic slab, which then react with the overlying mantle to form carbonated peridotite that serves as the source of ultrapotassic rocks with low-δ26Mg, low-silica, and high-LREEs. This study reports for the first time the Mg isotope data of ultrapotassic rocks formed in a continental arc setting and documents that carbonate-rich sediments play an important role in the formation of such rocks. Future work is needed to test if this process is common at both oceanic arc and continental arc settings.

Keyword

Ultrapotassic rocks, Mg isotopes, Carbonate metasomatism, Subduction zones, Neotethys Ocean

Supercritical fluids in subduction zones and their geochemical effects

Ren-Xu Chen[1]*, University of Science and Technology of China (chenrx@ustc.edu.cn)
Tie-Nan Chen[2], University of Science and Technology of China

Abstract

Supercritical fluids are ideal media for mass transfer from the subducting slab into the mantle wedge because of their high solubility of elements but low viscosity. Studying supercritical fluids is important for understanding the processes and mechanisms of crust–mantle interactions, the compositions of arc magmas, and the recycling of crustal material at convergent plate boundaries. We carried out geochronology, petrology, and geochemistry on a coesite-bearing eclogitic vein and its surrounding eclogites from the Dabie orogen. The results are used to reveal the composition and source of supercritical fluids, the P–T conditions and timing of their formation and their geochemical effects in subduction zones. The eclogitic vein is composed of garnet, omphacite, quartz, amphibole, rutile and apatite, with minor amounts of epidote, plagioclase and zircon. Coesite was identified in omphacite in the vein, demonstrating its formation under ultrahigh-pressure (UHP) metamorphic conditions that correspond to subarc depths in oceanic subduction zones. Zircon and rutile U–Pb dating yields ages of ca. 220 Ma, consistent with their crystallization at the UHP eclogite facies. Multiphase crystal inclusions (such as omphacite, quartz, epidote, apatite, amphibole, plagioclase, mica, rutile, calcite, and anhydrite) as well as liquid and gas phases of H2O were observed in the vein. The mineral element and isotope compositions of the vein and its host eclogites suggest that the vein was formed by supercritical fluids derived from dehydration of the eclogite. The fluid was recovered to have a composition of 31 wt.% SiO2, 20 wt.% CaO, 10 wt.% (SO4)2-, 8 wt.% (CO3)2-, 8 wt.% FeO, 7 wt.% Al2O3, and 9 wt.% H2O, with traces of Na2O, K2O and TiO2. The dehydration of subducting eclogites at subarc depths can produce supercritical fluids with suprachondritic Nb/Ta ratios. The UHP eclogites and mantle wedge peridotites metasomatized by supercritical fluids can acquire suprachondritic Nb/Ta ratios and thus provide a complementary reservoir to balance subchondritic reservoirs on Earth. The supercritical fluids are oxidizing and can oxidize the metasomatized rocks. The supercritical fluids are thus efficient carriers of oxidized components from the slab to the mantle wedge, eventually contributing to the oxidization of the arc magma source. The vein has heavier Fe-Mg isotopic compositions compared to the eclogites. The metasomatism of supercritical fluid causes the elevation of δ56Fe and δ26Mg values in garnet and omphacite in eclogites, suggesting that the supercritical fluids have higher δ56Fe (0.34-049‰) and δ26Mg (0.30-037‰) values than aqueous solutions and hydrous melts. Theoretical modeling suggests that supercritical fluid canstrongly influences the Fe isotopic composition of mantle wedge peridotite and thus can explain the Fe isotope variation in some arc magmatic rocks.

Keyword

Supercritical fluid, Eclogite, Subduction zone, Oxygen fugacity, Vein

The processes of serpentinization in subduction zones: Reaction rates and hydrogen (H2) generation

Ruifang HUANG[1]*, South China Sea Institute of Oceanology, Chinese Academy of Sciences (ruifanghuang_geo@163.com)
Weidong Sun[2], Institute of Oceanology, Chinese Academy of Sciences
Xing Ding[3], Guangzhou Insitute of Geochemistry, Chinese Academy of Sciences
Xiuqi Shang[4], Institute of Oceanology, Chinese Academy of Sciences

Abstract

Serpentinization is a low-temperature (≤500 °C) hydrothermal alteration of ultramafic rocks (commonly komatiite and peridotite). During serpentinization, olivine and pyroxene are reacted with aqueous fluids, producing serpentine, (±) talc, (±) brucite, and (±) magnetite. Serpentinization greatly influences geodynamics and the recycling of volatiles (such as H2O, carbon, and sulfur) in subduction zones. Serpentinites contain abundant H2O, up to 13.5 wt%, and they are also enriched in carbon and sulfur. High-pressure experiments have suggested that serpentine remain stable at a depth of >150 km. Therefore, serpentinization plays an important role for the recycling of volatiles. In particular, serpentinization produces hydrogen (H2), and the formation of H2-bearing fluids may greatly influence oxygen fugacity of fluids in subduction zones.

In spite of the significance of serpentinization, the mechanisms that control the rates of reaction and H2 generation remain poorly constrained. Experiments about the kinetics of serpentinization have been performed mostly using olivine and pure H2O as starting reactants, at temperatures of ≤300 °C and pressures of ≤2.0 kbar. Compared to synthetic forsterite, natural olivine has much slower rates of serpentinization, around 2-3 orders of magnitude slower. We have carried out serpentinization experiments at 300 °C and 3.0 kbar using natural peridotite, and found that peridotite has much faster rates of serpentinization compared to natural olivine, resulting from the influence of pyroxene and spinel (Huang et al., 2017, 2023). Hydrothermal experiments were also performed at 400-500 °C and 3.0-20 kbar, and the kinetics of peridotite serpentinization are around 1-2 orders of magnitude faster compared to the rates of olivine hydrothermal alteration. The pH and salinity of fluids strongly influence the kinetics of serpentinization (Huang et al., 2023).

Hydrogen generation during serpentinization can be greatly influenced by temperature, pyroxene and spinel, and fluid salinity (Huang et al., 2023). Compared to olivine, peridotite serpentinization produces larger amounts of H2, which reflects the effect of pyroxene and spinel. Spinel, aluminum, and chromium significantly enhance H2 generation. In contrast, pyroxene inhibits H2 production by around 1-2 orders of magnitude (Huang et al., 2021). Serpentinization of olivine produces ultra-reducing fluids, with oxygen fugacities down to FMQ-4.5, where FMQ represents

fayalite-magnetite-quartz buffer assemblage. This suggests that serpentinization greatly decrease oxygen fugacities of fluids in subduction zones.

References:

Huang, R. F., Song, M. S., Ding, X., Zhu, S. Y., Zhan, W. H. & Sun, W. D. (2017). Influence of pyroxene and spinel on the kinetics of peridotite serpentinization. Journal of Geophysical Research: Solid Earth, 122, doi:10.1002/2017JB014231.

Huang, R. F., Ding, X., Sun, W. D. & Shang, X. Q. (2021) Contrasted effect of spinel and pyroxene on molecular hydrogen (H2) production during serpentinization of olivine. Minerals, 11, 794, https://doi.org/10.3390/min11080794

Huang, R. F., Shang, X. Q., Zhao, Y. S., Sun, W. D. & Liu, X. (2023). Effect of fluid salinity on reaction rate and molecular hydrogen (H2) formation during peridotite serpentinization at 300 °C. Journal of Geophysical Research: Solid Earth, https:doi.org/10.1029/2022JB025218.

Keyword

Serpentinization, reaction rates, hydrogen formation, subduction zones

Hydrogen solubility of stishovite provides insights into water transportation to the deep Earth

Lei Kang[1]*, State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University (kanglei@nwu.edu.cn)
Mengdan Chen[2], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University
Liang Liu[3], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University
Danling Chen[4], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University
Changxin Yin[5], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University

Abstract

Water plays a crucial role not only in the origin and evolution of life but also in various Earth processes, including slab subduction, crust–mantle reaction, and recycling. During slab subduction, water is transported from the Earth's surface to its interior through subduction zones, and a significant amount of water returns to the surface mainly through magmatism, thus forming a large-scale water cycle. In subducting slabs, hydrogen exists in melts, fluids, fluid inclusions, hydrous minerals (e.g., amphibole and mica), and nominally anhydrous minerals (NAMs). Stishovite, a prominent mineral present in subducting slabs, remains stable at mantle pressures of 9–50 GPa and can incorporate various amounts of water (H^+, OH^-, and H_2O) in its crystal structure. Consequently, stishovite can play a crucial role in transporting water into the deep Earth through subducting slabs.

This study provides a comprehensive review and exploration of water solubility in stishovite, hydrogen incorporation mechanisms, and governing factors. Also, we have constructed a new model for water solubility in Al-bearing stishovite and delved into stishovite's role in transporting water through a subducting slab and implications for water distribution in the deep Earth. The key conclusions can be summarized as follows:

1. Water solubility in stishovite exhibits a positive correlation with Al content, which increases water concentrations via coupled substitution $Al^{3+} + H^+ \rightarrow Si^{4+}$ and enhances the incorporation of interstitial H_2O by Al substitution-induced expansion of the stishovite structure.
2. The calculation results based on our new model demonstrate that Al-bearing stishovite's water solubility strongly depends on pressure, exhibiting a positive correlation below 22–32 GPa and a negative correlation above, indicating a peak solubility range at 22–32 GPa, while temperature dependence is weakly negative up to 30 GPa and weakly positive beyond.
3. Following a cold subduction slab geotherm, Al-bearing stishovite's water solubility increases from 998 wt ppm at 14 GPa to 1317 wt ppm at 22 GPa. This suggests that stishovite can potentially accommodate water released from the breakdown of hydrous minerals, contributing to the water-rich transition zone.

However, several crucial unanswered questions persist in research on the water solubility of stishovite: (1) the solubility of Al and its impact on water solubility across varying pressure–temperature conditions require clarification; (2) the roles of minor elements like Fe and Ti, as well as oxygen fugacity, remain unclear; (3) partitioning coefficients governing water distribution between stishovite and other major phases (e.g., Cpx, Grt, and melts) during slab subduction are not yet understood; and (4) the new model for water solubility in Al-bearing stishovite proposed in this paper needs refinement through systematic experiments conducted under controlled conditions. These issues are essential for understanding how water is transported into the deep Earth during subduction and require further detailed experimental and simulation-based investigations to address.

Keyword

Stishovite, Water solubility, Water transportation, Subduction zone, Deep Earth

Imprints of eclogite-facies metasomatism in the North Balkhash ophiolite zone (Central Kazakhstan, west Central Asian Orogenic Belt)

Anfisa SKOBLENKO[1]*, Geological Institute of the Russian Academy of Sciences (an.pilitsyna@gmail.com)
Sergei SKUZOVATOV[2], Vinogradov Institute of Geochemistry, Russian Academy of Sciences, Siberian Branch
Valentina BATANOVA[3], Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, IRD, IFSTTAR, ISTerre, Grenoble, France

Abstract

The North Balkhash ophiolite zone (NBOZ) situated in the Central part of the Kazakhstan orocline, comprises serpentinite mélange with large blocks of igneous, metamorphic and metasomatic rocks along with varisized slivers of volcanogenic-sedimentary strata. The latter mostly include Middle-to-Upper Ordovician silicic-basaltic or volcanoclastic lithologies. Plutonic ophiolitic suites are attributed to residual dunite-harzburgite and layered dunite-wehrlite-pyroxenite-gabbro-plagiogranite complexes of 530–520 Ma in age. Separated blocks of plagiogranites aged 500-480 Ma distributed in the mélange, are assigned to derivatives of subducted basaltic oceanic crust and record the latest Cambrian-Early Ordovician stage of intraoceanic island-arc magmatism within the NBOZ.

Metamorphic formations hosted by serpentinite mélange, constitute varisized blocks up to several meters long, and include variously retrograded phengite-bearing epidote-glaucophane eclogites and garnet blueschists, which are immediately associated with the lower-grade metavolcanoclastic and albite-rich schists with various modal proportions of sodium-rich amphibole. The high-pressure rocks follow a clockwise ‘subduction-type’ evolution with the estimated near–peak stage parameters at ca. 1.6–1.9 GPa and 500–560°C beyond lawsonite stability field. 40Ar-39Ar phengite ages of ~491 Ma and ~465 Ma obtained for the eclogites and garnet blueschists, respectively, are interpreted to reflect the near-peak to early retrograde stages of rock evolution and mark two diachronous episodes of high-pressure re-equilibration within the NBOZ.

The epidote-glaucophane eclogites possess banded structure; the least retrograded micro-layers comprise near-peak assemblage of garnet porphyroblasts associated with oriented crystals of omphacite (Jd35-42Ae12-18), Sr-rich epidote (up to 0.86 wt.% of SrO), apatite aggregates up to several mm in size, Fe-Mg chlorite, minor kataphorite rimmed by glaucophane, rutile surrounded by titanite, and minor quartz. Eclogitic garnets contain occasional inclusions of aegirine-rich clinopyroxene (Jd21-31Ae43-55), apparently corresponding to relics of significantly oxidized prograde assemblage entrapped during early garnet growth. Intensively amphibolised bands intercalating with omphacite-rich layers, are composed of idioblastic garnet, ubiquitously developed Ca-Na amphiboles, epidote (SrO of ~0.1 wt.%) with Ba-rich phengite and chlorite, which frequently form veins or replace garnet, and subordinate omphacite (Jd31-37Ae8-11). Fine-grained titanite and zircon (~30-50 μm) are widespread in the rock matrix. Both amphiboles and epidotes demonstrate notable contents of LREE and U (up to 27 ppm in epidote), whereas

omphacites are enriched in transition metals (46-84 ppm of Sc; 411-628 ppm of V). Retention and enrichment in LILEs (particularly Ba, U, LREE, and Sr) by the peak eclogitic assemblage may have therefore record the interaction with sediment-derived fluids through devolatilization of downgoing slab during high-pressure re-equilibration at ca. 491 Ma, whereas serpentinite-derived fluids could contribute to selective enrichment in transition metals. Fluid-assisted recrystallization is proposed for the garnet blueschists and associated albite-rich schists, which is reflected by high total contents of LREE, LILEs, U, and variable modal amounts of barite and apatite. It has been proposed that tectonic slices comprised by fluid-modified metamorphic formations of various grades were tectonically juxtaposed at different levels in the subduction channel at ca. 465 Ma, and were subsequently exhumed in the Late Ordovician.

The research has been carried out following the plans of the scientific research of the GIN RAS (FMMG-2023-0009).

Keyword

Central Asian Orogenic Belt, Eclogite, Fluid-mediated re-equilibration, High-pressure metamorphism, Subduction channel

Fluid inclusions of ophicarbonates in Oman and Western Alps ophiolite and carbonation experiments of mantle minerals

Tatsu KAWAMOTO[1]*, Shizuoka University (kawamoto.tatsuhiko@shizuoka.ac.jp)
Tomohiro Inukai[2], Shizuoka University
Christian Nicollet[3], Université Clermont Auvergne
Kenneth Koga[4], Université d'Orléans
Estelle Rose-Koga[5], Université d'Orléans
Baptiste Debret[6], Sorbonne Université
Miki Tasaka[7], Shizuoka University
Hajime Taniuchi[8], AIST

Abstract

Carbonated serpentinites, ophicarbonates, are exposed in ophiolites that can be remnants of oceanic lithosphere. Multiple generations of fluid for carbonation are recorded in fluid inclusions of ophicarbonates in the Oman and the Chenailet and the Lago Nero ophiolites on the Franco-Italian border in the Western Alps. The Oman ophiolite records oceanic lithosphere in fast-spreading ridges, whereas the Chenailet and the Lago Nero ophiolites in slow-spreading ridges. The fluid inclusions of ophicarbonates are studied with Raman microscopy and microthermometry, revealing saline fluid inclusions commonly found in the carbonates. Their homogenization temperature ranges from 100 to 220 °C, suggesting they are hydrothermal origins. Three types of fluid inclusions are observed in the ophicarbonates studied in the Oman and the Western Alps: (1) fluid inclusions show a wide range of salinities from 0-11 wt. % NaCl eq., suggesting seawater boiling and subsequent variable mixing of brine and steam in the ophicarbonate of the Chenaillet and Lago Nero ophiolites, (2) fluid inclusions with an average of 5 wt. % NaCl eq., a little higher than seawater, which may circulate beyond the Moho and form veins into the oceanic mantle harzburgite of the Oman ophiolite, (3) meteoric water during obduction processes in the Oman ophiolite with low salinities of 0–1 wt.% NaCl eq. The role of slab-derived fluids in ophicarbonates can be understood by studying meta-ophicarbonates in the Queyras (France) and Monviso (Italy) regions of the Western Alps.

Carbonate ions are more soluble in saline fluids than in fresh water. It is reasonable to observe the saline fluids in carbonate minerals, though the fluid inclusions with low salinities are also found as seen in the third type mentioned above. Not only salinity, but pH may have great effects on the carbonate solubility especially in shallow levels. To understand the conditions for carbonation of these serpentinites, experiments have been conducted in which mantle rocks have been reacted with H2O-CO2 fluids using hydrothermal apparatus under 300–400 °C at 180 MPa with NNO oxygen buffer. The starting materials (olivine, antigorite with/without diopside) are used. In addition to magnesite and talc, quartz is also found. Experiments with magnesium-end components are largely consistent with previous work in the MgO-SiO2-H2O-CO2 system [Johannes (1969) American Journal of Science, 267, 1083-1104]. Various reactions have been

observed in the olivine-diopside and serpentine-diopside systems. The experimental results show that the carbonation of serpentine is accompanied by a dehydration reaction. Under all experimental conditions, the volume of the solid phase increases during reactions. The addition of a carbon dioxide-containing fluids to serpentine causes both dehydration and an increase in solid volume. Carbonate veins are commonly found in serpentinite in nature. In most cases, calcite veins are formed, but in the present experiments, only magnesite or dolomite is formed, at least at temperatures above 300°C. We conclude that natural carbonation reaction in ophicarbonates occur at low temperatures below 300°C or the fluids carry Ca, which may come from sedimentary or mafic rocks.

Keyword

ophicarbonate, saline fluids, seawater, listvenite, hydrothermal fluids

Halogen cycling at the slab-mantle interface: constraints from metabasites from SW Tianshan, China

Zheng-Hua Pan[1]*, University of Science and Technology of China (zhpan0@mail.ustc.edu.cn)
Ren-Xu Chen[2], University of Science and Technology of China

Abstract

Halogens play an important role in fluid activity and mass transfer in the Earth's interior. Halogens are enriched in surface reservoirs but depleted in the mantle. Subduction processes can transfer halogens to the deep Earth, leading to the formation of enriched components. A systematic study of whole-rock and mineral F and Cl concentrations was carried out for a series of blueschists, high-pressure (HP) eclogites and ultrahigh-pressure (UHP) eclogites from the Chinese southwestern Tianshan. In combination with whole-rock and mineral element compositions, phase equilibrium modeling and apatite U–Pb dating and element data, the results are used to constrain the halogen storage and transport in the subducting oceanic crust. Fluorine contents decrease from the blueschists to the UHP eclogites, whereas Cl contents increase from the blueschists and HP eclogites to the UHP eclogites. Combined with the halogen compositions of their possible protoliths, it is inferred that most of the Cl was lost, whereas F was retained during subduction of the oceanic crust to blueschist facies. Minerals in the UHP eclogites exhibit elevated Cr and Co contents and Ba/Th ratios, indicating that the infiltration of serpentinite-derived fluids resulted in Cl enrichment in the UHP eclogites. Reconstruction of whole-rock F and Cl contents from mineral models and halogen concentrations indicates continuous F and Cl loss from subducting oceanic crust during prograde metamorphism from the blueschist to UHP eclogite facies. The F loss from the subducting oceanic crust is consistent with the decreases in F contents in glaucophane, phengite and apatite. Apatite hosts 73-77% of the F in the rock and thus is the main F-host mineral in the subducting oceanic crust. Due to the different behaviors of F and Cl, the fluids released from the subducting oceanic crust had low F/Cl ratios before blueschist facies but high F/Cl ratios during prograde metamorphism from blueschist- to UHP eclogite-facies. The UHP eclogites metasomatized by serpentinite-derived fluids exhibit significantly higher Cl contents and comparable F contents relative to UHP serpentinites. This difference suggests that halogen-enriched UHP eclogites are important carriers of volatiles to subarc depths and beyond. Changes in the halogen composition of the subducting oceanic crust and halogen flux between different lithologies in the subduction channel significantly affect the element solubility in metamorphic fluids and thus the mass transfer from the subducting slab to the overlying mantle wedge.

Keyword

Apatite, Halogen, Fluid activity, Eclogite, Subduction zone

Fluid-mediated Cu and Zn isotopic fractionation in subduction zones: Constraints from high pressure veins within eclogites in the Dabie Orogen

Jian HUANG[1]*, University of Science and Technology of China (jianhuang@ustc.edu.cn)
Shu Bin Fang[2], University of Science and Technology of China
Shun Guo[3], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Fluids released by subducted slab is an important medium of material and energy exchange in subduction zones. High-pressure (HP) veins in eclogites are the products of fluid-rock interaction and provide insight into the composition and evolution of fluids in subduction zones. We here present the Cu and Zn isotopic data for different types of HP veins and their host eclogites from Ganghe and Hualiangting in the Dabie Orogen to reveal the behavior of Cu and Zn isotopes during fluid-rock interaction and fluid evolution. The HP veins include omphacite-epidote (Omp-Ep), epidote-quartz (Ep-Qtz), and kyanite-epidote-quartz (Ky-Ep-Qtz) veins. The Omp-Ep veins first crystallized from eclogite-derived, solute-rich fluids with the Ep-Qtz and Ky-Ep-Qtz veins successively crystallizing from the residual fluids after the Omp-Ep vein formation. The early Omp-Ep veins have variably lower δ65Cu (−1.32 to −1.12‰ at Ganghe, -0.70 to -0.66‰ at Hualiangting) but higher δ66Zn (0.36 to 0.38‰ at Ganghe, 0.40 to 0.41‰ at Hualiangting) relative to the host eclogites (δ65Cu: -0.71 vs. 1.84‰, δ66Zn: 0.22 vs. 0.33‰), indicating Cu-Zn isotope fractionation during slab dehydration in subduction zones with the lighter Cu and heavier Zn isotopes preferentially entering the vein-forming fluids from the eclogites. Systematic increase of δ65Cu from the Omp-Ep (−0.70 to −0.66‰) through Ep-Qtz (0.01‰) to Ky-Ep-Qtz veins (0.46 to 0.95‰) can be attributed to isotope fractionation induced by redox changes during the evolution of metamorphic fluids, as revealed by the negative correlations of δ65Cu with $Fe^{3+}/\Sigma Fe$ and $(Eu/Eu^*)_N$ in these veins. Additionally, the higher δ66Zn of the Omp-Ep veins relative to the Ky-Ep-Qtz veins can be explained by equilibrium isotope fractionation between crystallized minerals and evolved metamorphic fluids. Our results thus demonstrate that Cu-Zn isotopic fractionation occurred during the evolution of slab-derived metamorphic fluids in subduction zones. Incorporation of such fluids to the mantle can cause Cu-Zn isotopic heterogeneity observed in mantle rocks and their derivative melts. Thus, Cu-Zn isotopes can be used as sensitive tracers of element migration and oxygen fugacity variation during crust-mantle interaction.

Keyword

Cu and Zn isotopes, metamorphic veins, fluid-rock reaction, fluid evolution, crust-mantle interaction

"Detrital" zircons in eclogite: their origin and implications for mass transfer

Taehwan KIM[1]*, Korea National University of Education (taehwan.kim@knue.ac.kr)
Yoonsup Kim[2], Chungbuk National University
Moonsup Cho[3], Seoul National University
Keewook Yi[4], Korea Basic Science Institute
Jong Ik Lee[5], Korea Polar Research Institute

Abstract

Theoretically, the crystallization and preservation of zircon in mafic magma is unlikely because of its high solubility. Zircons appear, however, in basalts/gabbros, peridotites and kimberlites. The origin of zircon in (ultra)mafic rocks has been accounted for by igneous processes such as the incorporation of xenocrysts during magma emplacement and magmatic growth from late-stage melts. Post-magmatic processes include metasomatism and even fluid-mediated migration. In this study, on the basis of age, isotopic composition and REE pattern of eclogite zircons, we demonstrate the incorporation of “detrital” zircon xenocrysts and discuss implications on their origin and mass transfer in arc-related settings.

Zircon separates of a coarse-grained eclogite sample from the Antarctic Ross orogen are overwhelmingly rich, and as abundant as being comparable with those of common siliciclastic sedimentary rocks. Zircons vary in size and shape, and primarily consist of an inner zone with heterogeneous CL intensity and texture surrounded by outer zone. The zircon inner zone encloses non-HP minerals such as chlorite, biotite, feldspars, and titanite, while the outer zone captures eclogitic minerals such as omphacite, phengite, and rutile. The inner zones widely vary in both age (n = 70) and REE pattern, the former spanning the Paleoproterozoic (c. 2.29 Ga) to the Early Cambrian (c. 530 Ma). The Cambrian ages of the zircon outer zones record the timing of subduction-zone metamorphism as early as c. 528 Ma, based upon the absence of prominent negative Eu anomaly and the flattening of HREE. The age distribution pattern of the zircon inner zone is characterized by bimodal peaks of the Pacific-Gondwanan (c. 700-500 Ma) and Grenvillean (c. 1200-900 Ma) groups, consistent with that of detrital zircons from the Ross-orogen clastic (meta)sedimentary rocks. Ten youngest exotic or “detrital” zircon ages yielded the weighted mean of 546 ± 4 Ma.

We suggest that: (1) the “detrital” zircons in the coarse-grained eclogite sample are not inherited cores indicative of the assimilation process, but likely have been introduced from the surrounding (meta)sedimentary or basement rocks after the solidification of the basaltic igneous protolith; (2) the mechanism responsible for the incorporation of the “detrital” zircon-bearing sediments was likely a solid-state mixing with the eclogite protolith at a subduction front near trench; (3) the zircon xenocryst mixing has taken place not earlier than c. 546 Ma; and finally (4) a material recycling at subduction zone was rapid within <18 Myr duration, encompassing from the emplacement of continental arc granitoids, their exposure to surface and erosion, sediment deposition in an arc-related setting, burial and mixing with the eclogite protolith, and subduction to mantle depth (~60 km) with an average burial rate of >3 mm/yr.

Keyword

Eclogite, Zircon, Xenocryst, Subduction zone, Mass transfer

The fate of methane in subduction zone fluids

Lijuan ZHANG[1]*, Peking University (lijuanzhang@pku.edu.cn)

Abstract

Methane (CH4) is a critical but overlooked component in the study of the deep carbon cycle. Abiotic CH4 produced by serpentinization of ultramafic rocks has received extensive attention, but its formation and evolution in mafic rocks in subduction zone are poorly understood. Massive CH4-rich fluid inclusions are commonly found in ultrahigh-pressure (UHP) eclogites from the Western Tianshan, China. The combination of the petrological observations and thermodynamic models leads to a complete P–T–fO2- fluid evolution trajectory for the CH4-bearing eclogites. During the prograde metamorphism from the blueschist facies at ~50 km to UHP eclogite facies at ~120 km, the carbon species in the aqueous fluids were dominated by reduced CH4. During the exhumation with heating and decompression,the fluid evolved into a CH4-CO2-bearing aqueous fluid and the oxygen fugacity increased to FMQ-1. The reaction CH4 + CO2= 2C + 2H2O could occur, which demonstrates by the Deep Earth Water (DEW) model, and lead to the precipitation of solid graphite. With the progression of decompression and an increase in oxygen fugacity, the carbon species in the fluids completely changed into CO2, which persisted through the epidote-amphibole facies to even shallower depths during exhumation. Therefore, the fluids released by subducted slabs can be initially reduced, but continuously evolves to oxidized during decompression and exhumation, which provides a novel perspective for understanding the redox of arc magma.

Keyword

methane, CO2, graphite, eclogite, Western Tianshan

[Keynote] Formation of abiotic H2 and CH4 in subduction zones

Renbiao TAO[1]*, Center for High Pressure Science & Technology Advanced Research (renbiao.tao@hpstar.ac.cn)
Chao Wang[2], Center for High Pressure Science & Technology Advanced Research
Lifei Zhang[3], School of Earth and Space Sciences, Peking University

Abstract

Subducting slabs could carry large amounts of H2O and CO2 on Earth's surface into the deep mantle (Tao et al., 2018a). Various water-mineral interactions occur in subducting rock systems at high-pressure and high-temperature conditions. At the same time, the redox condition of the slabs will generally decrease along with the subducting processes (Tao et al., 2020). When the redox conditions are low enough, the recycled H2O and CO2 in subducting slabs will be reduced to abiotic H2 and CH4, which may be an important source of deep Energy. In this talk, we will summarize geological observations and experimental simulations of abiotic H2 and CH4 in subduction zones. For example, based on a comparative study between CH4-bearing ultrahigh- and CO2-bearing high-pressure eclogite from the Chinese S.W. Tianshan subduction zone, we proposed the favorable P–T– fO2 conditions for the formation of abiotic CH4 in subducted oceanic crusts (Tao et al., 2018b; Wang et al., 2022). On the other hand, we also carried out a series of high-pressure experiments to investigate the formation mechanism of abiotic H2 and CH4 in FeCO3 + H2O systems at subduction zone conditions (Wang et al., in preparation). Finally, combining petrological observation and high-pressure experimental simulation, we concluded that the subduction zone is a factory for producing abiotic H2 and CH4 at deep mantle conditions.

Reference:

Tao, R., Zhang, L., Li, S., Zhu, J., Ke, S., 2018a. Significant contrast in the Mg-C-O isotopes of carbonate between carbonated eclogite and marble from the S.W. Tianshan UHP subduction zone: Evidence for two sources of recycled carbon. Chemical Geology 483, 65–77. https://doi.org/10.1016/j.chemgeo.2018.02.015

Tao, R., Zhang, L., Tian, M., Zhu, J., Liu, X., Liu, J., Höfer, H.E., Stagno, V., Fei, Y., 2018b. Formation of abiotic hydrocarbon from reduction of carbonate in subduction zones: Constraints from petrological observation and experimental simulation. Geochimica et Cosmochimica Acta 239, 390–408. https://doi.org/10.1016/j.gca.2018.08.008

Tao, R., Zhang, Lijuan, Zhang, Lifei, 2020. Redox evolution of western Tianshan subduction zone and its effect on deep carbon cycle. Geoscience Frontiers 11, 915–924. https://doi.org/10.1016/j.gsf.2019.09.007

Wang, C., Tao, R., Walters, J.B., Höfer, H.E., Zhang, L., 2022. Favorable P–T–fO2 conditions for abiotic CH4 production in subducted oceanic crusts: A comparison between CH4-bearing ultrahigh- and CO2-bearing high-pressure eclogite. Geochimica et Cosmochimica Acta 336,

269–290. https://doi.org/10.1016/j.gca.2022.09.010

Keyword

abiotic formation, Subduction zone, H2 and CH4, metamorphism, experimental simulation

Subducted serpentinite contributes to the formation of arc lavas with heavy Mo isotopic compositions

Fu-Qiang DAI[1]*, Institute of Marine Geology, College of Oceanography, Hohai University (fqdai@hhu.edu.cn)
Yi-Xiang Chen[2], School of Earth and Space Sciences, University of Science and Technology of China
Ren-Xu Chen[3], School of Earth and Space Sciences, University of Science and Technology of China
Zi-Fu Zhao[4], School of Earth and Space Sciences, University of Science and Technology of China
Jie Li[5], State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Yu Wang[6], State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Abstract

The petrogenesis of basaltic arc lavas with heavy Mo isotopic compositions is controversial. Given that oceanic crust preferentially loses isotopically heavy Mo during subduction at forearc depth and the remaining Mo is isotopically light and locked in rutile, fluids derived from such crust at subarc depth cannot account for the heavy Mo isotopic compositions of basaltic arc lavas. Serpentinites can contain substantial Mo and volatiles and are a potential source of isotopically heavy Mo in basaltic arc lavas. However, the Mo isotopic composition of serpentinites and the Mo isotope behavior during serpentinite dehydration are poorly constrained. Here, we present Mo contents and isotope data for serpentinites from the South Sandwich Trench-Fracture Zone intersection, and deserpentinized peridotites and high-pressure meta-serpentinite veins from the western-central Alps and Betic Cordillera, Spain. Most of these samples have heavy Mo isotopic compositions (δ98/95MoNIST 3134, ranging from -0.26‰ to 1.84‰) with low Ce/Mo (0.10-23.98) and Ce/Pb (0.17-3.59) ratios, which are distinct from the compositions of eclogite-facies metabasalts and metapelites. In addition, no systematic variations in Mo contents and Mo isotopic compositions occur for the studied samples, indicating limited Mo isotope fractionation during serpentinite dehydration. The above results suggest that serpentinites and their derived fluids at subarc depths can serve as the main isotopically heavy Mo sources for basaltic arc lavas. The Mo isotope data with Ce/Mo and Ce/Pb systematics suggest that serpentinite-derived fluids or melting of serpentinite diapirs at subarc depths can explain the heavy Mo isotopic compositions of basaltic arc lavas. Furthermore, recycled oceanic slab (oceanic crust + serpentinized mantle) would has limited influence on the Mo systematics of the mantle, which explains why the mantle has maintained a nearly constant Mo isotopic composition since 3.5 Ga.

Keyword

Mo isotopes, Serpentinite, Island arc magmatism, Fluid, Subduction zone

Deciphering the relative timing of deformation, recrystallization and fluid infiltration in the Dalrymple Amphibolite: Implications to the slab-mantle wedge interface

Gabriel Theophilus Vinalay VALERA[1]*, University of the Philippines National Institute of Geological Sciences (gvvalera@up.edu.ph)
John Daniel Laurente[2], University of the Philippines National Institute of Geological Sciences
Dominique Anne Operania[3], University of the Philippines National Institute of Geological Sciences

Abstract

Megathrust faults separating the subducting slab from the overriding plate is a site of complex overlapping processes including mechanical mixing of components derived from the hanging and foot wall, shear stress-related deformation, and fluid infiltration and associated fluid-rock interaction. These processes are thought to ultimately control the petrological and geochemical characteristics of rocks comprising this interface. Understanding the complex interplay between these processes, their relative timing, and their effects require detailed studies of the rocks which may have once represented fossil slab-mantle wedge interfaces. One locality of such rocks is the Dalrymple Amphibolite located at the base of the central Palawan Ophiolite (CPO).

The clockwise pressure-temperature-deformation (P-T-D) path followed by the Dalrymple Amphibolite is subdivided in a prograde and retrograde metamorphic stage preserved in the amphibolite blocks and surrounding matrix. The prograde stage involves deformation of the subducting slab and its transformation into a block-in-matrix complex. Fluid infiltration during the prograde stage resulted to leaching of components away from the blocks and matrix. Retrograde metamorphic stage on the other hand coincided with the infiltration of another set of fluids preserved as quartz veins. These later fluids added highly mobile components and promoted the growth of low T minerals such as actinolite, chlorite, and muscovite in some retrogressed samples.

In this study, a relatively coherent epidote amphibolite block of the Dalrymple Amphibolite with notable finer and coarser-grained domains was investigated. The coexistence of fine and coarser grained epidote amphibolite blocks with similar mineral assemblage hints on the interplay between recrystallization and deformation in this high T, high shear stress environment. Zr-in-rutile geothermometry revealed a significant difference between the Zr concentrations of rutile between the two texturally different samples. Fine-grained Ep amphibolites have a mean-max Zr concentration in rutile of ~411 ppm, corresponding to a crystallization temperature of ~681°C. In contrast, the coarse-grained Ep amphibolites have a mean-max Zr concentration of ~217 ppm (~631°C). The marked difference in equilibration temperatures suggests that subsequent localized shearing and recrystallization at higher T transformed the coarser-grained sections into finer-grained epidote amphibolite. Another epidote amphibolite sample transected by multiple discordant quartz vein was also analyzed to determine the timing this fluid infiltration event and

the likely fluid source. Detailed mineral chemistry of zones proximal and distal from the vein revealed increasing actinolite component towards the quartz vein likely as a result of ion-exchange between the fluid and the epidote amphibolite. Elemental mapping of the epidote amphibolite reveals increasing Si, Ca, and Mg and decreasing Al, Na, and K towards the vein. These signatures indicate that the formation of the quartz vein is due to late-stage fluid infiltration in the Dalrymple Amphibolite linked to the retrograde metamorphism which affected the mélange.

Keyword

Dalrymple Amphibolite, Fluid infiltration, Deformation and recrystallization, P-T-D path

Contributions of serpentinizing fluids to the low δ^{26}Mg isotopes of subduction zone fluids: Evidence from jadeitites and jadeite-rich rocks from the Rio San Juan complex, the Northern Dominican Republic

KUN CHEN[1]*, CAS Key Laboratory of Crust-Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China, Hefei (Kun_Chen@mail.ustc.edu.cn)
YI-XIANG CHEN[2], CAS Key Laboratory of Crust-Mantle Materials and Environments, School of Earth and Space Sciences, University of Science and Technology of China, Hefei
HANS-PETER SCHERTL[3], Institute of Geology, Mineralogy and Geophysics, Ruhr-University Bochum

Abstract

Jadeitites are the products of direct precipitation through Na-Al-Si rich fluids (P-type) or replacement of magmatic protoliths by fluids (R-type) in subduction zones. Therefore, they are unique targets for investigating the chemical composition of subduction zone fluids. However, the genesis of jadeitites and the Mg isotopic compositions of subduction zone fluids are poorly constrained. Jadeitites and jadeite-rich rocks from the Rio San Juan complex (RSJC) of the northern Dominican Republic were of P- or R-type origins, which are ideal samples for addressing the above issues. Here, we present trace element and Mg-O isotopic studies for RSJC jadeitites and jadeite-rich rocks. The studied samples are divided into matrix-quartz-free suite and matrix-quartz-bearing suite based on the presence of quartz in the matrix. Most of the studied samples are characterized by enriched LREEs, flat HREEs patterns as well as enriched FMEs (Ba, Sr, Pb, U), Sb, Zr, Hf, Cr and Ni, which are similar to those of R-type jadeite-rich rocks and plagiogranites, but quite different from those of P-type jadeitites, indicating that R-type origin jadeitites are dominant in RSJC.

The matrix-quartz-free suite has a wide range of δ^{26}Mg values from −0.94‰ to −0.32‰, and the matrix-quartz-bearing suite has δ^{26}Mg values −0.48‰ to −0.22‰. The δ^{26}Mg values of R-type jadeitites are from −0.67‰ to −0.43‰, slightly higher than those of P-type (−0.94‰ ~ −0.47‰). Although all the studied samples have similarly lighter Mg isotopes to those of the Myanmar jadeitites, there are no correlations between δ^{26}Mg and CaO/TiO_2, CaO/Al_2O_3 and Sr/Nd. In addition, the studied samples (5.41–10.27‰) and estimated jadeite-forming fluids (4.71–6.42‰) have low δ^{18}O values. These signatures indicate that the light Mg isotopes of the RSJC jadeitites and jadeite-rich rocks were not derived from carbonate-fluid metasomatism. In contrast, the negative correlation between δ^{26}Mg and Na_2O in the studied samples indicates that the light Mg isotopes of jadeitites were caused by jadeitite-forming fluids. Besides, RSJC jadeite-rich rocks have higher Ni, Cr, As and Sb contents as well as lower δ^{26}Mg values than plagiogranite protoliths. The compiled results for global jadeitites show positive correlations between MgO, Cr and Ni. These evidences imply that serpentinizing fluids may have contributed to the light Mg isotope of the studied jadeitites and jadeite-rich rocks. Combined with the results of the binary

mixing model and Rayleigh fractionation model, we conclude that replacement of plagiogranites by serpentinizing fluids or direct precipitation of jadeitite from serpentinizing fluids at forearc depths could produce light Mg isotopic signatures of RSJC jadeitites and jadeite-rich rocks. Considering that fluid-metasomatized rocks, such as rodingites and jadeitites, are isotopically and genetically related to serpentinizing fluids, metasomatic processes associated with serpentinization are possible to contribute to Mg isotope heterogeneity in the mantle and to the formation of arc magmas with light Mg isotopes.

Keyword

Subduction zone fluids, Jadeitite, Mg isotope, Serpentinization

Petrological and geochemical diversities of pyroxene pseudomorphs in ultramafic rocks originated from the mantle wedges: Insights into elemental transfer in slab-mantle interfaces

Takumi Wani[1]*, Chiba University (wani.t1681@chiba-u.jpI)
Yuji Ichiyama[2], Chiba University
Tomoaki Morishita[3], Kanazawa University
Akihiro Tamura[4], Kanazawa University

Abstract

Fluid mobile elements are fixed in the mantle wedges as hydrous minerals formed by the influx of slab-derived fluids and consequent metasomatism. Particularly, phlogopite and amphibole possibly play important roles in elemental migrations and recycles in subduction zones, because they are involved in compositional changes in island arc magmas as the reservoirs of alkali elements (Tatsumi, 1989).

The Kurosegawa belt distributed in southwestern Japan is a tectonic serpentinite mélange zone, which preserves tectonic records of an Early Paleozoic subduction zone (Osanai et al., 2014). A small-scale ultramafic complex (Jikkoku Pass complex) and tectonic mélanges (Kiroko–Naguri mélange zones) distributed in the Kanto Mountains, central Japan, are interpreted as part of the Kurosegawa belt. The serpentinized harzburgite of the Jikkoku Pass complex contains pyroxene pseudomorphs composed of richterite + phlogopite + clinopyroxene + olivine + antigorite ± monticellite. The formation temperatures of the pseudomorphs are estimated at <500–600 ℃, based on the coexistence of Fe-rich olivine and antigorite. Early Paleozoic amphibolites in the Kiroko–Naguri mélange zones contain katophorite and rutile, indicating that they experienced high-pressure metamorphism. The Jikkoku Pass ultramafic complex and amphibolites in the Kiroko–Naguri mélange zones probably represent the mantle wedge and subducted oceanic crust of an Early Paleozoic subduction zone, respectively. The bulk compositions of the pyroxene pseudomorphs calculated from elemental mapping images indicate that K2O, Na2O, and CaO contents are 10–100 times more than primary orthopyroxene. Their trace element compositions are enriched in LREE, Cs, Rb, and Ba. These facts indicate that slab fluids given off by the dehydration of amphibolite facies pelitic rocks may have infiltrated into the overlying mantle wedge, and fluid mobile elements, especially alkaline elements, may have been fixed in the mantle wedge as pyroxene pseudomorphs.

Similar pyroxene pseudomorphic textures are also found in mantle wedge-origin serpentinized harzburgites from an Early Paleozoic supra-subduction zone ophiolite (Miyamori ophiolite) and a Cretaceous serpentinite mélange (Kamuikotan belt) in northeast Japan and the serpentinite seamount of the Mariana forearc. The constituent mineral assemblages of pyroxene pseudomorphs from the above three localities are clinopyroxene + antigorite, richterite + clinopyroxene + olivine + antigorite ± phlogopite, and (K-rich) richterite + tremolite + talc + antigorite, respectively. The pseudomorphs observed in the Kamuikotan belt and Mariana serpentinite seamount indicate the

formation at similar temperatures to those of the Jikkoku Pass complex, but those of the Miyamori ophiolite are estimated to have been formed at <450–500 ℃, based on the coexistence of clinopyroxene and antigorite. The calculated bulk compositions of the pyroxene pseudomorphs are characterized as follows; those of the Miyamori ophiolite are poorer in K_2O and Na_2O and are richer in CaO, whereas those of the Kamuikotan belt and Mariana serpentinite seamount are poorer in CaO and K_2O, compared with the Jikkoku Pass complex. These petrological and geochemical diversities of pyroxene pseudomorphs may have been due to the infiltration of slab-derived fluids with different geochemical characteristics, which were caused by the different lithology of slabs and the different thermal gradients of the mantle wedges.

Keyword

mantle wedge, slab-derived fluid, Kurosegawa belt, metasomatism, Ultramafic rock

The genesis of metabasic rocks in the Yadong region of the Himalayan orogenic belt

XIN DONG[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(dongxin5811935@163.com)

Abstract

The Greater Himalayan Sequence (GHS), in the core of the Himalayan belt, records information about the subduction and thickening of the Indian continental crust to the lower crust and its exhumation. The sporadically exposed ultrahigh-temperature (UHT) overprinted eclogites in the upper part of the GHS have drawn extensive attention from international scholars. However, there is still controversy surrounding whether the metabasic rocks distributed widely in other layers of GHS have undergone similar metamorphic processes, and there is debate over their genesis and exhumation mechanism.

The Yadong region, situated in the upper-middle part of GHS, has reported the presence of UHT overprinted eclogites in the upper layers. These rocks experienced peak-pressure eclogite-facies metamorphism (2.1 GPa and 750-770 °C) at ca. 17 Ma, followed by an exhumation process involving decompression heating, reaching peak temperatures of the UHT granulite-facies conditions (0.8 GPa and 950-1000 °C), and then cooled to the amphibolite-facies conditions (Wu et al., 2022). The protolith of the eclogites and the metamorphism of their surrounding rocks have not been reported. Our study shows that the metabasic rocks and their surrounding rocks in the upper and lower layers at the exposure of the eclogite underwent high-pressure (HP) granulite-facies metamorphism. Their protoliths formed in the Neoproterozoic and Ordovician. In the upper layers of the eclogite, the metabasic rocks experienced peak granulite-facies metamorphism (0.9-1 GPa and 800-845°C) and medium-pressure granulite-facies (0.6-0.7 GPa and 825-840 °C) isothermal decompression processes (occurring between 21-17 Ma). The protoliths of the metabasic rocks in these layers formed at ca. 800 Ma, with geochemical characteristics of E-MORB type rocks. In the lower layers of the eclogite, the metabasic rocks and their surrounding rocks underwent similar metamorphic processes (with similar P-T trajectory as the metabasic rocks in the upper layers), but with higher peak metamorphic pressures conditions (1.4-1.5 GPa and 880-915 °C). The peak metamorphism and retrogression occurred at ca. 36-18 Ma and 16 Ma respectively, with the protoliths being basic and granodiorite rocks formed at ca. 450 Ma.

In summary, the metabasic rocks and their surrounding rocks in the Yadong region of the GHS mostly underwent HP granulite-facies metamorphism, with the variety of protoliths and peak metamorphic time of predating ~20 Ma. We suggest that these HP rocks underwent prolonged burial processes, differing from the retrogression history of the reported eclogites in the same study area. Therefore, it is speculated that eclogites may not represent the overall metamorphic degree of exposed rock layers. Further research is needed on the exhumation mechanisms of different types of metabasic rocks.

1. Wu CG, Zhang LF, Li QY, Bader T, Wang Y, Fu B. 2022. Tectonothermal transition from continental collision to post-collision: Insights from eclogites overprinted in the ultrahigh-temperature granulite facies (Yadong region, central Himalaya). Journal of Metamorphic Geology. doi.org/10.1111/jmg.12653

Keyword

Metabasic rock, HP granulite-facies, Protolith, Yadong region, Himalayan orogenic belt

Serpentinization and deserpentinization of the mantle wedge at a convergent plate margin

ZHUANGZHUANG YIN[1]*, University of Science and Technology of China (zzyin@ustc.edu.cn)
Renxu CHEN[2], University of Science and Technology of China

Abstract

Plate subduction is an important mechanism for energy and mass transfer between the mantle and the crust and is a key factor in maintaining the habitability of the Earth. The relationship between the genesis of serpentinite at convergent plate margins and the composition of metasomatic mantle wedge fluid represents the forefront of geochemical research on subduction zone fluids. Previous studies have made many assumptions and inferences about slab serpentinites but have ignored the geochemical effects of dehydration of mantle wedge serpentinite. An integrated study of petrography, whole-rock and mineral major-trace elements and oxygen isotopes as well as zircon U-Pb ages, trace elements and Hf-O isotopes was carried out on serpentinites from the Hong'an orogen to constrain the protolith nature, metamorphic evolution and multiple episodes of crustal metasomatism of the serpentinites. These serpentinties are mainly composed of Ol+Atg+Liz+Mag±Bru±Mgs and have high Mg# and MgO/SiO2 ratios but low Al2O3/SiO2 ratios are well as low Ti contents, resembling those from the mantle wedge rather than the subducting oceanic slab. The enrichments of Th, U, LREE and HFSE in the whole-rock and the finding of zircon indicate that these rocks formed through metasomatism of mantle wedge peridotites by subducted crust-derived fluids. The ca. 310 Ma zircon domains exhibit positive εHf(t) values of 4.5-19.1, variable δ18O values and high Th/U ratios similar to those of oceanic eclogites in the Hong'an orogen but different trace element compositions, indicating their formation through metasomatism by fluids from the subducting Paleo-Tethyan oceanic crust. The ca. 430 Ma zircons exhibit U-Pb ages, trace elements and Hf-O isotopes similar to those of the protolith magmatic zircons in the oceanic-type eclogites. The older zircon domains also exhibit similar element and isotope compositions to those of inherited zircons from high- to ultrahigh-pressure metamorphic rocks in the Hong'an orogen. The ca. 220 Ma zircon domains show negative εHf(t) values of -16.0 to -2.7, indicating their formation through metasomatic overprinting by deeply subducting continental crust-derived fluids in the continental subduction channel during Triassic continental collision. In this context, mantle wedge peridotites were first metasomatized in the Carboniferous by subducted oceanic crust-derived fluids. Afterwards, part of the metasomatized peridotites were off-scrapped into the oceanic subduction channel, where they were hydrated by further subducting oceanic crust-derived fluids to form antigorite serpentinite at forearc depths. The antigorite serpentinite was carried to deeper depths during subsequent continental subduction and underwent dehydration there. This gave rise to metamorphic olivine with extremely high Fo values of 96.7 to 97.6 and higher MnO but lower NiO contents than common mantle olivine. Therefore, the present observations and interpretations of orogenic serpentinites provide insights into multistage fluid metasomatism at different depths during the

tectonic transition from oceanic subduction to continental collision.

Keyword

subduction zone, slab–mantle interaction, serpentinite, metasomatic zircon

Hydration of the deep mantle by slab-derived fluids: insights from arc-type hornblendites of eastern Arunachal Himalaya, NE India

Amrita DUTT[1]*, Physical Research Laboratory (amritadutt6@gmail.com)
Anil Dutt Shukla[2], Physical Research Laboratory
Sanjeev Kumar[3], Physical Research Laboratory

Abstract

Hornblendites are amphibole-rich rocks typically observed in arc settings. Thus, their chemistry can reveal significant information on the processes occurring in the sub-arc mantle and yield information on the nature of fluids and their probable source. In this study, we present the whole-rock major, trace, and isotopic chemistry along with mineral chemistry of the hornblendite dykes occurring in the Neotethyan ophiolites of eastern Himalaya, NE India to decipher their origin, and shed light on the source of fluids occurring in the mantle wedge of an intraoceanic subduction zone. The hornblendites contain >90 modal % amphibole with pargasite being the most dominant end member. They have high whole-rock MgO (~12–20 wt.%) contents with overall deplete LREE [(La/Yb)N = 0.22–0.47] indicative of their refractory nature. Geothermobarometric calculations reveal that the pargasites formed under a high P-T regime (~950°C; 1.6–1.7 GPa) and high fO2 conditions (ΔNNO+2). The-Sr-Nd isotopic ratios of these rocks, calculated at 127 Ma, are also indicative of their depleted mantle origin [(87Sr/86Sr)i = 0.703775–0.7042779; (143Nd/144Nd)i = 0.512733–0.512827), falling near the high-μ compositions. The elemental carbon concentration of these rocks is very low, with a total carbon of ~112 ppm and light δ13C isotopic ratios (~-25.4‰), indicative of an organic origin of the carbon. The whole-rock geochemistry, P-T conditions, and fO2 values of the hornblendites suggest formation from a depleted mantle in an island arc setting. The correlation of the Sr-Nd isotopic ratios of the samples with the high-μ mantle reservoir however, suggest inputs from a recycled subducted oceanic slab in the deep mantle. The isotopically light carbon ratios for the bulk carbon of the hornblendites further support the input of organic sediments from an oceanic slab in their formation. Thus, we propose that the hornblendites were sourced from a hydrated refractory mantle that underwent preferred crystallization of amphiboles instead of clinopyroxenes under high P-T and fO2 conditions at the root of an island arc. Based on the carbon isotopic ratios of the hornblendites, we further comment that the residence time of the 13C-depleted crustal component was too short to re-equilibrate with the mantle carbon isotopic ratios. This study opens further questions on the isotopic re-equilibration of carbon in the deep mantle, which may be studied in future.

Keyword

hornblendite, arc magma, isotopes

Fluid flow and isotopic inheritance in the subducted eclogitic crust recorded by in-situ Rb-Sr isotopes (North Balkhash ophiolite zone, Central Kazakhstan)

Sergei SKUZOVATOV[1]*, Vinogradov Institute of Geochemistry, Russian Academy of Sciences, Siberian Branch (skuzovatov@igc.irk.ru)
Anfisa Skoblenko[2], Geological Institute, Russian Academy of Sciences

Abstract

Metamorphic white micas are known to multiply grow and recrystallize as a response to distinct thermal events, deformations and fluxes of hydrous fluids in the evolving subduction-related complexes. Progressive recrystallization and preservation of prograde, non-recrystallized (early metamorphic) populations, as well as variable elemental/isotopic uptake in response to external fluid precipitation may produce ambiguous 40Ar-39Ar and Rb-Sr dates, which are crucial for constraining dynamics of subduction zones and tectonic reconstructions, as the recrystallization-induced dates may span over up to ~30–40 Myr. Using the in-situ, texturally linked (LA)-MC-ICP-MS Rb-Sr isotope data, here we constrain the P–T conditions of rehydration and its impact onto Sr isotopic disequilibrium and Rb-Sr geochronology of phengite-bearing assemblages produced by combined pervasive and channelized fluid overprint of HP rocks from the Kenterlau-Itmurundy paleo-oceanic HP complex (North Balkhash ophiolitic mélange, Central Kazakhstan). The eclogites are mostly hydrous rocks, which have amphibole, epidote and phengite evenly spread in the matrix, with only minor to no primary omphacite preserved due to retrogression. Some samples are macroscopically heterogeneous, with relatively dry (omphacite-dominated) and moderately to completely hydrated (with amphibole-dominated matrix exhibiting enlarged phengite flakes) sections/domains. Strongly hydrated domains are commonly crosscut by veins showing no orientation regularities and rich in enlarged amphibole and phengite crystals. Same coarse-grained phengite commonly associated with chlorite is observed in cracks, which cut garnet porphyroblasts.

Omphacite exhibits nearly homogeneous 87Sr/86Sr ratios at measured 87Rb/86Sr normally below 0.01, with a slight difference between “dry” (0.70521±0.00010) and moderately hydrated (0.70565±0.00037) domains. Amphibole has a uniquely uniform (87Sr/86Sr)0, which were recalculated to 500 Ma due to increased 87Rb/86Sr (0.02–0.11) ratios relative to Rb-poor omphacite and epidote. The 87Sr/86Sr ratios throughout both moderately and strongly hydrated zones are averaged at 0.70591±0.00018, which is higher than that of primary omphacites. Individual epidote grains have the weighted average 87Sr/86Sr of 0.70519±0.00004. The apparent effect of amphibolization and phengite growth is consistent with bulk-rock Rb-Sr systematics of omphacite-dominated, “dry” domains and their hydrous counterparts. The total Rb-Sr isochron using all phengite analyses yields an age of 482±16 Ma (MSWD = 3.3), which is equal within the error to the earlier reported 40Ar-39Ar age of phengite separates. However, the potential effect of progressive LILE uptake is evident by distinct isochrones of phengite with high 87Rb/86Sr ratios (486±17 Ma, MSWD = 4.5, 87Sr/86Sr of 0.7037±0.0034) and low (<10) 87Rb/86Sr (530±18 Ma,

MSWD = 1.5, 87Sr/86Sr of 0.7014±0.0020). The textural and isotopic data emphasize that phengite growth was mainly linked to post-peak, combined focused (veining) and pervasive (induced by inter-grain fluid migration) rehydration of eclogites. Isotopically depleted (with low 87Sr/86Sr) phengite thus represents the inherited prograde-to-peak population that did not approach the equilibrium with other prograde-to-peak phases (exemplified by omphacite) on a sample scale. In contrast, more radiogenic Sr in “younger” phengite may reflect progressive Sr isotopic re-equilibration with a contribution from high-Rb/Sr (e.g., metasedimentary) source.

The research has been supported by the Russian Science Foundation (grant 21-77-10038).

Keyword

subduction, eclogite, fluids, phengite, Rb-Sr geochronology

Mineral assemblage and temperature estimates of continent-derived metapelites and metapsammites in Sibuyan Island, Romblon, Philippines

John Kenneth Beran BADILLO[1]*, University of the Philippines Diliman (jbbadillo@up.edu.ph)
Gabriel Theophilus Vinalay Valera[2], University of the Philippines Diliman
Andrew Exequiel Sanchez Tabilog[3], University of the Philippines Diliman
Betchaida Duetes Payot[4], University of the Philippines Diliman

Abstract

The metamorphic rocks exposed in Sibuyan Island form part of the Romblon Metamorphic Complex (RMC), which are metamorphosed pelitic and psammitic rocks that occur along with the mafic-ultramafic units of the suprasubduction zone type Sibuyan Ophiolite Complex (SOC). The metapelites and metapsammites are observed in the western and eastern portions of the island, while SOC gabbros and peridotites occur at the center of the island. The occurrence of these metamorphic rocks is attributed to the arc-continent collision of the Palawan Microcontinental Block (PCB) and the Philippine Mobile Belt (PMB). This work presents novel field and petrological data from the metapelites and metapsammites in Sibuyan to provide insights into their metamorphic pressure-temperature-deformation (P-T-D) history.

In eastern Sibuyan, alternating metapelites and metapsammites that exhibit schistose texture are observed. The metapelites are composed of biotite (Bt) + muscovite (Ms) + quartz (Qz) + plagioclase (Pl) + orthoclase (Or) + aluminosilicate (Als) + rutile (Rt) + zircon (Zrn), whereas the metapsammites consist of Qz + Pl + Or + Ms + Als. In Barangay Mabini, an exposure of metapelites was documented near the coast. It is composed of dark-colored schists and is cut by leucocratic dikes that show foliation subparallel to those of the schists. Petrographic analysis and back-scattered electron (BSE) imaging of the metapelite schist and dike samples revealed similar mineral assemblage of Qz + Pl + Bt + Or + apatite (Ap) (± Ms ± chlorite (Chl) ± pyrite (Py) ± oxides) in varying abundances. Qz, Pl, and Or are more abundant in the dike, while Bt and Pl are more dominant in the schist. Pl and Bt are the common porphyroblasts, whereas Qz typically occurs in the matrix of both the schist and dike. The Pl grains in the dike exhibit oscillatory zoning, which is absent in the Pl grains of the schist. Most of the Qz grains in the matrix of both the schist and dike exhibit a sigmoidal structure.

Using the two-feldspar geothermometry of Whitney and Stormer (1977), the equilibrium temperatures for coexisting plagioclase and alkali felspar pairs in the schists and dike in Brgy. Mabini were calculated. Results show that the metamorphic temperature preserved in the feldspar pairs in the schists ranges from ~530 to 549°C and ~509 to 631°C, at 2.0 to 3.2 kbars in the rims of the dike, whereas the igneous temperature recorded in the cores of the feldspar pairs in the dike is within ~753 to 885°C, at 2.0 to 3.2 kbars. These temperatures and the subparallel foliations present in the dike and schist imply that the intrusion happened earlier than the deformation event

that possibly caused the metamorphism in the area. Also, the presence of mica, Or and Qz suggests a continental sandstone-mudstone protolith likely related to the PCB. Further petrological and geochemical analyses will be done to interpret the P-T-D history and petrogenesis of these metamorphic rocks in Sibuyan Island.

Keyword

schists, metapelites, metapsammites, Romblon Island Group, Sibuyan

Tectono-metamorphic events in the west central Philippines: Insights from the metamafic rocks of Tablas Island, Romblon

Andrew Exequiel Sanchez TABILOG[1]*, Rushurgent Working Group, National Institute of Geological Sciences, University of the Philippines Diliman, Quezon City, 1101 (astabilog@up.edu.ph)
Gabriel Theophilus Vinalay Valera[2], Rushurgent Working Group, National Institute of Geological Sciences, College of Science, University of the Philippines, Diliman 1101, Quezon City, Philippines
John Kenneth Beran Badillo[3], Rushurgent Working Group, National Institute of Geological Sciences, College of Science, University of the Philippines, Diliman 1101, Quezon City, Philippines
Betchaida Duetes Payot[4], Rushurgent Working Group, National Institute of Geological Sciences, College of Science, University of the Philippines, Diliman 1101, Quezon City, Philippines

Abstract

Metamorphism of mafic crustal materials can commence right after their formation and proceeds in response to changing pressures, temperatures, and fluid infiltration events. The resulting metamorphic textures and mineral assemblages reflect these conditions and can serve as records of events that affected the crustal rocks. In Tablas Island where evidences of arc-continent collision between the Philippine Mobile Belt and Palawan Microcontinental block can be observed, metamafic rocks are found in contact or proximal to the intrusive units of Sibuyan Ophiolite Complex. However, the metamorphic events that led to their formation remain unclear.

In northern Tablas, metamafic rocks such as amphibolites are inferred to be thrusted onto metapelitic schists along northeast striking, northwest dipping thrust faults. They are overlain by gabbros which are cut by plagiogranite veins emanating from the amphibolite. These lithologies are then crosscut by diabase dikes. In Calaton Hill, southern Tablas, amphibolites are inferred to be thrusted onto metapelitic schists along northwest striking, northeast dipping fault and are overlain by hornblende pyroxenite. The presence of sillimanite fibrolites overprinting the andalusite clasts in pelitic schists may imply that the deformation event affecting their protoliths are accompanied by heating. Recrystallized grains in amphibolites suggest that their protoliths have undergone amphibolite-to-granulite facies metamorphism. These observations may indicate that the amphibolites in Tablas could provide further insights on the tectonic events that occurred during the arc-continent collision in west central Philippines.

Keyword

arc-continent collision, Sibuyan Ophiolite Complex, amphibolites, Tablas Island

Metamorphic complexes of western and central Mongolia

ERDENEJARGAL CHOINDONJAMTS[1]*, 1.National University of Mongolia,2. Institut of Geology , Mongolian Academy of Sciences (j.erdene1978@gmail.com)
OYUNGEREL SODNOM[2], National University of Mongolia
ORGIL GANSUKH[3], Institut of geology Mongolian Academy of Sciences
ZORIGT KHASHTSETSEG[4], National University of Mongolia

Abstract

Recently, the researches of metamorphic complexes of western and central Mongolia belonging to the eastern part of the Central Asian Orogenic Belt has been widely reported. We conducted a collaboration work to understand the origin of the metamorphic complexes in Tarvagatai, Baidrag and Zavkhan terranes and to determine the age intervals of metamorphism in detail.

In the eastern part of the of the Central Asian Orogenic Belt, as the remnants of the Precambrian ancient craton, the Neoarchaean Bombogeer metacomplex of Baidrag terrane was intruded by the Paleoproterozoic Olonkhudug massif. Also, the migmatized gneiss of the Neoarchaean Ider metacomplex of the Tarvagatai terrane was cut by Paleoproterozoic Khunjliin Gol anorthosite massif. This might indicate that several cycles of tectonic-metamorphism are distinguished within these cratonic terranes.

Recently, geological and geochronological studies have been intensively carried out in the Zavkhan terrane, and a crystalline complex containing boudinage of the Urgamal eclogite was firstly discovered near the southeast end of the Zavkhan terrane. The Urgamal eclogite is mainly composed of garnet coexisting with omphacite, rutile, epidote, barroisite, white mica, and quartz, which have been retrogressed into a symplectite of hornblende, albite, and biotite. We measured zircon U–Th–Pb ages in a barroisite–rich sample of the Urgamal eclogite using an electron probe microanalyzer, which yielded an age of 1113 +31/ −52 Ma.

Keyword

Urgamal eclogite, Boudinage, Craton, Zavkhan terrane, Mongolia

Geochemical evidence from coesite-bearing jadeite quartzites for large-scale flow of metamorphic fluids in a continental subduction channel

Xiao-Ying GAO[1]*, University of Science and Technology of China (gaoying@ustc.edu.cn)

Abstract

Metamorphic fluids produced by dehydration of subducting crust transport mass and energy at the slab-mantle interface in subduction channels. It is commonly assumed that fluid flow is significant in oceanic subduction channels but insignificant in continental subduction channels. This assumption is challenged by a combined study of whole-rock geochemistry, Mg and O isotopes, zircon U-Pb ages and trace elements in coesite-bearing jadeite quartzites from the Dabie orogen, China. Although the target samples were collected from different outcrops in an area of ~50 km2, zircon U-Pb dating yields similar discordia lines with not only consistent upper intercept ages of 1.9-2.0 Ga but also consistent lower intercept ages of 224-235 Ma. This indicates the same Paleoproterozoic protolith and the same Triassic metamorphism for these jadeite quartzites. The O isotope analysis of mineral separates and whole-rock yields variable δ18O values from 6.3 to 9.4‰, indicating involvement of supracrustal components. Except for one outlier at -0.43‰, all the other rocks give variable δ26Mg values from -0.16 to 0.61‰, much higher than normal mantle values. The whole-rock Mg isotopes show significant positive correlations not only with MgO contents but also with Rb/La, Rb/Gd and Rb/Nb ratios, but a negative correlation with Na2O contents. These observations indicate that the middle Paleoproterozoic protolith of jadeite quartzites was weathered to produce a kind of sedimentary rocks in a passive continental margin and then underwent significant metasomatism by metamorphic fluids with high δ26Mg values during the continental subduction in the Triassic. The metamorphic fluids were produced by the breakdown of biotite in the metasedimentary rocks during their subduction to subarc depths for ultrahigh-pressure metamorphism. They would have acquired their geochemical compositions not only from the biotite breakdown but also through leaching reaction with the TTG provenance. In view of the spatial occurrences of the target samples, the metamorphic fluids would have flowed inside the continental subduction channel on a large scale. This is the first report of the large-scale fluid flow in the continental subduction zone and therefore demonstrates that fluid flow can be significant in continental subduction channels.

Keyword

Metamorphic fluid, Chemical metasomatism, Jadeite quartzite, Continental subduction

The effect of argillization and opalization on the properties of andesites and basaltic andesites on the thermal fields of the Kamchatka Peninsula

Ilya BOLSHAKOV[1]*, Lomonosov Moscow State University (bolshakov.ilya.210@yandex.ru)

Abstract

Within the areas of active volcanism, there are specific areas where the natural discharge of heated thermal waters and steam to the daytime surface takes place and that is where hydrothermal-metasomatic rocks appear. In the global diversity of hydrothermal-metasomatic rocks, two varieties can be distinguished that are most common in the near–surface zone - argillized and opalized rocks.

One of the simplest definitions of argillization is: argillization is a metasomatic process consisting in the replacement of the initial minerals of igneous rocks with clay. Most often, this process takes place in thermal fields characterized by medium acidic to slightly alkaline thermal waters (pH ~ 4-8.5). The final product of argillization is hydrothermal clay.

As a result of argillization on igneous rocks, a radical change in their properties occurs. In particular, in massive andesites undergoing argillization on the East Pauzhetka thermal field, porosity increases approximately by 7 times (from 2.6% to 18.1%) and density decreases by 15% (from 2.71 g/cm3 to 2.28 g/cm3), the velocity of longitudinal waves by almost 2 times (from 5.6 km/s to 3.0 km/s), the dynamic modulus of elasticity by 3.5 times (from 62.7 GPa to 17.0 GPa), uniaxial compressive strength in the air-dry state by about 7 times (from 142.3 MPa to 20.7 MPa) and magnetic susceptibility by 40% (from 31.1 SI*10-3 to 18.8 SI*10-3)

Opalization can be defined in the most rational way as follows: opalization is a near–surface hydrothermal-metasomatic process occurring under conditions of discharge of strongly and ultraacid thermal waters (pH < 4), consisting in leaching of primary components of effusive rocks and their replacement with opal.

Opalization begins with the leaching of volcanic glass of effusive rocks and individual sections of crystals. In particular, the inclusions represented by plagioclases first undergo acid leaching in the central parts, which usually have a more anorthitic composition due to its higher crystallization temperature, and some of the inclusions.

As a result of the impact of the opalization process on igneous rocks, the indicators of their properties also undergo significant changes. At the same time, in most cases, opalization negatively affects the properties of modified rocks, with the exception of especially weak differences in volcanogenic sedimentary rocks, the impact of opalization on which can lead to their hardening. In case of opalization of massive basaltic andesites composing the thermal fields of the Bolshoy Semyachik massif, the density can decrease by almost 3 times (from 2.90 g/cm3 to 1.07 g/cm3, and in individual samples the density value turned out to be 0.80 g/cm3), the dynamic modulus of elasticity decreases by more than 40 times (from 54.4 GPa in unaltered basaltic andesites up to 1.3 GPa in collomorphic opalites), uniaxial compressive strength is more than 45 times (from 157.4 MPa to 3.3 MPa), at the same time porosity increases from 3.5% to 51.4%, and

in individual samples exceeds the value of 60%.

Keyword

argillization, opalization, thermal fields, Kamchatka, properties

Tracing the incipient melting P-T-t conditions of felsic gneiss in South Altyn Tagh: implications on the exhumation of deep subducted slabs

Yongsheng GAI[1]*, Northwest University (gaiysh@nwu.edu.cn)
Liang Liu[2], Northwest University
Tuo Ma[3], Northwest University
Xiaoying Liao[4], Northwest University
Lei Kang[5], Northwest University

Abstract

The partial melting of HP–UHP rocks is impotant in facilitating the exhumation of deep subducted rocks, but in natural studies, this facilitation process is seldum quantificated due to the difficulties in precisely distinguish the incipient partial melting P–T–t conditions. In eastern South Altyn Tagh(SAT), NW China, (U)HP felsic gneiss have been studied to experence deep subduction process. In this study, a series of partial melting evidences in the felisc gneiss, including multi-phase solidus inclusions in garnet mantle and rootless granitic veins in the felsic gneiss have been discovered. Based on geochemical studies, we suggest the granitic veins are originated by the muscovite-dehydration melting of felsic gneiss, based on the high K2O (5.01–9.95 wt%), Rb (182–586 ppm) and low Sr (48.1–241 ppm) content, negative correlations between Rb/Sr and Ba (Sr) of the granitc veins, and the consistent whole-rock Sr–Nd–Pb isotopse between the veins and felsic gneiss. By pseudosection modelling, the initial decompression melting conditions of the felsic gneiss, which just above the solidus, are restricted around 2.2–2.6 GPa and 900–1100 °C, based on the compositions of garnet mantle with titanite and multiphase solid inclusions. The calculated compositions of initial melts by modelling under this restricted partial melting conditions show consistent K2O, Na2O compositions and K2O/Na2O (2.11–4.13) with the granitic veins, further support that incipient partial melting take place during this eclogite facies conditions. Insitu U–Pb dating of titanite preserved in garnet mantle of felsic gneiss show a intersection age of 485 Ma. Based on all the studies above, we suggest the incipient melting of the felsic gneiss in SAT was taken place under 2.2–2.6 GPa and 900–1100 °C, at c. 485 Ma. Besides, based on Ti-in-zircon thermometry, 176Lu/177Hf-in-zircon pressure proxy and zircon U–Pb dating, the crystallization P–T–t conditions of granitic veins were restricted around 0.16–0.82 GPa and 647–872 °C, at 484–488 Ma.

With all the studies above, we suggest the (U)HP felsic gneiss in South Altyn Tagh experienced incipient partial melting process at 2.2–2.6 GPa and 900–1100 °C, then fast exhumed from 2.2–2.6 GPa to ~0.8 GPa within 1–2 Ma. These results not only provide direct evidence that partial melting can facilitate the exhumation of deep subducted slabs, with maximum exhumation rate over 30–60 mm/a, but also provide further insights into the intracrustal differentiation and the generation of potassic granitoids in subduction zones.

Keyword

partial melting, granitic veins, fast exhumation process, South Altyn Tagh

The structure and transport properties of diopside supercritical fluid from machine learning potential

Dong WANG[1]*, University of Science and Technology of China (wangdong01@mail.ustc.edu.cn)
Jian Song[2], University of Science and Technology of China
Bowen Chen[3], University of Science and Technology of China
Yu Zhang[4], University of Science and Technology of China
Zhongqing Wu[5], University of Science and Technology of China

Abstract

In deep subduction zones with high temperatures and pressures, the miscibility gap between silicate melt and aqueous fluid diminishes, leading to the formation of a single phase with an intermediate composition, known as supercritical fluid. Supercritical fluids play a crucial role in mass transfer in the subduction zone due to their low viscosity and their ability to carry large amounts of elements. However, the structures and transport properties of supercritical fluids are poorly constrained. Conducting in-situ experiments at high temperatures is still challenging. First-principles calculations can only provide results at extremely high temperatures, since the computational cost required to make the results converge increases significantly as the temperature decreases. Machine learning potentials trained from first-principles data combine the computational efficiency of classical potentials with the accuracy of first-principles, providing a promising way to calculate the properties of supercritical fluids at relatively low temperatures.

Here, we constructed a representative train set for diopside supercritical fluid with 0 ~ 78 wt.% water ($CaMgSi_2O_6$-xH_2O) through a combination of concurrent learning, enhanced sampling, and principal component analysis. The train set was then used to train a machine learning potential for the diopside supercritical fluid. At high temperatures, the melt structure and transport properties calculated by the machine learning potential perfectly match the results from first-principles calculations. By using the efficient machine learning potential, we were able to obtain the structure and transport properties of diopside supercritical fluid down to 1000 K, building a bridge between experiments and theoretical calculations.

Keyword

supercritical fluid, first-principles calculations, machine learning potential

Subducted metasedimentary veneer impedes slab–arc carbon recycling

Jilei Li[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences
(lijilei@mail.iggcas.ac.cn)
Jay J. Ague[2], Yale University
Timm John[3], Freie Universität Berlin
Jun Gao[4], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The subduction zone carbon cycle plays a crucial role in regulating the global carbon cycle, controlling Earth's climate, and maintaining its habitability. The discrepancy between the amount of carbon released from subducting slabs at sub-arc depths and the carbon output from volcanic arcs suggests the existence of hidden carbon reservoirs within the slab-to-arc pathways. However, the precise location of these reservoirs remains enigmatic. Slab fluid serves as the primary medium for carbon transport in subduction zones, necessitating a comprehensive understanding of the fluid-rock interaction during migration to unravel the carbon flux imbalance between the slab and the arc. In this study, we investigate a high-pressure (HP) metasediment–selvage–vein system from the Southwestern Tianshan HP metamorphic belt (northwest China) to explore rock carbonation along the fluid conduit. Field evidence and petrological observations reveal that, compared to the carbonate-free metasedimentary host rock, the immediate wallrock adjacent to the garnet-bearing calcite-dominated vein (representing carbonic fluid under HP conditions) has undergone significant carbonation, resulting in rapid thinning of the vein structure. We find that substantial rock carbonation (involving dolomite-calcite-magnesite precipitation) occurs when slab-derived carbonic fluids migrate through the metasedimentary sequence at approximately 80 km depths. Furthermore, modeling demonstrates that the metasedimentary layer atop the slab has the capacity to sequester 20%–50% of the fluid carbon from the ascending slab dehydration flux. We propose that the metasedimentary veneer at the plate interface functions as a carbon filter, hindering the transfer of carbon from the slab to the arc. This mechanism mediates the carbon flux imbalance between the amount released by the slab and that emitted by the arc. This study also provides insights into decarbonation efficiency and mechanisms, carbon-transferring pathways, and the temporal aspects of the subduction zone carbon cycle.

Keyword

Subduction zone carbon cycle, Carbon sequestration, Fluid-rock interaction, Metasedimentary venner, Slab fluids

Vein-induced carbonatitic metasomatism of eclogites in subduction zones: implications for carbon cycling and mantle isotopic heterogeneity

Weihao Yan[1], Nanjing University
Weiqiang LI[2]*, Nanjing University (liweiqiang@nju.edu.cn)
Qin Wang[3], Nanjing University

Abstract

Ample evidence has shown that carbonates or carbonated eclogites can be subducted to the upper mantle or even the transition zone, facilitating deep carbon cycle. However, carbonates are geophysically buoyant and rheologically weak, how their chemical and isotopic signatures are transported in subduction zones remains elusive. Here we try to address this problem by a detailed Mg and Fe isotope study of a retrograded eclogite boudin and the surrounding marbles in the Dabie ultrahigh-pressure metamorphic belt, China. The studied objects resemble fossil reaction fronts of carbonation of silicate rocks in subduction zone. Both the main bodies of eclogite and marble preserve unaltered Mg isotope signatures, resulting in a sharp Mg isotopic gradient, with δ26Mg values increasing from –1.39‰ in eclogites to –0.23‰ in marbles across the lithologic boundary. However, carbonate veins within the eclogite boudin show remarkably low δ26Mg values (–0.74‰ on average), suggesting extensive diffusive bands during vein injection. The Mg-Fe isotope patterns reveal that the efficiency of carbonatitic metasomatism is low by mechanical mixing of eclogites and marbles at lithologic boundary, but high by injection of carbonatitic veins into eclogites. Thus, vein injection is the key mechanism for carbonatitic metasomatism of eclogites for driving in the deep carbon cycle and geochemical heterogeneity in the upper mantle and transition zone

Keyword

carbonated eclogites, Dabie, Mg isotope, Fe isotope

The mechanism for heavy Cr isotopes in some serpentinites and its implications

Ji SHEN[1]*, CAS Key Laboratory of Crust-Mantle Materials and Environment, University of Science and Technology of China (sjlcwqqq@ustc.edu.cn)

Abstract

Serpentinite is one of the most important water reservoir in subduction zones. The highly variable and heavy Cr isotope compositions of serpentinites have been observed, while its mechanism remains to be highly debated. Here, we have conducted Cr isotope composition analyses for whole-rock and individual mineral separates of serpentinites and associated peridotites and rodingites from Tibet and Fuchuan from China, Cyprus, and Tonga trench. We found that residual hydrothermal fluids after serpentinization reaction exhibit light Cr isotope characteristics, which is evidenced by obviously lighter Cr isotope compositions of the rodingites relative to those of MORB and OIB. However, in consideration of the high Cr content of ultramafic rocks, the released fluids have limited influence on the Cr isotope composition of serpentinites. Combining with the analysis of the primary minerals in serpentinite (serpentine and magnetite), we found that serpentine is always Cr isotopically heavier than magnetite ($\Delta 53Cr_{serp-mag}$=0.02 ‰~0.36 ‰), suggesting a complex Cr migration and redistribution process during or after serpentinization. Based on previous observations of Cr content and Cr isotope trends in serpentinite, we propose that the trend of enrichment of heavy Cr isotopes in serpentinite with low Cr content reflects the leaching effect of magnetite. This found highlights Cr isotope could be a potential monitor to Fe-Cr deposits at ophiolite complex settings.

Keyword

Chromium isotope, Serpentinite, Serpentinization, Fe-Cr deposits

Origin of fluid beneath the Noto peninsula, Central Japan: Stability of Lawsonite eclogite

Kazuaki OKAMOTO[1]*, Saitama university (kokamoto@mail.saitama-u.ac.jp)

Abstract

Crustal structure beneath earthquake swarm in the Noto peninsula, was already analyzed in detail (e.g. Nakajima et al., 2022), and concluded that large volume of fluids accumulated below the seismogenic zone beneath the Noto peninsula, in Central Japan. Fluid injection into the intra-continent (intra-arc) seismogenic zone is a trigger to slip active fault in back arc region. The fluid has been supplied from the uppermost mantle (50 to 150km) to the lower crust over a geological time scale. Origin of the fluid is considered that water has been transported from subducting Pacific plate to the upper mantle beneath the central Japan. Subducting plate can transport water down to deep mantle because hydrous minerals can be stable. Stability of hydrous minerals are dependent on P, T, and chemical composition of the rock. Lawsonite is major hydrous mineral stable in subducting oceanic crust in deep mantle. It is considered that temperature condition of the subducting Pacific plate beneath the central Japan is cold enough to stabilize lawsonite in the oceanic crust portion of the plate. Slab surface beneath the Noto peninsula is greater than 250 km depths. Ultrahigh pressure experiment in the water-bearing MORB system (e.g. Okamoto and Maruyama, 1999) reveals that 1wt% H2O can be stored in the depth (250 km depth) of the subducting oceanic crust. Further deep (down to 300 km depth), the lawsonite is decomposed to release fluid by dehydration reaction.

Keyword

Origin of fluid beneath Noto Peninsula, Japan, Subducting oceanic crust, Lawsonite eclogite, Dehydration reaction

Four alkaline shifts of metasomatic reactions by a texture analysis for a garnet amphibolite at 1GPa and ~700°C in Oeyama Ophiolite, Japan

Riichi AKAI[1]*, a post-research student at the University of Tsukuba (r1.akai@gmail.com)

Abstract

Metamorphic minerals have regarded as products of open system in grain scale, and some replaced minerals will also raise a question about metasomatism in thin-section scale. With regard to the analysis of metasomatism, linear algebraic methods constrain a steady state of element mobilities based on numerical conservation theorem in limited observed volume [1] that will be a opposite approach of verification for closed system [2]. Then, a metamorphic stage concretes an image of fluid mediated reactions.

The deformed garnet amphibolite at Wakasa region in Oeyama ophiolitic mélange has several replaced products on the rim of relic amphibole (ex. hornblende to tschermakite, zoisite-epidote, and plagioclase) which result in unexpected imbalance with exchange reactions of coexisted minerals, such as mass of Mg2+. These petrographic characters are common in Oeyama Ophiolite [3]. And, this Wakasa region has reported the oldest 477Ma K-Ar cooling age of Oeyama ophiolite for more coarse altered amphibolite. Relatively high-pressure condition 11kbar, ~670°C was derived by THERMOCALC with effective bulk composition assuming the metasomatic equilibrium. These temperature conditions lays on a temperature interval between plastic stage of peridotite and metasomatic hydration of Oeyama serpentinite [4].

Five reaction modelings by a thinsection's texture analysis result in volumetric increase (1-15%) and high inlet of AlO- and H+ with minor Na+. SiO2 also predicted as inlet in one reaction. These behaviors concordant with the exhumation model in recent pH model for high pressure fluid/rock interaction [5]. Furthermore, Fe2+, Mg2+ and H2O are expelled, probably in correspond to surrounding serpentine or chlorite unit. The garnet bearing reaction in five follows unique phase rule for total 14 phases in 12 components. Other reactions have one lesser 13 phases that assumes to be p=c+1 (p: number of phases, c: number of components) that allowed fully mobile based on Korzhinskii's phase rule [1, 6]. Three of five reactions which differ from Ti-phase has similar volume increase (ΔV=2%), and it's whole view suggests a kind of steady state of external controlled metasomatic fluid and/or some supercritical fluid state having some extinction for phases (ex. by lost of a lithostatic pressure and/or extensive variables). The main compositional changes by these replacements of amphibole can be assumed as "NaAl(Si)H absorbing filter" together with a metasomatic dehydration. The result of numeric modeling is concordant with the other petrography of metasomatised amphibolites and serpentinites in Oeyama ophiolite [3, 4]. This basic mathematical verification and open experiences will help to examine each geochemical research and environmental matters and take our efficient traditional approaches or invisible matters/empirical new modelings for some crustal fluid research or metasomatic analysis.

References:

[1] Akai R (2023) goldschmidt 2023 poster https://doi.org/10.7185/gold2023.20892
[2] Greenwood H.J (1968) IGC report, 6, 267-279
[3] Akai R (2010) goldschmidt 2010 poster, Earth, Energy, and the Environment, 74
[4] Nozaka T (2014) Lithos 184–187, 346–360
[5] Galvez M.E et al. (2016) Nature, 539, 420-424
[6] Korzhinskii D.S (1950) IGC report of 1948 part II, Problem of geochemistry, 50-57

Keyword

the best subset selection, metasomatic analysis, korzhinskii's phase rule, alkaline shift, Oeyama ophiolite

Protracted crustal evolution of the Nigerian Basement Complex: Insights from Neoproterozoic tectono-magmatic overprint and protolith source analysis.

Chinedu Uduma Ibe[1]*, University of Nigeria, Nsukka (chinedu.ibe@unn.edu.ng)
Silas Sunday Dada[2], DASIL Geoconsults & Co., 609-804 3rd Avenue, Southwest Calgary Alberta T2P 0G9, Canada.
Olivier Bruguier[3], Geochimie/Geochronologie, Geosciences Montpellier, CNRS, Universite de Montpellier, France.
M.A Omar Rahaman[4], Department of Geology, Obafemi Awolowo University, Ile-Ife, Nigeria

Abstract

The Nigerian Basement Complex, a high-grade terrain, has undergone a protracted crustal evolution from the Paleoarchean era (3.6-3.5 Ga) and continuing through multiple reworking episodes in the Neoarchean and Paleoproterozoic. This evolutionary trajectory climaxed during the Neoproterozoic with a tectono-magmatic overprint, primarily between 640 and 580 Ma. Isotopic evidence suggests that, except for the Late Archean accretion event during the Eburnean orogeny (2.1-1.9 Ga), juvenile crustal accretion was predominantly confined to the early Archean. Intra-crustal reworking, on the other hand, played a dominant role thereafter. Neoproterozoic plate tectonics fostered the emplacement of diverse granitoids and transformed the intensely reworked basement into a bimodal crust comprising metatexites and diatexites. These processes also obliterated and overprinted earlier structural fabrics. Despite all these pervasive modifications, trace element geochemistry and zircon typology reveal that the old basement has preserved its igneous origins and associations with Paleoproterozoic supracrustal rocks. The protolith sources exhibit near-chondritic rare-earth element distribution patterns and time-integrated 147Sm/144Nd ratios, hinting at the isolation of several segments of the Nigerian lithosphere from the convective upper mantle during the early Archean. In contrast, the vestigial eastern terrains consist of paragneiss and migmatite gneiss derived from probable continental sources and exhibiting granulite facies petrographic modal characteristics.

Keyword

Nigerian Basement Complex, Crust evolution, Neoproterozoic, tectono-magmatic overprint, lithosphere isolation

Carboniferous, not Paleoproterozoic, eclogite-facies metamorphism in the northern North China Craton as revealed by in-situ garnet Lu-Hf and U-Pb geochronology

YAOQI YAN[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China (yanyaoqi@mail.iggcas.ac.cn)
HAO WANG[2], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
JINHUI YANG[3], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
SHITOU WU[4], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
JING RAN[5], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
BAOQUAN ZHOU[6], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
YADONG WU[7], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

Abstract

High-pressure metamorphic rocks such as eclogites are primarily formed during oceanic or continental subduction. The exposure of eclogite in ancient subduction zones provides a metamorphic petrological record of the operation of modern-style plate tectonics. In general, the age of potential Precambrian eclogites is mainly defined by accessory phases such as zircon, which cannot be directly matched with the temperature and pressure conditions due to the complex metamorphism process it has undergone. In situ Lu-Hf and U-Pb geochronology techniques have recently been developed to date garnet, the primary mineral phase used for P-T determinations, with aims to overcome the abovementioned shortcomings. Here we reported a detailed in situ garnet Lu-Hf/U-Pb geochronological study on eclogites and associated gneisses exposed in the northern North China Craton (NCC), which has been considered by some scholars to be one of the four key locations with metamorphic petrological evidence supporting the operation of modern-style plate tectonics during the Paleoproterozoic. Garnets from two eclogite and two paragneiss samples yielded consistent in situ Lu-Hf ages of 343 ± 69 Ma to 350 ± 97 Ma and in situ U-Pb ages of 322 ± 34 Ma to 353 ± 37 Ma, which indicate that the eclogites in the northern margin of the NCC were formed during the Late Paleozoic rather than the Paleoproterozoic. The metamorphic zircons within the four studied samples contain eclogite-facies mineral inclusions of garnet, rutile, and phengite. They gave U-Pb ages of 310-325 Ma, which were consistent with those recorded by garnet within analytical errors but have much higher analytical precision. Accordingly, we take the zircon U-Pb ages of 310-325 Ma as the age of eclogite facies metamorphism in the northern NCC. The Paleoproterozoic zircons identified by previous investigations and this study may be derived from the Trans-North China Orogen as detrital or inherited zircons. This study underscores the potential of in situ Lu-Hf and in situ U-Pb

dating of garnet in differentiating between various metamorphic periods and refining the episodic metamorphism of Precambrian eclogite facies, and also advocates for the reexamination of reported Precambrian eclogites worldwide.

Keyword

eclogite, garnet, in situ Lu-Hf and U-Pb dating, metamorphism, modern-style plate tectonics

Low-pressure, high-temperature metamorphism in the central Mary Kathleen Fold Belt, north-eastern Australia: Tracking an anticlockwise P-T-t path by linking phase equilibrium modelling, microstructures, and in situ geochronology

Juergen REINHARDT[1]*, Department of Earth Sciences, University of the Western Cape, Bellville, 7535, South Africa (jreinhardt257@gmail.com)
Péter Horváth[2], Earth, Environmental, and Sustainability Sciences, Furman University, Greenville, SC 29613, USA
Armin Zeh[3], Institute for Applied Geosciences, Karlsruhe Institute of Technology (KIT), 76131 Karlsruhe, Germany
Michael J. Rubenach[4], School of Earth & Environmental Science, James Cook University, Townsville, 4011, Australia

Abstract

The Mary Kathleen Fold Belt, being part of the Mid-Proterozoic Mount Isa Inlier, NE Australia, experienced prograde low-pressure, high-temperature metamorphism with peak P-T conditions of 600-630°C at 3.8 to 4.8 kbar in its central part. This regional-scale prograde metamorphism correlates with major crustal shortening and resulted in the formation of a pervasive subvertical foliation (S2) and lineation (L2) in which the peak-metamorphic minerals are aligned.

Quantitative phase equilibrium modelling of a variety of metapelitic rock types ranging from Al-rich (aluminosilicate-bearing) to magnesian, low-Al (cordierite-orthoamphibole-dominated) compositions constrains a prograde pressure-temperature path with reaction sequences through the andalusite into the sillimanite stability field that are in line with the observed pre-peak and peak reaction textures and early- to late-syndeformational microstructures.

Incipient to pervasive retrograde overprinting of peak assemblages triggered by episodic H2O infiltration produced random mineral orientations, eliminating the S2-L2 structures. Critical retrograde assemblages and reaction textures that impose constraints on the cooling and decompression path are observed in cordierite-rich rocks. The sequential growth of late-formed aluminosilicates traces a P-T path from the sillimanite into the kyanite and andalusite fields, and eventually into the pyrophyllite stability field. Thus, the prograde-retrograde P-T path is distinctly anticlockwise as documented by the sequential, multi-stage growth of aluminosilicates.

Multiple dating methods have been applied to establish a geochronological framework for prograde and retrograde metamorphism in this area. Analyses of matrix monazites and monazite inclusions in andalusite and cordierite provided a unimodal age peak of 1581±5 Ma (method of Montel et al., 1996). LA-SF-ICP-MS analysis of a set of accessory minerals from both prograde and retrograde samples added further critical geochronological constraints. S2-aligned monazite in pristine prograde samples yielded U/Pb ages of 1580±4 Ma, confirming the monazite age from

microprobe data.

Newly crystallised retrograde monazite and xenotime in pervasively hydrated samples provide coincident U/Pb ages of 1572±5 Ma and 1573±3.5 Ma, respectively, which are close to (and hardly distinguishable from) the age of peak metamorphism. Prograde and retrograde rutile, distinguished microstructurally as well as by their Zr contents, yield both U/Pb cooling ages of 1570-1571 Ma, when the rocks would have reached a temperature of about 500°C. Combining the various U/Pb ages with thermobarometric constraints indicates that initial cooling from peak temperatures to 500°C was relatively rapid, in the order of 10-15°C per million years. This in turn argues for a distinct heating episode triggering prograde metamorphism.

Keyword

LP-HT metamorphism, anticlockwise P-T path, Mount Isa Inlier, geochronology

Synchronous Paleocene (ca. 60 Ma) India-Asia collision indicated by high-pressure metamorphic rocks in the Himalaya

Yanling ZHANG[1]*, Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University (zhangyling@mail2.sysu.edu.cn)
Changqing YIN[2], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Shun LI[3], School of Oceanography, Shanghai Jiao Tong University
Jiahui QIAN[4], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Peng GAO[5], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Wangchao LI[6], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Shuhan PAN[7], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University

Abstract

Despite half a century of extensive research, the timing and diachroneity of the initial India-Asia collision remains intense debated due to different definitions of the initial collision and the different methods adopted. In the western and central Himalayas, the timing of initial India-Asia collision has been well constrained at ~57 Ma and ~63-60 Ma, respectively, based on metamorphic ages of ultrahigh-pressure eclogites and high-pressure blueschists. In this study, the high-pressure pelitic granulites in the Eastern Himalayan Syntaxis are studied to elucidate their metamorphic evolution and provide new constraints for the onset of India-Asia collision. Petrological examination suggests that the high-pressure pelitic granulite has experienced four metamorphic stages (M1-M4). The prograde stage (M1) is characterized by the garnet core and its mineral inclusions of biotite + muscovite + plagioclase + ilmenite + quartz ± kyanite ± K-feldspar ± rutile, the peak stage (M2) assemblages of garnet + biotite ± plagioclase + K-feldspar + kyanite ± rutile + ilmenite + quartz, followed by the post-peak stage (M3) represented by the transformation of kyanite into sillimanite and rutile into ilmenite and later retrograde stage (M4) marked by the presence of andalusite. Phase equilibria modeling defined a clockwise P-T path involving a near-isothermal decompression process, with peak P-T conditions of 12.4-15.6 kbar/790-850 °C. The P-T path indicates a typical continent- continent collision, during which the pelitic rocks were subducted to a depth of ~50-55 km where they underwent high-pressure metamorphism. Our zircon and monazite dating results indicate that the metamorphic age of pelitic granulites is 60-15 Ma, with the oldest ages clustered at 60-58 Ma. The oldest metamorphic age of north Himalaya high- and ultrahigh-pressure metamorphic rocks may provide an upper limit for the timing of initial collision. Thus, the onset of the India-Asia collision must have occurred before 60-58 Ma in the Eastern Himalayan Syntaxis, roughly consistent with that in the western and central Himalayas. In summary, the northern margin of India and the southern margin of Asia collided synchronously along the entire Yarlung-Tsangpo suture zone at ~60 Ma.

Keyword

India-Asia initial collision, Himalayan orogen, high-pressure metamorphism, P-T path, Tibetan Plateau

Exsolution textures of Antiperthite and Mesoperthite in the Zhengjiapo BIF, Changyi Metallogenic Belt, North China Craton: evidence of UHT Metamorphic Overprint

Yanrong rong CHEN[1]*, CHINA UNIVERSITY OF PETROLEUM
(chenyanrong272371@163.com)
Xu Ping Li[2], Shandong University of Science and Technology
Yao Qi Zhou[3], China University of Petroleum

Abstract

Paleoproterozoic banded iron formation (BIF) in Zhengjiapo area of Changyi metallogenic belt, Eastern block of North China Craton contains contains abundant coexisting antiperthite and mesoperthite textures. The peak-temperature metamorphic conditions can be derived from this texture. The antiperthite and mesoperthite occur in felsic domains of the Zhengjiapo BIF ore and enable derivation of peak temperature metamorphic conditions. Thermodynamic phase modeling shows that equilibrium conditions of corresponding textures, considering the related mineral assemblage of Pl + Qz + Kfs + Mag + Opx + L, are in the range of 870-940 °C and 5.0-6.8 kbar. Ternary feldspar thermometry using reintegrated compositions of antiperthite and mesoperthite in the felsic domain of the studied BIF iron ore reveals even higher peak metamorphic temperatures of 1045–1080 °C. The ultra-high temperature and low-pressure conditions of the Precambrian BIF have been rarely reported from the North China Craton. Very few studies worldwide have also shown that BlFs and/or their wall rocks experienced UHT metamorphism, which mostly occurred in Archean and Paleoproterozoic. The result of this study documents important details of the metamorphic conditions of the BIF iron ore in the JLJB and sheds new light on the metamorphic development of the North China Craton with respect to the derived HT to UHT granulite facies conditions. The granulite facies BIF ore of the Zhengjiapo iron mine indicates that the BIF was involved in the collision-related tectonic process during Paleoproterozoic to have occurred in the Jiao-Liao-Ji orogenic belt. The current study was supported by the National Natural Science Foundation of China (U2244206) and(U1906207).

Keyword

BIF iron ore, antiperthite and mesoperthite exsolution, UHT metamorphism, Jiao-Liao-Ji orogenic belt

Metamorphic age and potential heat source for the Buchan-type metamorphism in the Wilson Terrane, northern Victoria Land, Antarctica

Yoonsup KIM[1]*, Chungbuk National University (yoonsup@cbnu.ac.kr)
Giun HAN[2], Chungbuk National University
Taehwan KIM[3], Korea National University of Education
Taehoon KIM[4], Korea Institute of Geoscience and Mineral Resources
Yuyoung LEE[5], Korea Basic Science Institute

Abstract

The low-pressure/high-temperature metamorphic field gradient has been reported from meta-sedimentary rocks and migmatites in the Wilson Terrane, northern Victoria Land (NVL), Antarctica, but the timing and potential heat source for the low-pressure metamorphism are still controversial. To tackle the issues, the metamorphic and intrusion ages of 2 meta-sedimentary rocks and 5 associated granitoid rocks, respectively, around O'Kane Glacier in the Wilson Terrane were examined. Sedimentary protolith in the study area consists primarily of sandstone, carbonate and pelite, and underwent the Buchan-type metamorphism up to migmatization (700–750 ℃ and 4–5 kbar). Zircon crystals from a meta-carbonate sample yielded the weighted mean 206Pb/238U age of 492.3±3.4 Ma (tσ, MSWD=1.17) with relatively high δ18O values (13.2–15.3 ‰). The age is reproduced in that of metamorphic monazite (491.3±3.7 Ma; tσ, MSWD=2.67) from a migmatitic gneiss sample. Granitoid samples were collected from boudinaged/folded patches in the sedimentary layers, and show a variety of deformation microstructures. The weighted mean 206Pb/238U ages of zircon from 5 granitoid samples are in the range of ~497–500 Ma, except for ~489 Ma from least-deformed one. The earlier ages are coeval with high-P metamorphism in the Lanterman Range (~498 Ma), NVL, and together with their arc-magmatic geochemical affinity such as negative Nb, Ta and Ti anomalies in the spidergram, are interpreted as the final stage of arc magmatism in the Ross orogen. On the other hand, the younger age is considered as syn- to post-orogenic magmatism during or subsequent to the regional metamorphism (~491 Ma). Thus, the emplacement of basaltic magma at ~495 Ma (e.g., gabbroic rocks in the Tiger Gabbro Complex) is the most likely heat source for the Buchan-type metamorphism in the region.

Keyword

Buchan-type, Wilson Terrane, Antarctica

Pressure calibration of natural-quartz Raman spectra variation under hydrostatic condition

Ryusei Harada[1], Saitama University
Shu Miura[2], Saitama University
Kazuaki OKAMOTO[3]*, Saitama university (kokamoto@mail.saitama-u.ac.jp)

Abstract

Pressure dependence of Quartz-Raman shift have been used for conventional geobarometers in metamorphic rocks (e.g. Enami et al., 2007). However, there is obvious discrepancy of estimated metamorphic pressures between the quartz-in garnet (QuiG) elastic geobarometry and equilibrium-based pressure modeling based on thermodynamics (e.g. Mulligan et al., 2002). Several researchers have suspected that pressure difference might be caused by lithological differences in deviatoric stress. Another possible reason is from reference experimental data about the quartz-Raman shift at various pressures. The present study reports systematic pressure calibrations of natural quartz-Raman spectra under hydrostatic conditions. Experiments were done using diamond-anvil cells. Based on our experimental data, equation for quartz-Raman geobarometry for P< 1 GPa is modified as: P(MPa)=0.2696[(ΔνP)206]2 + 30.43[(ΔνP)206]P(MPa)= 0.194[(ΔνP)464]2 + 90.79[(ΔνP)464]. Compared with previous study, estimated pressure becomes approximately 2 GPa lower. It is concluded that previous synthetic quartz-in garnet geobarometry over-estimated metamorphic pressures.

We also analyzed the Raman shift of quartz in garnet to research the effect of garnet host at various pressures. The quartz inclusions used in the present experiments, are from the garnet amphibolite, Hokkaido, Japan. Metamorphic conditions were estimated at 640-670℃ and 1.1 GPa (Ueda et al., 2013). In the present study, metamorphic pressure was calculated as 1.095 G at 660℃. On the other hand, that calculated using inclusion pressure from Schmidt & Ziemann (2000) as 1.174 GPa.

From the in-situ laser-Raman analysis under high pressures, the quartz inclusion in garnet was affected by the garnet shield effect. The peak shift was lower than that of bare quartz. There is residual pressure in the quartz inclusion. However, once it was exposed to the surface of the garnet, it is not affected by the shielding effect. If the quartz was completely included in the garnet, there was no correlation between distance from the garnet surface and Raman peak shift in quartz inclusions.

References: Enami M. et al, 2007. American Mineralogist 92, 1303-1315.
Schmidt, C. & Martin, A. Z., 2000. American Mineralogist 85, 1725-1734.
Mulligan, S.R., et al, 2022. Journal of Metamorphic Geology 40, 1067-1086.

Keyword

Quartz-Rama spectra, pressure calibration, synthetic and natural quartz, quartz-in garnet

geobarometry, In-situ QuiG Raman analysis

Fluid-fluxed anatexis of Paleoproterozoic granitic gneiss in the Yeongnam Massif, Korea

Yuyoung LEE[1]*, Korea Basic Science Institute (yuyoung2@kbsi.re.kr)
Moonsup Cho[2], Seoul National University
Jeongmin Kim[3], Korea Basic Science Institute

Abstract

The fluid-fluxed melting of igneous protoliths provides an opportunity to assess the role of fluid for the formation and modification of continental crust during high-temperature metamorphism. In order to investigate such an anatexis in the Buncheon granitic gneiss, Yeongnam Massif, we combined field, microstructural, and geochemical studies with the U–Pb and oxygen isotopic analyses of zircon and monazite. The granitic gneisses comprise metatexitic migmatites containing leucosomes, although neither melanosomes nor peritectic phases are associated with neosomes. These migmatites underwent syn-kinematic wet melting in the presence of ca. 0.9–1.4 wt.% H2O (estimated from the pseudosection modeling) via the reaction, plagioclase + K-feldspar + quartz + H2O = melt, that took place at ~650–750 °C and 4–6 kbar. The leucosomes differ in the degree of Eu anomalies and have variable amounts of rare earth elements, Zr, Y, and Th. Such variations are attributed to the segregation and migration of melts as well as the entrainment of residual phases. Sensitive high-resolution ion microprobe (SHRIMP) U–Pb ages of zircon and monazite were determined from two granitic gneisses and three leucosomes together with an adjacent, undeformed Hongjesa granite. Zircon grains are oscillatory-zoned, except for homogeneous overgrowth rims rarely present in two leucosomes. Both zircon domains were dated at ca. 1.98–1.97 Ga and ca. 1.86 Ga, respectively, suggesting that igneous protoliths were partly recrystallized during the late Orosirian. Monazites from two gneiss samples contain submicroscopic polycrystalline inclusions of K-feldspar + quartz + apatite, reflecting the presence of former melts, and yielded a pooled 207Pb/206Pb age of 1859 ±6 Ma (n= 30). In contrast, monazites from a leucosome are inclusion-free, and yielded the youngest age of 1840 ±16 Ma (n= 6). This result is interpreted to represent the melt crystallization at ca. 1.84 Ga following the ca. 1.86 Ga anatexis. On the other hand, monazite from the Hongjesa granite, yielded a weighted mean 207Pb/206Pb age of 1878 ±5 Ma (n= 11), most likely reflecting a prograde metamorphic growth. The δ18O values of ca. 1.98–1.97 Ga igneous zircon in granitic gneisses are 7.1–7.2 ‰, but those from the leucosome are reduced at 5.9–6.7 ‰. The latter is largely identical to 5.7–6.7 ‰ estimated from ca. 1.86 Ga domains of zircon in the leucosome and monazite in the granitic gneiss; in contrast, a slightly lower δ18O value of 5.46 ± 0.61 ‰ is recorded in the ca. 1.84 Ga monazite of leucosome. The relatively low δ18O values are most likely accounted for by an influx of fluid that has apparently triggered partial melting in the granitic gneiss, and the fluid itself is possibly linked to the crystallization of mafic magmas in an arc complex. Taken together, in contrast to the majority of zircons preserving the crystallization age of igneous protoliths, monazites are more susceptible to recrystallization during the fluid-present melting and permit us

to decode a protracted (~20 m.yr.) episode from partial melting to melt crystallization in the Yeongnam Massif. Such a longevity of melt-present system typifies the prolonged crustal reworking of Paleoproterozoic Korean arc situated

Keyword

Fluid-fluxed melting, Zircon, Monazite, Yeongnam Massif, North China Craton

Middle Permian high-pressure rocks preserved in the Southern Beishan Orogenic Belt, NW China: metamorphic evolution and tectonic implication

Wenxuan Li[1]*, University of Waterloo (w54li@uwaterloo.ca)
Shoufa Lin[2], University of Waterloo

Abstract

The Beishan Orogenic Belt, located between the southern Tianshan suture to the west and the Solonker suture to the east, is a typical accretionary orogen formed as a result of subduction and closure of the Paleo-Asian Ocean. The timing of the final closure of the Paleo-Asian Ocean in the orogenic belt remains controversial. We present here preliminary results of geochronology, petrography, mineral chemistry, thermodynamic modelling, and P-T path construction on tonalitic gneisses from the Shiyao Complex. Petrological examination reveals that the tonalitic gneisses experienced three metamorphic stages (M1-M3). The M1 is characterized by with epidote, garnet, hornblende, muscovite, plagioclase, quartz, rutile. The M2 assemblage is marked by the growth of garnet, ilmenite, plagioclase, hornblende on the consumption of muscovite and epidote, and the transformation of rutile to ilmenite and/or sphene. The M3 stage is represented by the development of chlorite, muscovite in the matrix. Thermodynamic phase equilibrium modeling defined a clockwise P-T path involving a decompressional heating process from P-peak eclogite-facies (M1) of 13.8-14.2 kbar/580-588 °C to T-peak amphibole-facies (M2) of 8.2-8.8kbar/630-650°C, with low- to medium-thermobaric ratios of 414-420°C/Gpa. This indicates a typical cold subduction, during which these rocks were subducted to a depth of 40-50 km where they underwent low temperature eclogite-facies metamorphism and then exhumated to a shallow depth of 20 km along the subduction channel. Zircon SHRIMP dating yielded a metamorphic age of 275.9±6.1 Ma, interpreted to be the age of the amphibole-facies metamorphism. In summary, our results, combined with available data, suggest that subduction leading to the closure of the Paleo-Asian Ocean in the Beishan Orogenic Belt was continuing in the middle Permian.

Keyword

High pressure metamorphism, P-T path, Zircon U-Pb dating, Middle Permian, Beishan Orogenic Belt

Experimental evidence for the exsolution of kyanite from Al-bearing stishovite: Implications for ultra-deep subduction/exhumation of continental crust

Liang Liu[1]*, NORTHWEST UNIVERSITY (liuliang@nwu.edu.cn)

Abstract

Based on experimental studies on the solubility (dissolution) of specific components (or exsolved minerals) in host minerals, exsolution microstructures identified in minerals, such as pyroxene/sodic amphibole in garnets, Fe-Ti oxides in olivine, K-feldspar in pyroxene, coesite in sphene, kyanite + spinel in former stishovite, from ultra-deep mantle xenoliths within kimberlites or lamproites, and from ultra-high-pressure (UHP) metamorphic rocks within subduction zones, is an important mineralogical probe to investigate the original depth as well as the mantle processes and slab subduction/exhumation dynamics. However, due to the complexity or multiplicity of the formation mechanisms of exsolution, especially the reversed experiments (compared to dissolution experiments) reproducing the exsolution microstructures, have rarely been reported, which make the interpretation of the genesis of the exsolution microstructures in minerals still controversial or even doubtful. In addition, with the intensive studies on UHP metamorphism and deep subduction of continental crust, mineralogical evidence of ultra-deep subduction to or near the depth of the stability field of stishovite (SFS) and subsequent exhumation to surface has been recognized in a number of typical UHP metamorphic terranes represented by South Altyn, NW China. However, since those evidences are mainly specific mineral exsolution microstructures or quartz paramorphs after stishovite, which in turn leads to the ultra-deep subduction to SFS is not widely recognized by the geoscience community. Therefore, in order to address these issues, this study attempts to further investigate the geological significance of exsolution microstructures and their implications based on exsolution experiments of kyanite in synthesized Al-bearing stishovite.

Our results show that the Al dissolved into stishovite exsolved completely in two stages. Firstly, ~69% of Al exsolved in the form of kyanite lamella as a decompression from 17 to 9 GPa (SFS). Then, the remaining ~31% of Al exsolved in the same form during the transformation from stishovite to coesite with continuous decompression to the stability field of coesite. As further decompression to the stability field of coesite/quartz + kyanite, the host stishovite transformed to coesite/quartz which correspondingly inherited kyanite lamellae exsolved from precursor stishovite. As decompression to the stability field of quartz + sillimanite, not only the host stishovite transformed to quartz, but also the former exsolved kyanite lamellae transformed to sillimanite.

Consequently, our results suggest that exsolution microstructures constrained by dissolution and exsolution experiments can indicate the subduction depth of UHP metamorphic rocks as well as UHP index minerals (e.g. coesite, diamond and stishovite). Therefore, the quartz associated with exsoleved lamella of kyanite + spinel in pelitic gneisses from South Altyn, China could be reasonably attributed to the decomposition of a precursor stishvotite, indicating continental crust experienced ultra-deep (SFS) subduction/exhumation. Moreover, the transformation of both

precursor host UHP minerals and exsolved minerals to low-pressure phases during retrograde metamorphism implies that lamella of sillimanite in quartz could not be excluded the possibility of a product of former kyanite in stishovite.

Keyword

Al-bearing stishovite, exsolution, ultra-high-pressure, ultra-deep subduction, experimental petrology

TIN ORE FORMATIONS OF ZIRABULAK-ZIAETDIN REGION OF UZBEKISTAN

Farrux Raxmatullayev RAXMATULLAYEV[1]*, Institute of mineral resources
(farruxraxmatullayev6868@gmail.com)

Abstract

Zirabulak-Ziaetdin ore region in Uzbekistan, which is located in the southwestern part of the Central Kyzylkum, is gold-rare metal. In the pre-Mesozoic basement of the region there are the Ingichke tungsten deposit, the Karakutan, Kyzbibi, Yangi Davon gold deposits, the small tin deposits of Karnab, Lapas, Semizkuduk, Kyzkurgan, Kochkaraly Changalli, etc. Sandstone-type uranium deposits are located in the sedimentary cover. .Insufficiently studied, but promising are the tin-ore objects of the region, located within two tin-ore fields: Karnabsky and Lapasssky.

The tin deposit Karnab ore field are confined to the southwestern endocontact of the C3-P1 biotite granite intrusion, which breaks through the core of a large anticline fold, on the wings of which marbled Devonian limestones and Ordovician terrigenous rocks are exposed. The Karnab intrusion hosting the mineralization is a C3-P1 granitoid complex. Contacts of an intrusion with a folded structure are secant. The northern contact is steep, the southern one is more gentle, complicated by a series of ruptures of the Karnab-Lapas deep fault. Dikes and stock-like bodies of leucocratic granites, aplites, and, to a lesser extent, pegmatites, are widespread in the exocontact zone.

Tin deposits of the Lapassky ore field are located in the zone of the southern exocontact of the Chirakdzhurinsky intrusive in carbonate-terrigenous sediments O2-3-D2.

Keyword

Tin, Karnab, Lapas, Zirabulak-Ziaetdin, pegmatites

The metamorphic events registered in the Santander Massif (Colombia)

Luis C. MANTILLA F. [1]*, UIS (lcmantil@uis.edu.co)
Carlos A. GARCIA R.[2], UIS

Abstract

The Santander Massif (SM) is an igneous-metamorphic basement, outcropping in the Colombian eastern cordillera, composed mainly by high and low-grade metamorphic rocks (Precambrian and early Paleozoic in age), along with igneous lithologies formed during different subduction events that took place during the late Paleozoic, Mesozoic and Cenozoic time.

The metamorphic rocks from the SM are traditionally grouped in the following stratigraphic units[1]: Bucaramanga Gneiss (its zircon crystals, analyzed by SHRIMP method, shows an U-Pb age between ~1550 and ~900 Ma[2]), Silgara Schist (its U-Pb detrital zircon geochronology shows an age ranging from 1624 to 451 Ma; [3]) and Orthogneis (a sin-tectonic igneous plutons emplaced then at 477 Ma;[4]). A more recent study in the Floresta Formation rocks, a sedimentary unit affected by low-grade-metamorphic event, shows a prominent U-Pb detrital zircons age pick at 410 Ma [5]; and a garnet and whole rock Lu/Hf geochronology from a sample collected in the SW area of the SM (affected by amphibolite facies and traditionally related to Silgara Unit), yielded an age of 271.11.5 Ma. Biotites and amphiboles from the Bucaramanga gneissic rocks has exhibited completely reset Ar/Ar spectra, with well-defined plateau ages in the 190-200 Ma [2,6].

The before mentioned data suggest a complex metamorphic history for the SM. At least two main regional metamorphic events have been recognized, related to the Grenville and Fammatinian orogenic events; but other metamorphic events, more local in their effect on the rocks (late Paleozoic and Mesozoic in age), have also been recognized in the MS, mainly related to contact, dynamo-thermal, hydrothermal and probably a burial metamorphism as well.

References:

[1] Ward D et al. (1973) Boletín Geológico XXI (1-3): 1-132.
[2] Cordani U et al. (2005) Geological Society, London, Special Publications, 246, 329-346.
[3] Mantilla L. and García C. (2016) Boletín de Geología, 38(1), 33- 50.
[4] Mantilla L et al., (2012) Journal of South American Earth Sciences 38 (2012) 1-12 [5] Mantilla L. and García C. (2018) Boletín de Geología - Vol. 40 Num. 1, 123-144.
[6] Van Der Lelij R et al. (2016) Gondwana Research. Vol. 31; 271-294

Keyword

Colombia, Santander Massif, Metamorphism

METAMORPHIC EVOLUTION OF THE UBENDIAN BELT IN NORTHERN MALAWI

Ruth MUMBA[1]*, Geological Survey Department (ruthmumba89@gmail.com)
Joseph Chirwa[2], Mines Department

Abstract

The Ubendian belt is a northwest-southeast trending metamorphic belt that borders the Tanzania craton on the southwest and separates the craton from the Bangweulu Block and Irumide belt on the Southwest and extends into the northern part of Malawi. It has eight tectonic blocks of different lithologies three of which namely the Ufipa, Mbozi and Nyika extend into Malawi. The belt has experienced several periods of reactivation since the Palaeoproterozoic era. Some of these activities obliterated the earliest metamorphic history of the rocks. This study was undertaken in part of northern Malawi in the Chitipa district using selected lithologies to constrain further the metamorphic evolution of the Ubendian Belt. The methods used in this study included geologic mapping, petrography and pressure-temperature analysis. The study investigated the structural geology of paragneisses, phyllites , granitic gneisses; and the pressure-temperature conditions of cordierite gneisses which are some of the oldest rocks in the area dated 1815±260 m.y. BP by Rb-Sr whole-rock isochron method from the previous work (Ray 1974).This information, coupled with previous data, gave us more information on the area's metamorphic evolution. It was observed that the earliest metamorphic event has been erased from the rocks. What is prominent are the effects of the Irumide and Mozambique orogeny. On pressure-temperature conditions, amphibolite facies were calculated and the possibility of a retrograde path as the mineral chlorite was observed.

Keyword

cordierite gneisses, Ubenbian, orogeny, pressure-temperature, Lithology

Crustal Thermal transitions and the Rise of the Tibetan Plateau: From Amphibolite to Ultrahigh-Temperature Granulite Facies Crust since the Miocene

XIU-ZHENG ZHANG[1]*, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (zhangxz@gig.ac.cn)
QIANG WANG[2], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
WEI DAN[3], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Abstract

Numerical models have highlighted the critical role of the thermal state transition (TST) from a cold to a warm mid-to-lower crust in dictating the morphological fate of orogens—shaping them into either linear mountain ranges, akin to the Alps, or expansive hot orogens with flat plateaus, reminiscent of Tibet. The Tibetan Plateau's rapid ascent, the most prominent topographic anomaly on Earth, is generally attributed to thermal mechanisms involving either the mantle, such as lithospheric delamination, or the crust, through processes like crustal flow. Yet, the precise timing and mechanisms underlying the shift from a cold to a warm state in the lithospheric mantle or deep crust remain elusive. This study presents findings from unique mid-to-lower crust xenoliths embedded in igneous rocks dated at 28, 3.8, and 2.3 Ma from central Tibet, shedding light on this transition. Our data reveal a cold, H2O-rich deep crust at 28 Ma, transitioning to a hotter, drier granulite crust by ~23 Ma, driven by an increasing geothermal gradient. These findings mark the first concrete temporal constraints on the TST, delineating the duration of this pivotal transition. The marked shift observed between 28 and 23 Ma aligns with the hypothesis of lithospheric mantle delamination induced by hot asthenosphere upwelling. Rising geothermal gradients likely transformed the once H2O-abundant mid-lower crust, generating substantial melt volumes until 2.3 Ma, when conditions evolved to ultra-hot (>1100 ℃) and arid states. Correlated with paleoelevation data, our results imply a nearly concurrent cold-to-hot thermal transition in the mid-lower crust with the topographic transformation from rugged mountains to a level plateau during the early Miocene. This supports the theory of crustal flow as the predominant mechanism for landscape leveling across central-northern Tibet.

Keyword

crustal xenoliths, high- to ultrahigh-temperature (UHT) metamorphism, thermal transitions, crustal flow, Tibetan Plateau

Early Aptian volcanism of the Kerguelen LIP and its implications for the evolution of the proto-Indian Ocean

Eun Young Lee[1]*, Department of Geology, University of Vienna, Vienna, Austria (eun.lee@univie.ac.at)
Seunghee Han[2], School of Earth Sciences and Environmental Engineering, Gwangju Institute of Science and Technology (GIST), Gwangju, Republic of Korea
Hakwon Jeong[3], School of Earth Sciences and Environmental Engineering, Gwangju Institute of Science and Technology (GIST), Gwangju, Republic of Korea
Sangheon Yi[4], Climate Change Response Division, Korea Institute of Geoscience and Mineral Resources (KIGAM), Daejeon, Republic of Korea
Susanne Gier[5], Department of Geology, University of Vienna, Vienna, Austria
Maria Meszar[6], Department of Geology, University of Vienna, Vienna, Austria
Bernhard Schnetger[7], Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg, Oldenburg, Germany
Hans-J. Brumsack[8], Institute for Chemistry and Biology of the Marine Environment (ICBM), University of Oldenburg, Oldenburg, Germany
David Watkins[9], Department of Earth and Atmospheric Sciences, University of Nebraska-Lincoln, Nebraska, USA
Brian Huber[10], National Museum of Natural History, Smithsonian Institution, Washington, DC, USA

Abstract

The Kerguelen large igneous province (LIP) is linked with the opening of the eastern Indian Ocean. During the Early Cretaceous, widespread volcanism coincided with the rifting to breakup between Greater India and Australia-Antarctica (East Gondwana). Subsequent to the breakup, a series of massive volcanic eruptions formed the basalts of the southern Kerguelen Plateau and other microcontinents in the proto-Indian Ocean. However, the role of the Kerguelen LIP in the opening and evolution of the Indian Ocean remains a contentious subject. A primary point of debate is the poorly constrained age and characteristics of early magmatic products and their uncertain relationships with the Kerguelen LIP. The International Ocean Discovery Program (IODP) Expedition 369 recovered Early Cretaceous volcanic and sedimentary sequences at Site U1513 on the Naturaliste Plateau, southeastern Indian Ocean. The Naturaliste Plateau, a large submarine continental block on the southwest Australian rifted margin, situated near the projected position of the Kerguelen plume during the opening of the eastern Indian Ocean. Recent investigations into the volcanic sequences have revealed new critical evidence supporting the involvement of the Kerguelen LIP in the East Gondwana breakup. Our study delves into the intricate relationships between the Kerguelen LIP and the post-breakup evolution of the proto-Indian Ocean and the southwest Australian rifted margin. Re-analyses of core-sections and samples discriminated an early Aptian interval, potentially synchronous with the southern Kerguelen Plateau volcanism. The interval reveals distinctive signatures of volcanic influence, including tuffaceous sediments and a high Hg content, even though the volcanism on the Naturaliste Plateau had already ceased during the early Barremian. These findings suggest that the

early Aptian deposits contain volcanic ash transported from the Southern Kerguelen Plateau. Additionally, this interval exhibits an abrupt transition from shallow and restricted marine to deep and open marine environments, signifying the initiation of post-rift thermal subsidence. Contrary to substantial post-rift subsidence experienced elsewhere following the final breakup, the Naturaliste Plateau displayed limited subsidence after the final breakup during the Barremian, likely attributed to the proximity or elevated temperature of the Kerguelen mantle plume. Consequently, we infer that the early Aptian activity of the Kerguelen LIP influenced the thermal condition of the lithosphere, which resulted in the rapid subsidence of the Naturaliste Plateau and associated environmental changes in the proto-Indian Ocean.

Keyword

Kerguelen LIP, Naturaliste Plateau, IODP Site U1513, Aptian, East Gondwana breakup

Neoproterozoic (ca. 830 Ma) carbonatite dykes from Qianlishan in the western North China Craton and their tectonic and metallogenic implications

Shuan-Hong ZHANG[1]*, Institute of Geomechanics, Chinese Academy of Geological Sciences (tozhangshuanhong@163.com)
Hong-Yu WANG[2], Institute of Geomechanics, Chinese Academy of Geological Sciences

Abstract

Carbonatite and the associated alkaline intrusive complexes are the primary sources of light rare earth element (REEs). Our field investigations in the western margin of the North China Craton (NCC) have firstly identified over 20 carbonatite dykes and minor coeval carbonate-rich lamprophyre dykes intruding into the Paleoproterozoic Qianlishan Group in the southern Qianlishan area. Zircon LA-ICP-MS U-Pb dating on six carbonatite samples yielded crystallization ages ranging from 835.2+/-3.7 Ma to 828.9+/-3.8 Ma, indicating emplacement of the carbonatite dykes at ca. 830 Ma during the Neoproterozoic. Geochemical data show that most of the carbonatite dykes are rich in light REEs with total light REEs >600 ppm to 4932 ppm, and the carbonate-rich lamprophyre dykes are characterized by high Cr (1219–1267 ppm) and Ni concentrations (857–1076 ppm). Petrological and scanning electron microprobe (SEM) analytical results show that the dominant REE-bearing minerals in the carbonatites are monazite, and other REE-bearing minerals are parisite and bastnäsite. Geochemical and carbon-oxygen isotopic results indicate that the ca. 830 Ma carbonatite dykes were produced by low-degree partial melting of a previously metasomatised subcontinental lithospheric mantle with assimilation of crustal material. Emplacement of the ca. 830 Ma carbonatite and carbonate-rich lamprophyre dykes in the southern Qianlishan area and the previously reported ca. 810 Ma mafic dykes in the middle Qianlishan area occurred in a continental rift environment. Simultaneous development of the Neoproterozoic (830–810 Ma) continental rifting events in the western margin of the NCC and the eastern margin of the Alxa Block as previously suggested may indicate a connection between the eastern Alxa Block and the western NCC during and before the middle Neoproterozoic.
This research was financially supported by the National Natural Science Foundation of China (41920104004, U2244213, 41725011) and the Fundamental Research Fund of Chinese Academy of Geological Sciences (JKYZD202320).

Keyword

carbonatite dyke, REE mineralization, large igneous provinces (LIPs), Neoproterozoic continental rifting, North China Craton (NCC)

Deciphering the Emplacement Mechanism of Paleoproterozoic Mafic Dyke Swarms in the Dharwar Craton: Insights from AMS and Fracture Analyses

SRINJOY DATTA[1]*, BANARAS HINDU UNIVERSITY, VARANASI
(dattasrinjoy94@gmail.com)
AMIYA KUMAR SAMAL[2], BANARAS HINDU UNIVERSITY, VARANASI
SAYANDEEP BANERJEE[3], BANARAS HINDU UNIVERSITY, VARANASI
RAJESH KUMAR SRIVASTAVA[4], BANARAS HINDU UNIVERSITY, VARANASI

Abstract

The Dharwar craton hosts several Paleoproterozoic mafic dyke swarms ranging in age from ca. 2.37 Ga to ca. 1.79 Ga. These dyke swarms, which are extensively exposed throughout the craton, have been studied in detail for their geochemistry, geochronology, and paleomagnetism. However, there remains a lack of understanding regarding their emplacement dynamics and magma flow patterns. Anisotropy of magnetic susceptibility (AMS) offers a straightforward method to investigate magma flow dynamics within dyke fractures. When combined with fracture data analyses, AMS data can yield valuable insights into dyke emplacement mechanisms.

In this study, samples from four distinct Paleoproterozoic dyke swarms, viz. ca. 2.37 Ga Bangalore-Karimnagar dyke swarm, ca. 2.25 Ga Ippagudda-Dhiburahalli dyke swarm, ca. 2.21 Ga Anantapur-Kunigal dyke swarm, and ca. 2.08 Ga Devarabanda dyke swarm have been studied considering their wide-ranging spatial and temporal distribution. The magnetic fabric data of the mafic dykes are compared to those of the associated host granites, as well as fracture geometry data, in order to explore potential relationships between magmatic stress regimes and pre-existing strain fabrics. The results indicate that, with the exception of the ca. 2.08 Ga Devarabanda dyke swarm, most dyke swarms exhibit lateral magma injection from distant plumes suggesting no plume centre is located below the cratonic lithosphere of the Dharwar craton. In contrast, the ca. 2.08 Ga dyke swarm displays a combination of lateral and vertical magma injection from a proximal plume center. By analysing the imbrication of magnetic minerals within the dyke planes, potential location of plume centers for the studied dyke swarms have been identified. Furthermore, by comparing the magnetic fabrics of the dykes with those of the host rocks and examining fracture geometry, emplacement models have been proposed for each dyke swarm. Overall, the study highlights significant influence of pre-existing strain fabrics and regional stress regimes on the emplacement of dyke swarms within the craton. Given that dyke swarms are often associated with supercontinent breakup or assembly, and considering the Dharwar craton's position in several major supercontinents, this research enhances our understanding of the Dharwar craton's tectonic architecture, with potential implications for the broader Precambrian tectonic framework.

Keyword

Mafic dykes, Emplacement mechanism, AMS, Dharwar craton

A new ca. 2.49-2.46 Ga Silicic Large Igneous Province (SLIP) event in the Bastar craton, India

Amiya Kumar Kumar SAMAL[1]*, Banaras Hindu University (amiyasamal007@gmail.com)
Ulf Söderlund[2], Lund University
Ankur Ashutosh[3], Banaras Hindu University
Tomas Naeraa[4], Lund University
Gulab C Gautam[5], Banaras Hindu University
Rajesh K Srivastava[6], Banaras Hindu University
Richard E Ernst[7], Carleton University

Abstract

Silicic Large Igneous Province (SLIP) represent a distinct class within the Large Igneous Provinces (LIPs), predominantly characterized by silicic magmatic rocks with subordinate proportions of basalt and/or mafic/ultramafic intrusive equivalents, originating without any subduction influence. Based on an in-situ LA-ICPMS U-Pb zircon date of 2480 ± 17 Ma obtained for a granophyre dyke emplaced in the Pakhanjore area, central-west Bastar craton and earlier reported coeval Bijli rhyolite, Pitepani basalts, Khallari ultramafic-mafic complex, Nuapada syenite, and several granitic intrusions, we identified a new ca. 2.49-2.46 Ga Dongergarh SLIP event in the Bastar craton, the second SLIP event discovered in the Indian Shield. The other SLIP event known in the Indian Shield is the ca. 750 Ma Malani SLIP, which is consisting of basaltic eruptions transitioning to massive silicic lava flows, granitic plutonism, and terminal dyke-swarm activity. Geochemical composition of the studied granophyre dyke aligns closely with Kotri and Bijli rhyolites, suggesting its eruption within an intraplate tectonic setting through crustal anatexis. The coeval magmatic rocks collectively constitute a comprehensive assemblage, displaying close spatiotemporal relationships clearly indicate the presence of a SLIP event. Although, no matching SLIP event known from other part of the world, however, there are coeval LIP events are known from the Superior, Wyoming, Hearne, Karelia, and Zimbabwe cratons, particularly the Matachewan LIP in the Superior craton, which consists of multiple pulses of mafic dykes emplaced between 2490-2450 Ma.

Keyword

SLIP, Granophyre, Bastar, LIP

[Keynote] Dyke swarms of the Indian Shield in space and time: characterizing Large Igneous Provinces, their plumbing system and likely mineral systems

Rajesh Kumar SRIVASTAVA[1]*, Department of Geology, Institute of Science, Banaras Hindu University, Varanasi 221005 (rajeshgeolbhu@bhu.ac.in)
Amiya Kumar Samal[2], Department of Geology, Banaras Hindu University, Varanasi 221005, India
Richard E. Ernst[3], Department of Earth Sciences, Carleton University, Ottawa, ON K1S5B6, Canada
Gulab Chand Gautam[4], Department of Geology, Banaras Hindu University, Varanasi 221005, India

Abstract

A systematic study of intracratonic regional mafic dyke swarms, within shield areas provide crucial insights on short-lived, mantle-generated large igneous province (LIP) events through space and time. More importantly, mafic dyke swarms record the pulse of the Earth and rhythm of intraplate mantle melting events through time. Significantly, if it is precisely dated, it may deliver incredible information on continental rifting and supercontinent break-up, secular evolution of the mantle, location of plume centres and their frequency, key paleomagnetic poles, mantle sources, and many more. In addition, dyke swarms and their LIP events are also drivers of catastrophic environmental change, regional uplift, regional basin formation, Ni-Cu-PGE and other types of ore deposits, and fluctuations in the reversal frequency of the Earth's magnetic field. One of the most important characteristics of the regional dyke swarms identified in any shield area represents part of the plumbing system of Large Igneous Provinces (LIPs). This is crucial as the young Mesozoice-Cenozoic record LIPs are expressed as continental flood basalts or oceanic plateaus, whereas, in the case of older LIPs of Precambrian age, the flood basalts have typically been removed by erosion, thus exposing the plumbing system component, which consists of regional dyke swarms, sill provinces and associated mafic-ultramafic intrusions; also, silicic magmatism and carbonatites and kimberlites can also be associated.

Like the other shield areas of the globe, the Indian Shield too hosts a spectacular record of dyke swarm emplacements in space and time. Based on several proxies that include mapping with the help of Google™ Earth images and ArcGIS™, field-data, trend and patterns of dyke swarms, geochronology, and geochemistry, more than 25 distinct dyke swarms are identified in different Archean cratonic blocks of the Indian Shield. On the basis of these dyke swarms, together with other magmatic intrusions, more than 15 very well-preserved LIP events are characterized. The geochemical attributes of many of these dyke swarms, by inference LIPs, indicate the assimilation of crustal material prior to their emplacement. This assimilation process establishes a probable connection to the formation of Cu-Ni-Co-PGE deposits. Some identified LIP events also show association with carbonatite, kimberlite and lamproite and related economic potentials, particularly rare-earth elements and diamonds. The age bar-code record of these magmatic units has a good match with magmatic records of other regions globally that provide a basis for a robust evaluation of the position of the various Indian cratons within the known supercontinents, viz., Kenorland, Columbia, Rodinia, and Gondwana.

Keyword

Dyke swarms, Indian Shield, Large Igneous Provinces, Plumbibg system, Mineral system

The Midcontinent Rift System LIP initiated passively — Evidence from diverse mantle source contributions during early rift development

Pete HOLLINGS[1]*, Lakehead University (Peter.Hollings@lakeheadu.ca)
Matthew Brzozowski,[2], Lakehead University
Jing-jing Zhu[3], Chang'an University
Robert Creaser[4], University of Alberta

Abstract

The magmatism associated with the Midcontinent Rift System (MRS) of Canada has generally been suggested to result from the impingement and melting of the Keweenaw Plume beneath the crust ca. 1.1 Ga. However, the long duration of MRS magmatism combined with paleomagnetic evidence consistent with rapid plate motion during that time suggests that plume melting may not have been the main source of the magmatism. This has raised questions regarding the nature of the mantle sources that fed the MRS and the processes that initiated rift development. Although important for understating early MRS development and associated critical mineral resources, addressing these uncertainties has remained challenging given that many of earliest MRS magmas were variably contaminated by crustal material, masking primary geochemical signatures. To overcome this, we integrated new Os isotope data of Initiation (>1,109 Ma), Early (1,109–1,104 Ma), and Hiatus (1,104–1,098 Ma) stage rocks with variations in their bulk-rock Nd isotope geochemistry. The MRS rock suite is characterized by highly variable γOsi values of -10 to 3857, with Early Stage melts exhibiting the greatest variability (-10 to 3857) and Initiation Stage melts exhibiting the smallest variability (4 to 50). This variability could not have resulted from different degrees of partial melting, retention of garnet in the mantle, or fractional crystallization because γOsi values do not correlate with La/Sm, Gd/Yb, and MgO, respectively. Based on mixing simulations, the radiogenic εNdi–γOsi values of the early mafic–ultramafic intrusions and sills suggest crystallization from melts derived largely from enriched Subcontinental Lithospheric Mantle (SCLM), which assimilated limited (<10%) crustal material during emplacement. In contrast, the variably negative to positive γOsi values of late diabase sills and subaerial lavas suggest crystallization from melts that originated from depleted portions of the Keweenaw Plume, which were subsequently contaminated during emplacement in the crust. Although contamination can explain the range of εNdi values exhibited by the rock suites, it cannot independently account for the range of γOsi values as i) this would require geologically unreasonable degrees of contamination and ii) not all of the rock suites were contaminated. It is likely that fractionation of sulfide liquid and/or Os-bearing platinum-group minerals also contributed to this variability. These results have two critical implications for magma sources and rift development. First, not all of the rock suites in the MRS crystallized from plume-derived melts as traditionally thought, with melt contributions from the SCLM being greatest during the early stages of rift formation. Second, the MRS likely initiated passively, with later plume impingement providing the energy and material necessary for voluminous magmatism.

Keyword

Midcontinent Rift, Re-Os isotopes, Passive rifting

Links between plume-generated LIPs and new ocean formation through time

Hafida EL BILALI[1]*, Carleton University, Canada (hafidaelbilali@cunet.carleton.ca)
Richard Ernst[2], Carleton University, Canada

Abstract

It is clear from the Phanerozoic geological record that plume-generated Large Igneous Provinces (LIPs) can be associated with major continental breakup and formation of new oceans. Prominent examples include the 62-55 Ma North Atlantic LIP, the 201 Ma Central Atlantic LIP, and the 132 Ma South Atlantic LIPs (including the Parana-Etendeka LIP), which are associated with formation of the North Atlantic, Central Atlantic and South Atlantic, respectively. In each case ocean opening began within a few million years after the arrival of the plume-generated LIP.

It is equally clear that some major plume-generated LIPs are not associated with breakup, such as the 251 Ma Siberian Traps LIP, which caused rifting (but no breakup) between Asia and Europe. A Proterozoic example is the 1106-1090 Ma Keweenawan LIP associated with the 2000 km long Mid-Continent Rift system in the Great Lakes region, but which failed to separate 'Canada' from the 'United States'. In both cases, coeval compressional stresses prevented ocean opening: assembly of Pangea in the case of the Siberian Traps LIP and the Grenville Orogeny in the case of the Keweenawan LIP.

We propose that formation of new oceans requires both a mantle plume and favourable extensional stresses in the plate at the time. It is further hypothesized that formation of every major ocean through geological history required the presence of a plume-generated LIP. In this present study, we provide an initial catalogue of plume-generated LIPs through time which can be linked with new ocean formation.

LIP events can be extensive (covering up to 10,000,000 km2) and for demonstrating a link with ocean opening it is key that the plume centre be located approximately along the new ocean boundary. We review criteria for locating plume centres of LIPs. The strongest constraint is giant mafic radiating dyke swarms which focus on the plume centre. Giant circumferential dyke swarm can also be important. Triple junction rifting can focus approximately on the plume centre, in some cases with offset of a few hundred km. Another criterion is variation in the thicknesses of flood basalts (as an indicator of proximity to the plume centre).

Keyword

Plume, Continental break-up, Failed break-up, Dyke swarm, Spreading ridge

The effective elastic thickness of lithosphere for continental large igneous provinces

Qin WANG[1]*, School of Earth Sciences and Engineering, Nanjing University (qwang@nju.edu.cn)
Yao Yao[2], Nanjing University
Richard Ernst[3], Carleton University
Hafida El Bilali[4], Carleton University

Abstract

The effective elastic thickness of the lithosphere (Te) provides a proxy to reflect the overall long-term (>106 years) rheological strength of the lithosphere. So far there are only a few studies on Te of large igneous provinces (LIPs) and lack comparison of Te of different LIPs. In order to clarify the influence of thermal and loading effects of LIPs on rheology of the lithosphere, we used the admittance method, the coherence method and the joint inversion method to calculate Te distribution and loading ratios (F) of the Emeishan LIP and surrounding area with topography data from ETOPO1, gravity data from WGM2012 and the CRUST1.0 model. The results indicate that the joint inversion method is more robust than the other methods. We then used the joint inversion method to estimate Te and loading ratios (F) of the Deccan Traps LIP (~66 Ma), the Central Atlantic magmatic province (CAMP) (201-202 Ma), the Siberian Traps LIP (~252 Ma), and the Kalkarindji LIP in Australia (~511 Ma). The results indicate that Te of the continental LIPs is independent of the crustal thickness (Tc) but has a positive correlation with Te/Tc. The eruption center (i.e., the area with thickest basalt lavas) has smaller Te/Tc values than the surrounding cratonic regions, but higher than tectonically active regions. Te/Tc values increase with the age of LIPs.

Development of LIPs is associated with surface loading by massive continental flood basalt and subsurface loading by mafic intrusions and magma underplating at the crust-mantle boundary. The loading ratio F in the eruption center of the Deccan Traps LIP, the CAMP and the Siberian Traps LIP is negatively correlated with Te. Compared with other LIPs, the Emeishan LIP shows the higher heat flow, lower F, lower Te and lower Te/Tc, which can be attributed to the enhanced tectonic activity during the eastward growth of the Tibetan plateau in the Cenozoic. The subsurface loading is dominant in the Emeishan LIP, the Decan Traps LIP and the CAMP, whereas the surface loading is dominant in the Siberian Traps LIP and the Kalkarindji LIP. In addition, the influence of LIPs on the lithospheric strength varies with space and time. During formation of LIPs, the mantle upwelling and magma underplating increase the lithosphere temperature and decrease the crust-mantle coupling, resulting in smaller Te values. The subsequent cooling will gradually increase the crust-mantle coupling and the overall strength of the lithosphere. However, the Te values in the eruption center will decrease because the surface loads from flood basalts and crustal intrusions produce high stress. Finally, the surface loads gradually decrease due to surface processes with time, the induced stress in the eruption center reduce simultaneously and the strength of the lithosphere gradually recovers. For the Kalkarindji

LIP in ~511 Ma, the influence of LIP on the strength of the continental lithosphere can be ignored.

Keyword

large igneous province, effective elastic thickness of the lithosphere, rheology, magma underplating, loading ratio

Record of Archean Large Igneous Provinces (LIPs) and their mafic dyke swarms

Richard Everett ERNST[1]*, Carleton University, Canada (richardernst@cunet.carleton.ca)
Hafida El Bilali[2], Carleton University, Canada
Kenneth L. Buchan[3], 273 Fifth Ave., Ottawa, Ontario, Canada
Kevin R. Chamberlain[4], Wyoming University, USA
Rajesh Srivastava[5], Banaras Hindu University, India

Abstract

Over the past two decades, there has been a significant expansion of the Archean Large Igneous Province (LIP) record through precise U-Pb dating, new approaches to geochemical characterization, improved reconstruction constraints (based on paleomagnetism and age matching of magmatic events), and a better understanding of LIP plumbing system architecture. Key criteria for the recognition of Archean LIPs are volcanic sequences with associated komatiites (indicating a high temperature mantle source), geochemistry consistent with intraplate origin (with potential modification by lithospheric mantle or crust), large inferred magmatic volume, and the presence of large mafic dyke swarms. Based on such criteria, there are a minimum of 70 Archean LIP-fragments (on different crustal blocks) from the 3.8 to 2.5 Ga period, which fall into a minimum of 30 age groups spanning different crustal blocks that could potentially represent single reconstructed LIPs/plumes. This represents an average of one LIP fragment every 20 myr and a minimum of one (potential) reconstructed LIP event every 40 myr. These values are remarkably similar to the post-Archean continental record of one LIP fragment per 20 myr, and age groups (representing potentially reconstructed LIPs) of about one per 30 myr. In both time periods (Archean and post-Archean) there is certainly incomplete information, In the post-Archean time (except for the past 200 myr) the oceanic LIP record is only preserved as fragments in collisional belt. While the Archean LIP record may include oceanic LIPs, a full understanding of this aspect of the geological record is hindered by a more extensive history of metamorphism, deformation and crustal fragmentation.

Archean dyke swarms are particularly valuable in recognizing and characterizing mantle plumes. We currently recognize nearly 40 dyke swarms from the 3.51-2.5 Ga period, which can be grouped by age across different crustal blocks and represent a minimum of 17 different events (2510-2500, 2550, 2575, 2620, 2660, 2700-2680, 2720-2710, 2725, 2750-2740, 2780-2770, 2860, 2920, 2960, 3265, 3320, 3470, 3510 Ma), each likely linked to a mantle plume. At least two Archean plume centres have been identified based on radiating swarms, both are in the Kaapvaal craton (at ca. 2.96 Ga and at 2.70-2.68 Ga). Additional candidates are being assessed.

Keyword

Archean, Large Igneous Provinces (LIPs), Dyke swarm, Mantle plume, Komatiite

A comprehensive geochemical study on mafic dyke swarms from the central-western Bastar craton, India, and their link with different Paleoproterozoic large igneous provinces of the Indian Shield

Ankur ASHUTOSH[1]*, Banaras Hindu University (ankurashutoshsingh@gmail.com)
Amiya Kumar Samal[2], Banaras Hindu University
Gulab Chand Gautam[3], Banaras Hindu University
Rajesh Kumar Srivastava[4], Banaras Hindu University

Abstract

The Archean Bastar craton of the Indian Shield is transected by several Mesoproterozoic-Neoarchean mafic dyke swarms of different trends and compositions. Among them, at least three distinct mafic dyke swarms have been documented in the central-western part of the craton, particularly around the Bhanupratappur and Pakhanjore regions. These include NW-trending ca. 2.36 Ga Bhanupratappur, ENE-trending ca. 2.25 Ga Chhura, and NNW-trending ca. 1.88 Ga Bastanar mafic dyke swarms. This study reports a comprehensive geochemical study on these distinct mafic dykes to understand their petrogenetic evolution. Geochemically, samples of all three swarms show basaltic to basaltic-andesite composition and exhibit fractionation of olivine, clinopyroxene, plagioclase, and Cr-spinel, however, a slight difference in the petrogenesis of these swarms is perceived. The ca. 2.36 Ga and ca. 2.25 Ga dykes show enriched LREE and flat HREE patterns, however, LREE enrichment is more pronounced in the ca. 2.25 Ga samples which may be due to variable degrees of mantle melting and crustal contamination. REE-patterns of the ca. 1.88 Ga dykes vary uniquely and are categorized into two groups; the Group 1 possesses an almost flat to slightly enriched pattern and the Group 2 follows an overall inclined pattern; each hinting at different degrees of mantle melting and derivation from a mixed spinel-garnet lherzolite source from variable depths. Furthermore, the melts of two older swarms, i.e., ca. 2.36 Ga and ca. 2.25 Ga, are from shallower depths originating from spinel-rich lithospheric mantle. Field setting, trends of dykes, and geochemical characteristics, together with available geochronological data, these distinct mafic dyke swarms can be linked with the three LIP events, viz. ca. 2.37-2.36 Ga Bangalore, the ca. 2.26-2.25 Ga Ippaguda, and ca. 1.89-1.88 Ga Bastanar LIPs of the Indian Shield.

Keyword

Mafic dyke swarms, Paleoproterozoic, Central-western Bastar craton, Large igneous province, Indian Shield

The Late Mesozoic Volcanic Events and Metallogenic Basin Dynamics Mechanism in Eastern Shandong and Adjacent Seas

Yan ZHANG[1]*, China University of Petroleum (East China) (3255338266@qq.com)

Abstract

The northern part of the Large Igneous Province along the eastern coast of China is a narrow and north-south oriented Large Igneous Province. The Late Mesozoic volcanic events were mainly generated by the interaction between magma from the mantle and the crust. A transcrustal magmatic system was formed within the crust of the Jiaodong Peninsula and adjacent areas. There is a unified and coupled relationship between the magmatic process and the mineralization process of the basin mountain process. With the occurrence of intense mineralization in eastern Shandong during the Late Mesozoic era, the mineralization dynamics background has gained important understanding, but further refinement and explanation are needed.This paper intends to use body wave, surface wave, receiver function, and gravity data to jointly invert and obtains high-precision three-dimensional velocity and longitudinal and transverse wave velocity ratio models to establish the mechanism of Cretaceous major volcanic events and deep fault system structural inversion. Based on the unified geodynamic model of "magma structure mineralization basin formation", a new model of cross crustal magma system basin mountain coupling mineralization is constructed. We Analyze the transformation process of deep thermal systems, explore the inherent relationship and laws between the rheological structure of the lithosphere and large-scale concentrated mineralization under the background of major volcanic events, and enrich the theory of mineralization in eastern Shandong.

Keyword

Large Igneous Province, The Late Mesozoic, Eastern Shandong, Geodynamic Model

Revealing 2.4 LIP in the Belomorian province, Fennoscandian Shield: U-Pb ID-TIMS studies of baddeleyite and baddeleyite-zircon aggregates

Maria Alexandrovna SUKHANOVA[1]*, Institute of Precambrian Geology and Geochronology RAS, St.Petersburg (mariia.sukhanova.01@mail.ru)
Ekaterina Borisovna Salnikova[2], Institute of Precambrian Geology and Geochronology RAS, St.Petersburg
Alexandra Vladimirovna Stepanova[3], Institute of Geology, Karelian Research Centre, Russian Academy of Sciences, Petrozavodsk
Svetlana Valerievna Egorova[4], Institute of Geology, Karelian Research Centre, Russian Academy of Sciences, Petrozavodsk

Abstract

The Belomorian province, eastern Fennoscandian Shield, is an Archean crustal block that expired a tectono-metamorphic reworking in the Paleoproterozoic (1.8 – 1.9 Ga) being involved in Lapland-Kola collision orogeny (Balagansky et al., 2016). In the early and middle Paleoproterozoic Belomorian province was affected by several mantle plumes resulted in mafic intrusions and dykes of ages 2.5, 2.45, 2.4, 2.3, 2.2 and 2.12 Ga (Stepanova et al., 2022).

Olivine gabbronorites are widespread in the Belomorian province and often occur as tectonic fragments of larger intrusive bodies or dykes. Metamorphic alteration caused the formation of corona reaction rims around mafic minerals. These rocks also contain baddeleyite-zircon aggregates morphologically similar to corona reaction rims. The central part of the aggregates consists of igneous baddeleyite surrounded by a zircon rim that forms a parallel columnar aggregate. The rim contains fluid inclusions suggesting its metamorphic origin.

The Ambarny intrusion is characterized by a significantly lower degree of preservation of primary igneous minerals and corona reaction rims are developed everywhere. Unaltered baddeleyite is scarce in these rocks but baddeleyite-zircon aggregates are widespread. Structural relationships of baddeleyite-zircon aggregates and corona reaction rims indicate the synchronicity of zircon rims of corona mineral reaction rims. Zircon in aggregates forms 35-90% of the crystal volume, which has a significant impact on the baddeleyite U-Pb isotope system. Discrete chemical abrasion technique (modified M. Rioux's (2010) technique) was applied to separate both baddeleyite and zircon phases. The procedure consists of high temperature annealing, pre-treatment with HCl (baddeleyite dissolves) and final decomposition with HF (zircon dissolves) and separate ID TIMS analysis of each phase. The age of baddeleyite is 2411±6 Ma, the age of zircon is 1911±35 Ma. This allows us to yield the age of the Ambarny intrusion at 2.4 Ga and determine the age of the formation of corona reaction rims in olivine gabbronorites (Salnikova et al., 2022).

The Kamennoe intrusion is characterized by the best preservation. Here, coronas around olivine are poorly developed, and well-preserved igneous baddeleyite is recognized. U-Pb ID TIMS single grain geochronological studies of baddeleyite yield an emplacement age of 2404±11 Ma.

The Kondostrov dyke comprise well-preserved olivine gabbronorites. Metamorphic alteration here are confined to tectonic zones; primary igneous minerals are preserved in undeformed parts of the

dyke. Baddeleyite here is also well-preserved with rare thin shells of zircon. However, the shells have little effect on the isotope system of baddeleyite, which made it possible to carry out geochronological studies using standard techniques. The age of baddeleyite is 2418±8 Ma.
These data indicate that ca. 2.4 Ga mafic igneous rocks in the Belomorian province belongs to a distinct igneous event and support the existence of ca. 2.4 Ga LIP.
The study was supported by grant No. 22-17-00211 from the Russian Science Foundation.

Keyword

U-Pb ID-TIMS, baddeleyite, Fennoscandian Shield, LIP

The Karoo large igneous province contains diamondiferous lamproites

Sebastian TAPPE[1]*, UiT The Arctic University of Norway (sebastian.tappe@uit.no)
Ntando S Ngwenya[2], University of Johannesburg

Abstract

Both lithospheric and sublithospheric mantle sources contribute to the vast volumes of primitive magmas in continental flood basalt provinces. Several large igneous provinces (LIPs) on cratons have been directly associated with rapid climatic and biotic change on a global scale. The outgassed volcanic CO2 and SO2 (and other volatiles) responsible for the observed environmental impact have been suggested to be sourced from either recycled crustal components in deep-seated mantle plumes or from volatile-rich components within ancient continental lithospheric mantle. These scenarios compete with models in which greenhouse and other gases are primarily released from sedimentary rock units intruded by LIPs. Distinguishing between these options has implications for modeling potential links between deep volatile cycles, volcanic activity, and environmental change. Many basalt and picrite units of the ca. 180 Ma Karoo LIP in Africa–Antarctica show trace element and isotopic features that are best explained by melt contributions from incompatible element enriched components within the lithospheric mantle of former Gondwanaland. This implies that thick continental roots took actively part in magma formation. However, the exact nature of these strongly incompatible element enriched components remains elusive. We identified a ca. 180 Ma old lamproite magmatic event in south-central Africa, sourced from within the diamond stability field. The ultrapotassic lavas provide first constraints on the origin and evolution of ‘pure’ K-rich components within the mantle source regions of a continental flood basalt province. Non-traditional stable isotope data do not support an origin of the K-rich component by subduction recycling of continental or oceanic crust. Rather, radiogenic isotope systematics suggest that such ultrapotassic components accumulated within a cratonic mantle root during episodic percolation of low-degree alkaline silicate melts since ca. 1 Ga. Such K-rich metasomes have relatively low melting points and, thus, are readily remobilized as the dominant enriched component of continental LIPs, which are sourced mainly from below the lithosphere. The most enriched Karoo picrites may contain up to 10% mass fraction from such K-rich cratonic mantle components. The carbon and sulfur budgets of these metasomes are, however, too small to cause significant environmental impact.

Keyword

lamproites, kimberlites, U/Pb perovskite geochronology, radiogenic isotopes, geodynamic modelling

Dyke swarms map of the Indian Shield on 1:25,00,000 scale

Amiya Kumar Kumar SAMAL[1]*, Banaras Hindu University (amiyasamal007@gmail.com)
Rajesh Kumar Srivastava[2], Banaras Hindu University
Richard E Ernst[3], Carleton University
Gulab Chand Gautam[4], Banaras Hindu University

Abstract

The Indian Shield consists of several Archean cratonic blocks, viz. Aravalli, Bundelkhand, Bastar, Singhbhum, Dharwar, and Southern Granulite Terrain (SGT) and Meso- to Neoproterozoic mobile belts with Archean protoliths. The different crustal blocks are separated from each other by thrust zones and/or rifts. These major structural features likely to be active at ca. 1500 Ma or possibly earlier. The entire Indian Shield is transected by a number of distinct dyke swarms, which range in age from ca. 2800 Ma (Singhbhum craton) to ca. 65 Ma (Deccan Volcanic Province). These spectacular records of mafic dykes (together with sills, volcanic rocks, and other associated magmatic units) are meticulously mapped with the help of Google™ Earth images and ArcGIS™. The mapping process involved the integration of field data, incorporating observations from cross-cutting relationships between the distinct dykes and with country rocks, available geochronology, in some cases, geochemistry, and earlier published dyke maps on the Indian dykes. Dyke trends and geometry played a crucial role in the identification of different generations of dyke swarms. Through this comprehensive approach, more than 25 distinct well-dated dyke swarms and several unclassified dyke swarms are identified from the Indian Shield, mostly emplaced within the Archean cratons.

The Dharwar craton consists of 12 dyke swarms; the Bastar craton comprises 11 dyke swarms; Singhbhum Granite Complex (southern part of the Singhbhum craton) craton is transected by 10 dyke swarms; Chhota Nagpur Gneissic Terrane (northern part of the Singhbhum craton) consists of 3 dyke swarms; Bundelkhand craton comprises 2 dyke swarms; Aravalli craton contains 2 dyke swarms; Southern Granulite Terrane, mostly in Kerala, comprises 2 dyke swarms. Besides these dyke swarms, a huge number of mafic dykes are emplaced within the Deccan Volcanic Province. This comprehensive mapping of the Indian Shield also encompasses various other magmatic units, such as mafic sills, and volcanic rocks. This includes the Panjal Traps in the Himalayan Mountain Range, occurrences of komatiite-tholeiite in Archean cratons, as well as kimberlite-lamproite-lamprophyre dykes and plugs, along with carbonatites.

Keyword

Mafic dyke, LIP, Dyke Map, Indian Shield

Petrological study of the Agulhas Plateau in the Southwest Indian Ocean: Results from core samples drilled during IODP Expedition 392

Kouki MORI[1]*, Chiba University (23wm1119@chiba-u.jp)
Yuji Ichiyama[2], Chiba University
Osamu Ishizuka[3], Geological Survey of Japan, AIST
Jörg Geldmacher[4], GEOMAR
Peter Cameron Davidson[5], GEOMAR
Jia Liu[6], Zhejiang University

Abstract

According to the plate tectonic reconstructions, large igneous provinces (LIPs) distributed in the Southwest Indian Ocean were formed during the breakup of the Gondwana (Parsiegla et al., 2008). After the antecedent formation of the Mozambique Ridge (MOZR) in ~125–130 Ma, the Agulhas Plateau (AGP) was constructed together with the Maud Rise (MR) and Northeast Georgia Rise (NGR) in 80–100 Ma (Gohl and Uenzelmann, 2001). The production by a mantle upwelling is expected for the formation of the MOZR (Jacques et al., 2019), but the origin and petrological relationships of the AGP with the MOZR and related oceanic edifices are poorly understood. Scientific drilling was operated in the AGP during IODP Expedition 392, and the mafic rocks comprising the AGP were successfully recovered. In this study, we investigate the emplacement processes and geochemical characteristics of the AGP mafic rocks and compare them with the related oceanic edifices in the South Indian Ocean.

Mafic lavas and intrusive rocks were collected from Sites U1579 and U1580 in the central part and Site U1582 in the northern tip of the plateau. Several mafic sills intruding into sediments were recovered at Site U1579 and Site U1580. These sills are composed of basaltic rocks in the margins of the sills and doleritic to gabbroic rocks in the interior of the sills. The basaltic rocks have olivine (altered) and plagioclase phenocrysts with variable sizes of vesicles and groundmass of plagioclase, clinopyroxene, Fe-Ti oxides, and altered glass. The doleritic to gabbroic rocks with ophitic to sub-ophitic textures are composed of coarse-grained olivine (altered), plagioclase, and clinopyroxene. Apatite, Fe-Ti oxides, and quartz are also included as accessory minerals. Pillow lavas recovered at Site U1582 have fresh grassy rinds as chilled margins and olivine (altered) and plagioclase phenocrysts with a glassy groundmass.

Based on the whole rock compositions, the collected rocks make a tholeiite series in a SiO2-FeOtotal/MgO space. The rocks of Sites U1579 and U1582 are almost homogeneous in composition, but the rocks of the largest sill of U1580 show heterogeneous composition, which might have been caused by the effect of crystal accumulation and fractionation. Incompatible trace element ratios (e.g., Nb/Y and Zr/Y) of the sills at Site U1580 gradually decrease with the increase of depth, indicating the various magma compositions that formed the sills. The trace element ratios of Site U1579 and U1580 are more enriched than those of normal type MORB, and the compositional ranges are similar to those of the MOZR. On the other hand, they are discriminated from those of the MR and NGR, which are significantly enriched in incompatible trace elements.

The samples of Site U1582 show highly depleted geochemical characteristics compared with Site U1579 and U1580, indicating that they were formed by the higher degree of partial melting of the mantle.

Keyword

IODP exp.392, Agulhas plateau, Mantle plume, Large Igneous Province (LIP), igneous sill intrusion

First Report of Carbonate Antecrysts in the Newania Carbonatite, Rajasthan, India: Implications for Carbonatite Petrogenesis

Amritpaul SINGH[1]*, Department of Geology, Panjab University, Chandigarh 160014,India (apsbhatti05@gmail.com)
Roger H. Mitchell[2], Department of Geology, Lakehead University, Thunder Bay Ontario, Canada P7B 5E1
Sudipa Bhunia[3], Mantle Petrology Laboratory, Department of Geology, Institute of Science, Banaras Hindu University, Varanasi 221005, India
Rohit Pandey[4], Mantle Petrology Laboratory, Department of Geology, Institute of Science, Banaras Hindu University, Varanasi 221005, India
D. Srinivasa Sarma[5], CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad 500007, India
Gurmeet Kaur[6], Department of Geology, Panjab University, Chandigarh 160014, India

Abstract

Antecrysts, which are not mantle xenocrysts, are produced from earlier generation(s) of magma, incorporated into younger pulses of genetically-related magma. Unlike kimberlites and lamproites, antecrysts are not typically present in carbonatites. This work describes the first occurrence of carbonate antecrysts in Newania carbonatite and discusses its relevance to carbonatite petrogenesis.

The Proterozoic Newania carbonatite complex (24°39'02"N, 74°03'40"E) is located NE of the village of Newania (Udaipur district of Rajasthan, India). It is an approximately 3 km in length and 1 km in width, NW–SE trending plutonic body, emplaced within the Untala granite of the Banded Gneissic Complex. Genetically-related alkaline silicate rock(s) are not present in and around the complex. Two types of carbonatite are recognized: (1) coarse to medium grained, grey, massive to banded ferroan dolomite carbonatite; composed dominantly of ferroan dolomite and accessory apatite, amphibole, phlogopite–biotite, magnesian siderite, pyrochlore, columbite-(Fe), monazite and graphite; (2) medium grained, maroon, dominantly massive ferroan magnesite carbonatite; ferroan magnesite is the dominant phase with subordinate dolomite, Fe-bearing dolomite and ferroan dolomite; apatite and mica are accessory phases. Antecrysts are found only in the ferroan magnesite carbonatite. These occur as very coarse (up to 1 cm), oval crystals of dolomite and Fe-bearing dolomite. Inclusions of ferroan magnesite occurs as re-absorbed euhedral crystals in antecrysts.

Dolomite–ferroan dolomite carbonates display an evolutionary trend of increasing Fe and decreasing Mg contents from antecrysts to subordinate carbonates in ferroan magnesite carbonatite to dominant carbonate in ferroan dolomite carbonatite. The ferroan magnesite occurring as inclusions in antecrysts and as the dominant mineral in ferroan magnesite carbonatite have similar compositions. Both display Fe-enrichment towards accessory magnesian siderite in ferroan dolomite carbonatite.

The compositional evolution of the carbonates in the Newania carbonatites together with data from experimentally-derived phase diagrams for carbonates suggest that the ferroan magnesite

carbonatite is crystallized prior to the ferroan dolomite carbonatite. Ferroan magnesite is the earliest crystallizing carbonate mineral and is separated from the magma as a consequence of crystal setting or by rheological processes. A few crystals which remained suspended in the magma subsequently became unstable in the evolving magma and were partially re-absorbed as dolomite to Fe-bearing dolomite antecrysts at a peritectic reaction point. This was followed by the crystallization of relatively evolved subordinate dolomite–ferroan dolomite carbonates and subsequent incorporation, together with antecrysts into the ferroan magnesite carbonatite.
The occurrence of either ferroan magnesite or ferroan dolomite as dominant phases in the Newania carbonatites indicate the magnesian composition of the parent carbonatite-forming magma. The parent magma, capable of generating ferroan magnesite carbonatite, followed by ferroan dolomite carbonatite is considered to be of F–silica–alkali-rich magnesian composition, generated at pressures exceeding 3.2 GPa from the partial melting of phlogopite-amphibole-magnesite lherzolite.

Keyword

Antecryst, Carbonatite, Newania, India

The areal extent of the Qiangtang-Panjal large igneous province

Wei Dan[1]*, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (danwei@gig.ac.cn)
Qiang Wang[2], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Gong-Jian Tang[3], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Xiu-Zheng Zhang[4], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Abstract

The Qiangtang-Panjal large igneous province (QP-LIP), which occurred between 290 and 285 Ma in NE Gondwana, is one of the three Permian LIPs. It. The occurrence of the PQ-LIP coincides with the rifting and breakup of the eastern Cimmerian continent and the birth of the Neo-Tethys Ocean. Thus, it is generally accepted that this LIP played an important role in the breakup of the Cimmerian continent. However, the geodynamic mechanism for the generation of the QP-LIP is highly controversial. In this study, we report 285 Ma mafic dykes occurred in the South Pamir, suggesting that the PQ-LIP extends westward into the Pamir syntax. Combined with regional data, the QP-LIP is limited to occurred in the eastern Cimmerian continent from the South Pamir, Southern Qiangtang, Lhasa, to Sibumasu terranes, and northern India-Australia plate. In contrast, no such event was found in the western Cimmerian continent (west of the Pamir syntax) and the northern Arabian-African plate, except for minor ~298 Ma bimodal magmatism found in Oman. The areal distribution characteristics suggest that the eastern Neo-Tethys is characterized by a magma-rich rifted margin, whereas the western Neo-Tethys by a magma-poor rifted margin. As the north drift of the Cimmerian continent was counterclockwise around the rotation pole at the western end of the Neo-Tethys, it may suggest the strong extension in the eastern Cimmerian continent caused by slab-pull forces responsible for the generation of the QP-LIP. However, similar scenarios also occur in many other rifted margins, such as in the East African Rift and the Red Sea, but the mantle plume-related LIP is confined to the south Rea Sea area. It is argued that the mantle plume may be coincidentally located in the northern India-Australia plate. Alternatively, it is more likely that different lithospheric structures control the areal distribution of the LIP and the type of the rifted margin.

Keyword

Cimmerian continent, South Pamir, rifted margin, large igneous province

Permian-Triassic silicic volcanic province of the West Siberian basin: Evidence for the temporal and genetic relationship with the Siberian Traps

Anton LATYSHEV[1]*, Individual Researcher (anton.latyshev@gmail.com)
Ivan Panchenko[2], Closed Joint Stock Company “Modeling and Monitoring of Geological Objects”
Maria Smirnova[3], Closed Joint Stock Company “Modeling and Monitoring of Geological Objects”
Peter Kulikov[4], Closed Joint Stock Company “Modeling and Monitoring of Geological Objects”

Abstract

Permian-Triassic Traps of the Siberian platform and coeval mafic volcanic rocks in the West Siberian basin constitute probably the most voluminous continental Large Igneous Province. The contribution of felsic volcanic rocks to this huge province has been underestimated until recently. We present the detailed results of the first comprehensive study of silicic rocks from the central part of West Siberia. Permian-Triassic volcanics in this area are buried under the thick (2.5–3.5 km) sedimentary cover and are available only as drill cores. They fill many rift structures, including the large Rogozhnikov-Nazym graben.

Lavas of rhyolitic-dacitic composition predominate among the volcanics, while volcaniclastic rocks are rare. Silicic lavas from all studied areas demonstrate both supra-subduction and within-plate geochemical signatures. A complex of structural and geochemical features of silicic rocks corresponds to the tectonic setting of post-collisional rifting. Basalts are subordinate in the studied area and resemble the Nadezhdinsky Formation from the Noril’sk region (the Siberian platform, the middle part of the volcanic sequence). Geochemical peculiarities confirm the genetic relationship between the West Siberian silicic and mafic rocks, and the Siberian Traps, and indicate the origin of the former from the interaction of the continental crust with a mantle source similar to that of the upper part of the Noril’sk volcanic sequence.

Nine new U-Pb ages constrain the timing of silicic volcanic activity in West Siberia as ~5-10 Myr near the Permian-Triassic boundary (253.69 – 248.21 Ma). Thus, silicic rocks in West Siberia are nearly coeval to the main phase of Siberian Traps emplacement.

Silicic rocks occupy about 105 km2 within the West Siberian basin and can be considered as a Silicic Large Igneous Province, coeval and genetically related to the mafic Siberian Traps LIP. The silicic volcanics distribution area in West Siberia coincides with zones of young continental crust, reworked in the Late Paleozoic by the subduction and collision processes, and associated episodes of magmatic activity and metamorphism.

Keyword

West Siberian basin, Silicic Large Igneous Province, Siberian Traps, Permian, Triassic

Multiple mantle components for alkaline lavas of the Tuli basin, Karoo LIP

Osvaldo González-Maurel[1]*, Universidad de Concepción (osvgonzalez@udec.cl)
Geoffrey Howarth[2], University of Cape Town
Julian Marsh[3], Rhodes University
Andy Duncan[4], University of Cape Town
Petrus le Roux[5], University of Cape Town

Abstract

The Tuli basin in Zimbabwe and Botswana is one of the largest and best-preserved remnants of rift-related sequences associated with the Karoo Large Igneous Province (LIP) of southern Africa. Early Jurassic tholeiitic high-Ti picrites and basalts mostly represent the continental LIP volcanism in Tuli, but rare alkaline rocks are also found in the volcanic sequence. Here we present new whole-rock major and trace element and Sr-Nd-Pb isotope data for the alkaline volcanic rocks from the Tuli basin. We have identified three distinctly different groups of alkaline rocks: nephelinites (K2O/Na2O < 0.5), potassic (K2O/Na2O = 0.5 to 2), and ultrapotassic rocks (K2O/Na2O > 2).

Nephelinites are characterised by an incompatible trace element enrichment, low Zr/Nb ratios, positive Nb-Ta anomalies, and radiogenic 87Sr/86Sri (0.705 – 0.707), low εNdi values (-7.0 to -6.7) and radiogenic Pb isotope ratios (208Pb/204Pb = 37.83 – 38.07; 207Pb/204Pb = 15.49 – 15.52; 206Pb/204Pb = 17.55 – 17.61). Potassic rocks have similar low Zr/Nb ratios, positive Nb-Ta anomalies, radiogenic 87Sr/86Sri (0.705 – 0.706), unradiogenic εNdi (-8.3 to -4.5) and highly radiogenic Pb isotope ratios (208Pb/204Pb = 38.89 – 39.54; 207Pb/204Pb = 15.59 – 15.65; 206Pb/204Pb = 17.75 – 18.31), however, they differ from nephelinites in recording higher K contents (and lower Na contents) and higher incompatible and rare-earth element concentrations. Lastly, ultrapotassic rocks show very pronounced positive K anomaly, negative Nb-Ta anomalies and BSE-like Sr, Nd and Pb isotope ratios (87Sr/86Sri = 0.704 – 0.705; εNdi = -1.7 – -1.1; 208Pb/204Pb = 38.10 – 38.20; 207Pb/204Pb = 15.51 – 15.55; 206Pb/204Pb = 17.60 – 17.78).

The high initial Sr and Pb isotope ratios and low εNdi together with high incompatible trace element concentrations from the nephelinites and potassic rocks, and the marked depletion of Nb and Ta from the ultrapotassic rocks, are consistent with a metasomatised SCLM source. However, such a source alone cannot consistently explain some signatures of the Tuli alkaline rocks. Nephelinites and potassic rocks differ from other Tuli magmas including picrites, basalts and ultrapotassic rocks in recording low Zr/Nb ratios and positive Nb-Ta anomalies, which are typically associated with plume-derived OIB lavas. Ultrapotassic rocks, in turn, are characterised by 87Sr/86Sri ratios and εNdi values roughly similar to BSE, which has been interpreted to be derived either from asthenospheric MORB sources or OIB-type mantle sources. This implies that there may have been some contribution from a sub-lithospheric (MORB- or OIB-like) component

in the nephelinite, potassic and ultrapotassic source.

Therefore, the mantle source is interpreted to be highly heterogeneous for the Tuli alkaline rocks, and each alkaline rock type represents a distinct source component. These source components resemble the more geographically dominant SCLM signature, but the high alkali compositions support incorporation of sub-lithospheric fluids/melts into the SCLM source. We thus suggest that the Tuli alkaline rocks were derived from a mixed mantle source, which differs from the broadly accepted origin for other alkaline rocks in the Karoo LIP that were interpreted to be sourced only from enriched mantle components.

Keyword

Alkaline rocks, Karoo, LIP, Mantle source

Late Permian basalts in the eastern part of the Emeishan Large Igneous Province, SW China: Implications for plume–lithosphere interaction

Wenmin HUANG[1]*, League member (459717413@qq.com)
Xijun LIU[2], members of Chinese Communist Party
Zhenglin LI[3], members of Chinese Communist Party
Xiao LIU[4], members of Chinese Communist Party

Abstract

The Emeishan Large Igneous Province (ELIP) is situated along the western margin of the Yangtze Craton, adjoining the southeastern edge of the Tibetan Plateau, SW China. Predominantly composed of basalts, the ELIP features two primary lava types: high-Ti and low-Ti basalts (using TiO2 content of 2.5 wt.% and Ti/Y ratio of 500). Spatially, the ELIP is segmented into inner, intermediate and outer zones based on biostratigraphy, sedimentology, and geochemical characteristics. The inner zone is characterized by thick sequences (2000–5000 m) of predominantly low-Ti volcanic rocks, interspersed with high-Ti basalts and occasional picrites. In contrast, the peripheral zone contains much thinner sequences (500 m) of high-Ti volcanic rocks, including lavas with extremely high Ti/Y ratios, all linked to mantle plume activity in the late Permian (~260 Ma). However, the basalts in the ELIP's outer zone display notable compositional diversity, leading to varied theories regarding their petrogenesis. This study provides a comprehensive examination, including detailed zircon U-Pb dating and Hf isotopic analysis, alongside whole-rock geochemical and Sr-Nd-Hf-Pb isotopic assessments of the basalts from Napo area in western Guangxi, within the ELIP's outer zone. The zircon 206Pb/238U weighted mean ages of these basalts are pinpointed at 258–257 Ma, aligning with the ELIP's main magmatic phase. They are alkaline basalts and show moderate Ti characteristic with the moderate TiO2 contents (1.82–2.09 wt.%) and Ti/Y ratios (473–568). They are characterized by moderate 86Sr/87Sr(t) ratios (0.70500 to 0.70532), slightly negative εNd(t) values (-1.95 to -1.38), positive whole-rock εHf(t) values (0.25 to 0.81), high zircon εHf(t) values (1.60 to 11.6) and distinctive "extreme DUPAL" Pb isotopic compositions, marked by high 208Pb/204Pb(t) ratios (37.9 to 38.7) and pronounced positive Δ8/4 values (54.8 to 91.2). These geochemical and isotopic features suggest that an oceanic island basalt (OIB)-like affinity for the Napo basalts and most likely involved subcontinental lithospheric mantle, indicative an interaction between the Emeishan plume and the lithosphere through decompression melting in a continental rift setting. The slightly varied Nd and Hf isotopic compositions in the whole rock samples imply the addition of a minor crustal component (<5%) to the Emeishan plume-lithosphere mantle source. Melt composition reconstructions estimate the magma generation pressure at 1.71–2.32GPa and mantle melting temperatures between 1400–1460℃, exceeding typical asthenospheric mantle temperatures (1280–1350℃). Our findings suggest that the substantial compositional variability in the ELIP's outer zone basalts resulted from interactions between the Emeishan plume and the lithosphere.

Keyword

Basalts, Late Permian, Extreme Dupal isotopic anomaly, Plume-lithosphere interaction, Emeishan Large Igneous Province

Evidence of prolonged Aptian-Santonian magmatic pulses in the Indian Shield linked with the Marion mantle plume and its role in the breakup of India–Madagascar

Rajesh Kumar SRIVASTAVA[1]*, Department of Geology, Institute of Science, Banaras Hindu University, Varanasi 221005 (rajeshgeolbhu@bhu.ac.in)
Fei Wang[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, P.R. China
Amiya Kumar Samal[3], Department of Geology, Institute of Science, Banaras Hindu University, Varanasi 221005
Wenbei Shi[4], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, P.R. China
Bijay Kumar Das[5], Geological Survey of India, SU: Gujarat, Ministry of Mines, Government of India, Gandhinagar 382010, India

Abstract

Systematic investigations into the spatiotemporal evolution of Gondwana megacontinents is always an appealing topic amongst geologists. Gondwana, comprising of East Gondwana (Madagascar, Greater India, Australia, and Antarctica) and West Gondwana (Africa and South America), is thought to be fragmented at ca. 180 Ma and coinciding with the separation of the Greater Indian plate (together with Madagascar and Seychelles) from the African plate. It is suggested that the separation of the Madagascar from the Greater India started ~90 (92-88) Ma and the Marion mantle plume played a pivotal role. However, a strong debate persists on the existence of the Marion mantle plume before ca. 92-88 Ma. This is crucial as track of Marion hot-spot was closely following the rifted eastern margin of Madagascar between 120 and 88 Ma (cf. Storey et al., 1995, Science, 267, 852-855). In the present work, we studied carbonatite xenoliths from the carbonatite breccia exposed at the Saidivasan, an integral part of the Ambadungar-Saidivasan alkaline carbonatite complex (ASACC), western India. Although it is documented that the ASACC, which intrude the Deccan basalts, has been emplaced at ca. 65 Ma and product of the Réunion plume, however, a new 40Ar/39Ar plateau age, which yields 97 ± 2.2 Ma, of a carbonatite xenolith extracted from the carbonatite breccia suggest its link with the Marion plume. This finding likely represents one of the early magmatic pulses associated with the Marion plume. This is probably the first report of a carbonatite magmatism of this age belonging to the Ambadungar-Saidivasan alkaline carbonatite complex. Available dates on different magmatic rocks, which are thought to be associated to the Marion hot-spot, range in ages from ca. 123 Ma to 80 Ma in the Indian Shield and ca. 98 Ma to 84 Ma in the Madagscar. While the major Marion plume induced magmatic activities were recorded ca. 92-88 Ma during the break-up of the India-Madagascar continents, the observed age range strongly suggests a prolonged magmatic pulse linked to the Marion plume. This comprehensive investigation provides a better constraint on initiation and spatiotemporal extent of the Marion mantle plume induced large igneous province.

Keyword

Carbonatite, Ambadungar-Saidivasan, Marion Plume, Gondwana, Aptian-Santonian

Paleoenvironmental Constraints on Pleistocene Ice Sheets Informed by Glacio-Volcanic Deposits in Northeast Iceland

Cameron Essex[1]*, University of Wisconsin-Milwaukee (cdessex@uwm.edu)
Barry Cameron[2], University of Wisconsin-Milwaukee
Ben Edwards[3], Dickinson College
Magnús Guðmundsson[4], University of Iceland

Abstract

A growing body of research suggests that deglaciation can lead to increased eruption rates by destabilizing existing magma bodies and even prompting new magma generation. Given its high rate of magma production and periodic glaciations through the Pleistocene, Iceland is the ideal locality on Earth to study volcano-ice interactions as much of its landscape is dominated by glacio-volcanic landforms such as tuyas and tindars. One of the main products from magma-ice interactions is volcanic glass, which locally contains dissolved volatiles such as water, carbon dioxide, and sulfur. The pressure dependence of volatile solubility in magmas allows estimation of the ice thickness at the time of eruption by measuring the volatile content of glassy eruption products such as pillow lavas rims and hyaloclastite. Here we use volatile estimates from samples of three tuyas (Gæsafjöll [65.77], Bláfjall [65.55], Búrfell [65.44]) to test the hypothesis that in northeastern Iceland the Pleistocene ice sheets thickened southwards towards the present-day location of the Vatnajökull ice cap. Major element and sulfur concentrations of the glasses were analyzed by electron microprobe (EPMA) at the University of Wisconsin-Madison, and major element concentrations are basaltic for all three tuyas (SiO2=46.99–51.22 wt. %; MgO=4.11–9.06 wt. %; CaO 8.90–13.88 wt. %; FeO=9.40–16.48 wt. %). Gæsafjöll and Bláfjall have similar major element concentrations, whereas Búrfell contains a component enriched in FeO and depleted in MgO and CaO. Glass (n=102) sulfur contents, which are proxies for water, range between 100 ppm and 3,100 ppm for all three edifices with sulfur contents generally increasing towards the south (Gæsafjöll=199.1 ppm–1,864.9 ppm; Bláfjall=130.4 ppm–2,356.3 ppm; Búrfell=163.3 ppm–3,001.8 ppm). Thus, our preliminary data support the idea that the Pleistocene ice bodies through which these three volcanoes erupted thickened to the south. Future work will include FTIR measurements of water and carbon dioxide to further test this hypothesis.

Keyword

Volcanology, Geochemistry, Tuya, Paleoclimate

Recognition of Hidden Effusive Centers from the Emanating Pattern of Lava Tube and Channels in Deccan Volcanic Province of Western India

ANSHUMAN MISRA[1]*, Doon University, Dehradun (anshumanmisra22@gmail.com)
K S MISRA[2], University of Petroleum and Energy Studies

Abstract

Non-recognition of volcanic cones, craters and effusive zones in large Deccan volcanic region of Western India, has intrigued the geologists for over a century. It was assumed that the effusive source existed somewhere in the west and presently submerged in the Arabian Sea and the lava has flowed to several hundred kilometres. This has led geologists to establish unified lava stratigraphy and supported it by inconsistence geochemical signatures. Contrary to this misconception, it is a common observation that lava cools and solidifies without long distance movement. Our mapping in western part of volcanic province, illustrates not only transportation through arterial system of lava tubes, channels and tunnels, from common centers but also a new emanating parameter for recognition of effusive centers. Multi-central as well as multi-level out-pouring has given rise to local lava stratigraphy around the effusive centers. In approximately 90% area, the centres are covered by the younger flows, 8% are deeply eroded and are difficult to recognize and only in remaining 2%, where they are exposed in recent times, are the best locations to study the physical volcanic features. Interpretation of remote sensing data sets, followed by verification in field has emerged as extremely useful method for mapping the thermally baked, indurated, hardened and reddened remnants of lava channels, tubes and tunnels. Channels are identified by unique sinuous shapes of levee portions; tubes in vertical sections by upward converging columnar jointing, slowly cooled nodular basalt in the core portions and tunnels by cylindrical hollowness. Weathering and erosion of more than sixty five million years, has dissected the Deccan plateau into several small plateaus and later into innumerable mesa hills. Innumerable remnants are mapped radiating out from these plateaus and mesa hills at different elevations. This disposition of remnants along with emanating pattern establishes the presence of large hidden multi-central volcanic fields, at different levels.

Keyword

Effusive Centers, Recognition, Lava channel lava tube, Deccan Volcanic, India

Neoarchean volcanism in the Western Dharwar Craton, India: Petrology, Geochemistry and Tectonic Significance of BADR volcanics from Shimoga basin

Arpita KARMAKAR[1]*, Geological Survey of India, Bangalore (arpita.karmakar@gsi.gov.in)
Nirmal Kumar T[2], Geological Survey of India, Bangalore
Anindya Bhattacharya[3], Geological Survey of India, Jaipur

Abstract

The extensive exposure of volcano-sedimentary sequence in Shimoga schist belt, Western Dharwar Craton, India, makes it an important window into tectonic evolution of early earth. Here we provide a comprehensive study on petrological and geochemical analysis of basalt, andesite, dacite, rhyolite (BADR) suit of Neoarchean Shimoga greenstone belt. The sequence comprises 20% volcanic rocks and 80% pyroclastics. The metabasalts are high Mg tholeiite and Komatiitic basalt, with intergranular texture defined by clinopyroxene and plagioclase as essential minerals and chlorite, actinolite as accessory phases. The rhyolite contains more than 90% quartz and shows flow banding. Pyroclastics are mostly basaltic andesite, andesite and dacite in composition. These rocks contain unusual shaped quartz grains such as rod shaped, spindle shaped, bi-pyramoidal, flame quartz, indicating possible volcanic source. Presence of K-feldspar also suggests volcanic input. Flattening and rugged termination of grains along grain boundary, the eutaxitic texture, strong compaction and welding, especially near the edges of crystal again confirms pyroclastic origin. According to the geochemical plots of Zr/TiO2 – SiO2, Nb/Y – Zr/TiO2 and Nb/Y – Zr/Ti, the volcanic suit is composed of mafic to intermediate to felsic volcanics starting from basalt, basaltic andesite, trachy-andesite, dacite, rhyodacite to rhyolite (BADR suit). Among the different volcanics, the metabasalt generally falls under tholeiite field, in contrast to dacite and rhyolite, which falls under calc alkaline series. The intermediate rocks particularly andesite and dacite show affinity towards both tholeiite and calc-alkaline magma series. The concentrations of major oxides are plotted against those of SiO2. Positive correlation indicated by Al2O3, Na2O and K2O whereas negative trend is seen in CaO, TiO2, P2O5, MgO and FeO. As the parental magma differentiates SiO2, Na2O and K2O increases (Positive slope) while MgO, FeO, TiO2, P2O5 & CaO decreases (Negative slope). Since these plots show a clear trend or correlation, hence all these volcanics are probably related or co-magmatic. On a primitive mantle- normalized diagram the basaltic andesite and basalt are characterized by enriched light rare earth elements (LREE) patterns relative to heavy rare earth elements (HREE) [(La/Yb) N =1.95 –15.03], with weak to negligible Eu anomalies (Eu/Eu* = 0.63–0.89). The intermediate and acidic rocks are characterized by enriched light rare earth elements (LREE) patterns relative to heavy rare earth elements (HREE) [(La/Yb) N = 3.12 –31.51], with negative Eu anomalies (Eu/Eu* = 0.2–0.89). High Mg basalts are likely reflecting melting of hotter ambient mantle in Archean. Ternary plot of FeOT-MgO-Al2O3 suggests basalts and basaltic andesites were formed in ocean ridge and floor settings, whereas the andesite, dacite and rhyolites were formed in

convergent margin settings. The Ti Vs Zr binary plot indicates island arc setting for these volcanics. The ThN-NbN binary diagram indicates continental margin volcanic arc.

Keyword

BADR volcanic suit, Continental arc, Shimoga schist belt

Development of New Concepts in Cretaceous Volcanism during Last Fifty Years in Peninsular India

K S MISRA[1]*, University of Petroleum and Energy Studies (drksmisra@gmail.com)

Abstract

The author enumerates several new concepts developed in the study of Cretaceous Volcanism during last fifty years. In early years from 1973, emphasis was on mapping the physical volcanic, tectonic and structural details. This was supported by interpretation of aerial photographs and satellite images. It has emerged that major igneous complexes are located along lineaments associated with major rift and grabens. Dipping felsic units in otherwise horizontal disposition, explosive volcanism, alkaline rocks and Carbonatite dyke were reported, suggesting continuation of Narmada-Tapti Tectonic Zone of continental dimension in Saurashtra. Later large-scale mapping of entire Saurashtra and Kutch was conducted to include tectonic disposition, major E-W trending dyke swarm, with parallel effusive zones and large felsic complexes, suggesting that the Cretaceous volcanism was initially felsic followed by dominant tholeiite units. Aeromagnetic data along with vertical gradient component showed that near surface felsic complexes have deeper strong magnetic anomalies, leading to the concept of decompression melting of successive lithospheric zones. Volcanic fields with a number of plugs, vents, craters and effusive centers were identified in Kutch region.

Non-recognition of effusive centres in large Deccan Volcanic Province has intrigued geologists for over a century. Earlier it was believed that the effusive source existed somewhere in the west and is presently submerged in the Arabian Sea. This assumption led to establish unified lava stratigraphy, contrary to the observation that soon after eruption; lava cools and solidifies without long distance movement. Mapping of thermally baked, indurated, hardened and reddened remnants of lava channels, tubes and tunnels, has brought out an integrated arterial system and radially emanating pattern. This has helped in identification of innumerable effusive centres, both in exposed as well as in areas covered by younger flows. Multi-central and multi-tier volcanic fields, with local lava stratigraphy have been identified in different parts of volcanic province.

Information about volcanic units was extracted from innumerable litho-logs and seismic profiles generated for hydrocarbon exploration. Nearly a dozen producing as well as perspective pull-apart, off-shore and oceanic basins associated with rift and grabens, transecting volcanic regions, are having unique interlayered volcano-sedimentary sequence ranging in age from beginning to the end of Cretaceous. This disposition also suggests repeated decompression volcanism along nearly vertical faults, subsidence and sedimentation continued for nearly eighty million years. Furthermore, high resolution seismic profiles, acquired by long offset configuration, pre-stacking time and depth migration processing techniques, have provided geological and thickness details of both basalt as well as sub-basalt sedimentary succession. It illustrates the tectonic controls on basin formation, subsidence, magma generation and effusion. This does not support the idea of hot spot below the northerly moving Indian plate. It was detrimental to exploration as a hot spot

would have vaporized the hydrocarbons. On the contrary the tectonic controls distilled the sediments by the upwelling heat and hydrocarbon seals were created by the effusion of volcanic units. Quest for understanding the Cretaceous volcanic units has increased many folds, as they are reservoir rocks for prolific production of natural gas.

Keyword

Cretaceous Volcanism, Concepts, Fifty Years, Peninsular India

Recent Evidence of the Evolution of Pleistocene Volcanism in the Northwestern End of the Central Volcanic Cordillera of Costa Rica, Central America.

Ana Sofia Sofia HUAPAYA R.P.[1]*, Dirección de Geología y Minas, MINAE
(sofia.huapayar@gmail.com)
Evelyn Rodriguez C.[2], Dirección de Geología y Minas, MINAE

Abstract

Recent studies conducted in the northwestern sector of the Central Volcanic Coordillera (CVC) of Costa Rica, located at a latitude of 10°30'00'' and longitude of 84°30'00'', have allowed the identification of volcanic debris deposit, the Ron Ron Unit, which exceed more than 50 km3. These deposits from the Lower Pleistocene (Proto-Platanar) whit a calc-alkaline composition are presumed to be the product of the collapse of a primitive volcanic structure, prior to the already known volcanic structure, the Bajos del Toro Unit, from the Middle Pleistocene (Paleo-Platanar). The petrographic characteristics of debris deposit, the estructural pattern - system of NW-SE strike-slip dextral faults with normal component system and the hydrothermal alteration are the evidence of the collapse of this primitive structure. The migration of the magmatic chamber to the east may have resulted in the emergence of a new volcano with the same magmatic composition, collapsing during the Middle Pleistocene and with episodes of calderic activity during the Upper Pleistocene (Alto Palomo Formation) to Early Holocene, forming the current Chocosuela-Palmira calderic complex, and whose most recent volcanic expression are resurgent structures such as the stratovolcano composed of the Platanar and Porvenir cones (Neo-Platanar). This studies provides new data that shows that the calderic processes in the Central American region were highly active during the Pleistocene, a product of the intensive tectonic deformation promoted by the closure of the Central American Isthmus.

The Ages of the lithological units is defined by K-Ar analyses, the lithological units whit petrography studies, XRD, scanning electron microscopy (SEM), and chemical analyses. For the morphotectonic intrepretation was used information of radar image from the Alos Palsar sensor (whit resolution of 12.5 m), Carta and Terra aerial photographs, a spectral image from Landsat 7ETM, and the Models SRTM and Aster elevation (DEM) models.

Integration of the field information and the mentioned analyses, can be reinterpreted the calderic complex known as Chocosuela-Palmira, dividing into three constructive and destructive temporal phases of Pleistocene volcanism in the NO extreme of the CVC: Proto-Platanar, Paleo-Platanar and Neo-Platanar.

The outputs of this study include a geological map at a scale of 1:50,000 of Quesada and Aguas Zarcas sheets, a tectonic map at a scale of 1:50,000 and a model of Pleistocen volcanic complex including the three constructive and destructive stages.

Keyword

Proto-Platanar, Paleo-Platanar, Neo-Platanar, Quesada, Chocosuela

Block-and-ash flows deposit from 2015 at Volcán de Colima (Mexico): Textural and granulometric characterization as a tool in determining the dynamics and interaction with topography

Laura Fabiola Fabiola HERNANDEZ DIAZ[1]*, Universidad Nacional Autónoma de México (lfabiolahd@geociencias.unam.mx)
Lucia Capra Pedol[2], Universidad Nacional Autónoma de México

Abstract

On July 10 and 11, 2015, Volcán de Colima, one of the most active Mexican volcanoes, underwent its largest eruption since the 1913 Plinian event. Highly mobile block-and-ash flows (BAF) originated from the dome collapse and subsequent extrusion of bubble-gas-rich magma from the conduit. This event is extraordinary as it surpassed the displacement of previous eruptions, approaching towns close to the volcano. Over the last eight years deep lahar erosion has exposed excellent outcrops of the eruptive sequence.

This study aim is to determine the textural and granulometric characteristics of the entire sequence to better understand the transport and sedimentation mechanisms in response to abrupt morphological changes. Along the Montegrande ravine, 50 stratigraphic sections were analyzed and sampled; granulometric analysis was conducted for the ranges of -11 to +4 phi with Rosiwal intersections and dry sieving methods and from +4 phi to 9 phi with a laser sedimentograph. The statistical parameters were calculated, and component analysis and shape analysis were performed.

Preliminary findings indicate that massive and stratified depositional units respond to abrupt changes in topography; their granulometry shows a general bimodal distribution and poor sorting. The results are related to factors such as distance from the source, channel geometry, and flow depth.

Keyword

Block-and-ash-flow, Volcán de Colima, Granulometric analysis, Topography

Post-2008 Eruption Volcanic Activities of Cerro Azul Volcano in the Galápagos Archipelago Estimated Using Time-series InSAR

Seohyeon Kim[1]*, Kangwon National University (rlatjgus514@kangwon.ac.kr)
Hyangsun Han[2], Kangwon National University

Abstract

The Cerro Azul volcano, located on southern part of Isabela Island in the Galapagos Archipelago, stands as one of the most active volcanoes globally, having erupted 11 times since 1932. Its most recent eruption occurred in 2008, followed by a period of unrest in March 2017 with no eruption. In this study, we applied the Small BAseline Subset Interferometric Synthetic Aperture Radar (SBAS InSAR) technique to 22 Envisat ASAR images (July 2008–September 2010) and 156 Sentinel-1 SAR images (April 2017–June 2022) to monitor the post-eruptive volcanic activities of Cerro Azul associated with the 2008 eruption. Cerro Azul volcano underwent gradual uplift during the observation period, with variations in uplift rates observed. The uplift rate of summit caldera was approximately 0.019 m/yr from July 2008 to September 2010 and approximately 0.033 m/yr from April 2017 to June 2022. For the two periods of distinctive uplift rate, we performed inversions of the time-series surface displacements to estimate changes in magmatic activity. Inversion results, based on the Mogi model, indicated that the depth of the magma source remained consistent at ~4 km below the caldera floor for both periods. The volume change of the magma source was ~4.40×10^6 m^3 from July 2008 to September 2010 and ~20.97×10^6 m^3 from April 2017 to June 2022. The annual average volume change of magma source in the two years immediately after the 2008 eruption was ~1.8×10^6 m^3/yr. However, this rate dramatically increased to ~3.9×10^6 m^3/yr from 2017 onwards. This suggests that the magma supply rate significantly increased after 2017 compared to the period from 2008 to 2010.

Keyword

Cerro Azul volcano, InSAR, SBAS, Time-series displacement, Inversion

Numerical Model of High-temperature Geothermal Based on Trans-crustal Magmatic System in Eastern Shandong Province

Jie LIU[1]*, China University of Petroleum(East China) (13964771227@126.com)
Yaoqi Zhou[2], China University of Petroleum(East China)

Abstract

The Yishu fault in eastern Shandong Province has experienced multiple periods of intense tectonic movement, which provides abundant geothermal resources. However, due to the multiple and complex evolutions here, little research focus on the formation mechanism of deep geothermal. Combined numerical modeling with trans-crustal magma, we analyzed the geophysical models to predict the distribution trend and depth of shallow lithosphere structure, the target depth of geothermal reservoir is over 6 km. Estimated the spatial modeling features, such as strata, structure, and fluids, explained the response of magma reservoir to the lithosphere structural anomaly, and further elaborated the theoretical model of deep geothermal reservoir formation in eastern Shandong. As such, this research reveals the deep structure and power mechanism of the trans-crustal magma in eastern Shandong. During the late Mesozoic, due to intense deep tectonic activity, and the trans-crustal magma upwelled to the surface along the large-scale fractures, accompanied by the thermo-upwelling and assimilation-contamination. The lithospheric mantle was dismantled and replaced, meanwhile the thickness of the lithosphere was thinned. Afterwards, the mantle was activated again and upwelled to the upper and middle crust, the crustal rocks there were melted, and the incompatible radioactive elements in the crustal rocks were transported with the magma. It increased the radioactive elements content in the shallow. With the heat generated by the elements rising, the thermal and rheological structure of the lithosphere changed. This study predicts the collective scale of geothermal reservoirs in the target area, and provides a basis for the evaluation of deep high-temperature geothermal resources and the study of thermal reservoir evolution.

Keyword

Trans-Crustal magmatic systems, Numerical modeling, Geothermal energy

Temporal distribution of the Plagioclase Feldspars in ~1200 m thick lava flow sequence from Deccan traps borehole, Western Deccan Province

Shubham Bharat WAGHMARE[1]*, Savitribai Phule Pune University
(waghmareshubham198@gmail.com)
Mahesh Mopkar[2], Savitribai Phule Pune University
SATISH SANGODE[3], Savitribai Phule Pune University
Ashish Dongre[4], Savitribai Phule Pune University
Amarjit Bhagat[5], Savitribai Phule Pune University

Abstract

The plagioclage feldspar represents the most common and universal constituent of the Deccan lava flow sequence occurring as groundmass, porphyry to phenocrysts such as the varieties of giant plagioclase feldspars (GPB) as stratigraphic markers. We present petro-mineralogic, textural and magnetic fabrics documentation for a complete lava flow sequence (~1200m) encountered in the borehole core KBH 07 from the Koyna drilling program. Modal percentage indicate 50-55% feldspar grains, 40-45% Clinopyroxene, 10-15% Opaques and 4-5% Olivine. Further, we produced semiquantitative estimates by developing the parameters based on the grain width and length ratios of feldspar groundmass, phenocrysts, olivine and opaque minerals largely comprising ophitic to sub-ophitic and porphyritic to glomeroporphyritic textures as a result of various cooling modes and rates of nucleation. The Ist order variability indicate general trend towards top marked by: a) decrease in the volumes (sizes) of the plagioclase feldspar, olivine and clinopyroxene crystals, b) decrease in clustering of the plagioclase phenocrysts towards and c) decrease in abundance of glomeroporphiritic textures. The parameters based on the counts of Feldspar groundmass (Fg) and phenocryst (Fp), their width and length (WxL), width:length (W/L) ratio, groundmass to phenocryst ratios (Fg/Fp) and the degree of preferred orientation. Similar ratios were also calculated for the for the opaque, olivine and pyroxene grains that are less abundant to study their association with feldspar. The opaques are generally evenly distributed when their size decreases; and they show inverse size relation with that of the feldspar grains. The IInd and IIIrd order variability is derived by comparing these parameters with our previously published magnetic fabric and rock density results on the same samples. Overall the higher order episodic variation reflects framework and modal distribution governed by magmatic compositional history, effusive mixing, fractionation, rates of nucleation and the cooling history.

Keyword

Deccan Traps, Petrography, Koyna Borehole

Plio-Pleistocene rear-arc magmatic belt in the Southern Central Andes: the Varvarco Volcanic Field

Sofía Iannelli[1]*, National Scientific and Technical Research Council - Buenos Aires University (sofia.iannelli@hotmail.com.ar)
Vanesa LITVAK[2], Universidad de Buenos Aires-CONICET
Carina GRECO[3], Universidad de Buenos Aires-CONICET
Andrés FOLGUERA[4], Universidad de Buenos Aires-CONICET

Abstract

Plio-Pleistocene magmatic evolution in the Southern Central Andes between 34 and 37.5°S, has been influenced by changes in plate kinematics associated with the subduction of the Nazca plate beneath the South American plate. Between Early to Middle Miocene times, a shallow subduction regime developed which provoked the eastward migration of arc-like magmatism towards the east. Afterwards, by Pliocene times, the Nazca plate re-steepened and in consequence arc-like magmatism retreated towards the west reaching its present-day position and developing in three coetaneous magmatic belts between the back-arc and the Chilean-Argentinean present day arc-front. Furthermore, during the Nazca plate steepening, a tearing took place at ~38°S which triggered the upwelling of an asthenospheric anomaly responsible for the emplacement of alkaline magmatism in the back-arc area. The steepening of Nazca plate provoked an extensional regime that controlled the emplacement of Plio-Pleistocene magmatism. In this context, between the back-arc and the active volcanic front, a Plio-Pleistocene N-S magmatic belt was emplaced in an anomalous rear-arc position.

Rear-arc magmatism comprised collapsed calderas, stratovolcanoes, and monogenetic cones along large volcanic fields. Between 34 and 38ºS, most of these volcanic fields developed along the Las Loicas Trough, a NW-SE oriented Plio-Pleistocene extensional collapsed structure. Along this belt, different magmatic fields were installed as the Puelche and Laguna del Maule volcanic fields. Particularly, in the middle part of the Las Loicas Trough developed the Pleistocene Varvarco Volcanic Field (VVF), one of the largest rear-arc magmatic districts emplaced near the surface projection of the Nazca plate tearing. The VVF is characterized by subhorizontal basaltic lava flows interbedded with pyroclastic flows, and intruded by dacitic to rhyolitic subvolcanic bodies and mafic dykes. Geochemically, the basal lava flows are calc-alkaline rocks while the upper lava flows are tholeiitic. Trace elements composition indicates that both groups came from the same magmatic source, although fractional crystallization (FC) degrees decreased towards the latest magmatic pulses. Overall, the VVF lavas show slab-fluid signal and no influence from the asthenospheric plume-like structure nearby. The VVF geochemical evolution would be mainly associated with different degrees of FC process, and to a lesser extent with variable sediment or crustal influence. The transition from calc-alkaline to more primitive and tholeiitic magmas would evidence the progressively steepening of the Nazca plate by Pliocene times. The associated extensional regime would have allowed the rapid ascent of magmas and would have favoured decreasing degrees of fractional crystallization.

The study of this rear-arc magmatic sequence allow us to understand the relation between its magmatic genesis and the subducting slab steepening, the westward migration of the asthenospheric wedge, and the development of a tearing. Moreover, this work enables to understand if the upwelling of the asthenospheric anomaly had an impact on the VVF magmas and, regionally, on the rear-arc magmatic belt, as intraplate-like geochemical features are described in the Payún Matrú volcanic field, east of the studied area.

Keyword

Fractional crystallization, extensional regime, volcanic arc, subduction angle

Geochemistry of the Volcanic Rocks of the Central Northeast Foothills of the Tilarán Volcanic Arc, Costa Rica

Martin Rojas Barrantes[1]*, Directorate of Geology and Mines, Costa Rica (martinr@minae.go.cr)

Abstract

The geochemistry of the volcanic rocks is analyzed (Upper Miocene to Quaternary) from the northeast of the Cordillera de Tilarán, Costa Rica. The volcanism that originates the volcanic rocks in this area of the Tilarán Volcanic Arc has been considered essentially calc-alkaline; however, differentiation is remarkable as a consequence of the magmatic evolution of the internal volcanic arc of northern Costa Rica, as shown from the analyzed samples. The objective was to analyze the geochemistry of a variety of samples in a relatively small area of 650 km2 to analyze the local volcanic evolution of the study area. The method consisted of several fieldwork campaigns as part of the geological mapping of the area and the sample collection from the best outcrops. Twenty-nine samples were analyzed (18 igneous and 11 pyroclastic rocks) under the total whole rock method according to the AQ200 standard. The results and analysis were processed with the GCDkit software. Since the volcanism is mostly mafic to intermediate in composition, the MgO content is used to analyze the differentiation processes. Also, the contents of TiO2, Fe2O3, Na2O, K2O, the trace elements Ni, Zr, Sr, Nb, Co, Sc, and Rb, the ratios Ba/La, Zr/Nb, U/Th, La/Yb, Th/Nb, and La/Nb, the REE normalized to chondrites, and the normalization to the primitive mantle to analyze the source of the magmas, the degrees and mechanisms of partial fusion, and the contribution of sediments and fluids to the metasomatism of the mantle. The Upper Miocene volcanism is sub-alkaline with marked tholeiitic and calc-alkaline affinity and transitions to both series, varying from basalts to dacites. The geochemical analysis suggests a strong differentiation of these magmas from OIB-type sources (calc-alkaline and alkaline rocks) to MORB-type sources (tholeiitic basalts) modified by the subduction processes. The Plio-Pleistocene pyroclastic volcanism is associated with ignimbrites of calc-alkaline dacitic-andesitic composition. Related to primary magmas, the analysis suggests greater or higher degrades of partial melting with an input of fluids and carbonate pelagic sediments from the subducting slab to the mantle metasomatism. The Monteverde Formation of the lower Pleistocene covers most of the area, forming transitional and sedentary soils mainly of andesite composition, associated also with pyroclastic and volcaniclastic volcanism. The Buena Vista Formation conforms to the subsequent volcanism of the Monteverde Formation and is composed of volcaniclastic deposits (lahars) of very indurate volcanic breccia. The pyroclastic Holocene deposits of Arenal volcano (Tephras) are calc-alkaline in andesitic-basaltic andesite composition. The primitive mantle normalization shows LILE enrichments and HFSE depletions associated with the input of marine fluids and sediment dehydration of the subducted slab to the mantle metasomatism, typical of arc volcanism with an alkaline component that may be more related to the back-arc than the intra-arc volcanism of northern Costa Rica.

Keyword

tholeiitic, calc-alcaline, metasomatism, trace elements, Tilarán

Records of lava-ice interactions during the Pleistocene in the Chiles volcano, Colombia-Ecuador border

CAMILA MARTINEZ[1]*, Universidad Nacional de Colombia (cmartinezar@unal.edu.co)
JOHN JAIRO SANCHEZ[2], Universidad Nacional de Colombia

Abstract

Chiles volcano is an active stratovolcano with a maximum altitude of 4748 m a.s.l., located on the border between Colombia and Ecuador, and which was covered by glaciers until 1950. During its evolution it has presented mainly two periods of effusive activity during the Chibanian (~572-271.4 ka) and Upper Pleistocene (~57.5-42 ka), respectively. They generated dacitic to andesitic lava flows that make up the current volcanic edifice. There is evidence of the direct interaction between volcanic activity and past glaciers in this area.

Studying lava-ice interactions and their products is essential to understand the eruptive history of this and other volcanoes around the world, to make paleoclimatic reconstructions of past glacial extents and to identify threats associated with eruptions that involve ice in their dynamics. Therefore, this study focuses on the reconstruction of the glaciovolcanic evolution of Chiles volcano and the recognition of its records such as geoforms and fracture patterns in lavas and it constitutes a pioneering study in Colombia on this topic.

This research is based on the analysis of aerial photographs, satellite images, slope and shadow maps and field observations. Additionally, it is supported by the temporal correlation with glacial stages defined from the altitude of moraine systems in other areas of Colombia and Ecuador, and with the Marine Isotopic Stages (MIS) defined globally.

According to the observations, nine glacial stages are defined for the Chiles volcano from the Chibanian to the present (numbered from one to nine, from oldest to youngest age). Stages two, three and four (Chibanian) show a temporal relationship with the first period of effusive activity, and stage six (Upper Pleistocene) shows a direct interaction which generated geoforms of glaciovolcanic origin classified as ridge-forming flows, and pseudopillow joints, kubbaberg or blocky joints, platy joints, and column-forming joints in andesitic and dacitic lavas. These ones can be recognized mainly the southern and southeastern flank of the volcano.

The most recent glacial stages (<35 ka) show geomorphological records like U-shaped valleys, terminal, lateral and ground moraines, kettle lakes and tarns, and till deposits that indicate an erosion process after volcanic activity, and which possibly removed the typical fractures of the most superficial areas of lava flows.

Overall, most of the evidence of glaciovolcanic interactions was observed on the southeastern and

southern flank of the Chiles volcano, especially due to the fracture patterns that predominate in lavas from its second period of activity, which confirms the ice-lava interactions in this region and helps to understand the evolution of the activity of this volcano and the extinct glaciers that covered it.

Keyword

Chiles volcano, Glaciovolcanism, Pleistocene, Glacial stages, Fracture patterns

The Late Cretaceous explosive volcanism products in Bolnisi district and associated mineralization: Lesser Caucasus, Georgia

Nino POPKHADZE[1]*, A.Janelidze Institute of Geology (nino_popkhadze@yahoo.com)
Robert Moritz[2], University of Geneva
Safak Somnez[3], University of Geneva
Malkhaz Natsvlishvili[4], RMG group
Joni Shubitidze[5], RMG group
Shota Tagviashvili[6], RMG group
Badri Gogia[7], RMG group
Giorgi Ugrekhelidze[8], RMG group
Ioane Lomsadze[9], RMG group

Abstract

The Late Cretaceous explosive volcanism products in Bolnisi district and associated mineralization: Lesser Caucasus, Georgia

Nino Popkhadze1, Robert Moritz2, Şafak Utku Sönmez2, Malkhaz Natsvlishvili3, Joni Shubitidze3, Shota Tagviashvili3, Badri Gogia3, Giorgi Ugrekhelidze3, Ioane Lomsadze3

1Nino Popkhadze, Al.Janelidze Institute of Geology of Iv. Javakhishvili Tbilisi State University&RMG nino_popkhadze@yahoo.com

2 University of Geneva, Department of Earth Sciences

3 RMG Rich Metals Group Company

The Bolnisi district is a part of the Lesser Caucasus and is located at its northern extremity. To the west, this ore district continues into the Eastern Pontides, Turkey. The Late Cretaceous (~87–71 Ma) bimodal volcanism in this region resulted in mafic and felsic rock types, the latter being a major host of the ore deposits and prospects, and being defined locally as the felsic Mashavera and Gasandami suites. The existence of caldera structures in this region has been mentioned by various scientists, which was primarily associated with the strong exposure of ignimbrites, cross-cutting extrusions, and lava domes. although this criterion alone is not sufficient, since the system is Cretaceous and a large mass of sediments has been washed away.

Different types of ignimbrites are described by the author in this region: welded, mon-welded, slightly welded, and crystal-rich ignimbrites. Thickness varies from several m up to 400-500 m maximum. At the Sakdrisi deposit, the transition from unwelded ignimbrites to welded ignimbrites can be seen, as well as the frontal part of this pyroclastic flow is outcropping, which is built of different compositions and sizes rounded to well-rounded lithic fragments and large blocks of rhyolite/rhyodacite composition; Gas- escape pipes and accretionary lapilli horizons are observed in this thick ignimbrite. Pumice tuff with different sizes of pumice and sometimes with transition zones to fine ash material, ash fall, and accretionary lapilli thick (up to several meters) horizons is outcropping in this region; different types of breccias including the phreatomagmatic, phreatic, volcanic and sedimentary is observed and mostly connecting with explosive character.

Ore deposits in Bolnisi district are connected to the Upper Cretaceous explosive volcanic event in different stratigraphic levels and there is lithological structural control on mineralization. Explosive breccia and pumice-bearing rocks (including different types of ignimbrites and pumice tuffs) are good permeable rocks for fluid, where mineralization is mostly localized. Even non-mineralized explosive breccia in the system creates a fracture system sometimes together with the regional faults where gold/copper gold-bearing quartz and quartz-sulfide veins and stockworks are developing [1].

REFERENCES

[1] Popkhadze N, Gogia B, Tagviashvili Sh, J, Ugrekhelidze G, Natsvlishvili M, Shubitidze J, Sönmez S, Moritz R. 3D lithological and structural model and perspectivity of the Late Cretaceous Sakdrisi Gold-Copper epithermal deposit, Bolnisi district, Lesser Caucasus, Georgia. Proceedings of the 17th SGA Biennial Meeting: Mineral resources in a changing world, 28th August-1st September 2023/Zurich, Switzerland, v.2: pp.53-56.

Keyword

Ignimbrite, Explosive volcanism, Pumice, Breccia, Caldera

Geochemical and geochronological evolution of mafic-felsic volcanic rocks prior to the collision of India and Eurasia: Evidence from the northwestern Ladakh Himalaya, India.

Nongmaithem Lakhan SINGH[1]*, Indian Institute of Technology (Indian School of Mines), Dhanbad (neesam10@gmail.com)
Athokpam Krishnakanta Singh[2], Dr. Harisingh Gour Viswavidyalaya, Sagar
B.P. Singh[3], Department of Geology, Banaras Hindu University, Varanasi
Rajagopal Anand[4], Department of Applied Geology, Indian Institute of Technology Indian School of Mines, Dhanbad
Salim Akhtar[5], Department of Earth Sciences, IIT Gandhinagar, Gujarat

Abstract

Contributions to geology, geochemistry and geochronology of the Ladakh Himalaya have impacted the understanding of the development of suture zones and pre- and post-collisional magmatism. The Shyok suture zone is sandwiched between the Ladakh block in the south and the Karakoram block in the north. There are pockets of magmatic rocks having different geochemical evolutionary histories, formed at different geological time scales in the Shyok suture zone. One of the most widespread volcanic suites exposed in the northwest Ladakh Himalaya is the Khardung volcanic suite that sits on the northern tip of the northwestern Ladakh block. This volcanic suite comprises basalt, basaltic andesite, andesite, dacite and rhyolite. These closely associated volcanic rocks exhibit calc-alkaline affinity, with the felsic rocks forming the voluminous bulk. Their chemistry shows enrichment in large ion lithophile elements (Rb, Sr, Ba, U, Pb) and depletion in high field strength elements (Nb, Ta, Hf, Ti) with increasing Eu negative anomaly from mafic to felsic rocks. Bulk-rock liquid line of descent (LLD) modelling showed fractional crystallisation as a predominant mechanism in their petrogenesis. The calculated zircon saturation temperature (TZr) in mafic magmas (745oC) is higher than the felsic magmas (682oC). Zircon age of 69 Ma-68 Ma for the mafic rocks, and a younger 59 Ma-64 Ma age for the more evolved dacite and rhyolite are consistent with their generation in the late stage of magmatism in an active continental marginal setting. This event occurred during the Late Cretaceous and the Paleocene Epoch due to the subduction of the Neo-Tethyan oceanic slab underneath the Eurasian plate boundary prior to the main collision between India and Eurasia.

Keyword

Geochemisty, Geochronology, Shyok suture zone, Ladakh Himalaya, Late Cretaceous

Radiogenic Sr, Nd, Hf and Pb isotope characteristics of Pumice from the Andaman Sea

Prabala Bhaskara RAMA MURTY[1]*, CSIR-NGRI (pbrmurty@gmail.com)
Neethu Sukumaran[2], CSIR-National Geophysical Research Institute
Miriyala Pavan[3], CSIR-National Geophysical Research Institute
Teeda Vijaya Kumar[4], CSIR-National Geophysical Research Institute
G Balu[5], CSIR-National Geophysical Research Institute

Abstract

During a survey of multibeam swath bathymetry in the Nicobar swarm region onboard RV Sonne, seabed sampling with a TV-guided grab recovered pumice clasts from the offaxial high of Andaman Sea. These pumice clasts had ferromanganese oxide coatings either partly or fully. We have sampled the fresh portion from the inner side and measured Sr-Nd-Hf-Pb isotopic ratios and major element abundances for three representative pumice of fully coated, partly coated and uncoated with ferromanganese oxides.

Prior to the isotope analysis, all samples were leached by an intense multi-step leaching with 6N HCl to remove the oxide coatings carefully and finally cleaned with Milli Q water. Analysis of major elements reveals contents of SiO2 ranging from 69 to 72wt% and total alkali from 6% to 9wt% suggesting that all pumice analyzed are rhyolytic in nature. Measured 87Sr/86Sr, 143Nd/144Nd,176Hf/177Hf, 206Pb/204Pb, 207Pb/204Pb, 208Pb/204Pb isotopic ratios are in the range of 0.70447-0.70454, 0.512765-0.512763 (2.68-2.81 Nd), 0.28305-0.28315 (10.02-13.05 Hf) 18.424-18.426, 15.608-15.619, 38.648-38.706 respectively. Very narrow variations in the Sr, Nd, Hf and 206Pb/204Pb isotopic ratios suggest that despite variable ferromanganese oxide coatings, analyzed pumice samples were essentially from a similar source.

Relatively large ranges observed in 207Pb/204Pb and 208Pb/204Pb ratios indicate the involvement of a DUPAL - like MORB source. Our results though preliminary with a limited number of samples, suggest more likely a source mixing between an EM2 component and Dupal-like MORB source. Comparison of the measured pumice compositions in all isotope space with the known volcanoes of regional Toba and Krakatau and local Barren Island and Narcondam suggests an unlikely scenario for a localized source, but a drifted one from Krakatau eruption. More geochemical and isotope data with the increased number of samples can resolve the source and origin of the pumices from the Andaman Sea.

Keyword

Andaman Pumices, radiogenic isotopes, source mixing and DUPAL anomaly

Tertiary and quaternary volcanism of the western part of Senegal: State of research and prospects

Raymond SAGNA[1]*, Service Géologique National du Sénégal (SGNS)
(raymond.sagna@sgns.gouv.sn)
Rokhaya SAMBA[2], Organisation of African Geological Survey (OAGS)
Alla DIAW[3], Service Géologique National du Sénégal (SGNS)

Abstract

Located at the western end of the African continent, the geology of Senegal is composed mainly of old formations of birimian and pan-African and sedimentary formations of the Meso-Cenozoic Senegalese-Mauritanian or «Senegalese-Mauritano-Guinean Basin». This basin formed after the opening of the Atlantic Ocean in the Middle Jurassic is filled with sediments of Trias-Lias to Quaternary age and covers ¾ of the area of the country. The basin has a monoclinal structure and is characterized by a rarity of outcrops with the exception of the horst of Diass. Deep knowledge of the basin is made possible by oil drilling and geophysical data.

This basin has experienced two volcanic episodes namely that of the tertiary including Upper Eocene – Oligocene – Miocene in the region of Thiès and Cape Verde and that of the ancient quaternary of Dakar.

Tertiary lavas are composed of alkaline basic rocks with porphyry nephelinite, melalitis nephelinite, fine basanite and doleritic basanites. These rocks are associated with clusters or veins of pegmatitoids and their outcrops are scattered over 7000 km2 between Dakar and Thiès and divided into 4 sets namely that are the volcanic ensemble of the Thiès region, the volcanic ensemble of the Dome of Diass, The peninsula of Cape Verde composed of four volcanic ensembles and the oceanic margin of the basin.

Thus, the geology of tertiary and quaternary volcanism seems to be well described. However, understanding magma from source magma remains a topic of discussion. Hence the realization of a set of Master's thesis and Theses. This work, which in addition to petrography involves isotopic and geochemical analyses and gas analyses, is gradually providing an answer to the origin of magma.

It is in this context that we have chosen to make a contribution to the

understanding of tertiary and quaternary volcanism including the characterization of the source of magma using isotopes but also a rare gas, Neon.

Thus, after having made the economy of the work carried out, we will decline in turn the methodological approach used and the expected results.

Keyword

volcanism IIIaire and IVaire, magma, isotopes, Neon

Monitoring magma chamber processes at silicic volcanoes through single zircon mineral chemistry and U-Pb ages in the Sabga Volcanic Complex, Cameroon Volcanic Line

Edith Etakah Bate TIBANG[1]*, University of Bamenda (edithbate@yahoo.com)
Cheo Emmanuel Suh[2], University of Bamenda

Abstract

In order to constrain the petrogenesis of silicic magma along the Cameroon Volcanic Line (CVL), zircon chemistry combined with U-Pb ages from two rhyolite samples obtained from two lithostratigraphic strata separated by a basaltic unit in the Sabga area are presented. Previously dated zircon grains with crystallization ages of 21.4 – 33.2 Ma from two rhyolite samples were analyzed for trace element contents and Lu-Hf isotopic compositions using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS). Ti in zircon temperature for both rhyolites vary from 636 – 886 0C, and very low oxygen fugacities below the quartz-fayalite-magnetite buffer (0.08 - (-19.9)) were also obtained. This low oxidation state suggests that the rhyolites evolved as part of the anorogenic setting of the early Tertiary plutonism along the CVL which are associated with tin mineralization. Zircon REE patterns and slight negative and positive correlation trends between hafnium and trace element ratios (e.g., Hf vs Th/U, Hf vs Sm/Yb and Hf vs U), are indicative of magma evolution through an open system fractional crystallization, with coeval growth of other REE-rich accessory minerals. The Epsilon hafnium values for Tertiary zircons from both rhyolites vary from -10.6 to 6.8 and yielded Neoproterozoic mantle model ages (TDM(Ma)) between 440- 1144 Ma. The Lu-Hf data discloses mixing of materials from a juvenile mantle source and reworked crustal contribution from the Neoproterozoic and a possible Paleoproterozoic basement (TDM (2511-2407 Ma).

Keyword

Cameroon Volcanic Line, zircon microchemistry, rhyolitic units, fractional crystallization, in situ Lu-Hf measurement; petrogenesis

Preliminary Study of Magma Mixing/Mingling in Pleistocene Volcanic Rocks of the Rakiraki Area, Viti Levu, Fiji

Kamal R REGMI[1]*, Nazarbayev University (kamal.regmi@nu.edu.kz)

Abstract

The most recent volcanism on the island of Viti Levu, Fiji, is represented by Pliocene and younger mafic-intermediate rocks found in the areas of Sabeto, Tavua, Rakiraki, and Vatia, including Cainozoic shoshonites in the Vatukoula area. Some post-subduction (Pleistocene?) rocks are best exposed in the Rakiraki area, particularly along the Nakauvadra River and in the cones of the Narewa Plug complex. The rocks along the river are mainly andesites and basaltic-andesites with sporadic breccia horizons and dykes. In contrast, the rocks exposed in the Plug are Hbl-andesites. These rocks belong to the Mba Basaltic Group. Porphyritic basaltic andesites from the River are predominantly composed of microlites of Pl, Cpx, Fe-Ti oxides, Opx, and Ol with phenocrysts of altered and serpentinized Ol and subhedral to euhedral lath-shaped to tabular Pl (sometimes showing resorbed cores with mantled overgrowth) and sporadic Cpx. Rarely, Opx and Pl are found as inclusions in Cpx. Fine-grained basalts are composed mainly of microlites of Pl and Cpx with groundmass rich in Pl and Cpx.

Phenocrysts in the porphyritic Hbl-andesites from the plug complex are represented mostly by euhedral, zoned, and twinned Pl and Hbl with lesser amounts of euhedral Cpx. In contrast, Pl, Hbl, Cpx, and Fe-Ti oxides are found in the groundmass. There are zeolites (wairakites) that seem to have originated at the expense of Pl, indicating a hydrothermal activity.

Field studies at both of these sites show preliminary evidence for mixing/mingling between magmas, i.e.: a) chilled margins around MME and FME in the basaltic-andesites in the River b) cm-scale quenched enclaves of basaltic composition, finer in grain size (made up of microlites of Pl and Cpx) and coarser-grained mafic enclaves with chilled margins in andesites of the Plug. In addition, in the River section, coeval masses of basalts and andesites indicate a genetic link and fragments of sedimentary rocks are present in the basaltic andesites, confirming phreatomagmatic eruption. Although previous studies indicated that andesites from the Plug were the products of fractional crystallization of gabbroic magma, the present study suggests stronger support for magma mingling. However, a supporting geochemical investigation is needed.

Keyword

Andesites, Basaltic-Andesites, Magma Mingling-Mixing, Rakiraki-Fiji, Narewa Plug

Carbon Isotope Fractionation in Silicate Melt: Window into Carbon Speciation

Hyunjoo LEE[1]*, Lamont-Doherty Earth Observatory, Columbia University (hl3507@columbia.edu)
Yves Moussallam[2], Lamont-Doherty Earth Observatory, Columbia University
Cyril Aubaud[3], Université Paris Cité, Institut de Physique du Globe de Paris, CNRS
Giada Iacono-Marziano[4], ISTO, UMR 7327 CNRS-Université d'Orléans
Keiji Hammond[5], American Museum of Natural History, Department of Earth and Planetary Sciences
Denton Ebel[6], American Museum of Natural History, Department of Earth and Planetary Sciences

Abstract

The isotopic fractionation of carbon between gas and silicate melts is a crucial parameter to understanding the carbon cycle at the planetary scale that requires accurate quantification. This experiment measured the carbon isotope fractionation factor between CO2 gas and carbon dissolved in silicate melt across a range of melt compositions at 350-420 MPa and 1160-1225°C. Integrating data from previous literature experiments and this study, a linear relationship was established between the fractionation coefficient and the depolymerization degree of the melt (NBO/T; non-bridging oxygens per tetrahedral cation). The fractionation coefficient increases for depolymerized melts (e.g., basalt) and decreases for polymerized melts (e.g., rhyolite). These relationships enable the calculation of carbon fractionation factors in silicate melts, providing a means to interpret δ13C measurements in natural volcanic gases and melts through forward and backward modeling of degassing paths from mantle to surface. The relationship is calibrated from NBO/T = 0 to 1, covering most major melt compositions. However, it is expected to stabilize and remain constant at NBO/T > 1. We hypothesize that the ratio of CO32-/CO2 dissolved in the melt is the key parameter behind this relationship. Carbon dissolved as CO2 molecule transfers to the gas phase with a fractionation factor of 0‰ whilst carbon dissolved as CO32- transfers with a fractionation factor of 3.5 ‰. Carbon isotopic fractionation might hence offer a window into carbon speciation in natural melts.

Keyword

Carbon isotopes, Carbon isotope fractionation factor, Carbon species, CO2 fractionation, δ13C-value

GEOLOGIC MAP OF THE PLEISTOCENE VOLCANO OF MONTE AMIATA (SOUTHERN TUSCANY, ITALY)

Claudia Principe[1]*, Istituto di Geoscienze e Georisorse - CNR, Pisa (c.principe@igg.cnr.it)
Luigina Vezzoli[2], Istituto di Geoscienze e Georisorse - CNR, Pisa
Sonia La Felice[3], Istituto di Geoscienze e Georisorse - CNR, Pisa

Abstract

Monte Amiata (305–231 ka; Italy) is an uncommon example of a completely effusive silicic (mainly trachytic) composite volcano. A detailed geological map (1:25,000 scale) based on Unconformity Bounded Stratigraphic Unit criteria is presented accompanied by volcano-tectonic, stratigraphic relationship, and volcano evolution schemes. The volcanic facies analysis and structural analysis criteria have been applied to decipher Monte Amiata's geological evolution and structure, and to infer the relations between volcanism and regional tectonics. The performed stratigraphic reconstruction is based on the recognition of a large number of lithostratigraphic units (Formation, Fm). Many of which are composed of various lithosomes. These lithostratigraphic units were grouped into the appropriate Unconformity Bounded Stratigraphic Units (UBSU) based on the recognition in the field of geological discontinuities. Based on the occurrence of a first-order geological unconformity representing a paleo-weathering surface of paleoclimatic significance, two major volcanic stratigraphic units and seven phases of activity are recognized. Petrographic descriptions of the rocks in the map legend are made at the scale of the hand sample to facilitate the identification of the various units in the field, based on the characteristics of volcanic textures, groundmass, grain size, and relative abundance of phenocrysts and mega-phenocrysts, and the presence of glomerophyres, magmatic enclaves, metasedimentary xenoliths, magmatic enclaves, and metasedimentary xenoliths.

Keyword

Silicic effusive volcano,, Silicic Sheet Like Lava Flows, Volcanic rift zon, Unconformity Bounded Stratigraphic Units, Geologic map

Updated post 3 ka BP volcano-stratigraphy of Ulleungdo volcano, South Korea: insights into the Holocene post-caldera eruptions

Ho-Jun AHN[1]*, Division of Earth Environmental System, Pusan National University (ahnhj@pusan.ac.kr)
Chang Woo KWON[2], Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources
Gi-Bom KIM[3], Department of Geological Science,Pusan National University

Abstract

This study focuses on reporting a newly found silicic volcaniclastic unit deposited at ca. 3 ka BP, and suggests an updated volcano-stratigraphy of the Ulleungdo since the past 3,000 years. A newly found phonolitic volcaniclastic deposits, named unit N-0, is exposed along the wall of the incised valley that extends from the Albong to Chusan coast. Eruption age of the unit N-0 is constrained at ca. 3 ka BP, based on the radiocarbon dating of the charred woods (3,051±117 yr cal BP) and peat (3,056±99 yr cal BP) collected in and below of the unit N-0, respectively. These are the youngest absolute ages reported in the Ulleungdo, suggesting that the volcanism of Ulleungdo was active even in the historical period of Korea. The Albong, considered as the youngest trachyandesitic–trachytic volcanic edifice of the Ulleungdo, unconformably overlies the unit N-0, indicating that eruptive quiescence exists between the unit N-0 and the Albong, and that the Albong eruption occurred at least after 3 ka BP. The Chusan breccias, directly overlying the unit N-0 on the Chusan coast, is strongly suspected to originate from the Songgotbong phonolitic lava dome considering that whole-rock and phenocryst compositions of the Chusan breccia are similar to those analyzed from the Songgotbong lava. The stratigraphic relationships among the unit N-0, Chusan breccias, and Songgotbong lava dome suggest that the Songgotbong lava dome is also younger than 3 ka BP. All lines of evidence we presented here propose that the explosive and effusive eruptions by compositionally distinct silicic magmas occurred at least three times since 3 ka BP, of which the eruptive centers are spatially separated. In order to fully understand eruptive history and assess the geohazard potential for future eruptions in the Ulleungdo, additional studies are required to constrain the eruption ages of the Albong and Songgotbong whose ages still remain uncertain.

Keyword

Ulleungdo, 3 ka BP, Volcano-stratigraphy

Volcano-tectonic activity of Pantelleria Island (Italy) and relationship with the Green Tuff emplacement

Gianluca Groppelli[1]*, CNR-IGAG (gianluca.groppelli@cnr.it)
Young Kwan SOHN[2], Gyeongsang National University
Gi Bom KIM[3], Pusan National University
Federica BARILARO[4], CNR-IGAG
Andrea DI CAPUA[5], CNR-IGAG
Gianluca NORINI[6], CNR-IGAG
Roberto SULPIZIO[7], University of Bari

Abstract

The island of Pantelleria (Italy) is a volcanic complex that lies along the continenal rift system of the Sicily Channel. It has been the site of intensive volcanic, tectonic and volcano-tectonic activity older than 300 Ka.

The most evident morphological elements comprise two different aged calderas situated in the south-central part of the island and a resurgent block inside the younger caldera. If the presence of two calderas is accepted by a large number of authors, the relationships of two are still disputed. The oldest caldera, Cinque Denti Caldera, occupies the central-southern part of the island and is related to four explosive eruptions associated to the emplacement of PDCs, dated between 175-106 and 114 ka. The youngest caldera, named Monastero Caldera, is related to the Green Tuff eruption at about 50 Ka. This formation represents the best-known pyroclastic product of this volcano, zoned from pantellerite to trachyte and represents the main stratigraphic marker in the island. After Green Tuff caldera forming eruption, volcanic activity continues associated with an important resurgent phase, forming Montagna Grande relief and carrying high the Green Tuff from sea level deposition to more than 800 m in altitude.

The results of geological and structural survey as well some morphological observation on detailed DEM allow us to depict an updated volcano-tectonic evolution of Pantelleria Island.

This work was supported in part by the Italian Ministry of Foreign Affairs and International Cooperation, grant number KR23GR08

Keyword

Volcano Geology, Caldera, PDC deposits, Reomorphism

Structure and composition of the Late Miocene Goderdzi Volcanic Complex, Lesser Caucasus, Georgia: implication for resurgent caldera formation

MIRIANI MAKADZE[1]*, Tbilisi State University, Faculty of Exact and Natural Sciences, Tbilisi, Georgia. (mirian.makadze@tsu.ge)
Avtandil Okrostsvaridze[2], Institute of Earth Sciences, Ilia State University. 0162 Tbilisi, Georgia.
Mehmet Keskin[3], Istanbul Technical University, Faculty of Mines, Istanbul, Türkiye
Nino Popkhadze[4], Al. Janelidze Institute of Geology of Tbilisi State University. Tbilisi, Georgia

Abstract

As is known, resurgent calderas are formed after especially large volcanic eruptions by ground collapse, the diameters of which can reach many of kms. Post-caldera andesitic domes are typical for these types of calderas. Here we describe a special type of probably resurgent caldera complex, whose domes are currently up to 3000 m. a. s. l., which is not typical for these types of calderas. This is a late Miocene volcanic formation in the Georgian Lesser Caucasus, known as the Goderdzi Volcanic Complex. The complex, forms a volcanic highland, the thickness of which exceeds 1200 meters and occupies more than 4500 km2 in Georgia. It is divided into three parts, near the rock-cut city of Vardzia, in the Mtkvari canyon: The lower part is composed by a thick of 200–250 m
of pyroclastic material, predominantly andesitic-dacitic composition. This part is overlain by a 60–90 m thick andesitic-dacitic ignimbrite. On top of the ignimbrites, another thick layer of coarse-grained lithic breccia andesitic-dacitic composition is observed (700-900 m thick). Presumed, total volume of the Goderdzi Volcanic Complex within the territory of Georgia exceeds 500 km3. The SiO2 content of this complex changes from 58% to 65%, εNd values vary between +2 and +4, and 87Sr/88Sr ratios vary between 0.7034 – and 0.7045, which indicate a mantle orgin [1].

The volcanic center of this complex is located on the state border between Türkiye and Georgia. Part of this center is located on the territory of Georgia within the Niala caldera (~7x8 km) and the Gumbati andesitic dome (2996 m e.s.l.). The caldera also extends to the territory of Türkiye (NE part of the Kars Plateau), where the Keltepe Andesitic Complex (3032 m e.s.l) is located. The zircon U-Pb geochronology indicates, that the age of the Mtkvari Ignimbrites (flows from the Nyala caldera and extends more 35 km) is ~7.5 Ma and the Gumbati andesitic dome is ~ 6.5 Ma [2].

The analysis of the structural and compositional data of the Goderdzi Volcanic Complex indicates that it may be linked to the eruption from a large resurgent caldera. The only objection to this assumption is the high altitude of andesitic volcanic domes (~ 3000 m. a.s.l.), which does not seem to be consistent with typical resurgent caldera structures. We suggest that this can be attributed to the regional uplift caused by the active continental collision between the Arabian and Eurasian over the last ~7 Ma.

During this period, the caldera structure appears to have experienced intense deformation and erosion, bat the andesitic domes have been more resistant to these processes as a solid, hard

igneous bodies.

References

[1] Lin Y. C,, Chung S.L., Biıngöl A. F., Yang L, Okrostsvaridze A, Lin T. H,, Lee H. Y., 2020. Diachronous Initiation of post-collisional Magmatism in the Arabia-Eurasia collision Zone. Lithos, 356-357:105394.

[2] Okrostsvaridze A, Chung S.L, Chang Y. H, Skhirtladze I., 2019. Geology and Zircon U-Pb Geochronology of the Mtkvari Pyroclastic Flow and evaluation of destructive processes affecting Vardzia rock-cut city. Quaternary International, 540 (25):137–145.

Keyword

Resurgent Caldera, Mtkvari Ignimbrites, Keltepe, Gumbati dome

Correlation of proximal and distal deposits of a caldera-forming eruption based on the variation of juvenile materials: A case study of Toya Volcano, southwestern Hokkaido, Japan

Mitsuhiro Nakagawa[1]*, Hokkaido University (mnakagawa@sci.hokudai.ac.jp)
Mizuho MIYASAKA-ANMA[2], Hokkaido University
Akiko MATSUMOTO[3], Hokkaido University

Abstract

We correlate eruptive deposits of the caldera-forming eruption (106 ka) of Toya volcano from proximal to distal areas, by focusing on the temporal changes in the diversity of juvenile materials. The proximal deposits are divided into six units, from unit 1 to 6 in ascending order. Of these, Unit 2 and Units 5 and 6 are large PDCs. The juvenile material can be divided into three types, crystal-poor type pumice (CP), crystal-rich type pumice (CR), and gray banded pumice (GRY). These can be distinguished not only by lithofacies but also by phenocryst assemblages, mineral compositions, and whole-rock and matrix glass chemistry. Although units 1 to 3 only contain CP, small amounts of CR and GRY are also recognized in Unit 4. Then, the proportion of CP decreases to about 90% in Unit 5, and that of CR becomes particularly high. In addition, CP decreases to about 50% in Unit 6, and GRY increases in addition to CR. We compare the proportions of types of juveniles in PDC deposits from proximal to distal areas. When the juvenile material becomes fine-grained, the classification is confirmed by the matrix glass chemistry. Then, it is revealed that Unit 2 and 6 are not distributed more than 30 km from the caldera, whereas Unit 5 has reached more than 50 km far from the caldera. Moreover, the co-ignimbrite ash, which are distributed at the area more than 400 km in the distance from the caldera, can also be correlated based on the difference in matrix glass chemistry between the earlier (Unit 2) and later (Units 5 and 6) PDC. In areas up to about 120 km far from the caldera, the lower part of the ash correlates with Unit 2, and the upper part with Units 5 and 6. However, in areas further than 100 – 150 km, the ash layers are composed only of units 5 to 6. According to the above procedure, the correlation of the eruptive deposits from proximal to distal areas has been successfully completed. Considering the time interval and the temporal change of the erupted magma types, the eruption can be divided into two main stages: Stage I (Units 1 to 3) and II (Units 4 to 6). The estimated eruptive volumes are 39 km3 DRE in stage 1, 133 km3 DRE in stage 2, and the maximum in unit 5 with 106 km3 DRE. Stage II is the main stage of the eruption and erupted various types of magmas, such as CR and GRY magmas in addition to CP. The catastrophic phases of the eruption were Units 5 and 6, in which obvious lag breccia layers occurred, indicating that collapse and enlargement of the caldera had occurred.

Keyword

Caldera-forming eruption, Juvenile materials, Co-ignimbrite ash, Correlation of tephra, Toya

Volcano

Morphological analysis of volcanic cones and its implication to Quaternary tectonics of the Jeju Island (South Korea)

Francois HATEGEKIMANA[1]*, Pukyong National University, Department of Earth and Environmental Sciences, Geological and Geo-Hazard Research Lab (francoishate@pukyong.ac.kr)
Sambit Prasanajit NAIK[2], Active Fault and Earthquake Hazard Mitigation Research Institute, Pukyong National University, Korea
Young-Seog KIM[3], Active Fault and Earthquake Hazard Mitigation Research Institute, Pukyong National University, Korea

Abstract

The morphological characteristics and distribution of volcanic cones of Jeju Island in Korea could be controlled by several factors, including stress field in the substrate and subsurface fractures. Controlling fractures, however, might not be visible on the outcrop in volcanically active areas like Jeju Island, because of the layer of volcanic rocks covering them. Furthermore, inferring the paleostress is much more difficult. Hence, it is essential to identify the concealed feeding fractures through an indirect approach based on a morphometric analysis. Thus, Jeju Island is one of the best places to study this issue. Measurements of ellipticity, maximum crater diameter, breaching azimuth, coeval cone alignment, and the line connecting depressed points on 152 Quaternary volcanic craters, were taken to identify magma-feeding fractures. Jeju Island in SW Korea comprises Quaternary volcanic rocks overlying the Tertiary ~ Quaternary sediments of the Seogwipo Formation, Tertiary unconsolidated sediments (U Formation), and Cretaceous granite. This study identified two dominant types of Pre-Pleistocene magma-feeding fractures including E-W and NE/ENE-trending fractures consistent with previously identified Pre-Neogene E-W and Miocene NE-trending fractures around Jeju Island. These fractures might be associated with the rotation of maximum horizontal stress direction (σHmax). Identifying subsurface structures is critical for seismic hazard assessment because their reactivation could result in destructive earthquakes.

Keyword

magma-feeding fracture, volcanic crater, morphometric analysis, Jeju Island, Quaternary

[Keynote] Hydrovolcanic activity in relation to Quaternary sea levels in Jeju Island, Korea

Young Kwan Sohn[1]*, Gyeongsang National University (yksohn@gnu.ac.kr)

Abstract

Jeju Island is a basaltic shield volcano built mainly by monogenetic volcanic activity on the Yellow Sea continental shelf under the influence of fluctuating Quaternary sea levels. Early eruptive activity was hydrovolcanic (either Surtseyan or Taalian), and volcaniclastic sedimentation occurred in either submarine or subaerial settings, depending on the sea levels. The hydrovolcanic activity lasted for over a million years and resulted in the deposition of the ca. 100 m-thick Seoguipo Formation. As the volcano grew above the fluctuating Quaternary sea levels, lava effusion became dominant in the middle to late Pleistocene, forming the current shield morphology of the volcano. In the late Pleistocene and Holocene, tuff rings and cones of Suwolbong, Udo, Ilchulbong, and Songaksan were produced by hydrovolcanic activity near the present coastlines. Suwolbong and Udo, which are pre-Holocene in age, were produced by phreatomagmatic explosions in the subsurface without any trace of marine processes. On the other hand, Holocene volcanoes (Ilchulbong and Songaksan) were produced by very wet Surtseyan to phreatomagmatic activity and preserve the records of paleo-sea-level at the time of eruption. Songaksan even contains the records of a paleo-storm event, i.e., storm wave-worked volcaniclastic deposits, up to an altitude of ~4.6 m above high tide level, implying that coastal volcanoes can preserve the records of extreme events in coastal areas, such as storms and tsunamis. The volcaniclastic materials of Songaksan were reworked by marine processes to form a marine sedimentary formation up to an altitude of a few m above present sea level, suggesting a period of higher sea levels during the middle to late Holocene. Footprints of humans, deer, birds, and marine benthic animals in the formation suggest that volcaniclastic sedimentation on Jeju Island continued until just before the historical era. Jeju Island thus shows that Quaternary sea-level fluctuations were a major control of volcanic activity and sedimentation on the island.

Keyword

hydrovolcanism, Quaternary sea level, Jeju Island, volcaniclastic sedimentation, continental shelf

Triggering of rapid ascent of magma and explosive eruption: The case for the Cretaceous Sinsudo Tuff in the Gyeongsang Basin, Korea

Yong-Un CHAE[1]*, Pukyong National University (chae@pusan.ac.kr)
Youn-Joong Jeong[2], Korea Basic Science Institute
Jong-Sun Kim[3], Korea National Park Service
Sujin Ha[4], Busan Metropolitan City
Young Ji Joo[5], Pukyong National University
Hyoun Soo Lim[6], Pusan National University

Abstract

In the East Asian region, including the Korean Peninsula, many sedimentary basins were formed due to the subduction of the paleo-Pacific plate under the Eurasian plate during the Cretaceous, and subduction-related volcanic activity occurred frequently around the area adjacent to the plate boundary. The Cretaceous Gyeongsang Basin (ca. 128 Ma~), the largest basin on the Korean Peninsula, was also accompanied by siliciclastic and pyroclastic sedimentation. The Sinsu and Changseon islands located in the southern part of the basin contain the Sinsudo Tuff, which is one of the representative tuff with ca. 2.5 m thick. The tuff has overall characteristics of being pumice-free and crystal-rich. Due to its stratigraphic and volcano-sedimentological importance, many studies have been conducted on its petrology, eruptional condition, and depositional process. As a result, it was revealed that the Sinsudo Tuff was deposited by surge (basal layered division) and current (upper massive division) of pyroclastic materials that underwent full fragmentation at shallow depth with a rapid magma rise. However, there is no information about the evolutionary history of the magma reservoir before the eruption that caused the rapid magma ascent interpreted based on its characteristics. Here we simultaneously determine changes of magma environment and crystallization ages from zircon crystals in the Sinsudo Tuff, which allows us to decipher the evolution history causing rapid ascent of magma and explosive eruption. U-Pb dating and elemental analysis of zircons were performed using LA-ICP-MS instruments installed at the Korea Basic Science Institute. As a result, zircons showing about 99 Ma, which indicate the eruption age, are divided into two characteristic domains with large differences in brightness in cathodoluminescence (CL) images. In general, dark domains have much higher (about 10-100 times) uranium content. Based on the combination of two domains in the CL image, individual zircons show dark overall, dark in the core with bright rims (reverse zoning), and only bright oscillatory zoning. And some boundary of the dark domains in the cores had dissolved and overgrown by bright ones. There is no reverse case, and this means an environmental change caused by the inflow/recharge of magma that formed bright domains into the magma reservoir that formed dark domains. The dark domains of zircons were formed in relatively highly evolved and cooler magma (ca. 770℃), while the bright domains of zircons were formed in less evolved and hotter magma (ca. 819℃). Similar U-Pb ages indicate that the cores of reverse zoning zircons are most likely not xenocrysts or inherited zircons, but are autocrysts and/or antecrysts. Dark domains of zircons crystallized first in more evolved magma reservoir, and then domains with bright and

distinct oscillatory zoning were formed with the recharge of less evolved magma from deeper sources. At the same time, bright domains grew on the rims of existing dark zircons due to the magma mixing in the reservoir. During ca. 99 Ma, rapid pre-eruptive rejuvenation in magma reservoir caused internal overpressure, which ultimately might trigger the rapid ascent of silicic magma through volcanic vent.

Keyword

magma evolution, rejuvenation of magma, zircon U-Pb dating, zircon geochemistry, Sinsudo Tuff

Reconsideration of the magma plumbing system of the Suwolbong tuff ring, Jeju Island, Korea based on rigorous microscopic analysis

Sun Young GO[1]*, Volcano Research Group, Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources (igo@kigam.re.kr)
Hyeon-Seon AHN[2], Quaternary Environment Research Center, Climate Change Response Division, Korea Institutue of Geoscience and Mineral Resources
Ung San AHN[3], World Heritage Office, Jeju Special Self-Governing Provincial Government
Jong Ok JEONG[4], Center for Research Facilities, Gyeongsang National University
Young Kwan SOHN[5], Department of Geology, Gyeongsang National University
Chang Woo KWON[6], Volcano Research Group, Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources

Abstract

The Suwolbong tuff ring is a basaltic monogenetic volcano in the quaternary intraplate volcanic field of Jeju Island, Korea. The tuff ring was previously interpreted as having a congested magma plumbing system consisting of multiple dike complexes based on graded and mixed chemical trends of alkaline to sub-alkaline glassy pyroclasts. Microscopic observations, petrological analysis, and componentry analysis of the glassy pyroclasts show that the glassy pyroclasts in the tuff ring have alkaline to subalkaline compositions but also found that they have contrastingly different textural characteristics. We could confirm that some of the glassy pyroclasts in the tuff ring are accidental and inappropriate for interpreting magmatic processes. Juvenile particles are vesicular, alkaline in composition, volumetrically abundant (avg. 35 vol.%), and show a correlation between the vesicularity change and the lithofacies change in the outcrop. In contrast, accidental particles are non-vesicular, alkaline to subalkaline in composition, less abundant (avg. 8 vol.%) in deposits, and show alteration rims. The accidental particles are interpreted to have been derived from the hyaloclastite layers deposited before the eruption of the Suwolbong tuff ring. When considering only the geochemical characteristics of the newly defined juvenile particles, the Suwolbong tuff ring is interpreted to have had a rather simple magma plumbing system in contrast to a previous model. This study shows that a clear distinction between juvenile and accidental particles, based on rigorous microscopic analysis, is essential for accurately understanding the properties of the source magma and the magma plumbing system in monogenetic volcanoes, which commonly contain considerable amounts of accidental materials.

Keyword

tuff ring, monogenetic volcano, magma plumbing system, tephra componentry, hyaloclastite

Mantle degassing in South Korea

Hyunwoo LEE[1]*, Seoul National University (lhw615@snu.ac.kr)
Heejun KIM[2], Korea Institute of Ocean Science and Technology
Donghwan KIM[3], Seoul National University
Wonhee LEE[4], Seoul National University
Minyoung CHOI[5], Seoul National University

Abstract

In East Asia, including Korea, widespread intraplate volcanism has appeared during the late Cenozoic. The origin of magmatism has been suggested by various hypotheses such as stagnant Pacific plate or mantle corner flow beneath East Asia. Here we provide a new perspective on the Cenozoic East Asian magmatism using geochemistry of volatiles. In order for this, 3He/4He (1 Ra = 1.38 x 10-6) ratios and δ13C-CO2 (vs. VPDB) values of Korean Cenozoic basalts and spring gas samples were measured. The maximum 3He/4He ratio (7.3 Ra) of the basalts appears within the range of the depleted MORB mantle (8 ± 1 Ra). In addition, the spring gases have the maximum 3He/4He ratio (6.8 Ra) corresponding to the lithospheric mantle range (6.1 ± 0.9 Ra). Moreover, spring gases show high carbon dioxide concentrations (up to 99 vol.%), and the δ13C-CO2 values mainly indicate the mantle origin (-6.5±2.5‰). Overall, gases containing mantle-derived volatiles are discharged to the surface adjacent to the Cenozoic volcanic rocks, which shows that it is largely consistent with the recently reported distribution of low velocity zones beneath the Korean Peninsula. Therefore, we propose that the asthenospheric mantle upwelling can explain the Cenozoic intraplate magmatism in Korea, releasing volatiles of the mantle origin.

Keyword

East Asia, Volatiles, Lithosphere, Asthenosphere, Cenozoic intraplate volcanism

Dualistic Bubble Formation in Explosive Silicic Volcanism of Baekdusan

Gi-Bom KIM[1]*, Pusan National University (kimgb@pusan.ac.kr)
Young-Kwan SOHN[2], Gyeongsang National University
Jongok JEONG[3], Gyeongsang National University

Abstract

Volatile exsolution and consequent gas bubble formation in subvolcanic magmatic liquid induce explosive volcanic eruptions. The liquid fraction of ascending magma bodies progressively loses volatile contents in response to ambient pressure drop. Exceptionally, some trapped in phenocrysts as melt inclusions preserve volatiles as long as their crystal traps remain undamaged. The difference in volatile preservation potential between the two mechanically separated magmatic liquid domains infers that the path of syn-eruptive magma degassing is fundamentally dualistic. Hitherto, the duality has been neither properly evidenced nor conceptualized. Here, we present direct evidence showing the dualistic nature of magma degassing in explosive silicic volcanism. Investigation of pumice deriving from the A.D. 940s Millennium eruption at Baekdusan (Changbaishan in Chinese) reveals that a considerable volume of gas bubbles has originated from melt inclusions in spatial and temporal separation from the host domain of magma. Common near-spherical bubble pockets containing jigsaw-fit crystal fragments therein indicate instantaneous and simultaneous total decrepitation of melt inclusions in response to drastic decompression shortly before or coincidently with magma fragmentation. The distinctive compositional zonation of Millennium pumice coupled with bubble pockets evince a magma mixing event, possibly the trigger of the Millennium eruption as well as the inducer of mass entrapment of melt inclusions.

Keyword

Baekdusan, Changbaishan, Millennium Eruption, Melt Inclusion, Plinian Eruption

Evidence for an upper crustal melt lens beneath Baekdu/Changbaishan Volcano

James HAMMOND[1]*, Birkbeck, University of London (James.hammond@bbk.ac.uk)
Weiqian Yu[2], China Earthquake Administration
Wei Wei[3], China Earthquake Administration
Cunrui Han[4], Birkbeck, University of London
Jiandong Xu[5], China Earthquake Administration

Abstract

Mount Bakedu/Paektu (also known as Changbaishan) located on the border of China and the Democratic People's Republic of Korea (DPRK) is famous for intense volcanism in Cenozoic. Many studies show evidence for partial melt beneath the volcano, but details on the structure of the magmatic system are lacking due to a lack of data in the region. In this study, using ambient noise tomography and receiver functions at a new dense seismic array, we obtained a high-resolution crust and upper mantle shear wave velocity (Vs) model beneath the volcano. The absence of velocity anomalies beneath nearby Wangtian'e and Namphothe volcanoes suggest a lack of magma within the crust. However our models show two low velocity anomalies coinciding with the location of TCV in the upper crust. The shallow one (<4km depth) overlaps with petrological estimates for the rhyolite magma reservoir, involved in recent eruptions and also depth inferred for hydrothermal reservoir from recently MT study. This may be associated with saline fluids and/or a magma reservoir. The deeper anomaly is located at depths between 7 and 14 km with a lateral extent of ~30 km. This low velocity anomaly is interpreted to be the main magma reservoir with an estimated melt fraction of ~4%-12% that could feed the surface volcanism and hydrothermal activities. This double layered low velocity anomalies is in agreement with the observations of volcanic seismicity, ground deformation and volcanic gas geochemistry in 2002-2006 volcanic unrest. Underlying the deeper low velocity zone in the lower crust is a region of faster velocity compared to the surrounding region. In the bottom of lower crust and uppermost mantle, our Vs model shows low velocities close to the Moho beneath TCV. This is likely the source of partial melt that supplies the volcano. We proposed that magma from the mantle continues to intrude into the lower crust, where through reactive transport it migrates to form a basaltic magma reservoirs beneath CBVF, leaving behind a chemically differentiated crust with faster seismic velocities.

Keyword

Volcano, Magma Chamber, Seismic Imaging, Baekdu, Changbaishan

Evidence for a localised upwelling beneath Baekdu/Changbaishan from seismic imaging and anisotropy

James HAMMOND[1]*, Birkbeck, University of London (James.hammond@bbk.ac.uk)
Cunrui Han[2], Birkbeck, University of London
Weiqian Yu[3], China Earthquake Administration
Wei Wei[4], China Earthquake Administration

Abstract

The westward subduction of the Pacific plate has led to widespread intraplate volcanism across the Korean Peninsula and NE China. However, the causes of these intraplate volcanoes and how the asthenospheric upwelling interacts with the lithosphere remain poorly constrained. In this study, we use data from across northeast China and the Democratic People's Republic of Korea. We apply a number of different seismological methods to reveal the mantle structure and dynamics beneath the region. We use teleseismic data to measure the phase and group velocities of Rayleigh and Love waves, and invert for the shear wave velocity and radial anisotropy within the crust and uppermost mantle. We also analyze shear wave splitting in converted P to S-waves at the Moho (Pms), S-waves from the subducted slab interface (local S), and SKS phases. Our results show that there are significant low-velocity anomalies and negative radial anisotropy to the northeast of Changbaishan. This suggests aligned partial melt is present within the asthenospheric mantle, underlain by a region consistent with vertical flow. The presence of many null SKS splitting phases, together with scattered local S anisotropy across a wide range of incidence angles further confirms a localized region of vertical flow. The flow is localized, suggesting it is not linked to a wider regional flow likely dominated by the Pacific subduction. Rather, it is more likely linked to an anomalous feature of the underlying subduction zone, such as a gap in the slab or deep dewatering linked to deep earthquakes. This mantle upwelling is deflected to the SW beneath Changbaishan and spreads asym-metrically at the base of the lithosphere, possibly because of the long history of volcanism in the region.

Keyword

Baekdu, Changbaishan, Anisotropy, Mantle Upwelling, Seismology

Eruptive and Emplacement Processes of the Namseongri Tuff, southern Jeju Island, Korea

Sunghyun KIM[1]*, Gyeongsang National University (kimsh1148@gnu.ac.kr)
Young Kwan Sohn[2], Gyeongsang National University

Abstract

Jeju Island is a volcanic island produced by intraplate volcanic activity during the Quaternary. In the southern coast of the island, the oldest rock formations, i.e., a basaltic volcaniclastic rock named the Namseongri Tuff and the shallow-marine sedimentary strata named the Seoguipo Formation, are exposed, preserving the records of volcanic and sedimentary processes during the early stage of Jeju Island formation. The Namseongri Tuff is composed of disorganized tuff breccia (dTB), massive lapilli tuff (mLT), inversely graded lapilli tuff (iLT), stratified tuff (sT), massive tuff (mT), and thinly stratified lapilli tuff of openwork lapilli (sLT), which commonly contain cauliflower and bread-crust bombs/blocks and are disrupted by later intrusions and faults. They are interpreted to have resulted from near-vent pyroclastic density currents and fall in an intra-crater or upper diatreme setting. The cauliflower and bread-crust bombs/blocks suggest that the magma was semi-solidified and fragmented by partly magmatic and partly phreatomagmatic processes, involving interactions with moisture-containing sediments. Accidental clasts in the tuff, derived from the volcaniclastic Seoguipo Formation and a lava beneath the tuff, suggest that the magma intruded the Seoguipo Formation and stayed underground for a while and became semi-solidified. The semi-solidified magma was fragmented by mixed magmatic-phreatomagmatic explosions most probably in a diatreme. At about 0.4 Ma, trachyandesitic magma intruded and erupted into the surface, cross-cutting the Namseongri Tuff and overlying the Seoguipo Formation. The Namseongri Tuff suggests that there was a peculiar style of phreatomagmatic activity during the early stage of Jeju volcanism.

Keyword

Phreatomagmatism, Cauliflower bombs/blocks, Bread-crust bombs/blocks, Jeju Island

Three-dimensional resistivity structure of Nari Caldera on Ulleung Island, Korea.

Kiyeon KIM[1]*, Korea Institute of Geoscience and Mineral Resources (KIGAM)
(kiyeon520@gmail.com)
Seong Kon LEE[2], Korea Institute of Geoscience and Mineral Resources (KIGAM)
Chang Woo KWON[3], Korea Institute of Geoscience and Mineral Resources (KIGAM)
Seokhoon OH[4], Kangwon National University

Abstract

Ulleung Island, an oceanic intraplate volcano located in the East Sea of Korea (Sea of Japan), has a caldera structure called the Nari Caldera, which was formed by the most explosive eruption of the latest volcanic activity. To understand the characteristics of the latest volcanic activity, it is necessary to identify the caldera structures. In this study, we perform the three-dimensional (3-D) inversion of audio-magnetotelluric (AMT) data and interpret the electrical resistivity structure of the Nari Caldera area on Ulleung Island. To consider the topographic and ocean effects, detailed land and ocean terrain models were used, and a finer, non-uniform grid was generated in the caldera area. Subsequently, 3-D inversion and imaging were conducted on AMT data collected at 25 stations. The 3-D resistivity model of the Nari Caldera area is divided into two bodies: a high resistivity body located to the south and a low resistivity body located to the north. The high resistivity body has a bowl-shaped distribution in the subsurface. According to geological studies, the Nari Caldera is a complex of at least two calderas located in the north and south. Therefore, the high resistivity body in the south is interpreted as an old caldera, specifically the Seongin Caldera. The Seongin Caldera fill is inferred to be the trachytic lavas from the stratigraphy of Ulleung Island and physical properties. The low resistivity body in the north of the Nari Caldera, based on the high geothermal gradient of Ulleung Island and the borehole stratigraphy, could be interpreted as trachytic rocks with hydrothermal alteration and highly porous and/or weathered rock. We expect that the results will contribute to preparations for any potential volcanic hazards.

Keyword

magnetotellurics, Ulleung Island, Nari Caldera, Seongin Caldera, 3-D resistivity structure

A brief introduction of paleomagnetic and rock-magnetic applications for volcanological research in the Korean Peninsula

Hyeon-Seon AHN[1]*, Korea Institute of Geoscience and Mineral Resources
(hs.ahn.86@kigam.re.kr)
Sun Young GO[2], Korea Institute of Geoscience and Mineral Resources
Chang Woo KWON[3], Korea Institute of Geoscience and Mineral Resources

Abstract

Understanding volcanic and volcanogenic processes and their timescales in detail is essential for volcanic hazards and risks analyses. It requires multidisciplinary studies regarding volcanoes. Paleomagnetic and rock-magnetic analyses have been applied worldwide to resolve diverse volcanological research topics. However, paleo- and rock-magnetic techniques remain underutilized or unadvertised in the Korean geoscience community. This presentation introduces a representative suite of available paleo- and rock-magnetic applications for Korean volcanological research topics, with the current status of use in Korea. The addressed topics in terms of volcanic processes are [1] to detect (crypto)tephra in a sedimentary succession through magnetic susceptibility, [2] to determine the (lava or pyroclastic) flow directions and processes, and source vents through anisotropy of magnetic susceptibility, [3] to estimate emplacement temperatures of pyroclastic density currents using natural remanent magnetization, [4] to estimate the heating of substrates beneath the ‘hot temperature’ emplacement of volcanic products, and [5] other cases of rock-magnetic applications. The addressed topics in terms of ‘age constraining’ (timescale) are [1] correlation/differentiation of volcanic units, [2] chronostratigraphic analysis using the recording features of geomagnetic reversals and excursions, [3] a numerical dating technique using paleo-secular variation of the geomagnetic field, and [4] a numerical dating using viscous remanent magnetization. We expect that future paleo- and rock-magnetic analyses introduced in this presentation will contribute to a better understanding of volcanic and other volcanogenic processes during eruption, transport, emplacement, and even post-emplacement, their ages and durations, and the spatiotemporal correlations of volcanic and volcanogenic units in the Korean Peninsula.

Keyword

paleomagnetism, rock-magnetism, volcanic processes, age, Korea

Variation of Eu isotope ratio in basaltic rocks in Jeju Island, Ulleung Island, Baekdu Mountain in Korea

Seung-gu LEE[1]*, KIGAM (sgl@kigam.re.kr)
Tae Jong LEE[2], KIGAM
Yoon-Soo LEE[3], Pohang University of Science and Technology
Ung San AHN[4], Jeju Special Self-Governing Province
Hyeoncheol KIM[5], KIGAM
Seung Ryeol LEE[6], KIGAM
Sung Hi CHOI[7], Chungnam National University
ShuangShuang CHEN[8], Sun Yat-sen University

Abstract

The geochemical composition of basalt which was formed from primordial magma of mantle origin provides valuable basic information to understand the magma differentiation process and the Earth's evolution process. And the isotopic composition provides geochemical information about the formation age or environment of primordial magma. Recent reports suggested that Eu isotope fractionation and magma differentiation may have a close relationship (Lee and Tanaka, 2021; Lee et al., 2023).

In addition, Hu et al. (2023) and Schauble (2023) predicted that Eu isotope fractionation can occur through the fractionation of hydrothermal solution or feldspar. These research results indicates that the isotope fractionation of Eu can be an important indicator in understanding evolution process of the Earth as well as the differentiation process of magma.

In this work, we determined Eu isotope ratio of various kinds of basaltic rocks from Jeju Island, Ulleung Island, Baekdu Mountain in Korean Peninsula in order to understand geochemical significance of Eu isotope ratio in the geological rocks derived from primitive magma, and discuss variation of Eu isotope ratio of various kinds of basaltic rocks because it serves as a cornerstone for deriving the geochemical significance of Eu isotope fractionation.

Hu, J.Y., Dauphas, N., Nie, N.X., Roskosz, M., Chen, X., Heard, A., Zhang, Z.J., Zeng, H., Alp, E.E., Hu, M.Y., Zhao J. (2023) Equilibrium fractionation of REE isotopes in nature: Insights from NRIXS and DFT+U studies of Eu and Dy phonon density of states. Geochimica Cosmochimica Acta, 348, 323-339

Lee, S-G., Tanaka, T. (2021) Europium isotope fractionation in highly fractionated igneous rocks with large Eu negative anomaly. Geochemical Journal, 55, e9–e17.

Lee, S-G., Tanaka, T., Lee, M.J. (2023) Geochemical implication of Eu isotopic ratio in anorthosite: new evidence of Eu isotope fractionation during feldspar crystallization. Geosciences Journal, 27/3, 271–284.

Schauble, E.A., (2023) Nuclear volume isotope fractionation of europium and other lanthanide elements. Geochemical Journal, 57/4, 118-133.

Keyword

Eu isotope fractionation, basaltic rocks, magmatic differentiation

Plutonic Nature of a Transcrustal Magmatic System: Evidence from Ultrahigh Resolution Sr-Disequilibria in Plagioclase Microantecrysts from the Southern Taupo Volcanic Zone, New Zealand

Daniel Coulthard Jr[1], Massey University
Raimundo Brahm[2], Victoria University of Wellington
Charline Lormand[3], University of Geneva
Georg ZELLMER[4]*, Massey University (g.f.zellmer@massey.ac.nz)
Naoya Sakamoto[5], Hokkaido University
Yoshiyuki Iizuka[6], Academia Sinica
Hisayoshi Yurimoto[7], Hokkaido University

Abstract

The residence timescales of antecrystic minerals contribute a key piece of information regarding the petrologic evolution of transcrustal magmatic systems and may be inferred using a combination of observations derived from microanalytical chemistry and diffusion modelling. Here, we present state-of-the-art stacked CMOS-type active pixel sensor (SCAPS) isotopographic images of tephra-hosted plagioclase microantecrysts from Tongariro Volcanic Centre in the southern Taupo Volcanic Zone, New Zealand. These crystals exhibit high-frequency Sr and anorthite zonation at sub-micron spatial resolution. We also find that all crystals display high-frequency intracrystalline Sr chemical potential variations, indicating that they have not resided at magmatic temperature for diffusive relaxation to advance significantly. To quantify crystal residence times at the well-constrained magmatic temperatures of these tephras, we first forward-modeled intracrystalline Sr diffusion over time using numerical methods. Results were then analyzed using novel spatial Fourier-transform techniques developed to understand the systematics the diffusive decay of Sr disequilibria in the spatial frequency domain. This ultimately permitted the estimation of Sr concentration profiles at crystal formation, prior to uptake into the carrier melt at the onset of eruption. Our data imply residence times of hours to days for the studied microantecrysts. This is inconsistent with long antecryst residence times in magmatic mushes at elevated temperatures, pointing instead to a cool plutonic nature of the magmatic plumbing system beneath the southern Taupo Volcanic Zone.

Keyword

Fourier-transform analysis, Sr diffusion in feldspar, ultra-high resolution crystal stratigraphy, dyke intrusion, crystal uptake

[Keynote] Crystal Size Distributions (CSDs) in lava samples: a case study on Ruapehu volcano, Southern Taupo Volcanic Zone (STVZ), New Zealand.

Silvia Catalina MORENO ALFONSO[1]*, Massey University (S.MorenoAlfonso@massey.ac.nz)
Satoshi Okumura[2], Tohoku University
Georg Zellmer[3], Massey University
Yoshiyuki Iizuka[4], Academia Sinica
Masahiro Yasutake[5], JASRI/SPring-8
Kentaro Uesugi[6], JASRI/SPring-8
Akira Miyake[7], Kyoto University
Stuart Mead[8], Massey University

Abstract

Traditionally, CSDs are determined by outlining crystals in 2D images that are not representative of the natural tridimensionality of the particles, requiring the measurement of a large number of crystals in order to obtain reliable results. Instead, the use of 3D data sets where the crystals can be measured directly provides more robust CSDs and is thus preferable.

In the case of lava flows with high density in microlites, crystals frequently overlap in 2D sections, which may cause significant errors on the CSD results obtained. Hence, the use of 3D images obtained through high resolution equipment such as synchrotron radiation micro-computational axial tomography (SR-XCT) are key for the direct measurement of the parameters in the crystals.

Sixteen lava samples belonging to the Mangawhero Formation of Mount Ruapehu were analysed through Scanning electron microscopy (SEM) at Academia Sinica (Taiwan) and through SR-XCT at the BL47XU of the SPring-8 synchrotron facility (Japan), to compare the similarities and differences between CSDs obtained through the analysis of both 2D and 3D data. For this, equant magnetite crystals were used since the measurements are expected to be similar in both 2D and 3D and thus can be compared using the transformation from 2D data to 3D data.

Additionally, using the 3D data, the CSDs slopes for pyroxenes were calculated and used in combination with a well-constrained orthopyroxene growth rates to determine magma residence times, which are estimated between 1 to 6 days. These timescales are similar to those found for tephra deposits from the last 10kyr of the Tongariro volcanic centre in the STVZ, in which the magma rises through the upper crust in 2 to 4 days as dykes controlled by the regional tectonic setting and triggering explosive eruptions.

We will discuss the similarities and differences between explosive and effusive eruptions from the STVZ in terms of CSDs, using additional petrographic and mineral chemistry data to elucidate which factors control explosive versus effusive volcanic activity in this area.

Keyword

CSD, SR-XCT, SEM, Ruapehu

Intense fractional crystallization dominated by amphibole in continental arc: A highly efficient way to generate felsic continental crust

JING RAN[1]*, Institute of Geology and Geophysics, Chinese Academy of sciences, Beijing, China (ranjing2711828803@163.com)
Hao Wang[2], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
Jin-Hui Yang[3], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
Yao-Qi Yan[4], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

Abstract

The continental arc is an important site for the production of continental crust, but there is still much debate about how primitive basaltic arc magmas are transformed into the felsic continental upper crust. A suite of mid-lower crustal rocks (exceeding 8 kbar) has been exposed in the Boluonuo region, northern North China Craton, including clinopyroxene gabbro, cumulate hornblendite, hornblende gabbro, diorite, tonalite, and quartz-rich granite, with silica contents ranging from 38 wt.% to 75 wt.%. These rocks exhibit arc-like elemental characteristics, including enrichment in light rare earth elements and large ion lithophile elements, depletion in heavy rare earth elements and high field strength elements (Nb, Ta). Moreover, the presence of large hornblende crystals (up to 40 cm long) in the cumulate hornblendites reveals its extremely water-rich arc magmatic nature, making it an excellent place to study the formation and evolution of continental crust in the continental arc. These rocks have consistent zircon U-Pb ages of ca. 280 Ma, enriched ISr (0.705 to 0.706) and negative εNd (t) (−9.6 to −7.3), implying that they are derived from the continuous differentiation of the same parental magma. The plagioclases in gabbro have high An contents up to 86, indicating that they crystalized in water-rich magma. The continuous growth of magnetite from clinopyroxene gabbro to diorite also indicates the high water contents of their parental magma. Additionally, the continuous crystallization of magnetite may be responsible for the iron depletion of the calc-alkaline magmas of the continental arc. Through a simple simulation, a basaltic magma with 50 wt.% silica can produce felsic magma by the 60% accumulation of hornblendite and gabbro. This ratio is much lower than the traditional belief that 80-90% differentiation is needed to produce granite, so the amphibole accumulation of arc magma is an efficient way to produce the continental crust. This ratio matches the proportions of rocks exposed in the Boluonuo region. This kind of accumulation process inevitably leads to the absence of intermediate rocks. In fact, intermediate rocks were relatively rare in the Boluonuo region. The accumulation of hornblende and its resulting loss of intermediate rocks are alternative explanations for the lack of amphibolite phenocrysts and “Daly Gap” in arc volcanic rocks, respectively. Furthermore, the high silica content of up to 75 wt.% in the trapped melts (quartz-rich granite) of cumulate hornblendite, also attests that amphibole-dominated intense fractional crystallization is an efficient way to produce felsic continental upper crust.

Keyword

Continental arcs, Water-rich magmas, Fractional crystallization, Amphibole, Continental crust formation

Current understanding of lithospheric mantle evolution beneath Peninsular India

AZHAR M. SHAIKH[1], IISER Berhampur
Partha Sarathi Swain[2], IISER Berhampur
S. Ravi[3], Geological Survey of India
Sebastian Tappe[4]*, 3UiT The Arctic University of Norway (sebastian.tappe@uit.no)

Abstract

Extensive exploitation of relatively abundant mantle-derived xenocrysts such as olivine, clinopyroxene, and garnet entrained by xenolith-deficient 1.1 Ga Wajrakarur kimberlites has significantly advanced our understanding of the continental lithospheric mantle (CLM) beneath Peninsular India (Griffin et al., 2009; Patel et al., 2010; Shaikh et al., 2023 and references therein). Two distinct populations of olivine xenocrysts have been identified in these kimberlites: one associated with mantle-derived peridotites and the second one with metasomatized mantle wall rocks. Independent thermobarometric calculations utilizing peridotitic olivine and clinopyroxene xenocrysts have revealed a moderately warm geotherm of 40 mW/m2, consistent with previously reported pressure-temperature conditions for rare mantle-derived xenoliths from this region of India. The compositions of garnet, olivine and clinopyroxene xenocrysts were used to reconstruct the structure of the lithospheric mantle column at 1.1 Ga, which indicates around 190 km thick CLM with an extensively metasomatized bottom. The compositions of metasomatic olivine and garnet xenocrysts indicate a kimberlitic to carbonatitic nature of the metasomatizing agent. Two layers were identified: a fairly depleted shallow layer (<145 km) and a metasomatized deeper layer (160-190 km), with an intervening garnet paucity zone (145-160 km). The garnet paucity zone is recognized as a mid-lithospheric discontinuity comprising structurally weaker lithologies. It now coincides with the current thickness of the lithosphere, suggesting its role as a detachment plane, contributing to the destabilization of the once thick and diamond-bearing cratonic keel. A further utilization of garnet xenocrysts and eclogite xenoliths to assess Fe3+/ΣFe ratios has enabled us to constrain the redox state of the CLM at 1.1 Ga. Oxybarometric calculations yielded ΔlogfO2 values indicating a wide range between FMQ-4.5 and FMQ-2.6 for garnet xenocrysts and FMQ-3.9 and FMQ-0.9 for eclogites. This broad range of ΔlogfO2 values correlates well with concentrations of Ti-Y-Zr-V in garnet, suggesting a metasomatic control on mantle redox state. This control may have facilitated the stabilization of various metasomatic phases in the CLM, which could have acted as compositionally contrasting metasomes required for the formation of 1.1 Ga kimberlites and lamproites in Peninsular India. In our latest quest for mantle cargo in the Wajrakarur kimberlites, we have exploited mantle-derived oxide minerals, an aspect that has been neglected in previous studies. In this contribution, we report major and trace element data for oxide minerals, which provide new insights into the evolution of the CLM.

References: Griffin et al. (2009). A translithospheric suture in the vanished 1-Ga lithospheric root

of South India: evidence from contrasting lithosphere sections in the Dharwar Craton. Lithos 112, 1109–1119. Patel et al. (2010). Major element composition of concentrate garnets in Proterozoic kimberlites from the Eastern Dharwar Craton, India: implications on sub-continental lithospheric mantle. Journal of Asian Earth Sciences 39, 578–588. Shaikh, A.M., et al. (2023). Redox state of the Dharwar craton root as inferred from eclogite and peridotite sourced mantle cargo, with implications for kimberlite and lamproite magma formation. Contributions to Mineralogy and Petrology 178 (12),86.

Keyword

kimberlite, continental lithospheric mantle, xenocrysts, wajrakarur, Dharwar craton

The role of lithospheric mantle in the formation of Earth's crust, gold and REE mineralization

Shanshan Li[1]*, China University of Geosciences Beijing (lishanshan199811@163.com)
Kun-Feng Qiu[2], China University of Geosciences Beijing

Abstract

Earth's enriched lithospheric mantle is postulated to be a natural repository of gold and rare earth element (REE) concentration. Shandong Province in eastern China hosts voluminous Archean TTG gneiss, and Early Cretaceous alkaline and granodioritic complexes that are associated with the Weishan REE deposit, the third largest known REE deposit in China, as well as the world's third largest Jiaodong gold province. However, whether their mantle source and partial melting pressure are different that caused diverse metallogeny remains ambiguous.

For the TTGs, zircon U–Pb data reveal magma emplacement during three major pulses at ca. 2.9 Ga, 2.7 Ga and 2.5 Ga in the Jiaobei Terrane, whereas magmatism in the Luxi Terrane was largely concentrated from ca. 2.7 to 2.5 Ga. Whole-rock geochemical and zircon Hf isotopic data show that the tectonic regime was initially dominated by a mantle plume, influenced by partial melting of a hydrous thickened oceanic crust or plateau. Subsequently, dripping or delamination of the lower crust and sub-continental lithospheric mantle (SCLM) that induced upwelling of the asthenosphere. The SCLM was gradually metasomatized by slab–derived fluids in the Jiaobei Terrane during ca. 2.7–2.5 Ga, and by additional melts from sedimentary protoliths in the Luxi Terrane during ca. 2.6–2.5 Ga. The spatial distribution of isotopic and geochemical patterns reveal the presence of a heterogeneous enriched lithospheric mantle beneath the Jiaobei and Luxi terranes, formed by variable degrees of metasomatism and partial melting.

For the Early Cretaceous intrusions, whole-rock geochemical and Nd isotopic data and zircon Hf-O isotopic data show that the alkaline magmas that formed in the Luxi Terrane had A- and I-type affinities, were oxidized, were fluorine-, sulfur-, and copper-rich, were H2O poor, and were generated by low-pressure partial melting of a source region containing enriched lithospheric mantle material and minor amounts of Paleoproterozoic A-type granitic crust. In comparison, the granodioritic magmas within the Jiaobei Terrane had I-type affinities, were relatively reduced, were sulfur-rich, contained low concentrations of Cu, were hydrous, and were formed by high-pressure partial melting of a source region containing enriched mantle material and large volumes of Archean to Paleoproterozoic crustal material. The A- and I-type magmas within the Luxi terrane also have higher HFSE (e.g., Th, Nb, Ta), ΣLREE concentrations and ΣLREE/ΣHREE ratios than the I-type magmas enriched in LILEs (e.g., Ba, Sr) in the Jiaobei terrane.

We suggest that the diversity of REE and gold mineralization was the result of interaction between the lithospheric mantle and hybrid sediment-derived melts and aqueous fluids within the Luxi terrane and with aqueous fluids within the Jiaobei terrane. Our study strongly suggests that the interaction between the lithospheric mantle and sediment-derived melts, the presence of coexisting REE- and fluorine-rich magmas, and low-pressure partial melting were all crucial factors in the

formation of REE deposits, whereas high-pressure partial melting and contemporaneous sulfur and chalcophile element enrichment were critical processes in the formation of gold mineralization.

Keyword

Lithospheric mantle, Metasomatism, Crustal evolution, Subduction, Gold and REE mineralization

Using mineral records to unravel magmatic roots beneath sibling volcanoes: A case study at Middle Sister and South Sister volcanoes, Oregon Cascades, USA

May Sas[1]*, Western Washington University (sasm@wwu.edu)
Sean Halstead[2], Western Washington University
Emma Calvert[3], Western Washington University
James Peale[4], Western Washington University
Alex Newsom[5], Western Washington University
Madelyn Cook[6], Western Washington University
Nathan L Andersen[7], Cascades Volcano Observatory, United States Geological Survey

Abstract

To understand how a given magmatic system has evolved, and how it may continue to evolve and behave in the future, it is essential to develop a schematic model of magma storage parameters (e.g., pressures and temperatures) and magmatic conditions. A primary way to begin developing these schematics is by turning to mineral textures and compositions, which may record changing magma storage conditions and can discriminate among magmatic components derived from different reservoirs within a transcrustal magma system (TCMS). This project utilizes mineral textures in concert with compositional zones of major mineral phases to begin developing a TCMS model for Middle Sister (MS) and South Sister (SS) stratovolcanoes in central Oregon, western USA. This work also sets to establish an improved understanding of magma origins and processes at this locus, the Three Sisters Volcanic Complex (TSVC), as it is situated on the confluence of the Cascade volcanic arc and the Basin and Range extensional province, both of which likely contribute to the high compositional variability observed at this center. Units selected target a range of compositions—basaltic andesite to rhyolite— to shed light on mantle compositions and deep crust processes, as well as storage conditions and variability throughout the crust. An array of unit ages (ca. 47-14 ka) was targeted to note any changes or differences, or lack thereof, during the most active eruptive period at both MS and SS. Results indicate a peridotite mantle source for basaltic andesites at both systems, with contribution of lower crust material beneath MS (MS-type magmas) based on elevated Ni contents in MS olivine that are too enriched to originate from a fractionated, pyroxenite-derived melt. A peridotite mantle with variable crustal contributions is consistent with petrogenesis models for the older, MS-adjacent North Sister stratovolcano, where previous workers call on high degrees of mantle partial melting due to extension, with resultant incorporation of mafic lower crust. In contrast, compositions of olivine found in the only basaltic andesite affiliated with SS suggest minimal incorporation of crustal material (SS-type magmas). These differences in Ni contents allow for the distinction of olivine-bearing components (e.g., enclaves, crystal clots) as MS-type vs. SS-type and have revealed that both mafic magma types have interacted with SS silicic lavas, and potentially catalyzed their eruption. Pyroxene trace element contents in mafic-intermediate lavas at both volcanoes exhibit subtle differences, some of which require origins from distinct magma batches and others that could potentially be related via cycles of recharge and fractionation. On the other hand, a pair of

SS flows with identical pyroxene compositional populations erupted ca. 5 ky apart, implying the mobilization of the same crystal cargo from a long-lived mush system beneath SS. Together, these findings suggest that the shallow TSVC magma system is dominated by discrete crystalline reservoirs, some of which may have been tapped by multiple eruptions. The mafic roots of the magma systems beneath SS and MS likewise appear to be largely distinct, but both have contributed recharge magma to silicic reservoirs associated with SS volcano.

Keyword

volcanic arc, magma interactions, olivine, pyroxene, trace elements

Multi-component Magmas of Middle Sister and South Sister in the Three Sisters (Klah Klahnee) Volcanic Complex, Oregon Cascades, USA

Alex Newsom[1], Western Washington University
Madelyn Cook[2], Western Washington University
May Sas[3]*, Western Washington University (sasm@wwu.edu)
Nathan L Andersen[4], Cascades Volcano Observatory, United States Geological Survey

Abstract

The Three Sisters (Klah Klahnee) Volcanic Complex (TSVC) in central Oregon is located at the confluence of several geologic regimes in the Pacific Northwest of the United States, including the Cascade Arc and the Basin and Range extensional province. The overlap between the two regimes results in a high volume of diverse eruptive products (basalt to rhyolite), especially in Oregon, which hosts >1,000 Quaternary vents. Such complex geologic settings assist in the development of more silicic melts and complicated transcrustal magmatic systems (TCMS). The TSVC includes a mafic periphery and three main stratocones: North, Middle, and South Sister. Middle Sister (MS; primarily mafic-intermediate) and South Sister (SS; primarily intermediate-felsic) are adjacent to one another, recently active (50–2 ka), currently experiencing inflation west of SS, and considered very high threat volcanoes by the United States Geological Survey. MS and SS experienced alternating periods of heightened activity whereby one volcano was mainly quiescent while the other was frequently active, leading to questions concerning underlying reservoir interactions. This study focuses on two lavas, a MS-affiliated dacite (dacite of Linton Creek, dlc, ~37 ka) and a SS-affiliated rhyolite (rhyolite of Separation Creek, rsc, ~25 ka), that contain a diverse assortment of magmatic components. Unit rsc erupted in the saddle between MS and SS during a transitional period when SS activity was decreasing and MS activity was increasing. Unit dlc, the oldest known TSVC dacite, is located southwest of MS. Both lavas are porphyritic and contain individual phenocrysts, glomerocrysts, and evidence for more silicic components interacting with more mafic components. These various components provide clues about the structure of the TCMS underlying the TSVC and how new magmatic intrusions contribute to the differentiation and eruption of shallow reservoirs. This study presents compositions and textural observations of major mineral phases to identify distinct mineral populations in these magmatic components and the host lavas. In rsc, olivine compositions from mafic enclaves and glomerocrysts overlap with those of olivine found in MS basaltic andesites, while dlc olivine compositions overlap with olivine from the only known SS basaltic andesite. The presence of amphibole in rsc and amphibole pseudomorphs in dlc supports a SS magmatic affinity, as amphibole in the TSVC is almost exclusively found within SS silicic eruptions. While dlc lacks the abundance of mafic enclaves found in rsc, magma recharge and reheating are preserved by the presence of amphibole pseudomorphs, multiple plagioclase and pyroxene populations, ubiquitous resorption textures, and pyroxene crystals with extensive reaction rims. These mineral compositions indicate that the MS-associated dlc is dominated by SS-type magmatic components, whereas the SS-associated rsc

records the recharge of a SS-type rhyolitic reservoir by MS-type mafic magma. This study improves the currently poorly constrained TCMS model of the TSVC and the understanding of silicic magma generation in the Cascade Arc.

Keyword

dacite, rhyolite, magma interactions, olivine, amphibole

Petrologic study of the youngest stage lavas of Zao Volcano, NE Japan

Kanako OKI[1]*, Yamagata University (o.kanako.sci@gmail.com)
Masao Ban[2], Yamagata University

Abstract

Zao Volcano is an active stratovolcano in central part of the volcanic front of NE Japan arc. The volcanic activity is divided into six stages and the newest stage started at about 35 ka. The eruption products of the newest stage consist of pyroclastics and subsequent amounts of lavas. Petrological and geological studies of the pyroclastics have already performed, but those of lavas were not sufficient. Here, the petrological and geochemical characteristics were examined in this study.

The lava units are Nigorigawa lava (Ngl) (ca. 35 ka), Nigorigawa-upstream lava (Nul) and Goshikidake-east lavas (Gel) (ca. 30 to 10 ka), and Furikodaki lava (Fkl) and Goshikidake-south lava (Gsl) (younger than ca. 10 ka). The rocks are olivine bearing cpx-opx basaltic andesite to andesite, except for Gel, which lacks olivine phenocryst. Modal percentages of plagioclase and cpx phenocrysts are similar among units. Those of opx in Nul and Gel are slightly higher than the other units. Olivine phenocrysts were relatively abundant in Ngl. Plagioclase phenocrysts having dusty zone and patchy or honeycomb core are observed in all lavas, and the amounts of each type of the phenocrysts are various among lavas. Opx phenocrysts are divided into five types by chemical zoning; homogeneous (H), broad high-Mg band (B), moderate width high-Mg band (M), thin high-Mg band (T), and compositionally oscillatory zoning (Os) types. H-type phenocrysts and the cores of B, M, T-types are usually low-Mg in composition. Cores of Os-type are either low or high-Mg. Os-type is dominant in Ngl, H-type is representative in Nul and Gel, and M and B-types are dominated in Fkl and Gsl.

All rocks belong to medium-K calk-alkaline series. The compositional trend slightly changed temporally. The youngest lava units (Fkl, Gsl) are higher (57–58.5 wt. %) than the others (54–57 wt. %) in SiO2 range. The oldest unit (Ngl) rocks plot on higher trend than the middle age units (Nul, Gel) in K2O, and Zr vs. SiO2 diagrams. In addition, the youngest units trend crosscuts the trends of the other age units in FeOt, TiO2 vs. SiO2 diagrams.

Dissolution texture, such as patchy and dusty zone of plagioclase phenocrysts, and the wide compositional range of opx phenocrysts observed in most of the rocks suggest these suffered magma mixing. Coexistence of low and high-Mg opx phenocrysts in most of the rocks indicates that magma plumbing system is basically composed of shallow felsic magma reservoir which receives the injections of mafic to intermediate magmas. The whole rock compositional trends are different by different age units, that implies the compositions of shallow reservoir and/or the injected magmas differ temporally. Furthermore, the zoning features of opx phenocrysts differ by different age units, that suggests the injection processes were different by different age units.

Keyword

magma plumbing system, shallow magma reservoir, phenocryst texture, compositional zoning, Zao Volcano

Maturation of continental arc crust via mush remobilization during magmatic flare-up

Long CHEN[1]*, Ocean University of China (chenlong@ouc.edu.cn)
Shengyao Yu[2], Ocean University of China
Dongyong Li[3], Ocean University of China
Sanzhong Li[4], Ocean University of China
Huahua Cao[5], Ocean University of China

Abstract

In volcanic arcs, magma originating from the mantle initially exhibits a basaltic composition, which then undergoes a transformation into intermediate to felsic rocks, a phenomenon known as volcanic arc maturation. Nevertheless, the exact role that magma mushes played in this process and whether the efficiency of this maturation process increases during magma flare-ups remain to be investigated. This study elucidated a three-stage transition in the composition of plutonic rocks from mafic to felsic during a Cretaceous magma flare-up event in the Gangdese arc of southern Tibet. This lithological evolution, coinciding with a gradual enrichment in radiogenic isotope compositions, suggests the influence of mixing processes. Apatite in both the first-stage mafic rocks and the third-stage felsic rocks reached Nd isotope equilibrium with their host rocks. However, the apatite in the second-stage intermediate rocks consistently exhibited a depletion in Nd isotopes compared to their host rocks, but similar to those found in the first-stage mafic rocks. The distinct covariation relationships between SiO2 and apatite-compatible elements, as well as apatite-incompatible elements in all three stages of rocks, confirm the incorporation of apatite-rich mushes into the mixing process. Structural mapping and trace element analysis indicated varying degrees of influence of mafic rock compositions by accumulation. These findings suggest that the mafic rocks represent a solidified apatite-rich mush formed through the crystallization of mafic melts, which later undergo remobilization and are incorporated into felsic magmas to form intermediate rocks. The latest felsic rocks represent the end member of the felsic magmas, formed through crustal anatexis or mafic magma differentiation. These rock suites provide evidence of continental arc crust maturation during a Cretaceous magma flare-up in the Gangdese arc. Similar evolution patterns are also observed in the Andean Cordillera, highlighting a common occurrence in continental volcanic arcs.

Keyword

Continental arc maturation, Mush remobilization, Gangdese arc, magma flare-up, Apatite

Genesis and Evolution of Zoned Magmatic Enclaves in Cretaceous Granitoid: A Case Study from Taejongdae, Busan

Mohammed S. M. Adam[1]*, Pukyong National University (mosaif74@gmail.com)
Young-Seog Kim[2], Pukyong National University

Abstract

This study conducted a thorough investigation of zoned magmatic enclaves (zoned MEs), reported in the Cretaceous granitoid in Busan, known for their complex orbicular rock zones. We studied the evolution of these zoned MEs through a comprehensive examination of the petrological, mineralogical, and geochemical characteristics of the zones, the utilization of SHRIMP U-Pb zircon dating, and the interpretation of Lu-Hf isotope data. The major findings offered a thorough comprehension of the concealed mechanism by which zoned MEs are created. The genesis of these zoned MEs can be attributed to two distinct phases of mixing and mingling within two different magmas. The initial phase took place within a deep dioritic magma, situated at depths ranging between approximately 7.1 and 7.7 km. The second phase occurred in a relatively shallow granitic magma located approximately 1.7–2.4 km below the surface. The dioritic magma was generated through amphibole-dominated fractional crystallization under relatively high pressure and temperature (PT) conditions. Meanwhile, the host granite magma was formed by fractionation of magma generated through partial melting of the continental crust in significantly lower PT conditions than the dioritic magma. Later on, the two magmas were mingled and mixed to produce the zoned MEs in the study area. The zoned MEs observed in the granitoids provide valuable insights into the hidden magmatic processes that occurred before the intrusion of granitic plutons.

This research was supported by a grant (2022-MOIS62-001(RS-2022-ND640011)) of National Disaster Risk Analysis and Management Technology in Earthquakes funded by the Ministry of Interior and Safety (MOIS, Korea).

Keyword

Zoned MEs, Cretaceous granitoid, Lu-Hf isotope, Thermoparometry

[Keynote] Petrogenesis of episodic volcanic-intrusive rocks in SE China: crystal-melt segregation and magma mixing

Xisheng XU[1]*, Nanjing University (xsxu@nju.edu.cn)
Changhong Liang[2], Nanjing University
Xueying Wang[3], Nanjing University

Abstract

Intensive episodic magmatism occurred in SE China during the Cretaceous, produced a series of volcanic-intrusive rocks at different stages of magmatic activities in chain-like calderas. We conducted comprehensive petrological, geochemical, isotopic and zircon trace element analyses for several representative calderas (Yunshan, Shiniushan, Kuocangshan, Yandangshan and Xiaoxiong calderas) to reveal the crystal-melt segregation and magma mixing during the magmatism, which provided further insight into the evolutionary process of the calderas and the driving force of paleo-Pacific plate subduction.

Our results show that the magmatism produced multistage volcanic rocks and equivalent intrusive rocks regarding their crystallization ages and Nd-Hf isotopic compositions. The volcanic and intrusive rocks can be connected by fractional crystallization.

In general, the erupted silicic rhyolitic rocks are characterized by distinctly negative Eu anomalies and depletions of Ba, Sr, P, and Ti, while the coexisted intrusive rocks (i.e., porphyritic quartz monzonite, granite porphyry or porphyritic quartz syenite) show complementary geochemical signatures, such as positive Ba anomalies and neglectable Eu anomalies. Micropetrographic observation and back-scattered electron imaging for the intrusive rocks reveal textural indicators of crystal accumulation, such as imbrication and synneusis of plagioclase phenocrysts.

A fractional crystallization modeling and K isotope analysis for whole rock and their K-bearing minerals show the fractional crystallization of feldspar plays an important role in crystal-melt segregation. Mafic microgranular enclaves found in the volcanic-intrusive rocks indicating that magma recharge events occurred in the magma reservoir, which promote crystal-melt segregation processes.

Keyword

Crystal-melt segregation, Mafic microgranular enclaves, Cretaceous calderas, SE China

Magmatic evolution and geochronology of Mesoproterozoic A-type Darsi granite pluton from Nellore Schist Belt, Southeast India

NARSHIMHA CHINTHAPALLY[1]*, Department of Geology, Centre of Advanced Study, Kumaun University, Nainital, India (drsimhaou@gmail.com)
Santosh Kumar[2], Department of Geology, Centre of Advanced Study, Kumaun University, Nainital, India
Keewook Yi[3], Korea Basic Science Institute, Ochang Campus, Chungbuk, Republic of Korea
Youn-Joong Jeong[4], Korea Basic Science Institute, Ochang Campus, Chungbuk, Republic of Korea

Abstract

The felsic magmatism in the Darsi area, referred to as Darsi granite (DG), constitutes an NNE-SSW trending ellipsoidal pluton as an integral part of several Mesoproterozoic anorogenic (A-type) plutons of Nellore Schist Belt (NSB), Southeast India. Field relation, mineral and whole rock elemental geochemistry, and SHRIMP U-Pb zircon geochronology have been carried out to reveal the origin and evolution of DG pluton and its implication on crustal evolution through time. The DG comprises quartz, K-feldspar, plagioclase, minor amphibole, zircon, apatite, fluorite, titanite and opaques. DG biotites are primary, siderophyllite to annite, buffered between QFM and NNO, syn-crystallizing with other mafics in water-undersaturated (H2O ≈ 3.35wt.%) alkaline (A-type) magma. Ti-in-biotite thermometer yields 585°C-607°C (av. 600°C) of biotite stability. The DG is peraluminous (molar Al2O3/CaO+Na2O+K2O=1.27) with SiO2 (≥72 wt.%), FeO*/FeO*+MgO (0.87 wt.%), K2O (5.04 wt.%), Ba (320 ppm), Zr (925ppm), Nb (129 ppm), Y (147 ppm) and low MgO (0.04 wt.%), Na2O (3.45 wt.%), TiO2 (0.20 wt.%), P205 (0.01 wt.%), and ΣREE, similar to ferroan A-type granite formed from crustal sources. The Y/Nb ratio (1.13 ppm) of DG corresponds to the granites of oceanic islands and continental rift (A1 type) affinity. The SHRIMP zircon U-Pb isotopes from DG yields an upper intercept age of 1298.9±6.9 Ma (MSWD = 1.05) with a weighted mean 207Pb/206Pb age of 1302 ± 54 Ma (MSWD=0.019), as zircon crystallization age or age of DG magma emplacement. The DG pluton (1298.9±6.9 Ma) seems to represent the early pulse of granite magmatism compared to other A1 type Punugodu (1257±6Ma) and Kanigiri (1284.5 ± 3.9 Ma) plutons of the NSB. The DG zircon records 576±5 Ma tectonothermal event more akin to the Gondwana supercontinent. The arc-related mafic magmatism (1315±11 Ma) in the NSB is represented by the Purimetla, Kanigiri and Pedda Cherlo Palle gabbroids formed in the subduction zone setting. Based on available petrochronological and geochemical records, it is suggested that the mafic-felsic magmatism in the northern part of the NSB is related to the Mesoproterozoic subduction-collision-accretionary orogens followed Rodinia supercontinent assembly, which later experienced Pan-African tectono-thermal event.

Keyword

Petrogenesis, Geochronology, Darsi Pluton, Nellore Schist Belt, SE Inida

Mafic magmatic enclaves in Zao Volcano Stage III products, NE Japan: Evidence of conversion of magma feeding system

Masao Ban[1]*, Yamagata University (ban@sci.kj.yamagata-u.ac.jp)
Shin Sato[2], Chi-ken Sogo Consultants Co., Ltd.

Abstract

Mafic magmatic enclaves are frequently observed in calc-alkaline volcanoes in Japan and possess useful information of the magma feeding system beneath the volcanoes. Here we present an example of the enclaves in Zao Volcano, NE Japan, which have key evidence of a conversion of the feeding system.

The activity of Zao Volcano is divided into six stages. In this study, the stage three eruption products were examined. These are divided into lower, middle, and upper units, mainly composed of lava flows. Rocks are quartz bearing two pyroxene andesite, two pyroxene andesite, and two pyroxene basaltic andesite, respectively. All rocks are medium-K calc-alkaline mixed rock. Mafic magmatic enclaves as well as troctolitic inclusions are observed in the middle unit. The whole rock compositional trends of lower and middle units are similar except for some elements and are linear. The compositions of mafic magmatic enclaves in middle unit are plot on silica poorer extension of the middle unit trend, and the compositions of the upper unit are very similar to that of the mafic magmatic enclaves.

The peak Mg# compositions of opx and cpx phenocryst cores are lower in the lower unit (opx, 62~63; cpx, 67~68) than in the upper unit (opx, 70~74; cpx, 70~72). The compositions in the middle unit span both values of the upper and the lower units. Pyroxene thermometer calculations applied on peak compositions of the lower and the upper units gave ca. 960 and 1030 degrees C, respectively. Bimodal distribution of An contents of plagioclase is observed in all units. The richer one is ca. An90 regardless the unit. On the other hand, the poor ones are around An55 in the lower unit and around An72 in the upper unit. Both ones coexist in the middle unit.

These data indicate that the felsic magmas of the lower and upper units were different, whereas the mafic magmas were similar. In the middle unit, both of the felsic magmas involved in the eruption. Repeated injections of the new mafic magma would convert the lower temperature felsic end-member of the lower unit to higher temperature one in the shallow reservoir. In the period of the middle unit, both of lower and higher felsic magmas were involved in the mixing, afterwards the former was no longer active. The mafic magma that stored beneath the shallow reservoir would precipitate An rich plagioclase and olivine and become the source of the troctolitic inclusions.

Keyword

Mafic magmatic enclave, troctolitic inclusion, shallow magma reservior system, temporal change, Zao Volcano

Variscan magmatism with linkage to slab-breakoff? Implication from age data and mineralogy in the Western Carpathians granitic rocks

igor Broska[1]*, Earth Science Institute Slovak Academy of Sciences (igor.broska@savba.sk)
Yi Keewook [2], Korea Basic Science Institute
Sergii Kurylo[3], Earth Science Institute Slovak Academy of Sciences
Igor Petrík[4], Earth Science Institute Slovak Academy of Sciences
Marian Janák[5], Earth Science Institute Slovak Academy of Sciences
Maria Maraszewska[6], Earth Science Institute Slovak Academy of Sciences
Martin Ondrejka[7], Comenius University

Abstract

The mineralogy and geochemistry of the Variscan Western Carpathian granitic rocks is derived from protolith character and level of mixing mantle and lower crustal material. High Sr/Y and La/Yb ratios giving them “adakitic” s.l. signature indicate their formation in deep lower crustal conditions by partial melting in the stability field of garnet, in disequilibrium with plagioclase at reduced water contents indicating association with slab break-off process during subduction. Such geodynamic conditions should be an important factor in triggering large granite formation because it opened the way for increased heat and fluid flow from the asthenosphere and it could have happened during the Devonian period after the collision. The slab break-off had been followed by exhumation and crust melting and forming diatexites during decompression. The dated diatexites show age a span of 362 and 360 myr. To summarize SHRIMP age determination performed at Korean SHRIMP laboratory, the principal formation of calc-alkaline granitic rocks in the Western Carpathians occurred in the time range 359 – 342 Ma and in this sense they emplaced as (post)-collisional granites. The data indicate several magmatic peaks estimated on (1) 358-359 myr, which is a phase with formation of tonalite-granodiorite suites with more I-type affinity, (2) 355-353 myr is culmination of granite flare up, and (3) 347-342 myr, is an era of gradual evolution from tonalite to granite formation or formation of mixed granotonalites documented by micro-XRF mapping. The episodic granite formation can be connected with episodic more pronounced rising of asthenosphere as a main heat source for partial melting. The hot granite character allowed effective mixing indicated by missing of larger presence of mafic microgranular enclaves within the Western Carpathian granite massifs, therefore these granites can be considered also as H-type. Former dissolved mafic melt phase in crustal felsic system was detected in the Visean Kriváň massif by preserved plagioclase cores with high basicity of An56. In general mixing within felsic melt is indicated by common multistage formation of plagioclase formed from at least two compound chemically contrasting parts, the occasional occurrence of quartz "ocelli", and also irregular ilmenite, apatite, monazite segregations. In addition, the local presence of antiperthite in granitic rocks indicates very high primary temperatures of parental magmas. Thus, we can assume the formation of granites from a very hot melt in the deep crustal conditions with a high level of mixing in MASH zone resulted in low amount of enclave persisting. The places within granite plutons where the enclave were dissolved is possible to detect by magnetic measurement because

such sites show high magnetic susceptibility inherited from high amount of dissolved Fe-Ti minerals from mafic and intermediate melts into host felsic melt.

Acknowledgement: This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-22-0092.

Keyword

granites, slab breakoff, Western Carpathians, mixing, enclaves

Origin and evolution of Fe-Ti oxides in leucogranites of Muglib and Pangong regions of Ladakh Trans-Himalaya, India: Insights from textural and chemical features of manganoan-ilmenite and re-equilibrated biotite

Ravi Ranjan Kumar[1]*, North- Eastern Hill University, Shillong, Meghalaya (raviranjan.bhu.5679@gmail.com)
Santosh Kumar[2], Department of Geology, Centre of Advanced Study, Kumaun University, Nainital, India

Abstract

The Shyok Suture Zone (SSZ) is bounded by the Ladakh Batholith in the south and the Karakoram block in the north of Ladakh Trans-Himalaya. The granite magmatism in this region is represented by the Karakoram Cretaceous granite (106–95 Ma) derived from the Karakoram Proterozoic basement, the Karakoram Cenozoic granite (76–56 Ma) from the juvenile crust, and the Karakoram Miocene granite (26–9 Ma) significantly contributed from the Indian crust. The Fe-Ti oxides (ilmenite-magnetite) are common accessory minerals in many felsic volcano-plutonic rocks. The leucogranites from Muglib and Pangong regions display medium to coarse-grained to massive porphyritic textures with biotite±chlorite–plagioclase–K-feldspar–quartz–ilmenite–magnetite assemblage. These leucogranites are calc-alkaline metaluminous to peraluminous and magnetite to ilmenite series granites. Ilmenite from these leucogranites has a low Cr2O3 (0.11–0.17 wt.%) and high MnO (4.34–5.07 wt.%), whereas magnetite is depleted in MnO (0.34–0.52 wt.%) and TiO2 (0.19–0.29 wt.%). The magnetic susceptibility (MS) values of leucogranites range from 17.8×10-3 to 42.2 × 10-3 SI unit, corresponding to magnetite (oxidized) series granite (> 3×10-3 SI unit). The manganoan-ilmenites are found to be associated with biotite, magnetite, and plagioclase. The Muglib and Pangong regions are bounded by the Shyok Metamorphic Complex (SMC) in the north and the Tangtse Metamorphic Complex (TMC) in the south, and it is further bounded by the Pangong Metamorphic Complex (PMC) in the south-eastern part. Therefore, the study area represents a highly deformed and tectonically active region. Since the SSZ rocks experienced greenschist to amphibolite-facies metamorphism, leucogranites might likely have recorded some tectono-metamorphic imprints. The observed textural and mineral geochemical features of the magnetite-ilmenite assemblage reveal magmatic crystallization and deformation-induced recrystallization during metamorphism and diffusion-induced re-equilibration with co-existing silicate minerals. Biotite is a predominant mafic mineral in these granites, which has re-equilibrated during metamorphism. The Ti-in-biotite geothermometer shows crystallization of primary biotite crystallized between 700ºC and 745ºC, which re-equilibrated during 600–660ºC. The elevated oxidizing conditions induced the Mn diffusion from biotite into ilmenite, forming the manganoan-ilmenite. This also implies short-range equilibrium conditions during metamorphism, as the ilmenite-magnetite geothermometer depicts ~550ºC, which is nearly close to the temperature at which the primary biotite re-equilibrated.

Keyword

Manganoan-Ilmenite, Leucogranite, Muglib-Pangong, Shyok Suture Zone, Ladakh Trans Himalaya

Mafic-felsic magma interaction of granitoids and microgranular enclaves in Lohit Plutonic Complex, Arunachal Trans-Himalaya, Northeast India: constraint from field, petrography, mineralogy, geochemistry and U-Pb SHRIMP chronology.

DIEZENEINO MEYASE[1]*, NAGALAND UNIVERSITY (diezenzets05@gmail.com)
Vikoleno Rino[2], NAGALAND UNIVERSITY
Rokozono Nagi[3], NAGALAND UNIVERSITY

Abstract

The Andean type calc alkaline Lohit Plutonic Complex (LPC) of Arunachal Pradesh in eastern Himalaya, is an integral part of the Trans-Himalaya magmatic arc formed by subduction of the Neo-Tethys oceanic lithosphere beneath the Tibetan continental plate. The felsic magmatic rocks of LPC referred as Lohit Plutonic Granitoids (LPG) hosts mafic (hybrid) microgranular enclaves (ME). ME are a common feature in calc alkaline granitoids and it is generally accepted that ME can offer significant insight on the nature of crust-mantle interactions and processes involved during magma evolution. Previous studies reported the occurrence of enclaves in LPG however there is no systematic study of the petrogenesis of ME in LPG, which limits our understanding of the evolution of Late Cretaceous-Eocene magmatic system in the region. Thus, we present an integrated field-based petrography, mineralogy, whole rock geochemistry and zircon U-Pb geochronology of the ME and host LPG with an aim to unravel the processes responsible for the generation and evolution of the ME and host granitoids. The ME are mostly lenticular, ovoid to sub-rounded dark coloured fine grained with varying sizes ranging from ca. 3 to 20cm exhibiting sharp, crenulated or diffused boundaries with host LPG indicated of mafic (hybrid)-felsic magma mixing. The LPG and ME have a common assemblage of pl-qtz-bt-kfs-hbl-ap-ep-ttn-zr-Fe-Ti oxides but in different proportion and sizes. The ME exhibit higher contents of ferromagnesian minerals (biotite ±amphibole) and plagioclase and lower contents of quartz and k-feldspar as compared to host LPG. Textural features such as ubiquitous needle-shaped apatite, bladed biotite, quartz aggregates rimmed by biotite and/or hornblende, corroded feldspar, feldspar phenocryst with inclusions of biotite, apatite and quartz, zoned plagioclase, and mafic clots recorded from ME strongly reflect the evolution of LPG through mixing and mingling. The amphiboles of host LPG and ME are classified as magnesio-hornblende. The biotites of ME and host granitoids are transitional between siderophyllite and eastonite end-members. Composition of plagioclase of ME and host LPG mostly range from oligoclase to andesine while few ME belongs to labradorite. The presence of amphibole-plagioclase-titanite-apatite is characteristic of their crystallization from a hydrous magma under enhanced fO2 conditions. Both ME and host LPC granitoids are strongly metaluminous. Primitive mantle-normalized trace element patterns of the ME and host granites are broadly similar with enriched Sr, Pb, Nd and Sm and depleted in Rb, Nb, Ti and possess moderately fractionated rare earth element patterns (La/Yb)N ratios ≤ 10.53, and strong to moderately negative Eu anomalies typical of continental arc-related igneous rocks. Zircon U-Pb

dating on zircon grains from ME and host granodiorite yield concordia ages of 49.93 ± 0.92Ma (MSWD = 0.62) and 50.39 ± 0.91 Ma (MSWD = 0.91), respectively. The comparable mineralogical and geochemical compositions and similar zircon crystallization age of ca 50±0.7 Ma for ME and host LPG suggests that tectonothermal event in the Himalayan-Tibetan collision zone is responsible for delamination and the uprise of enriched lithospheric mantle-derived melts to shallow crustal levels followed by crustal-mantle interactions to generate mafic and felsic (hybrid) magma in the Lohit Plutonic Complex.

Keyword

Lohit Plutonic Granitoids, Microgranular enclaves, Trans-Himalaya, India, U-Pb SHRIMP

Petrogenesis of Precambrian granitic suites around Ropp Complex: Constraints from zircon U-Pb-Lu-Hf Isotopes, mineral chemistry, and whole-rock geochemistry

Kayode Abdulgafar AMUDA[1]*, Bayero University Kano, Kano, Nigeria
(akamuda.geo@buk.edu.ng)
Musa Bala GIREI[2], Bayero University Kano, Kano, Nigeria
Safiyanu Muhammad ELATIKPO[3], Ahmadu Bello University, Zaria, Nigeria

Abstract

The Precambrian granite plutons along the western margin of the anorogenic Ropp complex epitomize a pivotal locale bearing imprints of multiple orogenies, namely Eburnean, Kibaran, and Pan-African events, thereby offering insights into the prevailing geodynamic regime during the genesis of the I- type granitic rocks within the west-eastern Nigeria terrane (ENT). Zircon LA-ICP-MS U-Pb dating of the granitic gneiss yielded ages of 2157, 1427, and 631 Ma, while the Older Granite (OG) yielded the age of 620 Ma, suggesting that metamorphic event at 1.43 Ga, interposed between two magmatic episodes: 2.16 Ga (Eburnean orogeny) and 0.63-0.62 Ga (Pan-African orogeny). The OG exhibits characteristics of moderately evolved calc-alkaline granites that are peraluminous, and show ferrous and high-K characteristics. These granites exhibit weak negative Eu anomaly, alongside elevated contents of Ba, Sr, and K/Rb, coupled with low concentrations of U, Th, Nb, and Ta, Rb, and very low HREE and Y, resembling the typical features of high Ba-Sr granitoid. The low Mg# (<40) observed in the OG, along with the range of ratios of some trace elements, notably low Nb/La (average = 0.33), Nb/U (average = 10.60), typify a magma sourced from the crust. The zircon εHf(t) values ranging from negative to positive (Granitic gneiss = −16.25 to +6.09 and OG = −3.96 to +3.86) suggest the involvement of partial melting of older crust with mantle input in the genesis of the parent magma. Furthermore, the low Y/Nb (average = 1.02), and Yb/Ta (average = 1.34) ratios in the OG also indicate mantle input signatures. The physicochemical conditions of the magma, inferred from biotite chemistry and whole-rock analyses, suggest that the OG are ilmenite series granites formed under low $fO2$ conditions ($\log fO2$= −15.63 to −17.18) condition. The crystallization temperature and pressure of the OG are moderate (T = 706–770^{O}C and P = 100 to 295 MPa), with the depth of emplacement estimated at 5.2 to 8.6 km using the newly improved Qtz-geobarometer. Metamorphism, represented by the syn-collisional 631 Ma granitic gneiss, and magmatism represented by the post-collisional 620 Ma Older Granite, are contemporaneous with other granitoids in the ENT. The genesis of the granitic gneiss magma is attributed to slab-melt derived from sinking oceanic crust subduction, which convects and underplates the lower crust (reworked older crust). Subsequently, slab break-off during the waning stage of the Pan-African orogeny induced the upwelling of the asthenosphere, leading to partial melting of the sub-continental lithospheric mantle (SCLM) and the lower crust, thereby generating the parent magma of the OG. The ascent of this magma follows a vertical tectonic extensional fault to the shallow crust, ultimately culminating in the

formation of the Older Granite.

Keyword

Pan-African orogeny, High Ba-Sr granite, I-type granite, west-eastern Nigeria Terrane (W-ENT), U-Pb-Lu-Hf Isotope

Microgranular enclaves in granitoids are products of mafic to hybrid magma globules mingled and undercooled into partly crystalline host granitoids: Distinct field and microstructural evidences from calc-alkaline granitoid complexes

Santosh KUMAR[1]*, Department of Geology, Kumaun University, Nainital 263001, India (skyadavan@yahoo.com)

Abstract

Many calc-alkaline granitoid complexes have magmatic enclaves that are fine-grained to porphyritic, mesocratic to melanocratic, and rounded to elliptical. These enclaves are called microgranular, microgranitoid, or mafic magmatic enclaves. However, there is still ongoing debate regarding their nature, origin and evolution, which has led to the proposal of two diverse processes for their origin: autolith/cumulate/cognate (cogenetic) facies of host granitoid or mafic to hybrid enclave magma globules that injected, mingled and undercooled into host granitoid magma. This paper documents a series of field and microstructural features which strongly favour the mingled and undercooled origin for mafic to hybrid microgranular enclaves. These enclaves serve as a potential tool to understand the processes of coeval mafic and felsic magma interaction in volcanic and plutonic environments. The changing rheology solely controls the shape and geometry of enclaves within a timeframe from the initial to the waning stages of the host granitoid magma chamber evolution. Synplutonic mafic to hybrid dykes may inject and disrupt at the waning stage of granitoid magma evolution, forming angular to brecciated enclaves. The enclaves commonly show irregular distribution but may be uniform over a relatively large area, and they may be concentrated in swarms governed by the flow of host granitoid magma, suggesting that both were deformed during semi-solid (crystal-charged) magmatic conditions. The occurrence of enclave inside microgranular enclave (double or composite enclave), features like magmatic flowage, mafic-felsic xenocrysts, acicular apatite, and sharp and pillow-like contacts indicate co-existence and mingling of magmas with contrasting composition and temperature. Other vital features supporting mafic-felsic magma mixed, mingled, and undercooled origin for the enclaves are a round shape of enclaves with crenulated and chilled margins with partly digested hornblende crystal towards thermal front of enclave magma globule; a few crystals (xenocrysts) in enclaves are disequilibrated, rounded through partial dissolution and may be coated by another mineral, giving rise to a rapakivi-like texture; and presence of quartz ocelli. Mantle-derived mafic magma may provide thermal input, mass and volatile transfer to the granitoid melts, generating a convectively active mafic-felsic magma system. The system may be solidified at any stage of mafic-felsic magma mingling and mixing, a chaotic process during which a portion of mafic to hybrid magma can survive mixing and form the enclaves. The field and microstructural evidence of enclaves oppose the cumulate/cognate/cogenetic relation with host granitoid and instead strongly favour the origin and evolution of microgranular enclaves as mafic to hybrid magma globules that mingled and undercooled against relatively cooler, partly crystalline host granitoid

magma in a plutonic condition, as opined firstly by Ron H Vernon, and later by Robert A Wiebe, and several others.

Keyword

Structures, Enclaves, Granitoids, Magma Mingling, Undercooling

Geochemistry, zircon U-Pb geochronology, and Lu-Hf-O isotopes of Paleoproterozoic granite gneisses from Askot-Chiplakot klippe, Kumaun Lesser Himalaya, India: Insight into petrogenesis and evolution of north Indian continental lithosphere

Kapil Singh PANWAR[1]*, Kumaun University (kapilspanwar1@gmail.com)
Santosh Kumar[2], Kumaun University

Abstract

The Askot-Chiplakot klippe marks the northern extremity of the inner Lesser Himalaya within the Kumaun region, which includes the Paleoproterozoic magmatic and sedimentary lithological units belonging to the pre-Himalayan northern India continental margin. The felsic magmatism in this region is represented by Askot granite gneiss (AGGn) and Chiplakot granite gneiss (CGGn), some of which bear augen structures. The present paper aims to understand the nature, timing, and source of Paleoproterozoic magmatism based on field relations, whole rock geochemistry, zircon typology, U-Pb geochronology and Lu-Hf-O isotopes. The results are used to interpret the Columbia supercontinent assembly and growth-related magmatism and its geologic correlations for understanding the evolution of the northern Indian continent that participated in the geodynamic evolution of the Himalaya. The AGGn and CGGn bear bt-ms-pl-Kf-qz-zrn-ap±mag assemblage with subordinate muscovite in the CGGn. Modally, the AGGn represents syenogranite and monzogranite, whereas CGGn corresponds mostly to monzogranite and a few to quartz-rich granite. The AGGn is moderately peraluminous S-type (molar A/CNK=1.39-1.80), whereas the CGGn is moderately to strongly peraluminous (A/CNK=1.48-2.70). The AGGn and CGGn were formed from the melting of metasediments, where CGGn is influenced more by mafics in the source. The elemental variations demonstrate fractional differentiation of biotite and feldspars with a minor role of apatite and heterogenous sorting of K-feldspar in the evolution of AGGn and CGGn under a syn-collisional tectonic regime. The zircon typology suggests a hybrid (metaluminous and peraluminous) nature for the AGGn and CGGn melts. Zircons from AGGn samples yield crystallization ages of 1838±56 Ma, 1852.1±7.8 Ma, 1853.6±8.4 Ma, and 1854.8±5.8 with inherited zircon cores of 2407±12 Ma and 2453±26 Ma, while zircons from CGGn samples provide zircon crystallization ages of 1846±8 Ma, 1850±9 Ma, and 1884±12 Ma, with an inherited zircon core of 2605±12 Ma, suggesting the Columbia supercontinent assembly and growth-related episodic felsic magmatism by the reworking of Neoarchean-Paleoproterozoic crust. Two-stage Hf model ages of zircons range from 2.2 to 2.48 Ga, and the zircon εHf(1856 Ga) (-5.9 to 12.12) strongly suggest a role of ancient crust as well as juvenile magmatic input in varied proportion in the formation of AGGn and CGGn. The involvement of heterogeneous sources can also be depicted from zircon typology and variable initial 176Hf/177Hf ratios. The unimodal distribution of zircon ∂18O ‰ (+5.89 to +9.92) corresponds to the derivation of AGGn from crustal sources. In contrast, the observed bimodality of ∂18O (+1.17 to +10.02) indicates mantle and crustal components in the genesis of CGGn. The progressive enrichment in ∂18O ‰

from the zircon core to the rims of CGGn probably points towards incorporating 18O-enriched components in the CGGn melt during the growth of zircons. The presence of inherited zircons and radiogenic mantle involvement strongly suggests that the significant reworking of Neoarchean to Paleoproterozoic crustal components occurred in the northern Indian lithosphere during the Paleoproterozoic era. This process ultimately led to Paleoproterozoic felsic magmatism with some juvenile or mafic crust-derived magma input, which now exists in the Leser Himalayan domain.

Keyword

Geochemistry, Zircon Geochronology, Lu-Hf-O Isotopes, Granite Gneisses, Kumaun Lesser Himalaya

Boundary issue of the Cretaceous granitoid realm in between the Karakoram terrane and the Ladakh magmatic arc along Shyok Suture Zone, Ladakh Trans-Himalaya, India

SITA BORA[1]*, Department of Geology, Government Degree College, Kanda (Bageshwar), India (sitabora@yahoo.com)
Santosh Kumar [2], Kumaun University
Keewook Yi[3], Korea Basic Science Institute,162 Yeongu-Danji-ro, OChang, CheongWon-gu, Cheongju, Chungbuk 28119, Republic of Korea

Abstract

Could the boundary of granite be determined in a suture zone which evolved after amalgamation of the continents? This issue first time came to notice when the Sensitive High Resolution Ion Microprobe (SHRIMP) U-Pb zircon investigations done in the Cretaceous granitoids of the Shyok Suture Zone (SSZ) of Ladakh Trans Himalaya that is considered a boundary between the Ladakh magmatic arc system in the southwest and Karakoram terrane in the northeast. The SSZ consists of volcano-sedimentary sequences along with ophiolitic melange and intruded by granitoids in diverse time and space. Earlier scientific geochronological studies suggested that the majority of the Ladakh and Karakoram magmatic history were existed during 109 Ma, 95 Ma, 70 Ma, and in the Miocene period along the southwestern, the Northeaster parts and within the SSZ. The complexity of the Cretaceous magmatism arises because the SSZ is later affected by the geologically mapped boundary that is the Karakoram fault and the central part of the KF is sheared and deformed during Miocene. It is observed that the Cretaceous magmatism was vast which had been documented not only parallel to the NW and SE trending SSZ and KF but also recorded across the SSZ and central part of the Karakoram shear zone. It was earlier considered that most of the Karakoram batholith was feed by the leucogranite of Miocene which is not the case rather the Karakoram batholith is of Cretaceous as similar to the Ladakh granitoid. Therefore, the main question still remains that weather the Cretaceous magmatism in Ladakh regime and Karakoram terrane could consider under same magma chamber process that emplaced at same time and/or it is to be separated in the map because it lies across the Suture zone and affected by KF which is so far till date consider a boundary between Karakoram and Ladakh magmatic arc system.

Keyword

Ladakh Granitoid, Karakoram Terrane, Cretaceous magmatism, Shyok Suture Zone, Ladakh Trans-Himalaya

Geochemical signature of Tinkoto, Tiguida, Koulountou and Dioudioukounkou plutonic masses of the transitional zone between volcanic belt / Dialé basin (Kedougou-Kenieba Inlier South-Est Senegal/West Africa Craton)

MAME CODOU NDIAYE[1]*, ENSMG/UCAD/DAKAR/SENEGAL
(mamecodou1.ndiaye@ucad.edu.sn)

Abstract

The Kédougou-Kéniéba inlier (KKI) is a Birimian formation located in the western part of the West African Craton. Bassot (1963, 1966, 1987) subdivides KKI into Mako and Dialé-Daléma Supergroups. The geochemical study shows that large plutonic masses of the Mako-Dialé transitional zone are all calc-alkalin and peraluminous or metaluminous. These are Dioudioukounkou, Tiguida, Koulountou and Tinkoto granites. The granite of Koulountou show cobalt content of 12.3ppm, nickel 51.4ppm), vanadium 46.6ppm and chromium 106.6ppm. The levels of zirconium are 130.5ppm while the levels of radioactive elements are low: Th 10.3ppm and U 6.3ppm. The granite of Dioudioukounkou is richer in light rare earths with a LaN/SmN ratio equal to 4.63. It has SiO2 levels of 73.28%. The alkali content (Na2O+K2O) of the Dioudioukounkou granite is 6.82%. The Tiguida granite is marked by a low enrichment of light rare earths with a LaN/SmN ratio below the detection limit. The Tinkoto granite has a SiO2 content of 67.93%. The alkali content is 7.30%. The proportion of CaO of Tinkoto granite is higher (3.38%). The rare earth content (∑REE) of the Dioudioukounkou granite is 286.1 ppm; 28.7ppm for Tiguida; 75.6 for the Tinkoto granite and 111.3 for the Koulantou granite. Sun and McDonough's (1995) normalized rare earth spectra have a relatively medium to high slope. These plutonic rocks have low fractionation rates with LaN/YbN ratios of 17.45 for the Dioudioukounkou granite and below the detection limit for the other granites mentioned above. There is an enrichment in light rare earths with a LaNSmN ratio equal to 4.61 for the Dioudioukounkou granite, 3.76 for the Tinkoto granite, 1.94 for the Koulountou granite and below the detection limit for the Tiguida granite. The granites in the study area are globally enriched (12 to 103) times the primitive mantle while the peraluminous granodiorites are poorly enriched (16 times the primitive mantle).

Keyword

granite, Koulountou, Tiguida, Tinkoto, Dioudioukounkou

Genesis of tonalite-granodiorite batholith during subduction to accretion period of the Altai orogen (NW China) and its implications for continental crustal growth

Jianjun ZHANG[1]*, Institute of Geology, Chinese Academy of Geological Sciences, Beijing, 100037, China (jianjunzhang@live.cn)

Abstract

The model and accretionary mechanism of continental crust in the Altai orogenic belt is still widely debated. The formation of calc-alkaline I-type granitoid (mostly granodiorite and tonalite) is often considered a crucial process in continental crustal growth. This paper focuses on the widely distributed tonalite-granodiorite plutons formed during the Silurian to Devonian subduction-accretionary stage in the Altai orogen, NW China. Utilizing emerging non-traditional isotopic methods such as O, Li isotopes, along with conventional isotopic approaches, we investigate five tonalite and granodiorite bodies with decoupled Nd-Hf isotopes features and contain Precambrian inherited zircon grains in the southeastern margin of the Altai orogenic belt, to carry out detailed mineralogy, petrology, and geochemical studies. Through the analysis of the internal structure, trace elements, and in situ O and Hf isotopes of the newly identified Precambrian inherited zircon from these granitic rocks, we will discuss their origin, source, and palaeogeographical significance. Furthermore, we will trace the contribution of subducted oceanic sediments in the source of these calc-alkaline I-type granites and the mafic enclave they hosted. Combined with experimental simulations, we further explore the genesis of these tonalite-granodiorite batholith, the mode of continental crust accretion in the Altai orogenic belt and whether it is related to the ‘andesite model’.

Keyword

Tonalite, Altai orogen, crustal growth, relamination, accretion

Silicic microgranular enclaves from the Port Mouton pluton of the Northern Appalachians: implications for the development of the peripheral plutons of the Meguma terrane

Greg Gregory SHELLNUTT[1]*, National Taiwan Normal University (jgshelln@ntnu.edu.tw)
Jaroslav Dostal[2], Saint Mary's University

Abstract

The Meguma terrane of the Northern Appalachians is primarily composed of Cambro-Ordovician metapelites and metapsammites that were intruded by Late Devonian (390-360 Ma) granitic plutons. The South Mountain Batholith is composed of a number of smaller plutons (378-373 Ma), but represents the largest (~7300 km2) of the Late Devonian spatially contiguous intrusions. Peripheral and to the south are a series of smaller plutons (e.g., Port Mouton, Barrington Passage, Shelburne) that are contemporaneous or slightly younger than the South Mountain Batholith (SMB) and represent petrogenetically distinct magma pulses. The Port Mouton pluton (373 +/- 1 Ma) is composed of tonalite and monzogranite with silicic microgranular enclaves and was intruded by lamprophyric dykes. The silicic enclaves are peraluminous, magnesian, and calc-alkalic to calcic which is similar to the host rocks of the Port Mouton pluton (PMP). The enclaves can be divided into two groups based on their Al2O3 content. Group 1 is Si-rich (SiO2 = 74.3-79.7 wt%), Al-poor (Al2O3 = 10.0-12.2 wt%), and has lower Na2O (2.18-2.34 wt%) whereas the Group 2 is similar to the host rocks (SiO2 = 65.6-74.3 wt%; Al2O3 = 14.7-17.9 wt%; Na2O = 2.76-3.82 wt%). Moreover, the Group 1 enclaves have higher TiO2 and Fe2O3t at lower SiO2 then the most evolved rocks of the PMP. The higher SiO2 and lower Al2O3 and Na2O contents reflects the lower mode of albitic feldspar and higher quartz mode. Rhyolite-MELTS modeling shows that fractional crystallization of the most primitive rocks (P = 3 kbar; fO2 = dFMQ +1; H2O = 3.0 wt%) of the PMP can generate the Group 2 enclaves. The Group 1 enclaves cannot be generated by fractional crystallization and may represent a late stage magma that incorporated additional Fe-Ti oxide minerals. Nevertheless, these granitic rocks are compositionally similar to volcanic-arc granites from the main portions of Cordilleran batholiths. However, trace element-based tectonomagmatic discrimination diagrams show the enclaves and host rocks of the PMP to be similar to “slab failure” plutons whereas the SMB rocks mostly classify as volcanic-arc. Therefore, it is possible that the peripheral plutons of the Meguma terrane represent a younger period of magmatism related to slab failure that migrated southward whereas the older SMB plutons represent an older period of volcanic-arc magmatism.

Keyword

Northern Appalachians, Devonian, Meguma, enclaves, Peripheral plutons

Geo-characterization of Late Cretaceous mafic microgranular enclaves and host granites: A case study in the Eonyang granite, South Korea

Hui Je Jo[1]*, Korea Institute of Geoscience and Mineral Resources (jhj8218@kigam.re.kr)
Ho-Sun Lee Lee[2], Pusan National University
Sung Won Kim[3], Korea Institute of Geoscience and Mineral Resources

Abstract

Cretaceous–Paleogene plutons, generated in response to slab rollback and trench retreat, are concentrated in the Gyeongsang Arc System (GAS) along the southeastern margin of the Korean Peninsula. Cretaceous plutons, exposed in the GAS, are classified into three distinct age groups and most Late Cretaceous plutons (Palgongsan, Eonyang-Yangsan, Yucheon, Taejongdae, Bonggilri, Goheung) with a high-K calc-alkaline affinity are characterized by their mafic magmatic/microgranular enclaves (MMEs). The 76 to 71 Ma MMEs, which exhibit various textures and chemical compositions, are found within the synchronous host plutons.

This study investigates the interaction between the mafic and felsic magmas during the Late Cretaceous, using new geochronological, geochemical, and Hf isotope data from whole rock and zircon of the MME and host Eonyang granite in the Unmunsa area, adjacent to the previously reported Eonyang-Yangsan and Yucheon granites. The zircon U-Pb ages and εHf(t) values of the host granite (70 ± 1 Ma, 6.6 ± 2.4) and MME (73 ± 1 Ma, 6.4 ± 5.5) are identical within errors to those of the Eonyang and Taejongdae plutons. This implies extensive interaction between the primitive magmas with less involvement of source materials and pre-existing crustal materials. The whole-rock geochemical compositions and trends depict complex magmatic processes (fractionation and mixing/mingling) between the felsic and mafic melts. In contrast to earlier studies, the zircons from the MME and those from the host granite show clear differences. The MME zircons show relatively more positive Ce anomalies, enrichment in middle to heavy REEs, and textural differences, suggesting the MME and host zircons crystallized in felsic melts under different T-fO2 conditions. The combined data from whole-rock and zircon element compositions of the MMEs and host rocks offer valuable insights into the petrogenesis of Cretaceous granitic plutons in the GAS, indicating the roles of fractional crystallization, assimilation, and magma mixing.

Keyword

MMEs, Granitoids, Geochemistry, Eonyang, Gyeongsang Arc System

Apatite geochemical indicators for magma mixing and fractional crystallization

BaoQuan ZHOU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (zhoubaoquan19@mail.iggcas.ac.cn)
JinHui YANG[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
JinFeng SUN[3], University of Chinese Academy of Sciences
Hao WANG[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
YuSheng ZHU[5], Institute of Geology and Geophysics, Chinese Academy of Sciences
YaDong WU[6], Institute of Geology and Geophysics, Chinese Academy of Sciences
Lei XU[7], Institute of Geology and Geophysics, Chinese Academy of Sciences
QingFeng MEI[8], Institute of Geology and Geophysics Chinese Academy of Sciences
Jing RAN[9], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Magma mixing and fractional crystallization are fundamental processes in the origin of granites. Apatite is one of excellent minerals to trace magma mixing and fractional crystallization processes using its chemical components. However, it is difficult to distinguish these two processes only using the compositions of apatite. Here we present the integrated geochemical and Sr isotopic composition of apatite from the mafic microgranular enclaves (MMEs) and their host biotite granite in the Early Cretaceous Qianshan pluton to identify some apatite geochemical indicators for differentiating magma mixing and fractional crystallization. The variable Sr isotopic compositions of apatites in the enclaves (0.7097 to 0.7216) and the host biotite granite (0.7132 to 0.7201) directly constrain the magma mixing process. Discontinuous variable Sr isotope and/or trace elements such as Sr and Y content, and Eu/Eu* in apatite within the same sample are effective methods for identifying magma mixing. Additionally, the variation trends of trace element ratios, such as Sr/Sm and Sr/Y can also reveal magma mixing. However, the effect of fractional crystallization on the apatite composition depends on the partition behavior of elements in different minerals. For example, Eu/Eu* and Sr/Y may be effective indicators for the progressive crystallization of feldspar, while La/Lu may be an effective indicator for amphibole. Based on these observations, a magma mixing-fractional crystallization model ("MFC" model) of apatite composition establishes the genesis of MMEs and the host biotite granite in the Qianshan pluton. The observed discontinuous decrease in apatite Sr content, Sr/Y and Eu/Eu* is attributed to the mixing between the mafic and felsic magmas. The increase of LREE/HREE in localized apatite grains (Sr/Y>1) can be ascribed to fractional crystallization dominated by amphibole, plagioclase and alkali-feldspar. Subsequent alterations in the apatite composition predominantly result from the mixing of this differentiated magma and the felsic magma. Therefore, the mixing of mantle-derived mafic magma and crust-derived felsic magma is the main factor in the formation of MMEs, and the early crystallization of amphibole and plagioclase, as well as subsequent crystallization of alkali-feldspar and biotite, also play crucial roles. The biotite granite was formed by a felsic magma with minor involvement of mafic magma, coupled with the crystallization of plagioclase, alkaline feldspar and biotite. This study confirms the sensitivity of

apatite Sr isotopes and trace elements content and ratios to magma mixing and fractional crystallization, thus providing valuable insights into the intricate magma evolution processes and petrogenesis of granitoids that may be attenuated in the whole-rock compositions.

Keyword

Apatite, Magma mixing, fractional crystallization, A-type granite, mafic microgranular enclaves

Early Cretaceous high-δ56Fe rhyolites in central Tibetan plateau: Insights into genesis of A-type magmas

Lu-Lu HAO[1]*, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (haolulu@gig.ac.cn)

Abstract

The role played by felsic igneous magmatism in crustal differentiation is of importance for the evolution and habitability of the Earth system. However, the petrogenesis of felsic igneous rocks, particularly A-type rocks, remains highly debated, hindering our understanding of crustal differentiation processes. One key issue worthy of investigation is whether A-type rocks are produced by partial melting of crustal rocks or via extreme crystal-melt fractionation, which corresponds to two different ways of forming and refining continental crust. Recently Fe isotopes have been used to trace the origin and magmatic differentiation of granites. A-type granites generally have heavier Fe isotope compositions than I-, and S-type rocks and were conventionally considered to result from protracted, closed magma chamber fractionation of moderately reduced mafic magmas. However, increasing studies have revealed several other mechanisms that could explain heavy Fe isotopic signatures of granites, e.g., exsolution of fluids with isotopically light Fe isotopes, magma compositional control. Therefore, the genetic model of extensive crystal fractionation for generating A-type granites remains questionable and requires further validation. Here we report Fe isotope ratios of Early Cretaceous A-type rhyolites in Gerze area of central Tibetan plateau to constrain their genesis. Gerze rhyolites show high near-chondritic Zr/Hf and Nb/Ta ratios, indicating insignificant fluid-melt/rock interaction during their formation. Fe isotope variation caused by partial melting generally is small, which cannot explain the very high δ56Fe values of Gerze rhyolites. Combined with bulk-rock Sr-Nd-Hf isotopes, crustal assimilation as the origin of heavy Fe isotope signature can be ruled out. Fe isotope fractionation can be affected by magma compositions, yet, Gerze rhyolites show low (Na + K)/ Al (~0.8) and (Na + K)/ (Ca + Mg) (4-11) values, which should not be expected to yield very high δ56Fe values (up to 0.7‰). Finally, we suggested the removal of isotopically light Fe-bearing minerals as the main mechanism to produce Fe isotope variation in Gerze rhyolites. Thus, this study supports fractional crystallization to yield A-type granitic magmas and provides key insights into the evolution of continental crust.

Keyword

crustal differentiation, A-type rhyolite, Fe isotope, Tibetan plateau, fractional crystallization

Early Cretaceous fayalite- and ferrosilite-bearing rhyolitic porphyries and associated biotite-bearing rhyolitic porphyries from the Baishuizhai area, South China: high-temperature crustal melting and magmatic evolution

Xiao LIU[1]*, Guilin University of Technology (liuxiao@glut.edu.cn)
Qiang Wang[2], Guangzhou Institute of Geochemistry
Xi-Jun Liu[3], Guilin University of Technology
Lin Ma[4], Guangzhou Institute of Geochemistry

Abstract

Fayalite- and ferrosilite-bearing felsic igneous rocks are a distinctive category of A-type granitic magmas, and the origins of these rocks have proved controversial. Here, we report a study of earliest Early Cretaceous (145–142 Ma) fayalite- and ferrosilite-bearing rhyolitic porphyries (FFBRPs) closely associated with biotite-bearing rhyolitic porphyries (BBRPs) from the Baishuizhai area, Guangzhou, Guangdong Province, South China. The Baishuizhai suite provides an excellent opportunity to establish the magmatic origins and evolutionary processes responsible for the FFBRPs. Rocks from the Baishuizhai suite have SiO2 contents of 73.2–77.7 wt.%, Na2O + K2O contents of 7.83–9.42 wt.%, and Fe2O3T contents of 1.52–2.97 wt.%, respectively. They have A-type granite mineral assemblages (euhedral fayalite and ferrosilite in addition to anhedral amphibole and biotite) and geochemical characteristics [e.g., high 10,000 × Ga/Al (3.7–4.7) and FeOT/MgO (13.0–34.8) ratios, and high Zr + Nb + Ce + Y contents (496–906 ppm)]. The rocks have slightly enriched in situ plagioclase Sr [(87Sr/86Sr)i = 0.7070–0.7076] and whole-rock Nd [εNd(t) = −2.3 to −2.0] compositions, depleted zircon Hf isotopic compositions [εHf(t) = −0.9 to +7.0], moderate to low zircon δ18O values (6.3‰–7.8‰), and intermediate in situ plagioclase Pb isotopic compositions [(206Pb/204Pb)i = 18.368–18.727, (207Pb/204Pb)i = 15.488–15.673, and (208Pb/204Pb)i = 38.049–38.801]. We infer that the primary magmas of this rock suite were formed by the partial melting of a hybridized source consisting predominantly of juvenile crustal rocks (60%–80%) with subordinate metasedimentary rocks (20%–40%). Fayalite and ferrosilite in the FFBRPs were most likely crystallized from dry, hot, and reduced magma in a deep (~20 km) chamber. The deep magma gradually evolved during ascent to water-enriched magma in a chamber at intermediate depth (3–4 km), followed by residence in a shallow (<3 km) chamber. According to the established temporal–spatial distribution of Early Cretaceous A-type granites in South China, we suggest that partial melting of the hybridized source was induced by the underplating of mantle-derived mafic magmas, which were produced by decompression melting of upwelling asthenospheric mantle in response to slab rollback of the Paleo-Pacific Plate.

Keyword

Fayalite- and ferrosilite-bearing rhyolitic porphyry, Petrogenesis, Early Cretaceous, Slab rollback, South China

Late Mesozoic high Ba-Sr granitoid in the Xiao Qinling area of Eastern Qinling Orogen, Central China: Petrogenesis and tectonic setting

Chengli ZHANG[1]*, Department of Geology, Northwest University, Xi'an, Shaanxi Province, China (clzhang@nwu.edu.cn)
Huan Yang[2], Department of Geology, Northwest University, Xi'an, Shaanxi Province, China

Abstract

Muhuguan pluton is outcropped at the southwest end of Xiao Qinling area in the Eastern Qinling orogenic belt. The LA-ICP-MS U–Pb zircon dating yield ages from 160 to 150 Ma, representing the earliest magmatism in the late Mesozoic and being of great significance to reveal the early stage of late Mesozoic tectonic setting of Qinling Orogenic Belt, central China. This pluton is composed mainly of monzogranites and some granites, and some coeval mafic microgranular enclaves (MMEs) and mantle-derived mafic dykes are occurred within them. The granitoids are characterized by high and variable SiO2 (62.01~73.55%) and Al2O3(13.6~17.5%, A/CNK=0.97~1.06), high K2O(2.89~5.28%; K2O/Na2O=0.71~1.49), LREE and LILE, insignificant Eu anomalies (δEu=0.80~1.13), depletion in HREE and Y, especially anomalous high Ba (762~3265×10-6) and Sr (200~959×10-6)as well as high Sr/Y(12.6~87.9) and K/Rb (218-530), indicating the high Ba-Sr granitoids. Furthermore, they have moderate Mg# (30.2~43.0), and low Cr, Ni contents and low and variable radiogenic Nd isotopes (εNd(t)=-13.7 to -4.9), suggesting production from the partial melting of the basic-basic-rocks and clastic rocks in the Qinling complex. The occurrences of coeval mafic enclaves and mantle-derived dikes within the host granitoids as well as highly variable Nb/Ta ratio of granitoids suggested that pluton were modified by mantle-derived magmatic activity during the formation process. In addition, K2O, Rb, Rb/Sr and Rb/Ba of rock mass increase with the increase of SiO2, while CaO, Sr, Ba and their K/Rb are negatively correlated with SiO2, indicating that there was fractional crystallization of some hornblande, clinopyroxene and plagioclase during process of the magmatic evolution. All characteristics mentioned above fully prove that the Muhuguan high Ba-Sr granitoids was most likely formed by the partial melting of the crustal material due to the heating from the upwelling of mantle material under the adjustment of the thickened crust resulted from the collision between the southern and northern continental blocks as well as the lithosphere extension and thinning during the transitional period form post-collision to intraplate in the late Jurassic, which has no directly connection with the magmatic activity caused by westward subduction of the Paleo-Pacific Ocean to the eastern mainland of China since late Jurassic of the late Mesozoic.

Keyword

High Ba-Sr granite, Zircon U-Pb dating, Geochemistry, Qinling Orogenic Belt, Central China

The extensional tectonic environment within the Urumieh-Dokhtar magmatic belt, NW Iran

REZA MONSEF[1]*, Department of Geology,Estahban branch, Islamic Azad University,Estahban,Iran (r.monsef@kce.ir)

Abstract

The Urumieh-Dokhtar magmatic belt as a part of the Alpine-Himalayan orogenic belt represents a linear igneous activity, extending from the northwest to the southeast of the Iranian plateau. The Urumieh-Dokhtar magmatic belt consists of Miocene magmatic rocks in the central part, which are mainly composed of volcanic and pyroclastic rocks of basaltic to dacitic compositions as well as lower amounts of intrusive bodies with calc-alkaline to high-K calc-alkaline to shoshonitic affinities. The U-Pb zircon geochronology from monzodiorite, micro-granodiorite, and dacitic rocks reveals the crystallization ages of 15 to 20 Ma (Burdigalian-Langhian). These rocks exhibit enrichment in large ion lithophile elements and light rare earth elements and depletion in Nb, Ta, and Ti, characteristics of the subduction-related environment. Samples are characterized by a high 87Sr/86Sr ratio (0.7056 to 0.7071), εNd value (0 to -3.5), and high 143Nd/144Nd ratio (0.51246 to 0.51267). The Pb isotopic evidence is particularly high with 208Pb/204Pb ratio (38.731 to 39.097), 206Pb/204Pb ratio (18.770 to 19.004), and 207Pb/204Pb ratio (15.645 to 15.706). AFC modeling shows magmas evolved through assimilation combined with fractional crystallization, and that the effects of assimilation range combine to crustal thinning phenomena. Geochronological data show that the Urumieh-Dokhtar magmatic belt magmatism was active and widespread during the Miocene when trans-tensional basin systems were working due to mantle diapirism. The convectively upwelling asthenosphere and partial melting of earlier metasomatized subcontinental lithospheric mantle may trigger such magmatism. These geochronological data in conjunction with geological and geochemical data suggest that the Miocene magmatic flare-up was the most active event in the Central part of the Urumieh-Dokhtar magmatic belt and was a high-flux magmatism in an extensional tectonic setting.

Keyword

U-PB Geochronology, Isotope geochemistry, microgranodiorite, orogenic, Uromie-Dokhtar magmatic belt

Granitoids of the north of the Urals: U-Pb geochronology (SIMS, LA-ICP-MS, ID TIMS) and isotope geochemical (OZrn, Sm-Ndwr, Lu-HfZrn) characteristics

Oksana Vladimirovna UDORATINA[1]*, Institute of Geology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences (taykey@yandex.ru)
Ksenia Viktorovna Kulikova[2], Institute of Geology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences
Alexander Sergeevich Shuisky[3], Institute of Geology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences
Anna Alekseevna Soboleva[4], Institute of Geology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences
Valentin Leonidovich Andreichev[5], Institute of Geology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences
Irina Igorevna Golubeva[6], Institute of Geology of Komi Science Centre of the Ural Branch of the Russian Academy of Sciences

Abstract

Granitoid magmatism in the north of the Ural orogen is represented by derivatives of two large geodynamic stages - pre-uralids (pre-uralids, proto-uralids, timanids) and uralids. Granitoids of the Central Ural megazone record the pre-Ural history of the evolution of the active margin and the collision of Baltica and Arctida. In the pre-uralids, there is a change from island-arc magmatism (735–720 Ma) with the melting of I- (M-) granitoids to accretionary (670 Ma) – I-granitoids, then to collisional (620–520 Ma) – simultaneous melting of A-, I-, S-granitoids, then riftogenic (520–480 Ma) – melting of I- and mainly A-type granites.

Granitoids of the East Ural megazone (Shchuchinsky and Voykar-Rayiz zones) are already associated with the Ural history - the formation and closure of the Ural paleoocean. Island-arc uralides of the primitive island arc (460–430 Ma, I-granitoids), replaced by granitoids of the mature island arc (412–368 Ma) and ending with collisional granitoids, early (360–316 Ma) and late (277–249 Ma) years).

Thus, the development of the pre-uralid orogen covers a fairly long period of time, starting from 620 to 520 million years. With this age, granitoids of all types are observed in the north of the Urals. After the turn of 520 Ma, only type I and A granites are observed, marking the rifting stage. It began a new tectonic cycle, the actual Ural cycle, which ended with the formation of the Ural folded region. The composition points of non-collision I- and A-type granites gravitate more towards the fields of intraplate formations and have a more mantle source. I-type granites, formed already in the Ural time, are characterized by typically island-arc characteristics.

Isotopic studies have shown that the values of oxygen and hafnium isotopes in zircons and neodymium in rocks show variability in the maturity of the granitoid substrate from the Northern to the Polar Urals. Markers of the most mature recycled material are recorded in pre-uralid granitoids of the Northern and Subpolar Urals: $\delta^{18}O$ from +7.10 to +8.51‰, εNd = -4.8 – -0.3, $\varepsilon Hf(t)$ = -3.35 – -1.95. Granitoids of the pre-Uralids of the Polar Urals are characterized by

components of mantle origin, as well as a more moderate contribution of crustal material to the original magma: δ18O from +4.7 to + 6.22‰, εNd = +0.6 – +5.6, εHf(t) = +2.15 – +15.1. In general, an older model age (TDM2) of the protolith is noted for pre-uralid granitoids of the Subpolar (1.76–1.03 Ga) and Northern (2.09–1.11 Ga) Urals compared to that for the Polar Urals (1.48–0.64 Ga). Isotopic characteristics of Uralide granitoids indicate a significant contribution of the mantle component during their formation: δ18O from +4.19 to + 5.69‰, εNd = +4.1 – +7.4, εHf(t) = +8 – +15.7. The model age (TDM2) of the protolith for the Uralide granitoids of the Polar Urals is 1.01–0.37 Ga. Thus, almost all the obtained data δ18OZrn, εHf(t)Zrn, εNd(t)wr show a significant contribution of the mantle component during the formation of granitoids of various types in the north of the Urals.

Keyword

isotope-geochemical characteristics of granitoids, U-Pb age, north of the Urals, Polar, Subpolar, Northern Urals

Formation and tectonic implication of the late Mesozoic Yunmengshan batholith, North China Craton: new constraints from zircon Hf-O isotopes and apatite geochemistry

Jin-Feng SUN[1]*, University of Chinese Academy of Sciences (sjf@ucas.ac.cn)
Miao-Miao Ling-Hu[2], University of Chinese Academy of Sciences
Ji-Heng Zhang[3], University of Chinese Academy of Sciences
Zi-Mu Li[4], University of Chinese Academy of Sciences
Jin-Hui Yang[5], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Yunmengshan batholith is a typical late Mesozoic intrusion in the western segment of the Yanshan belt, northern margin of the North China Craton, and well known as the “Yunmengshan metamorphic core complex”. It includes Yunmengshan granitoids and Shicheng diorite, which formation records important information for the westward subduction of the Pacific plate and the destruction of the North China Craton. In-situ zircon U-Pb and Hf-O isotopes, coupled with whole-rock and apatite geochemical compositions, are carried out for diorites from the Shicheng intrusion and monzogranites (medium-grained and fine-grained) from the Yunmengshan intrusion, aim to probe into their magma sources and petrogenesis. Our newly obtained zircon U-Pb ages show that the diorite was formed at about 156 Ma, while the medium-grained and fine-grained monzogranites were formed at 143-142 Ma and 139-136 Ma, respectively. Shicheng diorites have relatively low SiO2 and high MgO contents, with zircon εHf(t) values of-17.8 to -13.4 and δ18O values of 5.7 to 6.9‰, indicating their parental magma were derived from an isotopically enriched lithospheric mantle, with the involvement of ancient crustal materials during their formation. The medium-grained and fine-grained monzogranites have relatively high SiO2 contents (67.8-74.4 wt.%),with enriched zircon εHf(t) values of -21.3 to -14.7 and -25.6 and -12.2, and zircon δ18O values of 5.8‰ to 6.8‰ and 5.9‰ to 7.0‰, respectively. All their geochemical features indicate that they were generated by the partial melting of the basaltic lower continental crust at about 2.5 Ga. However, apatite from the medium-grained and fine-grained monzogranites show significantly distinct geochemical characteristics, precluding the fractional crystallization progress as their genetic link. Combined with whole-rock geochemical compositions, REE patterns for apatites from different rock types provide key evidence for their origin of distinct source materials. Thus, the Yunmengshan batholith record multi-stages magmatic activities (Late Jurassic and the Early Cretaceous), which derived from distinct magma source as enriched mantle and lower crust. Geochemical features of apatite can be an useful tool to trace magma sources and process.

Keyword

Yunmengshan, North China Craton, Zircon Hf-O isotopes, Apatite geochemistry, Petrogenesis

Tectonic understanding of Syenites and Quartz Syenites from Peralimala and Angadimogar plutons, Kerala, India

SAI KRISHNA PRIYA VALLURI[1]*, OSMANIA UNIVERSITY (krishnapriyavalluri@gmail.com)
AMARENDHAR S[2], OSMANIA UNIVERSITY
SRINIVAS M[3], OSMANIA UNIVERSITY

Abstract

Syenite and Alkali granite intrusives of NeoProterozoic age sporadically puncture the Precambrian granulite facies terrain of charnokites and migmaties of SW India. The intrusive bodies understudy occurs at Peralimala (PM) and Angadimogar (AM) and are prominent ones amongst the 18 bodies that invaded the Peninsular shield of India, providing the evidences of prominent felsic magmatic events during Pan African period. An elongated body of PM [$11^0$53'N - $75^0$39'E] occurs in Kannur district of Kerala and believed to have emplaced along the Bavali lineament. On the other hand, the AM pluton [$12^0$38'N - $75^0$00'E] in Kasaragod district of Kerala is emplaced close to the continental margin and along a NW-SE trending fault lineament. Petrochemically both these bodies have distinctive characters which differentiates one from the other.

The PM is dominantly a syenite body composed predominantly of perthitic K-Feldspar (microcline > orthoclase) and pyroxene > amphiboles with +biotite, while AM pluton is a quartz-syenite body showing variation to quartz monzonite and alkali granite from core to periphery and is composed of predominant K-feldspar with orthoclase > microcline, plagioclase and quartz, Mafic minerals such as amphibole dominant over pyroxenes and biotite.The AM rocks are well fractionated peraluminous and high calc-alkaline series rocks. They are high in Na2O (~5.5%) and low in K2O (~4.3%) along with high Zr, Nb, Th & U, and low Rb, Sr, Cu, V and Ba. The ∑REE of these rocks range between 60 to 715 ppm and characterized by positive Eu anomaly. They also show an enriched LREE pattern. On the contrary, the PM rocks are peraluminous to metaluminous high potassium shonsonite series rocks. They show low Na2O (~3.3%) and high K2O (~9.7%) along with high Rb, Sr, Cu, V & Ba, and low Zr, Ga, Nb, Th and U. The ∑REE of these rocks range between 30 to 105 ppm and show a distinctive negative Eu anomaly. The AM and PM rocks when normalized with mantle compositions show similar pattern for their incompatible elements, but their compatible elements show irregular pattern. Their normalized pattern further shows negative Nb, Ti and P anomaly, while Sr of AM rocks show negative anomaly and PM rocks show a distinctive positive anomaly.

The diversity in the geochemical features between the two plutons is interpreted to be because of the heterogeneity of the source or may be related to fractional crystallization of a homogenous source. Their alkaline nature indicate that the magma was derived from the deep crust or upper mantle. These two plutons are generally considered to be anorogenic or post orogenic in nature representing the within plate-volcanic arc zones, and that which have formed away from active continental margin. In Peninsular India these alkaline plutons have a strong Pan-African imprint similar to the Pan-African post-kinematic plutons from the Afro-Arabian shield having high SiO2,

K2O (~12%) & Na2O, and low CaO, FeO & MgO.

Keyword

Alkaline Plutons, Kerala, Pan-African, Angadimogar (AM), Peralimala (PM)

A Method for Calculating Magma Oxygen Fugacity with Uraninite in Granites

Jian GUO[1]*, Beijing Research Institute of Uranium Geology (guojian9818@163.com)
Ziying LI[2], Beijing Research Institute of Uranium Geology
Jiangtao NIE[3], Beijing Research Institute of Uranium Geology
Yuyan ZHANG[4], Beijing Research Institute of Uranium Geology

Abstract

Oxygen fugacity is an important physicochemical parameter of magmas beside temperature, pressure, and elemental concentrations, and is a major research topic in natural and experimental petrology. In previous studies, apart from direct measurement with oxygen probe, it is more common to use valence-varying elements in rocks and minerals to indirectly estimate the magma oxygen fugacity. Uraninite is the main U-bearing accessory mineral in granites. Uranium in uraninite occurs mainly as U4+ or U6+, depending on the magma oxygen fugacity. Li (2015) utilized X-ray photoelectron spectroscopic (XPS) in-situ micro-analytical technique to determine the elemental valency of natural U-bearing minerals. In this study, we used XPS to directly measure the uraninite U6+ and U4+ contents in granites, estimated the magma oxygen fugacity, and discussed the reliability of this new technique.

The granite samples for the oxygen fugacity estimation were collected from the Wuliting intrusion (24°46′41.08″N, 114°23′20.87″E) in Jiangxi Province, China. Scanning electron microscope (SEM) observation was conducted to determine the crystallization states and paragenesis of uraninite grains. Uranium valence state analysis was conducted at the Key Laboratory of Catalytic Material Science in the South Central University for Nationalities, using a Thermo Scientific MultiLab 2000 XPF system.

For our uraninite samples, we chose five grains (with better uranium XPS signals) for 25eV U-valency narrow scanning, calibrated using C1s = 284.6eV. To obtain better imitating results, we picked the uranium oxide 4f7/2 channel U4+ and U6+ standard binding energy to 380.31 ± 0.47eV and 381.75 ± 0.47eV, respectively.. The U4+ peak binding energy is of 379.94 ~ 380.19eV, and its full width at half maximum (FWMH) values of 1.78~1.90eV. The U6+ peak binding energy and FWMH values are of 381.64 ~ 381.77eV and 1.60 ~ 1.84eV, respectively. The uraninite U6+/U4+ ratios are of 0.30 ~ 0.46.

Using Jiang (2005)’s estimation of average crystallization temperature of magmas, the Wuliting granites may have formed at 680℃. We caculated and suggested that the Wuliting granitic magma has oxygen fugacity of -18.26 to -17.89 (average -18.08).

As a common accessory mineral in granites, uraninite records the oxygen fugacity of early-stage magmatic evolution. The XPS in-situ microanalytical technique adopted in this study represents a rapid way to determine the U-valence states, and can effectively avoid the impacts of redox reactions (between uranium, decomposition medium and interfering elements) on the analytical accuracy in conventional wet-chemistry analytical techniques. Uraninite is an independent uranium mineral, and thus the analytical error of uranium is smaller than those of the trace

elements (e.g., Ce) in zircon. Analysis of uraninite can also avoid the issue of crystal-melt partitioning relationship of the valence-varying elements, and lower the theoretical derivation and analytical errors. Therefore, the calculation results are relatively reliable.

Keyword

Magma oxygen fugacity, Granite, Uraninite, X-ray photoelectron spectroscopic

Petrogenesis of mafic enclaves hosted in the Zouzan pluton, Eastern Iran: Insight from the U-Pb zircon geochronology, whole-rock Nd-Sr isotopes, and elemental geochemistry of amphibole and apatite

Seyed Ali Mazhari[1], Research Center of Geographical Sciences and Social Studies, Hakim Sabzevari University, Sabzevar, Iran
Kwan Nang Pang[2], Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan
Santosh KUMAR[3]*, Department of Geology, Kumaun University, Nainital 263001, India (skyadavan@yahoo.com)
Kazem Aliabadi[4], Research Center of Geographical Sciences and Social Studies, Hakim Sabzevari University, Sabzevar, Iran

Abstract

The calc-alkaline granitoids often contain mafic to hybrid magmatic enclaves. There has been a debate about whether these enclaves are a cumulate of host granitoids or a result of a mixed origin of mafic and felsic magmas. To better understand the origin and evolution of enclaves and their relationship with the host rocks, we investigated the mafic enclaves and associated lithological units of the Zouzan pluton. The observed enclave-host field relationships and microstructures strongly suggest that the mafic enclaves (MEs) originated as pockets or blobs of mafic magma that intruded, mingled, and mixed within the coeval crystallizing host granitoid magma. The newly obtained U-Pb zircon ages reveal that the granitoids, gabbro-diorites, and MEs, mainly constituting the Zouzan pluton in the northeastern part of the Lut Block in Eastern Iran, were formed during the Eocene period (40 Ma). The MEs exhibit intermediate Nd-Sr isotopic signatures ($^{87}Sr/^{86}Sr_i$= 0.704-0.705 and εNd_t= +2.21 and +2.82) as compared to the gabbro-diorites ($^{87}Sr/^{86}Sr_i$= 0.7030-0.7034 and εNd_t= +4.46 and +5.38) and granitoids ($^{87}Sr/^{86}Sr_i$= 0.7063-0.7078 and εNd_t= +0.48 and +1.22). Amphiboles in the Zouzan pluton rocks consist predominantly of magmatic origin belonging to calcic amphiboles. The granodiorite amphiboles exhibit higher Al_2O_3, K_2O, Na_2O, Ba, Hf, U, and Th contents, whereas diorite-gabbro amphiboles show enrichment in SiO_2, MgO, Sr, Sc, V, Y, Nb, and rare earth elements (REE). The ME amphiboles display a bimodal distribution of trace elements, encompassing characteristics of both mafic and felsic rocks amphiboles. Apatites in the Zouzan pluton rocks can be classified as magmatic fluorapatite. Granodiorite apatites exhibit higher F, Rb, Cr, Nb, Ta, Zr, Pb, U, and Th contents, whereas diorite-gabbro apatites are characterized by an elevated content of Cl, Sr, Sc, V, Co, and Y. The ME apatites display intermediate trace element compositions, bridging the apatite compositions found in the mafic and felsic magmatic rocks of the Zouzan pluton. The diverse geochemical behaviour observed in the ME apatite and amphiboles suggests a complex magmatic process involved in forming the Zouzan pluton. The most likely dominant process is the interactions between crystal-charged mafic and felsic melts, synchronously coinciding with the physical and chemical interactions between the mafic enclave and the host felsic magmas.

Keyword

Geochronology, Petrogenesis, Mafic enclave, Zouzan pluton, Eastern Iran

An amphibolitic source for “adakitic” I-type plutons in continental collision zones

Qiwei LI[1]*, China University of Geosciences (qwli@cug.edu.cn)
Junhong Zhao[2], Institute of Geochemistry, Chinese Academy of Sciences
Oliver Nebel[3], Monash University

Abstract

Rocks with “adakitic” affinities are widespread in continental collision zones, recording important information about crustal thickening. Residual garnet during partial melting of the lower crust is traditionally considered to be responsible for heavy rare earth element and Y depletion, which is a key characteristic feature of these rocks. However, magmatic garnet is rarely observed in such adakiticigneous rocks and associated protolithic eclogite is also rarely reported. Instead, amphibole is a proposed abundant phase in lower arc crust. Whilst both garnet-and amphibole-rich assemblages can act as potential sources for intracrustal intermediate-silicic melts, their distinctive fractionation of fSm/Ndand fLu/Hfshould, with time, lead to different Nd-Hf isotopic compositions in high Sr/Y rocks. Here we report whole-rock radiogenic Sr-Nd-Hf and stable Fe isotope compositions of well-characterized Oligocene to Miocene (33-14 Ma), post-collisional high-K adakiticintrusions from the Gangdese belt, South Tibet. The plutons have a low alumina saturation index and depleted Dy/Yb, pointing to negligible amounts of sediment contribution. They are characterized by variable initial 87Sr/86Sr ratios (0.7048 to 0.7078), mostly negative εNd (−4.9 to +0.3), positive εHf values (+1.5 to +8.3), and variable but heavy δ57Fe values ranging from +0.04 ±0.08‰ to +0.35 ±0.08‰. Modeling of Fe isotopes and fractionation factors of fSm/Ndand fLu/Hfindicate an amphibolite source. A Nd-Hf isotope correlation that is quasi-parallel to the mantle array can be best explained by the evolution of amphibolitic lower crust with a residence time of ca. 400 Myrs. Although these adakitic rocks have depleted, mantle-like Hf isotope compositions, they are part of an existing, older crustal foundation and thus represent a process of crustal reworking, instead of crustal growth. Therefore, proportions of mantle-derived materials that contributed to the Phanerozoic crustal growth based on Hf-in-zircon signatures alone may be overestimated. Combined mineral and whole-rock radiogenic and stable isotopes are required to address this issue in the future.

Keyword

Sr-Nd-Hf-Fe isotopes, Gangdese adakitic intrusion, amphibole effect, Nd-Hf decoupling, crustal reworking

Petrological and geochemical characteristics of the mafic-ultramafic complexes in the Bhavani Shear Zone, South India: implications for crustal evolution.

ABEENA PV[1]*, CENTRAL UNIVERSITY OF KERALA (abhipv25@gmail.com)
PRATHEESH P[2], CENTRAL UNIVERSITY OF KERALA

Abstract

The South Indian shield encompasses two main geological features: the Archaean granite–greenstone terrains of the Dharwar craton in the northern region, and the high-grade South Indian Granulite Terrain (SIGT) in the southern region, intersected by a network of major faults or shear zones. Within the SIGT, there is extensive evidence of magmatic activity, ranging from acidic to ultramafic intrusives. Notable examples include the layered anorthosite complexes of Sitampundi and Bhavani, as well as multiple occurrences of Precambrian mafic dyke intrusions, anorogenic carbonatite-syenite, alkaline mafic-ultramafic, and anorthosite units dating to the late Precambrian period (800-600 Ma). Field observations and structural studies conducted within the Bhavani shear zone (BSZ) indicate a history of multistage deformation, accompanied by multiple magma emplacements. The mafic and ultramafic rocks within the BSZ exhibit distinct field characteristics, reflecting variations in emplacement processes, as well as differences in post-emplacement deformation and alteration. Certain mafic dykes within the BSZ have been dated to approximately 1980±25 Ma based on 40Ar/39Ar, K/Ar, and Rb/Sr dating methods. The geochemical features of these complexes reveal the presence of cumulus/phenocryst olivine phases along with slightly enriched Large Ion Lithophile Elements (LILE) and depleted High Field Strength Elements (HFSE), characterized by prominent negative anomalies in Nb and Ti, which exhibit a typical arc signature. The pattern normalized to Mid-Ocean Ridge Basalt (MORB) of the amphibolite indicates depletion in HFSEs (such as Zr, Sm, Ti, and Y) and enrichment in LIL-elements (like Rb, Ba, Sr), with negative Nb anomalies suggesting the involvement of a subduction component in the depleted mantle source, indicating formation within a supra-subduction zone tectonic environment. Ultramafic rock samples from the Bhavani Shear Zone (BSZ) display a La/Nb ratio ranging from 1.78 to 8.77 with an average of 3.65, Ba/Nb ratios ranging from 7.68 to 278.67 (average of 71.57), and Zr/Ba ratios varying from 0.01 to 2.23 with an average of 0.28. Conversely, mafic rocks exhibit La/Nb ratios between 0.72 and 9.32, Ba/Nb ratios ranging from 4.84 to 75.87, and Zr/Ba ratios ranging from 0.03 to 0.60, with average values of 2.68, 27.56, and 0.24, respectively. These elemental ratios bear closer resemblance to Ocean Island Basalt (OIB) types, likely derived from a supra-subduction source. Furthermore, the tectonic discrimination, trace element ratios, and mantle source characteristics of these mafic-ultramafic complexes suggest a supra-subduction zone OIB mantle with a significant amount of upper crustal contamination. Certain mafic dykes exhibit characteristics of both OIB and Island Arc Tholeiite (IAT), indicating the possibility of multiple emplacement characteristics or mixing of pre-existing mantle sources during the late Archaean or Palaeo-Proterozoic period. This study, in conjunction with the correlation of other complexes, sheds light on the Paleoproterozoic process

of crustal amalgamation and suturing between the South Indian crust and the Dharwar craton.

Keyword

South Indian shield, Bhavani shear zone, Geochemistry, Petrogenesis, Supra-subduction

Geochemical characteristics of exsolved deep crustal aqueous fluid in a granitic system: Insights from the quartz reefs in the Bundelkhand craton, India

DIVYANSHI SHUKLA[1]*, Lucknow University (sdivva020@gmail.com)
Sarajit Sensarma[2], Lucknow University

Abstract

Understanding the deep crustal supercritical aqueous fluids and its dissolved accessory phases as an effective transport agent for trace elements and REE have been receiving much attention. The abundantly present ~2.0Ga quartz reefs (SiO2 >93wt%; quartzolite on IUGS classification plot), associated with Bundelkhand granitoid offer a suitable plutonic setting to study the evolution of exsolved Si-rich supercritical aqueous fluid in a silicic to intermediate magmatic system having a protracted history of approximately >300Myr. Here, we report for the first time on the chemical compositions of the primary mineral phases (quartz, zircon, magmatic epidote, Fe-Ti oxides, and mafic clots) present in quartzolite, and estimate the p-t history using multiple mineral calibrations compatible to silicic magmatic system in order to better constrain the emplacement depths and evolution for the exsolved silicate-dissolved fluid.

Chemical composition of quartz from both quartzolite and the granite-quartz reef contact have high Ti-content: Ti >100ppm, comparable to magmatic quartz of adjacent granitoid (Ti>100ppm), later subjected to low temperature dissolution-reprecipitation process with high Al2O3 (~2 wt.%), low Ti. Zircons have sub-rounded grain margins, yet still preserving the original euhedral prismatic character with Ca >1000ppm, Al >10000ppm and Fet >10000ppm, coupled with low Hf/Zr ratio (0.0072-0.2194) displaying characteristic of a hydrothermally altered magmatic zircon. Magnetite in the samples is rich in Ti (~22000ppm), Al (~10452ppm) and Mn (~132ppm). Vanadium-bearing rutile (V: ~7400ppm) have high Mg (~892ppm) though Mg is usually extremely incompatible to rutile; Al content (~5669ppm) also significant. Mg-rich rutile is usually characteristic of high-grade rocks of mantle origin. Magmatic epidotes in the rocks have comparable pistacite values (Ps: 0.27-0.33) and have trace amounts of MnO and MgO (≤ 0.304 wt.%). Mafic clots (look like chlorites) contain exceptionally high CaO up to ~25 wt.%, hitherto unknown in these rocks. Centimeters to meters thick contemporaneous mantle-derived carbonatitic dykes in the area may have contributed to high enrichment of Ca in mafic clots.

Combining results of Ti-in-quartz, rutile saturation temperature, Ti-in-Zircon, and diagnostic microstructures in the samples, temperature range of crystallisation from 1342ºC- 452ºC is obtained, i.e., a temperature interval of 900ºC, though xenocrystic zircon may have yielded >1000ºC, in compliance with zircon in adjacent granitoid. The estimated minimum temperature is notably below the granitic solidus (~700ºC), suggestive of a magmatic-hydrothermal origin.

Our results imply that crystallization progressed from hypersolidus condition to near hydrothermal precipitation. Euhedral magmatic epidotes supplemented by microstructural evidence suggest crystallisation depth at about 25-28 km for quartzolites (~8 kb), in coherence with results for adjacent granitoid (9-2 kb). Temperatures and pressure estimate thus point towards emplacement

of exsolved solute-rich aqueous fluid (quartz reefs) at deeper part of the crust unlike earlier suggestions of their shallow-level emplacement. Present study also provides some important results on elemental mobilization in a high P-T extremely silica-rich supercritical fluid in a plutonic setting, not much known in literature.

Keyword

crust, supercritical fluid, quartz reef, magmatic-hydrothermal, India

Intra-volcanic chain B isotope variations: a case study from the Chilean Central Andes

Osvaldo González-Maurel[1]*, Universidad de Concepción (osvgonzalez@udec.cl)
Sinethemba Ncetani[2], University of Cape Town
Petrus le Roux[3], University of Cape Town
Benigno Godoy[4], Universidad San Sebastián
Frances Deegan[5], Uppsala University
Dieter Garbe-Schönberg[6], CAU Kiel University
Inés Rodríguez[7], Universidad Católica de Temuco

Abstract

Boron (B) is an ideal geochemical tracer for hydration of the overlying mantle wedge at subduction zones. Magmatic B-isotope compositions are useful in detecting and quantifying exchange processes between the slab and mantle due to B-affinity for silicate melts and aqueous fluids with no significant isotopic fractionation during crystallization.

This study presents new and published whole-rock B-isotope data from eruptive units of volcanoes of the Pleistocene-Holocene San Pedro-Linzor Volcanic Chain in the Central Andes (west to east/youngest to oldest): La Poruña (21°53′S; 68°30′W), San Pedro (21°53’S, 68°23’W), Paniri (22°03’S, 68°13’W), and Toconce (22°11’S, 68°04’W). Our obtained δ11B values are relatively low (La Poruña: -1.39 to +0.94; San Pedro: -2.09‰ to +1.26‰; Paniri: -6.11‰ to +0.23‰; Toconce: -11.16‰ to -5.06‰) compared to mantle-derived magmas affected by fluids released by subducting altered oceanic crust (0 ‰ to 18‰). This is consistent with suggestions that such low δ11B values require a role for a 11B-depleted component, like MORB-mantle (δ11B = ca. -7.1‰) or Central Andean basement (δ11B = ca. -8.9‰). Since 87Sr/86Sr ratios from these volcanoes reflect significant degrees of crustal contamination, their low δ11B values likely also reflect contamination from low-δ11B continental crust.

Based on δ11B-87Sr/86Sr covariations (lower δ11B and higher 87Sr/86Sr values = more contamination vs higher δ11B and lower 87Sr/86Sr values = less contamination), our regional study reveals progressive lessening of crustal assimilation over time on three spatial scales: I. within individual eruptive units from early-erupted distal samples to later-erupted proximal samples (initial to final effusion); II. between stratigraphically older units to younger units within each volcano; and, III. from the older volcano located within the interior of the Altiplano Puna Magma Body (APMB), a large long-lived, mid-crustal melt zone, to younger volcanoes located progressively towards its edge, i.e., Toconce to Paniri and to San Pedro to La Poruña.

Keyword

Central Andes, Boron isotopes, Strontium isotopes, Crustal assimilation

The ~2.5 Ga peraluminous monzo-granite (north-central India) with superchondritic Zr/Hf and OIB-like Nb/Ta: constraints for role of mantle fluid in crustal evolution and crust-mantle interactions

Abhishek Kumar Madhesiya[1], Department of Geology, University of Lucknow, India
Sarajit Sensarma[2]*, Department of Geology, University of Lucknow, India
(sensarma2009@gmail.com)

Abstract

Magmatic-hydrothermal crystallization in the evolution of silicic magmatic system is of considerable importance. Co-magmatic metaluminous coarse monzogranite to quartz monzodiorite transition into peraluminous fine-grained phyric monzogranite to quartz monzodiorite in the 2.6-2.3 Ga Bundelkhand Granitoid (India) having a common plutonic history, with significantly higher proportions, perhaps >80%, of 'recrystallized-look' polygonal-amoeboid subgrain developed along early formed large quartz and feldspars boundaries (textural change), are concomitant to increasing thin mafic veins network (fluid activity) in the latter. Combining two-feldspar thermometry, TitaniQ, and accessory phase thermometry of the Bundelkhand granitoid covering nearly >26000 km2 in northcentral India, this work seeks to decode dissolution-precipitation in the late stage of crystallization with development of fine-grained peraluminous monzo-granites. Field observations refute to the development of any secondary foliation though quartz and feldspars 'recrystallized-look' polygonal-amoeboid subgrains; the latter formed during magmatic-hydrothermal crystallization (subsolidus). Microstructures (e.g., undeformed lamellar twined albite, zoned plagioclase with oligoclase rim, antirapakivi feldspar) of hypersolidus origin are preserved in the rock, even though magmatic-hydrothermal transitional crystallization may have inhibited it. In bulk compositions and trace elements including REEs concentrations both magmatic crystallization and dissolution-precipitation processes are deterministic; however, they differ showing increasing persistency in HFSE (e.g., Zr/Hf, Nb/Ta) and HREE behaviour during interaction with mantle-derived fluids. The superchondritic Zr/Hf (>40) and OIB-like Nb/Ta (14-16) suggest deeper eclogite/peridotite-sourced fluid-rock interactions, plausibly also linked to coeval carbonatite magmatism in the craton. Al-rich mafic vein network (mantle/crust-mantle-derived fluid) induced peraluminosity to the bulk rock.

The dissolution-precipitation process caused 'recrystallized-like' domains temperatures (≤ 600°C) well below known granitoid solidus (< 700°C), in tune with the temperature of Mn-rich ilmenite exsolved phase in Ti-rich magnetite pairs at about 500°-400°C. The phase equilibria support that the system is fluid-induced and bulk compositions shifted from water saturated cotectic line towards Qz-Or line on the Qz-Ab-Or system. The trace element showed consistent pattern; negative Ba- and Sr- anomalies do not suggest significant feldspar fractionation of the crystallizing granitoid, rather of deeper fluid-induced origin. Also, the presence of Nb-Ta-Ti negative anomalies in the N-MORB normalized plot is consistent with deep mafic source melt/fluid involved in granitoid crystallization. The F-bearing primary Fe-rich biotite and

accessory minerals (apatite, titanite, rutile) support that this deep fluid was reasonably F-rich as well. The data testify that the observed dissolution-precipitation was indeed as high-temperature process with active role of F-rich silicate-dissolved mantle-derived fluids. Usually hot fluids, which can be strongly halogen rich, precede asthenospheric mantle upwelling, which can be derived by their immiscible separation of mantle supercritical fluid into aqueous-silicic and mafic melts in addition with CO2-F-rich fluid/hydrous carbonatitic liquid; the mafic melts emplaced as intrusive dolerite and carbonatite dykes. Our previously published as well as the new data thus point to deep fluid of mantle / crust-mantle origin played a prominent role in the formation of peraluminous granitoid in Bundelkhand, unlike the commonly held model metapelites source, at the Archean-Proterozoic transition. The present contribution provides an evidence of hydrous mantle-derived fluids linked to wet-metasomatised subcontinental mantle in crustal evolution and chemical differentiation.

Keyword

Peraluminous granitoid, deep fluid, magmatic-hydrothermal, magma, India

Carbon-sulfur relationships in magmatic sulfide deposits: Implications for metal transfer between the mantle and crust

Shelby CLARK[1]*, Missouri University of Science and Technology (sct6m@umsystem.edu)
Marek Locmelis[2], Missouri University of Science and Technology
Dany Savard[3], Université du Québec à Chicoutimi
Marilena Moroni[4], University of Milan

Abstract

Most world-class magmatic sulfide deposits formed in the uppermost crust. Extending the search space for such deposits to exhumed mid-to-lower crustal rocks is an important goal of economic geology research. To guide the exploration for deep-seated deposits, it is important to constrain the processes that control metal transfer between the subcontinental lithospheric mantle (SCLM) and the overlying crust. One field area that allows to study the processes that control lower crustal sulfide ore-forming processes in outcrops is the Ivrea Verbano Zone (NW Italy), an exposed cross section of the SCLM and the overlying lower continental crust. The IVZ was intruded by a series of alkaline ultramafic pipes that host Ni-Cu-PGE-Te-Au sulfide mineralization locally intergrown with carbonates and hydrous silicates (i.e., phlogopite, amphibole). Previous studies of the best-preserved pipe at Valmaggia speculated that mantle sulfides might have attached to bubbles and were transported into the lower crustal Valmaggia pipe. To test this hypothesis, we integrated petrographical observations with mineral compositional data obtained by electron microprobe and laser ablation ICP-MS analysis from the Valmaggia pipe. Sulfides in the pipe display a wide range of textures from semi-massive to disseminated and blebby. Sulfide-associated carbonates either occur at the margins of large sulfide blebs or as inclusions in sulfides. Hydrous silicates commonly rim, or are intergrown with, sulfides. Blebby sulfides show heterogeneous unmixing in their rim portions adjacent to carbonates and/or hydrous silicates, characterized of increased concentrations of both lithophile and siderophile/chalcophile trace elements. Carbonate inclusions in sulfide blebs are generally Mn-rich calcite, whereas carbonates at the margins of large sulfide blebs are dolomite. Carbonates not in contact with sulfides are primarily Fe-rich magnesite. The three different modes of carbonate occurrence indicate that the carbonate composition is sulfide-dependent. The fractionation of carbonates (calcite-dolomite-magnesite) in spatial relation to the sulfides, as well as the trace element heterogeneity in sulfides, is interpreted to represent a co-precipitation relationship in which Ca/Ca-Mg carbonate and sulfide melts are entrained in an ascending metasomatic fluid/melt until becoming trapped in an olivine cumulate mush and co-precipitating in-situ. Such a model is distinct from the previously suggested bubble-pair transport model. Future work will be aimed at further unraveling the mechanisms that control carbon, sulfur and metal flux from the mantle into the crust and, consequently, the genesis of deep-seated ore deposits.

Keyword

Ivrea-Verbano Zone, sulfide mineralization, metasomatism, mantle carbon

Formation of amphibole rich selvege in high P mafic granulite and its relation with the regional hydration of CGGC

Somdipta CHATTERJEE[1]*, Jadavpur University (somdipta.chatterjee@gmail.com)
Sanjoy Sanyal[2], Jadavpur University
Pulak Sengupta[3], Jadavpur University

Abstract

Chotanagpur Granite Gneiss Complex (CGGC) predominantly consists of a vast area of felsic orthogneiss lithounits, formed by episodic felsic magmatism throughout the Proterozoic times. The study area situated in the eastern margin is also dominated by various felsic orthogneiss litho units. The felsic litho package also contains a minor amount of mafic units of distinctly different origins. One is enclave suite mafic rocks with profuse garnet, and leucosomal segregation, representing high P granulite facies condition of peak metamorphism. The other is mafic dyke intrusion within the felsic units, with rare garnet, thin grain size, and lack of leucosomes corresponding to a medium-pressure amphibolite facies metamorphism (6.5-7 kbar; 650-700 °C). Detailed study of lithology, petrography and mineral chemistry of the mafic granulite suggests that peak metamorphism has been accompanied by amphibole dehydration melting that resulted in leucosomal segregation of various types, in combination with profuse peritectic garnet at 12-13 kbar and 850-900 °C. The leucosomal segregations are rimmed by an amphibole-rich selvedge of variable thickness. Growth of such amphibole-rich selvedges at the interface between leucosome and melanosome is commonly interpreted as a product of hydration caused by quenching of the leucosomes. Though in-situ crystallisation of melt resulted in a relatively anhydrous assemblage and limited melt loss suggests that the melt-released fluid probably played a role in the amphibole selvedge formation, several features suggest that these selvedges are the results of an independent infiltration-driven metamorphic event. Features include, (a) pervasive growth of amphibole in both leucosome and melanosome, and both are affected by extensive hydration, (b) absence of internal deformation of amphibole and replacement of recrystallised grains in the leucosome by amphibole, (c) hydration induced over a large volume of rock cannot be explained by a relatively small proportion of melt (<15%) suggest fluid infiltration from an external source, which is facilitated along structurally weak zone (e.g. interface between leucosome and melanosome). Amphibolte facies metamorphism of the mafic dyke is identical to the P-T condition of amphibole selvedge formation of the mafic granulite. In CGGC, similar hydration is observed in other parts of the CGGC and the host felsic orthogneisses and signifies a major metamorphic event that represents a continental collisional tectonic setup during the long Tonian period. Such a regional extent of fluid infiltration suggests a relatively large quantity of fluid in the lower crustal conditions. Such a large quantity of regional fluid infiltration probably indicates a mantle source of the fluid.

Keyword

fluid-infiltration, mafic granulite, amphibole selvedge, CGGC

Whole rock geochemistry and isotopic constraints on the mafic-ultramafic rocks of the Madawara Igneous Complex, Bundelkhand Craton (central India)

Abhishek Kumar PANDEY[1]*, Indian Institute of Science Education and Research (IISER), Bhopal (bhu.manuabhi3@gmail.com)
Arundhuti Ghatak[2], Indian Institute of Science Education and Research (IISER), Bhopal

Abstract

The Madawara Igneous Complex (MIC) in the southern part of the Bundelkhand Craton is composed of a plutonic sequence of ultramafic-mafic rocks, surrounded by metamorphosed volcano-sedimentary supracrustals (e.g., pillow basalts, banded iron formations) and tonalite-trondhjemite-granodiorite gneisses (TTG). The sill-like ultramafic-mafic rocks are represented by dunite (now serpentinized), pyroxenite, gabbro, and pegmatitic gabbro. Whole-rock Sm-Nd analysis of the plutonic sequence gives a TDM age of serpentinized dunite and pyroxenite of 3.70 Ga–3.34 Ga (avg. 3.50 Ga), while the gabbro and pegmatitic gabbro ranged from 3.41 Ga–2.90 Ga (avg. 3.19 Ga). Large uncertainties in crystallization ages may be due to perturbation of the Sm-Nd system caused by 2.7 Ga amphibolite-facies metamorphism, as well as the latter magmatic intrusions that are reported from the Central Bundelkhand Craton. The whole-rock Pb-Pb isotopic system is also perturbed, which is possibly influenced by intrusive magmatic activity such as the emplacement of mafic dykes at 1.98 Ga, 1.8 Ga, and 1.0 Ga in the craton.

Comparison of major and trace elements of the studied rocks with global data of komatiite and komatiitic basalts from Archean greenstone belts suggests similarity of the serpentinized dunite, pyroxenite, and gabbro-pegmatitic gabbro with komatiite, komatiitic basalt, and tholeiitic basalt, respectively. Well-constrained positive correlations of major and trace elements with MgO (wt%) and the nearly parallel trend of the studied rocks with global fractionation trends of komatiites to komatiitic basalts indicate the ultramafic rocks formed through fractional crystallization processes and may thus be genetically related, while the mafic rocks seem to be formed as a different group of rocks with a younger emplacement age than the ultramafic rocks. Archean greenstone-belt rocks experience multiple episodes of metamorphic and low-temperature hydrothermal alteration events. However, plots of Ti vs. other trace elements suggest that element mobility was restricted for most elements, except for LILEs (such as Ba and Pb) that show a larger scatter. Trace-element modelling, as well as ratios such as Th/Yb, Th/La, Zr/Y, and Nb/Y, all helped to filter out the effects of crustal contamination. Positive εNd(TDM) (2.26 to 3.97) indicates an initially depleted magma source. Chondrite-normalized REE plots exhibit super-chondritic LREE [ultramafic: (La/Sm)N = 2.1-2.9; mafic: (La/Sm)N = 2.02 to 2.35] patterns, with flat to slightly depleted HREEs [ultramafic: (Gd/Yb)N = 1.02 to 1.39; mafic: (Gd/Yb)N = 1.8 to 2.1]. Two distinct magma sources of the examined rocks are established by various bivariate plots and the REE pattern, which indicate that the ultramafic rocks originated from a spinel lherzolite source, and the mafic rocks originated from a deeper spinel-garnet mixed source. The LREE-enriched patterns, along with the negative anomalies shown by the HFSEs (Nb, Ti, and Ta) and enrichment of trace

elements like Th, Pb, and U, suggest derivation of the magmas from subduction zone settings, where the mantle was contaminated by slab-derived fluids.

Keyword

Madawara Igneous Complex, sill-like ultramafic-mafic unit, subduction

PETROGENESIS OF MIGMATITES AND LEUCOGRANITE FROM MAIN CENTRAL THRUST ZONE IN AND AROUND MUNSIARI, KUMAUN HIGHER HIMALAYA

CHITRA JOSHI[1]*, Kumaun University, Nainital (chitrajoshi.333.jk@gmail.com)

Abstract

PETROGENESIS OF MIGMATITES AND LEUCOGRANITE FROM MAIN CENTRAL THRUST ZONE IN AND AROUND MUNSIARI, KUMAUN HIGHER HIMALAYA

Author: Chitra Joshi
Organization: Kumaun University, Nainital
E-Mail: chitrajoshi.333.jk@gmail.com

The Himalayan belt extends laterally about 2500 km from west to east with 250-300 km width have undergone deep burial, deformation, remobilization, metamorphism and Tertiary
Leucogranite intrusions due to the active collisional tectonics between Indian and Eurasian plate. The relationships among the migmatization, evolution of Higher Himalayan Crystallines (HHC) and generation of leucogranite in the HHC in the tectonic and time framework have been one of the major fields of petrological interests in Himalayan geodynamics. The leucogranite magmas are interpreted to have been derived by melting of pelitic/metasedimentary rocks commonly found in the upper portions of thickened crust. Geochronology of migmatites is complicated by the complex behavior of accessory mineral chronometers in melt-bearing rocks. An interesting feature of the Himalayan leucogranites is extreme heterogeneity in Sr isotope ratios, even in the scale of outcrop, such that reliable Rb-Sr isotopic ages are difficult to obtain.
Miocene granites and migmatites are some of the most studied features of the Himalayan Tibetan Orogen. They are central to understanding its evolution and the basis for many evolutionary models. Their relative timing in relation to major structures, the origin of the heat source for melting and the tectonic impact of melting, are fundamental to understanding the Orogen. Establishing the protolith of migmatites is important for understanding the tectonic history of high-temperature metamorphic terranes. However, the most important use of wholerock geochemistry in migmatites is to understand the various open- and closed-system processes that operate in the anatectic crust. Whole-rock compositions of the residue compared with the unmelted protolith can be used to calculate the amount and composition of extracted melt as well as to evaluate the mobility of elements in anatectic systems.

Keyword

Leucogranite, Protolith, Migmatite, Anatectic, Orogen

New occurrence of carbonatite in the Kudakkal area of Pakkanadu-Mulakkadu Alkaline Complex, Tamilnadu, Southern India.

RAJENDRA PRASAD KANCHI[1]*, DEPARTMENT OF GEOLOGY, UNIVERSITY COLLEGE OF SCIENCE, OSMANIA UNIVERSITY, HYDERABAD-500007, INDIA. (rpkanchi143@gmail.com)
K Sreenu[2], Department of Geology, UCS, Osmania University, Hyderabad, India-500007
Sunki Amarendhar[3], Department of Geology, UCS, Osmania University, Hyderabad, India-500007
Santosh Kumar[4], 2. Department of Geology, Center of Advanced Study, Kumaun University, Nainital.
Madabooshi Srinivas[5], Department of Geology, UCS, Osmania University, Hyderabad, India-500007

Abstract

A new occurrence of carbonatite at Kudakkal in the Pakkanadu-Mulakkadu Alkaline Carbonatite Complex, Tamilnadu. The carbonatite occurs within the alternate bands of pyroxenite. The carbonatite exhibits pale pink to white (colourless) colour and is composed of calcite (80% modal volume), pyroxene, amphibole, olivine, mica (phlogopite), and opaques. The presence of mafic-rich (olivine, pyroxene, amphibole, mica) cumulate segregations and euhedral phenocrysts indicate that magma stored at deeper chamber and underwent partial crystallization before emplacement. The carbonatite has a high CaO various from 34 to 37 wt%, SiO2 various from 14 to16 wt%, and has high LREE to HREE with high sum of the REE content (1472 to1731 ppm), which classifies them as calcio-carbonatite or sovites. The enrichment of Sr over Rb is a hallmark feature of calico-carbonatite and the stable isotope (δ18OV-SMOW and δ13CV-PDB) values range from -5 to -8 and 7 to 8 respectively. The distinctive δ13C signatures confirm the primary nature and mantle origin for these carbonatites. There is a lack of systematic correspondence between δ13C and δ18O values. The O and C isotopic values correspond with mantle values mainly calico-carbonatites. Geochemical signatures and field relations of the Kudakkal carbonatites are associated with pyroxenite and syenites which indicates that a carbonated alkali magma from which carbonatite are derived by liquid immiscibility and confirms their origin from a mantle source.

Keyword

Geochemistry, Carbonatite, Pakkanadu-Mulakkadu Alkaline Carbonatite Complex, Tamilnadu, India

Melt inclusions study on Chamundi granite from southern India: Entrapment conditions and compositions

MOHD AQIB[1]*, Department of Studies in Earth Science, University of Mysore, India (aligaqib@gmail.com)
K.G. Ashamanjari[2], DOS in Earth Science, University of Mysore, Mysore, India
Sakthi Saravanan Chinnasamy[3], Department of Earth Sciences, Indian Institute of Technology Bombay, Powai, Mumbai, India
Mohd Qaim Raza[4], Department of Earth Sciences, Indian Institute of Technology Bombay, Powai, Mumbai, India

Abstract

Chamundi granite (CG) is an anorogenic plutonic rock with a highly varying grain size. It shows very coarse-grained porphyritic granite to very fine-grained aplite. These variations in grain sizes represent the genesis and depth of granite formation. This granite intrudes into the associated Peninsular gneisses at a prominent landmark place called Mysore. This intrusion exhibits a sharp contact with gneisses, and that gives evidence of contact metamorphism. The CG contains composite plutons or plutonic complexes, ranging in composition from undifferentiated quartz granites to K-feldspar granites to extremely evolved granites containing biotite-mica.

The CG exhibits several types of structures like platy or planar, flow lines, joints, as well as small intrusions are well exhibited in this granite with a number of quartz veins. The youngest rock in the Dharwar supergroup area relates to the anorogenic Chamundi granite intrusion at 790 Ma (Crawford, 1969), which also reflects a zircon, U-Pb age of 800 Ma of the Closepet granite which indicates that this granite has perhaps several age components. The granites of this region contain abundant melt and fluid inclusions, and these are potential candidates for contrasting melt and fluid composition and granite emplacement conditions.

In the present study, melt inclusions (MI) were identified in the granites based on colour i.e. brown to black and granular texture. The diameter of MI ranges from 10 to 20 μm and, at times goes up to 100 μm.

Outermost portion of some MIs of the crystal contain devitrified glass. Microthermometric studies were carried out in the MIs of the CG, they are generally crystalline and appear glassy which shows textural differences and must be homogenized before analysis. After heating experiments, we observe three MI types (A, B, and C) in quartz based on homogenization temperatures and composition. Type-A, -B and -C with their homogenization temperatures are <800°C, 800 to 1000°C and 1000 to 1200°C respectively. Wide temperature variations must be reflecting wide compositional differences in MIs from Chamundi granite, India.

Keyword

Chamundi granite, Closepet granite, Melt inclusions, Volatiles, Evolution in Western Dharwar

Craton

[Keynote] The Panjal Traps: a synthesis

Greg Gregory SHELLNUTT[1]*, National Taiwan Normal University (jgshelln@ntnu.edu.tw)

Abstract

The Panjal Traps are composed of basalt with subordinate silicic volcanic rocks. Zircon U-Pb dating of the silicic (289 ± Ma; 287.2 ± 2.5 Ma; 287.3 ± 2.8 Ma) and mafic (288.2 ± 0.3 Ma) rocks confirm their Early Permian eruption age. The initial basalt eruptions from the eastern Kashmir Valley and Lidder Valley have chondritic Sr-Nd isotopes (87Sr/86Sri = 0.7043 to 0.7073; εNd(t) = -1.4 to +1.3) whereas the later flows have a wide range of Sr-Nd (87Sr/86Sri ≥ 0.7083; εNd(t) = -6.8 to -1.5) isotopic values. The basalt from the northern Pir Panjal Range are compositionally similar to ocean-floor basalt (87Sr/86Sri = 0.7081 to 0.7172; εNd(t) = +2.4 to +4.3) whereas the basalt from the southern Pir Panjal Range are similar to rocks from eastern Kashmir Valley (87Sr/86Sri = 0.7086 to 0.7110; εNd(t) = -6.1 to -4.4). Os- and O-isotopic data confirm that the northern Pir Panjal Range rocks are distinct (δ18OVSMOW = 6.8-7.9‰; 187Os/188Osi = 0.1230-0.1256) from others regions of the Panjal Traps (δ18OVSMOW = 9.0-12.9‰; 187Os/188Osi = 0.1343-0.2832) and indicate that they may be derived from different mantle sources. The silicic volcanic rocks were derived by partial melting of the Himalayan crust (87Sr/86Sri = 0.7073 to 0.7119; εNd(t) = -7.2 to -8.9) as they contain Early Paleozoic to Archean inherited zircons. The primary melt composition of the basalt from the northern Pir Panjal Range is picritic and have mantle potential temperatures (TP) of 1400-1450oC. The early lavas erupted just after the retreat of the Late Paleozoic Gondwanan ice sheet within a continental rift setting that eventually transitioned into a nascent ocean basin and formed of Neotethys Ocean.

Keyword

Flood basalt, Kashmir, Permian, Cimmeria, Continental Rift

Molybdenum isotopes in intraplate basalts record slab-mantle interactions in Earth's deep mantle

WEI FANG[1]*, University of Science and Technology of China (wfang15@ustc.edu.cn)
Li-Qun Dai[2], University of Science and Technology of China
Zi-Fu Zhao[3], University of Science and Technology of China

Abstract

Existing Mo isotope data shows that intraplate basalts have highly variable Mo isotopes. However, the heterogeneity of Mo isotopes in intraplate basalts was interpreted to be inherited from recycling of different slab components, and the related slab-mantle interaction processes remains unclear. We synthesize Mo isotope and other geochemical data for global intraplate basalts, which provide insights into Mo recycling in Earth's deep mantle. Global intraplate basalts display highly variable δ98Mo values of -0.84‰ to 0.10‰, suggesting mantle Mo isotopic heterogeneity. Most of the basalts have low δ98Mo values and high Ce/Mo ratios that are similar to those of the oceanic eclogites, indicating that recycled dehydrated oceanic crustal components were involved in their mantle sources. However, some intraplate basalts have heavy Mo isotopes. This reveals that shallow slab components were dragged by the downgoing slab and have carried heavy Mo isotopes into the deep mantle. Significantly, high δ98Mo values of these basalts are associated with low Ce/Mo ratios, high fluid-mobile element contents, and depleted radiogenic Sr-Nd isotopes. Given that recycled basaltic oceanic crust and sediment are generally efficiently dehydrated during subduction and sequester light Mo isotopes, subducted serpentinised lithospheric mantle is a plausible candidate to transfer fluids with heavy Mo isotopes into the deep mantle. Thus, Mo isotope systematics of intraplate basalts record complex geochemical fluxes from subducting slab to the deep mantle, in which subducted serpentinites play an important role in the Mo isotope recycling. Our study highlights the effectiveness of Mo isotopes as indicators for slab-mantle interactions in Earth's deep mantle.

Keyword

Molybdenum isotope, Intraplate basalts, Subducted serpentinite, Mantle heterogeneity, Crust-mantle interaction

Geochemical characterization of Jonnagiri greenstone belt of eastern Dharwar craton, India: Insight into the crustal evolution of Jonnagiri greenstone terrane.

Saumyodeep DAS[1]*, Indian Institute of Technology Bombay (smdpds@gmail.com)
Sakthi Saravanan Chinnasamy[2], Indian Institute of Technology Bombay

Abstract

The Jonnagiri greenstone belt (JGB), located in the eastern Dharwar craton of southern India, stands out as a distinctive and economically important greenstone belt. The greenstone sequence of Jonnagiri comprises of metabasalts, meta-felsic volcanics, and schistose meta-tuffs collectively encircled by granitoid intrusives. One of these intrusives are unique as it hosts orogenic-type gold deposit, particularly within the Dona sector of the JGB. Our current research is dedicated to investigate the greenstone sequences of the JGB, focusing on their geochemical evolution and deciphering their tectonic settings. The geochemical study involves the distribution patterns of major and trace elements to understand the petrogenetic processes and tectonic evolution of the area. Petrographic analysis reveals the presence of amphibolites (metabasalts) and meta-felsic volcanic rocks (ranging from meta-rhyolite to meta-rhyodacite), along with schistose rocks such as quartz-sericite-schist and talc-chlorite-schist. Various geochemical discriminant diagram suggests that the rocks are subalakliine in nature and showed varying trends in the Harker diagrams depicting a variable calcic, sodic and potassic content and magnesian deficient characteristics. The reason of the variability can be attributed to metamorphism and the limited extend of hydrothermal alteration. The trace element distribution, behaviour supports a minimal influence from hydrothermal alterations, exhibited by a weak elemental mobility. The metabasalts and meta felsic-volcanics showed depletion of HREEs over LREEs with evident negative Nb-Ta, Zr, Ti and Yb anomaly suggesting their high incompatible nature during the mantle melting process and factional crystallization. The tuffaceous schistose rocks exhibited fractionation of MREE over LREE/HREE due to fractionation from amphibole phase and depletion of Nb-Ti is prominent. All these characteristics indicates a subduction driven activity. Previously proposed tectonic models show an arc-back-arc settings for the Jonnagiri metabasites, indicating a back-arc type of tectonic setting adjacent to the main arc. Elemental distribution patterns and ratios, particularly Zr/Nb and Nb/Th, confirms that the mantle source for the JSB is likely from wedge melting, with varying tectonic regimes ranging from arc to back-arc or forearc settings. Observations from Th/Nb and Nb/La confirm crustal-lithospheric contamination and proxies from Th-Nb indicates involvement of mantle-crustal interaction. Geochemical signatures reveal typical characteristics of island arc basalts (IAB), with enrichment of LREE, LILE, and Pb, and depletion of HREE and HFSE due to fluid mobile scavenging during subduction. In conclusion, the JSB likely underwent subduction-related processes, including crust-mantle interactions, crustal recycling, and plume contamination, contributing to their diverse tectonic signatures.

Keyword

Eastern Dharwar craton, Jonnagiri greenstone belt, Geochemistry, Subduction, Crust-mantle interaction

Subduction of an oceanic plateau and its effect on magmatism through the analysis of melt inclusions: The case of the Hikurangi plateau subduction in the Kermadec arc

Raimundo Brahm[1]*, Victoria University of Wellington (raimundo.brahmscott@vuw.ac.nz)
Monica Handler[2], School of Geography, Environment and Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington, 6140, New Zealand
Richard Wysoczanski[3], National Institute of Water & Atmospheric Research, 301 Evans Bay Parade, Hataitai, Wellington, New Zealand
Frank J. Tepley III[4], College of Earth, Ocean, and Atmospheric Sciences, Oregon State University, Corvallis, OR, USA
Bruce Charlier[5], School of Geography, Environment and Earth Sciences, Victoria University of Wellington, PO Box 600, Wellington, 6140, New Zealand

Abstract

The geochemical characteristics of primary arc magmas are the product of the particular conditions and interactions of the subducted slab and the source mantle wedge. Incompatible trace and volatile elements are transferred from the slab to the source mantle through the release of a liquid phase (fluids, melts and/or supercritical liquids). The composition and nature of the slab liquid is in turn controlled by the physical and geochemical characteristics of the slab layers. Studies of along-arc geochemical variations have shown some correlations with progressive changes in the subduction architecture (e.g., subduction rate, sediment cover).

In some cases, abrupt changes in subduction conditions occur along a single subduction setting that can considerably affect magma genesis. One of these cases is the subduction of oceanic plateaus. The Kermadec arc represents this unique case, where the subduction of the thick (15-23 km) Hikurangi plateau in the southern section of the arc (south of c. 35°S) contrasts with the subduction of the thin oceanic crust of the Pacific plate.

In this study we analyze major and trace element compositions of olivine-hosted melt inclusions found in dredge samples collected along the Kermadec arc. The objective is to identify the effect that the subduction of the thick Hikurangi plateau has on magma genesis, by comparing the geochemical signatures of volcanic products generated by the subduction of a normal oceanic crust and a thickened oceanic plateau.

Keyword

subduction zone, petrogenesis, primary magma, arc magmatism, large igneous provinces

THE USE OF AEROHYPERSPECT DATA FOR THE DETECTION OF HYDROTHERMAL-METASOMATIC ROCKS AS INDICATORS OF SOLID MINERALS Kirsanov A.A. Lipiyainen K.L., Smirnov M.Yu., Kirsanov G.A., Khimchenko P.V., Tkachenko M.A. (Karpinsky Institute, St. Petersburg, RUSSIA)

Aleksaandr Andreevich KIRSANOV[1]*, Institut Karpinskogo (Aleksandr_Kirsanov@vsegei.ru)
Koncstantin Lvovich Lipiyainen[2], Karpinsky Institute,
Mihail Yurevich Smirnov[3], Karpinsky Institute,
Maxim Aleksandrovich Tkachenko[4], Karpinsky Institute,
Pavel Vladimirovich Khimchenko[5], Karpinsky Institute,

Abstract

Currently, experimental and methodological studies are being conducted at the A. P. Karpinsky Geological Institute to identify areas of hydrothermal-metasomatic rocks in order to predict potentially promising areas for the search for solid minerals. The work is based on the application of spectral analysis of hyperspectral aerial photography data in the spectral ranges: visible, near and middle infrared (380-2500 nm), with 625 channels.

The research includes a technological chain that includes a number of sequential works: - conducting an area aerial survey with an aviation hyperspectrometer; - preliminary processing of aerial survey materials; - creation of a hyperspectral remote basis (GDO) based on aerial survey materials for the work area; - field spectrometry of rocks using the PSR+ spectroradiometer (spectral range 350 nm – 2500 nm, 1024 channels); - creation of a library of rock spectra - spectral analysis of GDO using a library of spectra to identify hydrothermal-metasomatic rocks; - creation of a scheme for the spatial distribution of hydrothermal-metasomatic rocks as indicators of minerals; - analysis of the scheme using geological, geochemical, mineralogical and geophysical data to identify (localize) potentially promising areas for solid minerals.

The most effective methods for extracting information contained in hyperspectral images are specially developed algorithms and methods that involve comparing the spectrum of an image pixel with the reference spectrum of a mineral. It seems that a multi-stage information processing scheme with cascading use of various algorithms should give the best results. Algorithms were developed aimed at solving the following tasks: - isolation of indicator minerals and their display in the form of figurative dots and halos; - identification of spectrometric halos by a complex of minerals as search signs for the identification of minerals; - detection of hydrothermal-metasomatic rocks by spectra obtained as a result of spectrometry of rock samples selected within ore fields and/or deposits; - identification of a specific association of indicator minerals for a certain type of minerals; - identification of hydrothermal-metasomatic rocks by mineral associations.

The following are selected as indicator minerals of near-ore metasomatites: - propylitization: feldspar (albite) + carbonate + chlorite + epidote + sericite; - beresitization: quartz + sericite + pyrite; - hardening: quartz; - sulfidization: pyrite; - kaolinization: kaolinite.

Halos of near-ore rock changes (propylitization, berezitization, acidification and sulfidization) have been identified for the Kuznetsovsky site. The probabilistic scheme of spectrometric halos of near-ore metasomatites reflects their model distribution in accordance with geological data - spatially convergent hydrothermal transformations of ore-bearing rocks (propylitization and berezitization) form halos in the crushing zones of intrusive rocks of the Kogtakh complex in the vicinity of the Vostochnoye and Kuznetsovskoye deposits.
At the May site, the probabilistic scheme of spectrometric halos of near-ore metasomatites presents a model of their distribution, which correlates with geological materials. The halos of propylitization and berezitization, which are natural, are developed by effusions of medium-basic composition and subvolcanic rocks of the Azyrtalsky complex and cover the most extensive areas in the vicinity of the Mayskoye and Tibekskoye deposits. They are associated with halos

Keyword

hydrothermal-metasomatic rocks, solid minerals., hyperspectral, halos,, deposit

[Keynote] Oceanic propagators and the formation of oceanic crust in divergent margins

Webster Ueipass Mohriak[1]*, State University of Rio de Janeiro - UERJ (webmohr@gmail.com)

Abstract

Oceanic crust can form mid-ocean spreading ridges in various tectonic settings, including divergent, transform, and convergent margins. The development of continental margins in the South Atlantic is a diachronous process associated with oceanic propagators. The Santos Basin, the largest salt basin in the South Atlantic, is a unique region that provides insight into the role of oceanic propagators in the development of conjugate divergent margins in southeast Brazil, southern Angola, and Namibia. The incipient oceanic ridges formed an oceanic propagator in the southernmost South Atlantic that advanced from the Pelotas Basin and penetrated the continental crust of the southern Santos Basin. The marine incursions in the Aptian Gulf resulted in the precipitation of evaporite sequences associated with a Late Aptian transitional phase. The oceanic propagator advanced northward and started to split the salt basin during the Late Aptian or Early Albian, but it was aborted and shifted eastward, forming the Mid-Atlantic Ridge. As a result, most of the salt basin was left on the Brazilian margin, and only a narrow region in the distal margin of southern Angola records thick salt masses in the Namibe Basin.

Some deeps in the axial trough of the central Red Sea exhibit incipient spreading ridges associated with neo-formed oceanic crust. Mabahiss Deep in the northern Red Sea is a possible analog for salt basin splitting by oceanic ridges formed in the past 5 million years. In the southern Santos Basin, geophysical methods suggest a possible oceanic ridge associated with the Florianópolis Fracture Zone. Plate reconstruction of the South Atlantic salt basins in the Albian reveals that the aborted spreading center developed neo-formed oceanic crust, separating two salt provinces in the Santos Basin. The interpretation of regional seismic reflection lines in the southern Santos Basin supports the model of an incipient spreading center that advanced northward in the Late Aptian and was aborted in the Early Albian. This caused a clear V-shaped depression in the crust that separates the asymmetric salt masses in the Santos Basin and the conjugate margin in Angola.

Keyword

oceanic propagator, oceanic crust, Red Sea, Santos Basin, South Atlantic

Significance of Chrome-spinel chemistry in mafic-ultramafic rocks of Pauni and Taka areas, Western Bastar craton, Central India: Implication for their tectonic setting

RAJKUMAR RAMDAS MESHRAM[1]*, Geological Survey of India
(rajkumar_meshram@rediffmail.com)
Vivek P Malviya[2], Geological Survey of India
G Gopalkrishna[3], Geological Survey of India
Mohammed Shareef[4], Geological Survey of India
Tushar M Meshram[5], Geological Survey of India
M L Dora[6], Geological Survey of India
S R Baswani[7], Geological Survey of India

Abstract

Chrome-spinel occur as accessory grains or layers in ultramafic, mafic and related rocks of different geological environments and have distinct chemical composition, linked primarily to their parental magmas. Chromite in mafic-ultramafic and related rocks reveals the magma chemistry and source rock characteristics as well as mechanism of operative mantle processes viz., tectonic provenances. The mafic-ultramafic rocks of Pauni and Taka area occurred as small linear to lensoidal bodies within granite gneisse and chlorite schist. The ultramafic rocks are represented by talc-tremolite-chlorite schist, serpentinite, chromitite, peridotite and talc-treolite-serpentine schist. The serpentinite and associated talc-tremolite-chlorite ± serpentine schist occurs as enclaves and small lensoidal bodies within granite gneiss around Taka area, western Bastar craton, Central India. Serpentinite and talc-tremolite schist consists of chromite in the form of fine dissemination, cumulates and at places as bands. Chrome spinel is black to dark brown, euhedral to subhedral and equant crystals. At places occurs as anhedral and highly fractured crystals. The fractures are filled by secondary quartz-carbonate, talc and serpentine matrix. Petrographically, ultramafic rocks are made up of talc, tremolite, chlorite with minor serpentine and chrome spinel in the different forms. Serpentinite is medium grained and show mesh and hour glass textures. Mesh rims are of fibrous serpentine (lizardite) and magnetite. Cr-spinel are oxidized to ferritchromite to magnetite, but the chrome spinel retains their primary composition. In EPMA study, Chrome-spinel from both the areas contain high Cr # from 0.70 to 0.94 wt %, Mg# from 0.32 to 0.61 wt %, TiO2 from 0.04 to 0.23 wt % (low to high) and Fe3+ from 0.01 to 0.05 wt %. The tectonic discrimination diagram such as Al2O3 vs TiO2 and Al2O3 vs Fe2+/Fe3+ suggests suprasubducion zone (SSZ) peridotite field. High Cr# and low TiO2 indicate arc tectonic settings and probably were formed in the mantle beneath fore arc tectonic setting. Parental magma compositions of this high Cr- spinel specify the reaction between boninitic melts and depleted peridotites that generated by partial melting in deep mantle. High Cr#, high Mg# and low SiO2 indicate primary composition for Cr-spinel and low TiO2 values are typical of ophiolitic chromitite. The above chemical characteristics of the chromitite indicate that they are of typical Cr-rich podiform chromitites. Cr-spinel from studied areas are primary in composition, formed in

the 550ºC to 500ºC temperature and in green schist facies metamorphism. During the late-Archaean time, the subduction of oceanic crust beneath continental margin produces mafic melt in arc type tectonic setting.

Keyword

Cr-spinel, mafic-ultramafic, suprasubducion, Bastar craton, Central India

A Study on the Volatiles of Monogenetic Volcanoes, Jeju Island, South Korea

MINJAE KANG[1]*, Osaka Metropolitan University (kmh2928@naver.com)
Takayuki Ushikubo[2], Kochi Institute, JAMSTEC
Kenji Shimizu[3], Kochi Institute, JAMSTEC
Ung San Ahn[4], World Heritage·Mt. Hallasan Research Institute
TETSUYA SAKUYAMA[5], Osaka Metropolitan University

Abstract

Various petrogenetic models regarding the origin of Jeju magmatism have been proposed, such as diapiric ascent from the depleted asthenospheric mantle (Tatsumi et al., 2005), contribution of a subducted oceanic crust indicated by the δ18O values of the basaltic lava samples (Kim J.I., 2023) and so on. Volatile components such as H2O or CO2 are known to play a crucial role in the mantle melting process. However, there is no comprehensive study on primitive volatile contents in the Jeju basalts, yet. Melt inclusion (hereafter MI), trapped within phenocrysts, can contain primitive melt composition, particularly volatiles, if MIs were trapped before degassing. In this study, we focus on MIs in olivine phenocrysts from Jeju scoria samples collected from Seondol (~95ka, JS07) scoria cone, located in the eastern region of Jeju Island. Samples were subjected to analyses of whole-rock major element compositions, major element compositions of host olivine and MIs, and volatile element concentrations (H2O, CO2, F, S, Cl) of MIs. The main purpose of this study is to find out the volatile contents of the primary melts and understand the petrogenesis of the Jeju basalt.

Volcanic rocks of Jeju Island have been classified into three types, having distinct parental magmas (Tatsumi et al., 2005): High-Alumina Alkali (HAA), Low-Alumina Alkali (LAA), Sub-Alkali (SA). The whole-rock compositions of JS07 scoria is intermediate between LAA and SA. On the other hand, the compositions of MIs are broadly scattered ranging from LAA to SA despite a single scoria unit. The effect of crystal fractionation on the major element compositions of the MIs was investigated using the chi-square test, and it was found that there are at least seven parental magmas to reproduce the broad chemical composition of the MIs.

At the root of the differentiation trend in LAA, parental magmas (LPM-1, 2) exhibit a minimum of 1.0 wt% H2O and 1,000 ppm CO2. However, other LPMs, such as 3, have undergone significant degassing of volatile components, while 4, despite its low H2O content, exceeds 2,100 ppm in CO2. In the case of SA, all parental magmas (SPM-1~3) contain at least 0.8 wt% H2O and 1,000 ppm in CO2.

To evaluate the influence of the subducted oceanic plate, we compared the volatile contents and ratios (H2O/F and Cl/F) of the primitive melts obtained from this study with those of MORB and basalts from Japan (Kuritani et al., 2021). The results indicate that Jeju MIs exhibits higher in halogen concentrations, as well as H2O/F and Cl/F ratios compared to MORBs. The ratios are rather similar to those of the Gotō Islands, which are 200km away to the east of Jeju Island. This result suggest that source mantle of Jeju magma has been influenced by the subducted oceanic

plate.

Keyword

Jeju, Monogenetic, Volcano, Volatile, Ocean plate

Trindade-Martin Vaz Archipelago petrological evolutionary insights recorded in fassaitic greencore clinopyroxene and REE evolutionary trends

Anderson SANTOS[1]*, Rio de Janeiro State University (andersonsantos@dmpi.com.br)
Eduardo Júnior[2], UFBA
Gabriela Rodrigues[3], UFRRJ
Mauro Geraldes[4], UERJ
Thais MOTHÉ[5], UERJ

Abstract

Mantle sources may be subject to distinct modifications due to the variable possibilities of magma generation and changes in the mineral chemistry recorded in melt and fluid inclusions. Melting infiltration in the sublithospheric-lithospheric mantle and further enrichment in light rare-earth elements and volatiles (e.g., F, Br, Cl, H2O, CO2) is an important mechanism associated with mantle metasomatism, which process has been invoked to explain REEs enrichment, carbonatitic and/or silicatic paragenesis besides highly alkaline signature in volcanic rocks mainly in ocean island basalts. Mineralogy is a crucial study to interpret magmatic evolution and to understand thermodynamic process during fractional crystallization. Some features marked in mineral history reveal several magmatic processes that allow us to elaborate hypotheses to elucidate an evolutionary model. Feldspars and pyroxenes present an extensive window of crystallization and compositional variation depending on physical parameters such as oxygen fugacity, pressure, temperature, and chemical composition (P-T-X-M). These possible parametric changes are to be associated with time that allow the minerals to register, in their crystalline structures, physical-chemical modifications. The Brazilian southeast margin presents a ca. 1,200 km long alkaline volcanic complex composed of over 30 seamounts, banks, guyots and islands aligned in the W-E direction at the Espirito Santo State parallel (20º S). Seamounts, banks and guyots present volcanic rocks characterized by OIB-like rocks presenting LREE enrichment as well as isotopically heterogeneous mantle source related to a mixing of depleted (DMM) and enriched mantle sources (HIMU, EMI and EMII) with minor constitution of FOZO and C mantle components. We propose an evolutionary model for the youngest Brazilian volcanism and distinguish both islands, Trindade and Martin Vaz, as two different contemporary plumbing systems based on new lithogeochemistry, isotopic and mineral chemistry data and compiled data from the literature.

Keyword

Mineral Assemblage, Martin Vaz-Trindade Archipelago, Geothermobarometry, Evolutionary Plumbing System, Hybrid Mantle

The geochemical nature of serpentinites from the Mashhad mafic-ultramafic complex as an evidence for Palaeotethys oceanic crust subduction in NE Iran

KOUROSH MOHAMMADIHA[1]*, Geological Survey and Mineral Exploration of Iran
(K.Mohammadiha@gmail.com)
Mohssen Moazzen[2], University of Tabriz
Uwe Altenberger[3], Potsdam University
Robab Hajialioghli[4], University of Tabriz

Abstract

Abstract
The Mashhad ultramafic complex with a Permo-Triassic stratigraphic age is exposed at the NE of Binaloud Mountain and adjacent to the Mashhad city (SW to NW of Mashhad). This area is located in within the Kopet Dagh zone and at NE of the Binaloud Mountain range. This area is mainly composed of mafic and ultramafic rocks, metamorphosed carbonate and pelitic rocks and granitoids in a NW- SE trend. Serpentinized peridotites, especially amphibole peridotites are the main types of ultramafic rocks in this area. Minerals in these rocks include olivine, orthopyroxene, clinopyroxene, brown amphibole and opaque minerals as the original minerals and serpentinite group minerals (lizardite and antigorite), tremolite-actinolite, chlorite, talc and carbonate minerals are the secondary minerals. MgO content of ultramafic rocks, Mg, Al and Cr contents in spinel, Ti and Na contents in clinopyroxene and Ti content in primary amphiboles (pargasite and hornblende pargasite) all show mantle origin for the Mashhad area ultramafic rocks. High pressure-low temperature metamorphic rocks, which are indicative of subduction are not present in this area, but according to the major, minor and rare earth elements chemistry of the Mashhad serpentinites, these rocks show subducted serpentinites features, with a peridotite protolith derived from lherzolite or olivine-poor harzburgite. The protolith of these rocks metasomatized and refertilized by melt formed in a subduction zone before serpentinization. Serpentinized peridotites of Mashhad are of subducted serpentinites type, which are more enriched in in trace elements in comparison with abyssal serpentinites. The origin of these serpentinites are lherzolite or olivine-poor harzburgite. Considering Mg# and Cr# of spinel and high oxygen fugacity for clinopyroxene formation conditions in Mashhad ultramafic rock in comparison with oxygen fugacity in mid ocean ridge, Mashhad peridotites can be related to supra-subduction zone. Serpentinized peridotites occur in alternation with metapelitic rocks. These rocks are remnants of Paleotethys oceanic crust which are emplaced during late Triassic as an accretionary prism in the subduction zone and is thrust on the Iranian crust.

Keyword

metaperidotite, subducted serpentinite, metasomatic mantle, geochemistry, NE of Iran

Ophiolites in the westernmost South Tien Shan: geochemical characterization and tectonic settings.

Bakhtier NURTAEV[1]*, Institute of geology and geophysics (nurtaev@ingeo.uz)
Svetlana Zenkova[2], Institute of geology and geophysics
Oksana Tsay[3], Institute of geology and geophysics
Dilshoda Kurbanova[4], Institute of geology and geophysics

Abstract

The ophiolitic rocks, discovered in the westernmost region of South Tien Shan play a crucial role in understanding the Paleozoic tectonic evolution of the Turkestan ocean. These rocks can provide valuable insights into the suturing and terrane-accretion processes. The current study includes mineral chemistry, whole-rock geochemistry, and field observations of igneous and sedimentary rocks from ophiolitic mélange outcrops of the South Tien Shan. The study aims to determine the nature and timing of the formation and emplacement of the ophiolite belts.

The Southern Tien Shan region is home to the main ophiolite massifs that are distributed across two separate belts. These belts are the northern belt that stretches from Sultan-Uvais to South Fergana and the southern belt that runs from Kuldjuktau to Karatyube and South Gissar. Ophiolites have varying geochemical characteristics and a crustal architecture that is laterally discontinuous and vertically heterogeneous. These differences are due to variations in igneous and tectonic processes that were involved in the formation of ancient oceanic crust in different geodynamic settings.

The Turkestan suture which separates the Kazakh-Kyrgyz continent from the Kyzylkum-Alai microcontinent is marked by the presence of ophiolites in several areas adjacent or parallel to the suture trace, for example, in the Bukantau, Tamdytau, North Nuratau, South Ferghana, and Atbashi-Inylchek areas, some of which are also associated with metamorphic rocks.

The Gissar suture zone is a geological formation that comprises a mixture of lower Carboniferous basalts and serpentinized ultramafic fragments, as well as carbonate and clastic sedimentary rocks. The Gissar suture zone is positioned to the south of the Gissar batholith and marks the boundary of the Gissar back-arc ocean basin, which was a short-lived basin that opened along the northern passive margin of the Karakum-Tarim terrane during the early Carboniferous and closed during the Late Carboniferous. The origin of the Gissar Suture is uncertain with several possible interpretations, including an oceanic or a rifted/marginal basin, or backarc rifting with subsequent partial breakup. It is crucial to identify the precise nature of the ophiolites in the westernmost parts of the Tien Shan to link them to independent oceanic basins.

The Southern Tien Shan has ophiolite associations that vary in age, with the older formations located towards the west, and the younger formations towards the east. We will explore different models that explain the formation of these ophiolite types and the processes that led to their evolution.

The Talas-Ferghana and Ural-Tien Shan Faults have played a crucial role in the region’s

development, as they may have acted as a partial barrier that controlled the distribution of syn-collisional convergence and magmatism in the South Tian Shan. The Late Paleozoic orogeny of the western Central Asian Orogenic Belt was influenced by strike-slip tectonics, which is connected to oblique plate interactions.

Keyword

South Tien Shan, ophiolitic rocks, geodynamic settings, strike-slip tectonics, sutures

The origin of the DUPAL anomaly in the Tethys mantle domain

XIJUN LIU[1]*, Guilin University of Technology (xijunliu@glut.edu.cn)
JI-FENG XU[2], China University of Geosciences
PATERNO R CASTILLO[3], dScripps Institution of Oceanography, UCSD
WEN-JIAO XIAO[4], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
YU-JIA SONG[5], Guilin University of Technology
PENG-DE LIU[6], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences
WEN-MIN HUANG[7], Guilin University of Technology

Abstract

Plate tectonic-driven material circulations between plate and deep Earth is the first order force to control the Earth geodynamic system. The presence of Pacific-type and Indian-type mid-ocean ridge (MORB) isotopic source domains in the upper mantle is a clear manifestation of global-scale mantle compositional heterogeneities. The heterogeneity reveals systematic differences in the Pb isotope composition between the Indian Ocean-South Atlantic mantle in the Southern Hemisphere and the Pacific-North Atlantic mantle in the Northern Hemisphere at the spatial scale. This large-scale difference in mantle isotopes in the Southern Hemisphere is known as the DUPAL anomaly. The DUPAL anomaly of the Indian-type mantle domain is a long-lived feature that can be traced back to the Palaeozoic Tethyan mantle domain.Tethys DUPAL mantle domains are the largest and long-lived mantle domain, but the origin are unclear. We present the compared Nb-Pb isotope evolution of these two mantle domains and found that the Tethyan mantle and circum-Pacific (PAO, Paleo- and modern Pacific) mantle. The results showed the Tethyan and circum-Pacific mantle domains underwent marked different Th/Pb and U/Pb fractionation events. The Tethyan mantle displays lower εNd(t) and higher 206Pb/204Pb(t), 207Pb/204Pb(t), 208Pb/204Pb(t) and (208Pb*/206Pb*)(t) for ratios than that of the circum-Pacific realm mantle, a typical characteristic of DUPAL anomaly mantle. Such a large-scale and long-lived DUPAL anomlay in Tethyan mantle domains most likely reflects the contribution of plate tectonics-driven crustal recycling in producing large-scale mantle domains. The Tethys and Panthalassic-Pacific ocean realms underwent different tectonic evolution history. The Panthalassic-Pacific ocean realm had remarkable permanency existing as a big ocean at lease throughout the Phanerozoic, that implies that continental materials were limit to recycle into underlying mantle, thus the underlying mantle was relative free of the continental material contamination and then result in the low Th/U Panthalassic-Pacific ocean realm mantle domain. In contrast, the break-up of the Gondwana supercontinent makes the Tethys realms to experience repeated opening and closures, which transferred large volume of continental materials into the underlying mantle and then produce the high Th/U Tethyan mantle domain. This study shows that plate tectonic-driven material circulation should play a role in producing large-scale and long-lived mantle heterogeneity and thus plate tectonic evolution may genetically link mantle chemical geodynamics. This is crucial for understanding how Earth system works.

Keyword

Tethys, DUPAL anomaly, ophiolite, Pb isotope, Low Th/U

Microdiamonds in Oceanic Mantle and Continental Volcanic Rocks Provide Significant Clues for the Earth's Two-Way, Deep Recycling System

Jingsui YANG[1]*, Nanjing University (yangjsui@163.com)
Dongyang Lian[2], Nanjing University
Yun Wang[3], Nanjing University
Zhiyun Lu[4], Zhejiang University
Fei Liu[5], Institute of Geology, CAGS
Chuqi Cao[6], Institute of Geology, CAGS
Yildirim Dilek[7], Miami University

Abstract

Macrodiamond (>1mm) is known to occur mainly in alkaline ultramafic rocks (i.e., kimberlites) in the continental lithosphere. However, new research has discovered that microdiamonds (<1mm) can be produced in various tectonic settings and rock types globally. This contribution compares microdiamonds from different geological environments, including microdiamonds found in ancient oceanic lithosphere in Phanerozoic ophiolites and Precambrian greenstone belts, in kimberlites and basic intrusions in the continental lithosphere, and in volcanic rocks occurring in ocean – continent transition zones. Although the geological histories of these microdiamond grains are different, most of them have significant common characteristics: (1) the grain size of diamonds is commonly several hundred micrometers, they are generally yellow green and colorless, they have cubic octahedral crystal form, and they are mainly Ib and Iab types; (2) microdiamonds have light C isotope characteristics δ 13C between -20 and -30 ‰), interpreted as organic in origin, different from kimberlite macrodiamonds with mantle origin characteristicsδ 13C is between -10 and 0 ‰; (3) inclusions in microdiamonds commonly exhibit chemical characteristics of crustal sources, such as Mn and fluids containing Si and H2O; (4) mineral assemblages of strongly reduced environments accompanied by microdiamond particles, containing alloy minerals such as SiC and elemental minerals such as natural iron; (5)high pressure phase mineral inclusions have been found in some microdiamonds, as well as high-pressure phase (>10 GPa) mineral assemblages found in accompanying host-rocks. These characteristic features indicate that the formation environment of microdiamonds is comparable, likely in an ultrahigh pressure and super-reduced geological environment, and their material source may originate from deeply subducted crust. Thus, we infer that microdiamonds were most likely derived from deep recycling of subducted crustal materials, and that mantle plumes may have played a significant role in the transport of microdiamonds into lithospheric mantle depths. Firstly, deep subduction delivers oceanic crust to the lowermost mantle or even into the mantle transition zone. Following the decomposition of oceanic crust in this environment, biogenic carbon forms carbon rich fluids. Then, due to the disturbance of mantle plumes rising from the core – mantle boundary and changes in the temperature –pressure conditions, diamonds begin to crystallize in carbon rich fluids and are rapidly carried by mantle plumes to the continental and oceanic mantle lithosphere at shallow depths. Accompanied by plate extension and deep rifting,

microdiamond-bearing melts and fluids ascend to the shallow mantle; alternatively, they may be quickly transported along with kimberlitic and alkaline-basic magmas to the Earth’s surface. Microdiamonds occurring in various geological environments clearly provide a new concept and tool for studying the Earth’s deep, two-way recycling system, mantle circulation patterns, and deep mantle dynamics. We think that through a systematic comparative study of microdiamonds in oceanic mantle rocks, greenstone belts, and continental basic rocks and kimberlites, we can establish a global scale, deep Earth material recycling model.

Keyword

microdiamond, oceanic mantle, continental volcanics, deep recycling, greenstone belt

Tectono-magmatic and metamorphic development of Shyok Ophiolite Belt from Ladakh Trans-Himalaya, India: Insights from microstructures, phase petrology, and P-T trajectory

Ravi Ranjan Kumar[1]*, North- Eastern Hill University, Shillong, Meghalaya (raviranjan.bhu.5679@gmail.com)
Shailendra Pundir[2], Wadia Institute of Himalayan Geology, Dehradun, India
Santosh Kumar[3], Department of Geology, Centre of Advanced Study, Kumaun University, Nainital, India

Abstract

The subduction of the Neo-Tethyan Oceanic lithosphere below the Eurasian Plate formed the magmatic arc system, and subsequently, the oceanic lithosphere obducted at places with the closure of Neo-Tethyan Ocean along the Indus Suture Zone (ISZ) and Shyok Suture Zone (SSZ) in the Ladakh Trans-Himalaya. The remnants of the oceanic lithosphere, the Shyok Ophiolite Belt (SOB), are exposed in the SSZ in the northern margin of the Ladakh Batholith and south of the Karakoram Block. The phase petrology of SOB gabbro and meta-gabbro is carried out to infer the nature and origin of gabbro, and P-T trajectory and tectono-metamorphic regime of metagabbro, and their implication on the geodynamic evolution of the India-Eurasia convergence zone. The SOB gabbro comprises the clinopyroxene, calcic amphibole, plagioclase, biotite, and Fe-Ti oxides, whereas the metagabbro contains additional phases of albite and quartz. The phase chemistry of SOB gabbro reveals largely subalkaline to calc-alkaline orogenic, boninite, island arc Alaskan-type tholeiitic gabbroic intrusion, which follows the ophiolite evolutionary trend at 1000-1150°C, moderate to high-P, and elevated oxygen fugacity. The SOB metagabbro records a prograde metamorphic overprint on primary igneous phases. The calculated T–M(H2O), T–M(O2), and P–T pseudosection reveal the peak metamorphic conditions at ~8.85 kbar and ~780 °C, developed during burial subduction. The nearly-isobaric cooling retrograde stage characterizes the melt-out and magnetite-in and its stable P–T condition at 3 kbar and 650°C, indicating a rapid exhumation to a shallow crustal depth. The metamorphic reaction pathways integrated with P–T pseudosection modelling define a near-clockwise P–T loop. The apparent high thermal gradient of 22-24°C/km corresponding to a maximum burial depth of ~32 km and the P–T trajectory suggest a warm and mature stage of an intra-oceanic subduction zone setting for developing the SOB metagabbro. The petrological results on SOB rocks and their correlations with ISZ and other ophiolitic massifs suggest development of an intra-oceanic subduction/collision-related system within the Neo-Tethyan during Indian-Eurasian plate convergence.

Keyword

Gabbro, Meta-gabbro, Ophiolite, Shyok Suture, Ladakh Trans-Himalaya

Investigating Ca-Mg ionic exchange in Macquarie Island unobducted abyssal serpentinites

Cesare Nico ALBASIO LODI-CUSANI[1]*, Curtin University
(cesare.albasiol@postgrad.curtin.edu.au)
Katy Evans[2], Curtin University

Abstract

Macquarie Island (MI), located in the ocean south of New Zealand, offers access to unobducted oceanic lithosphere rocks, including abyssal peridotite samples. These samples avoid the typical limitations of drilled or dredged samples. The MI island rocks are depleted abyssal peridotites (spinel Cr# around 50) with geochemical and textural similarities to ODP 209 1274A rocks from the Mid-Atlantic Ridge (MAR).

However, the specific petrology and degree of serpentinization of the ultramafic rocks on MI have yet to be thoroughly explored, in comparison to other prominent ultramafic bodies. To understand the characteristics of serpentine and other minerals, a comprehensive analysis was conducted using optical microscopy, SEM (Scanning Electron Microscope) imaging, Electron Dispersive Spectrometry (EDS) and EPMA (Electron probe microanalyzer) on thin sections.

The serpentinization grade of the rocks was determined using the visual scale developed by Birner et al., with 0.25 steps implemented (0 is unaltered, 5 is completely serpentinized). MI samples serpentinization score range from 3.5 to 4.75.

The MI abyssal peridotites offer the opportunity to study Ca–Mg ionic exchange associated with serpentinisation. In this process, bulk rock Ca is lost to the fluid, and Mg is taken up by the rock. This process has been observed in controlled experiments on serpentinization. However, this effect has not been studied thoroughly in real settings, despite its significant implications for planetary ecosystems, via the seawater Mg/Ca ratio.

A comparison between the MI rocks and serpentinized abyssal peridotites from ODP Leg 209 1274A was used to constrain the impact of Mg–Ca exchange on the MgO/SiO2 ratio. The positive contribution of Mg uptake parallel to the lost Ca in ODP 209 1274A whole-rock MgO/SiO2 ratio is around 0.03-0.05.

At the mineral scale the effect in MI serpentinites is observable in bastite: with a Mg# change parallel to CaO decrease. The effect of 1:1 Ca-Mg exchange on a hypothetical fully serpentinized reconstructed MI protolith from mineral analyses has an impact around 0.02-0.03 on MgO/SiO2. This is consistent in order of magnitude with the observation in ODP 209 1274, suggesting Ca-Mg exchange is approximately 1:1.

In-situ Mg isotope analyses of clinopyroxene and alteration minerals are required to better constrain Mg–Ca ionic exchange on the grain scale.

Keyword

geochemistry, peridotite, serpentinite, Macquarie Island, Ca/Mg ratio

Identification of ca. 520 Ma MOR-type ophiolite suite in the inner Cathaysia Block, South China: Evidence from shearing-type oceanic plagiogranite

Longming LI[1]*, Hefei University of Technology (longming_li@hfut.edu.cn)
Shoufa Lin[2], University of Waterloo
Guangfu Xing[3], Nanjing Center, China Geological Survey
Fan Xiao[4], Nanjing Center, China Geological Survey
Wenjiao Xiao[5], Xinjiang Institute of Ecology and Geography

Abstract

An ophiolite suite, predominantly composed of residual mantle peridotites, mid-ocean ridge basalts (MORB)-like ultramafic rocks and oceanic plagiogranites, has been identified in the Zhenghe-Dapu fault zone, Cathaysia Block, South China. The peridotites experienced strong serpentinization and are characterized by low 187Os/188Os ratios of 0.11621 to 0.12008 and very low 187Re/188Os values of 0.031-0.129, similar to those from highly refractory mantle residues. Thus, this indicated that the lithospheric mantle was transported through tectonic processes to the Earth's surface. The meta-ultramafic rocks, mainly amphibolites, can be classified into two groups. Group I is characterized by high Ni, Cr and low K2O content. Their spoon-like REE patterns, along with lower concentrations of highly incompatible elements, indicate that its protolith was of cumulate origin. Group II displays depleted REE patterns and low Nb/Yb, Th/Yb and Ti/V ratios, which are geochemically similar to N-MORB. Both groups exhibit positive εNd (t) values (1.2-4.1) and relatively high (87Sr/86Sr)i ratios (0.7046-0.7096), suggesting their origin from partial melting of depleted mantle sources in a mid-ocean ridge setting that experienced greater extent of fluid-rock alteration. The meta-plagiogranites intercalated with the mylonitic amphibolites are characterized by low K2O (0.09-0.21 wt.%) and ∑REE contents along with low K2O/Na2O and Rb/Sr ratios, which are consistent with those of typical oceanic plagiogranite. They exhibit strongly positive zircon εHf (t) values (+9.5 to +15.1) and positive whole rock εNd (t) values (+2.8 to +3.6). Their extremely low MgO (0.6-1.65 wt.%), Cr (0.22-6.26 ppm), and Ni (0.77-4.74 ppm) compositions and low Mg# (22.4-31.9) preclude their origination from mantle-derived primary magma but oceanic crust. Low zirconδ18O values (4.02 to 5.4‰) and decoupled Sr-Nd isotope feature imply the involvement of high-temperature seawater alteration in their source region. The enriched light rare earth elements (LREE) patterns with strongly positive Eu anomalies, similar to the East Karmoy type plagiogranite in Western Norway, imply that the plagiogranites were derived from anatexis of amphibolite in an active shear zone near the mid-ocean ridge. The magmatic and metamorphic zircons from the meta-plagiogranites yield nearly identical secondary ion mass spectrometry (SIMS) U-Pb age ranging from 523 to 521 Ma and 522 to 518 Ma, respectively. The simultaneous magmatism and metamorphism also prefer such an active high-temperature shear zone, where the plagiogranites were formed slightly later than the oceanic crust. The age of ca. 520 Ma represents the formation age of the oceanic crust rather than its emplacement age. The identification of the ca. 520 Ma ophiolite suite along the Zhenghe-Dapu

fault zone indicates that the Cathaysia Block should consist of at least two different terranes rather than a single tectonic unit in the Cambrian, and the final amalgamation of the eastern and western Cathaysia Block may have occurred far later than ca. 520 Ma, most likely during the late Early Paleozoic.

Keyword

Oceanic plagiogranite, Re-Os isotope, Zircon Hf-O isotope, Cathaysia Block, South China

Neo-Tethyan ophiolites of Iran: formation of nascent oceanic lithosphere above double subduction

Iman MONSEF[1]*, Department of Earth Sciences, Institute for Advanced Studies in Basic Sciences (IASBS), Zanjan 45137-66731, Iran (iman_monsef@yahoo.com)

Abstract

Zagros and Makran ophiolites represent remnants of Neo-Tethyan oceanic lithosphere exposed along the Zagros suture zone and Makran accretionary prism in southern Iran. Zagros and Makran ophiolites are classified into two distinct belts with different spatial and temporal characteristics. The older Jurassic-Early Cretaceous ophiolitic belt includes the Sikhoran, Soghan, and Abdasht ophiolites in Zagros, and the Kahnuj, Fanuj, and Iranshahr ophiolites in Makran. The Kurdistan, Kermanshah, Neyriz, and Hajiabad ophiolites in Zagros, and the Sorkhband and Rudan ophiolites in Makran constitute the younger Late Cretaceous ophiolitic belt. Initially, the Neo-Tethyan oceanic lithosphere was formed in a mid-ocean ridge extending between the Arabian and Eurasian plates. Geological, geochronological and geochemical lines of evidence reveal that the Zagros and Makran ophiolitic belts formed in distinct nascent fore-arc basins related to Neo-Tethyan intra-oceanic double subduction. Early Neo-Tethyan intra-oceanic subduction at the southern margin of Eurasia produced an older Zagros and Makran fore-arc basin. This first stage of subduction led to the upwelling of asthenosphere and resulting melting to generate fore-arc basalt (FAB)-like melts. Penetration of slab-derived components into the mantle wedge due to continued subduction caused a depleted metasomatized mantle and generated island-arc tholeiitic (IAT)-like melts. During the Late Cretaceous time, a new south-verging Neo-Tethyan intra-oceanic subduction formed a younger fore-arc basin at the north margin of Arabia. The initiation of subduction has caused a slightly metasomatized depleted residual mantle resulted in FAB-like melts production. The continuation of true subduction generates a metasomatized depleted residual mantle and IAT-like melt extraction. Finally, the onset of rapid slab rollback led to asthenospheric upwelling, which caused a metasomatized ultra-depleted residual mantle producing boninitic (BON)-like melts.

Keyword

Neo-Tethys, Ophiolite, Zagros, Makran, Iran

Melts of sediment in the mantle wedge of the Neoproterozoic Fuchuan Ophiolite and the mark of subduction initiation

Wei WANG[1]*, China University of Geoscienes, Wuhan (wwz@cug.edu.cn)
Junhong Zhao[2], China University of Geoscienes, Wuhan
Si-Fang Huang[3], Shangqiu Normal University
Rui Li[4], China University of Geoscienes, Wuhan

Abstract

Melting of the sediments in the mantle region could provide invaluable information on the crust-mantle interaction, however, such rocks are rare on account of specific conditions of preservation. A small number of felsic intrusions in the mantle section of the Neoproterozoic Fuchuan Ophiolite in the South China Block display geochemical features typical of melts derived from subducted sediments, thus providing a record of melting of oceanic sediments at depth, offering an opportunity to evaluate mass transfer from the descending plate. These felsic bodies, dated to ca. 837-848 Ma (zircon U-Pb ages), were emplaced during the slab subduction rather than obduction onto the continental margin. The Zircon trace element chemistry and Hf-O isotopes ($\delta^{18}O$ up to 11.3 ‰), and whole-rock geochemistry (e.g. K_2O=4.25-9.10 wt.%) and Nd-isotope (εNdt=-2.2 to -0.4) characteristics of these felsic intrusions indicate subduction zone melting of sediments. The P-T estimates for these sediment-derived melts suggest a temperature range of 650-790℃ and the plagioclase stability regime pressure conditions. Considering the thermal structure of the subduction channel, these felsic intrusions clearly mark the subduction initiation. Further, the presence of sediment-derived melts in the Fuchuan ophiolite supports a spontaneous subduction that may serve as a proxy for the modern-style plate tectonics in the mid-Neoproterozoic.

Keyword

Neoproterozoic, Fuchuan ophiolite, Felsic intrusions, Sediment recycling, Subduction initiation

New Data on Ophiolites of Western Chukotka, Northeastern Eurasia

Tatiana PILITSYNA[1]*, Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements (IMGRE) (allafia@yandex.ru)
Alexander GANELIN[2], Geological Institute (GIN) of Academy of Sciences
Alexey PILITSYN[3], Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements (IMGRE)
Sergey SOKOLOV[4], Geological Institute (GIN) of Academy of Sciences

Abstract

The main tectonic elements of Western Chukotka from north to south are the Western Chukotka terrane (WCh), South Anyui suture (SAS), and Yarakvaam terrane (YR). The SAS separates the structures of the Chukotka fold belt (including WCh) from the Alazeya-Oloy fold zone that is participating in the Kolyma Structural Loop to the south. The suture formed as a result of closure of an oceanic basin and collision of the North American and Siberian continents (Seslavinsky, 1979; and others). The collision took place at the end of the Early Cretaceous and terminated in Aptian time (Sokolov et al., 2009). The age of undeformed post-collision granites ranges 31 from 115.7±1.7 Ma to 112±1.3 Ma (Katkov et al., 2007). While there is general agreement on the timing of the closure of the basin, there are different viewpoints as to its origin. The SAS was customarily regarded as a structure that originated after the closure of the rift-related Late Mesozoic oceanic basin that separated Asia from the Hyperborean (Arctic) plate. As the Aluchin and the Gromadny-Vurguveem massifs are regarded as a part of the Alazeya-Oloy fold zone (Ganelin, 2017), the new study contains new data on the composition, geodynamic setting, and age of the ophiolites and discusses their possible interpretations.

The studied northwestern part of the ophiolite Gromadny-Vurguveem massif, where previously unstudied plutonic rocks (gabbroids, plagiogranites and ultrabasites) are exposed, makes it possible to correlate age and material characteristics with previously studied rocks from the central part of the massif.

Studies of the age of volcanics of the volcanogenic sequence near the village of Stadukhino allow us to answer the question of whether this sequence is part of the ophiolite association together with the gabbros of the Gromadnensko-Vurguveem massif, as previously assumed (Radzivil, 1975). The features of the evolution of volcanism and the geodynamic conditions of the formation of volcanics have been established.

In The Aluchinsky ophiolite complex the Middle-Late Palozoic volcanic-terrigenous deposits, exposed on the right bank of the river Bolshoi Anyui in the cliffs, were studied, opposite the mouth of the river Aluchin. These are the most representative outcrops of the Late Paleozoic volcanic complex known in the area. The obtained factual material allows us to make modern dating, as well as answer the question of whether these formations are the third (upper crustal) member of the Aluchinsky ophiolite association.

The northern and southern parts of the northern plate of ultramafic rocks of the Aluchin massif were studied, which was previously studied in the central part, where only lower crustal

cumulative peridotites were identified. The obtained material allowed us to establish the presence of mantle peridotites in this plate, which are an important (diagnostic) member of the ophiolite association.
The conducted studies confirm the synchronicity and comagmatic nature of the plutonic rocks of the Gromadnensko-Vurguveem and Aluchinsky massifs, and also made it possible for the first time to identify the upper crustal complex of this ophiolite association, which is represented by previously unstudied Late Paleozoic volcanics.

Keyword

ophiolites, South Anyui Suture, Middle-Late Palozoic, gabbro, ultramafites

PGE geochemistry of Macquarie Island basaltic glasses and picrites

Gyuchan PARK[1]*, School of Earth and Environmental Sciences, Seoul National University (qkrrbcks7@snu.ac.kr)
Jung-Woo PARK[2], School of Earth and Environmental Sciences, Seoul National University
Vadim KAMENETSKY[3], Institute of Oceanology, Chinese Academy of Sciences

Abstract

Platinum group element (PGE) geochemistry of mantle-derived magmas can provide important information on partial melting conditions, which include fertility of mantle sources, degree of partial melting, and oxygen fugacity. Mid-ocean ridge basalt (MORB) magmas are known to be sulfide-saturated and PGE contents are depleted in evolved MORB magmas. However, the timing of sulfide saturation and the presence of PGE-bearing minerals in primitive MORB magmas remain in debate. MORB glasses and cogenetic picrites from Macquarie Island, SW Pacific offer a unique opportunity to address this issue. In this study, we investigated sulfide petrography and PGE geochemistry of 24 MORB glasses and 13 picrites from Macquarie Island to constrain sulfide saturation history and PGE host phases in the early stage of MORB magma differentiation.

Results show that progressive decrease in PGE contents in MORB glasses with decreasing MgO, which indicates compatible behavior of PGE during magma differentiation. Most glasses and picrites show positive correlations between PGE concentrations, suggesting that liquid sulfide is a major PGE host during magma differentiation. The presence of magmatic sulfide inclusions in olivine phenocrysts with Fo# of 88 – 90 mol% in picrites shows sulfide saturation in primitive magmas. Multiple in-situ LA-ICP-MS analyses were conducted on individual sulfide blebs in the groundmass and olivine of a picrite sample (38277) to investigate their PGE compositions. The primitive mantle-normalized PGE pattern of the average sulfide composition closely mirrors that of the whole-rock PGE composition of the host picrite (except for Pt), showing sulfide is the predominant PGE host in the picrite. It should be noted that some picrites exhibit significant differences in the whole-rock PGE contents between replicate analyses due to the nugget effects of PGE-bearing phases. The compositions of the nuggets inferred from the difference in replicate analyses are best explained by Ru-Ir-Os(-Pt) alloys, Pt alloys, or Ru-Ir sulfarsenide as well as sulfide liquid. Whether the PGE minerals are liquidus phases in primitive MORB magmas requires further investigation.

Keyword

Platinum-Group Elements, Mid-Ocean Ridge Basalt, Early sulfide saturation, Platinum-group mineral

Early Neoproterozoic oceanic crust fragments in the Lhasa Terrane, Tibet

Peiyuan HU[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(azure_jlu@126.com)
Qinguo Zhai[2], Institute of Geology, Chinese Academy of Geological Sciences
Yue Tang[3], Institute of Geology, Chinese Academy of Geological Sciences
Yiming Liu[4], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The origin and evolution of the Precambrian Lhasa Terrane in the central Tibetan Plateau remain enigmatic. In this contribution, we focus on the early Neoproterozoic amphibolites and quartzites from the Nyainqentanglha Group in the northern Lhasa Terrane. We present U–Pb age and Hf isotopic data for detrital zircons from early Neoproterozoic quartzites in the Lhasa Terrane, Tibet. An integrated petrological, geochronological, geochemical, and Sr–Nd–Hf isotopic study was also undertaken on amphibolites associated with the quartzites. The depositional age of the quartzites is constrained to be between ca. 931 Ma (youngest detrital igneous zircon core) and 869 Ma (oldest metamorphic zircon rim). The detrital zircons have a main age population from 1200 to 1000 Ma, and lack zircons with ages of 1000–900 Ma. Zircons from the amphibolites yield concordant ages of ca. 913–902 Ma, which are comparable to the depositional age of the quartzites. The amphibolites have N-MORB-like compositions and are characterized by high positive zircon εHf(t) (+7.2 to +14.0) and whole-rock εNd(t) (+5.5 to +6.0) values. Their compositions have been modified by crustal contamination. The formation of these quartzites and amphibolites was related to the transitional process from continental rift to embryonic oceanic crust, marking the opening of part of the Mozambique Ocean adjacent to the African side of the northern East African Orogen.

Keyword

Tibet, Lhasa terrane, Petrogenesis, Early Neoproterozoic, Oceanic crust

Tectonized Neotethyan lithosphere in southeastern Tibet: Results of the Luobusa ophiolite drilling

Xiangzhen XU[1]*, CARMA (Center for Advanced Research on Mantle), Key Laboratory of Deep-Earth Dynamics of Ministry of Natural Resources, Institute of Geology, Chinese Academy of Geological Sciences (xuxiangzhensjl@aliyun.com)
Basem Zoheir[2], Department of Geology, Faculty of Science, Benha University
Jingsui Yang[3], CARMA (Center for Advanced Research on Mantle), Key Laboratory of Deep-Earth Dynamics of Ministry of Natural Resources, Institute of Geology, Chinese Academy of Geological Sciences
Fahui Xiong[4], CARMA (Center for Advanced Research on Mantle), Key Laboratory of Deep-Earth Dynamics of Ministry of Natural Resources, Institute of Geology, Chinese Academy of Geological Sciences
Guolin Guo[5], School of Earth Sciences and Engineering, Nanjing University
guangying Feng[6], CARMA (Center for Advanced Research on Mantle), Key Laboratory of Deep-Earth Dynamics of Ministry of Natural Resources, Institute of Geology, Chinese Academy of Geological Sciences
Zhaoli Li[7], CARMA (Center for Advanced Research on Mantle), Key Laboratory of Deep-Earth Dynamics of Ministry of Natural Resources, Institute of Geology, Chinese Academy of Geological Sciences
Tianfu Li[8], CARMA (Center for Advanced Research on Mantle), Key Laboratory of Deep-Earth Dynamics of Ministry of Natural Resources, Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The Luobusa ophiolite in the southeastern Tibet holds the largest chromitite resource in China. These rocks present an ideal opportunity to study the origin and evolution of ophiolite-related chromitite ores. The Luobusa Ophiolite Scientific Drilling (LSD) program resulted in two boreholes (LSD-1 to a depth of 1478 m with a core recovery of 94% and LSD-2 to a depth of 1854 m with a core recovery of 97%). The profile of both pilot-boreholes includes three main lithological units, i.e., mantle tectonites (harzburgite and lherzolite with lenses of residual dunite), mantle-crust transition (mainly cumulative dunite), and crustal cumulates (i.e., gabbros). The crustal cumulates occur at the bottom of the borehole, whereas the mantle tectonites form the upper part of the section. This stratigraphic reversal reflects the complex tectonic evolution of the Luobusa ophiolite.

A large dataset of whole-rock geochemical compositions integrated with microanalytical data of olivine, pyroxene, and Cr-spinel suggests formation of the Luobusa ophiolites by variable degrees of mantle partial melting (540 %) and evolution from a MOR to a SSZ setting. The mantle-normalized PGE patterns of mantle tectonites and transitional zone dunites are distinctive, with different IPGE and PPGE anomalies coupled with variable Pd/Ir ratios, suggestive of complex origins. Similarly, the heterogeneous 187Os/188Os ratios of the Luobusa peridotites, with γOs values overlapping those of depleted mantle, primitive mantle, and enriched mantle sources, imply a polygenetic or multi-stage model of formation. Most of the mantle tectonites have 187Os/188Os

ratios lower than the present-day primitive mantle value, and overlap with the chondritic values. Cumulative dunite, on the contrary, has 187Os/188Os ratios close to the primitive mantle value. Negative γOs values calculated for some samples may indicate disturbance of the Re-Os isotope system by cryptic metasomatism and/or serpentinization. The Re-Os isotopic characteristics of Luobusa ophiolites and the olivine and orthopyroxene separates are suggestive of a residual phase origin. The higher 187Re/188Os and 187Os/188Os ratios in the crustal cumulate rocks can be interpreted as a manifestation of extraction and enrichment of melt phases in a slow spreading ridge setting, where interplay of melt extraction and melt-peridotite interaction is typical.

Keyword

Luobusa ophiolite Scientific Drilling program, whole-rock elemental and PGE geochemistry, Re-Os isotope systematics, slow-spreading ridge, Tibet

Ophiolites record plume-ridge interaction and two-stage oceanic crust accretion of the Meso-Tethys Ocean in the Central Tibetan Plateau

Yue TANG[1]*, Institute of Geology, Chinese Academy of Geological Sciences (174ty@163.com)
Qingguo Zhai[2], Institute of Geology, Chinese Academy of Geological Sciences
Peiyuan Hu[3], Institute of Geology, Chinese Academy of Geological Sciences
Yiming Liu[4], Institute of Geology, Chinese Academy of Geological Sciences
Wei Wang[5], College of Resources and Environmental Engineering, Guizhou University

Abstract

The variations of mantle sources and plume-ridge interaction beneath mid-ocean ridges are crucial to controlling the oceanic lithosphere's rock assemblage and accretion processes. Here, we present a combined analysis of petrological, chronology, and geochemical characteristic data for the North Renco ophiolite, central Tibetan Plateau. The North Renco ophiolite comprises tectonic remnants of oceanic crustal rocks and is stratified into two units (V1 and V2 units). The V1 units mainly consist of large-scale sheeted dikes, cumulated gabbros, and shallowly metamorphosed oceanic island fragments. Zircon U-Pb dating suggests the sheeted dikes were formed at ~170 Ma, while the oceanic islands were spawned during 167-165 Ma. Geochemical analysis indicates that the sheeted dikes exhibit typical E-MORB characteristics, lacking any imprints of subduction. This is complemented by a relatively depleted Nd-Hf isotopic composition, which hints at their derivation from an asthenospheric mantle subject to metasomatism by deeply enriched mantle components. The oceanic island remnants are distinguished by their classic interstratification of basalt with limestone (marble), with geochemical indications aligning with typical oceanic island basalts (OIB), implicating their origins in an intra-oceanic mantle plume/hotspot domain.

The V2 units are primarily composed of gabbro and pillow basalt structural blocks. Geochemical characteristics reveal that these are of the typical N-MORB sequence, consistent with the southern Renco ophiolite we previously reported. This suite of rocks originates from a depleted asthenospheric mantle, the product of the spinel lherzolite mantle's decompression partial melting (~1350°C, and 10-20% partial melting). The zircon U-Pb dating approximates the formation of this phase to ~150 Ma, well consistent with the southern Renco ophiolite, which indicates the oceanic crust accretion process under a rapid spreading ridge during the Late Jurassic.

Integrating the results of these studies, we suggest that the North Renco ophiolite encapsulates a dual-phase record of oceanic lithospheric accretion. The inaugural phase, entwined with plume-ridge interaction, reflects the influential role of the Meso-Tethys intra-oceanic mantle plume/hotspot in guiding crustal accretion. The succeeding phase underscores a rapid expansion of oceanic crust at distances far away from the plume/hotspot amidst the context of spreading mid-oceanic ridges, culminating in the development of the Penrose-type ophiolite as epitomized by the southern Renco ophiolite. The superposition of two magmatic episodes may be associated with the reduction in the size of the oceanic basin and the adjustment of the spreading ridge position attendant upon the northward drift of the Lhasa terrane.

Keyword

Tibetan Plateau, Meso-Tethys, Bangong-Nujiang suture zone, Ophiolite, Plume-ridge interaction

Mantle heterogeneity caused by melt addition to mid-ocean ridge peridotite: Evidence from the Mid-Ocean Ridge Taitao ophiolite, southern Chile

Weiwei WU[1]*, Nanjing University (cugcags@163.com)
Jingsui YANG[2], Nanjing University
Yu YANG[3], SinoProbe Lab, Chinese Academy of Geological Sciences
Yun WANG[4], Nanjing University
Dongyang LIAN[5], Nanjing University

Abstract

The heterogeneity of oceanic mantle likely resulted from variations in the degree of melting and in the initial compositions, and interaction with melts. However, the metasomatic enrichments in the sub-ridge mantle lithosphere at fast-spreading ridge are generally assumed to be limited. Peridotites in the Mid-Ocean Ridge Taitao ophiolite give us an excellent opportunity to understand the spatial extent of the mantle heterogeneity and to examine the patterns of mantle melting, melt addition process at a fast-spreading ridge. Based on the mantle textures, petrological, mineralogical and geochemical characteristics, we can distinguish two mantle components: (1) Type 1 residual lithospheric mantle, pertaining to partial melting occurred at or near the Chile Ridge; (2) Type 2 reacted lithospheric mantle, ascribed to Type 1 residual lithospheric mantle affected by multi-stage melt-rock interactions that occurred at different lithospheric depths during progressive exhumation on the Neogene (~6 Ma) Taitao seafloor. The compositions of Type 1 residual harzburgites display minor variations and encompass the entire abyssal peridotites trend (i.e., Cr# of spinels range from 29.6 to 37.0). Type 2 reacted peridotite shows textural features, exhibits elevated Cr# values of spinel (34.5 to 58.0) and strong incompatible element zonation and negative Eu anomalies in clinopyroxene, indicating a short-term percolation of a evolved mid-ocean ridge basalt (MORB). We attribute such mantle metasomatic enrichments to the lateral infiltration of variably evolved melts from a local magmatic center, which may be now exposed as the gabbroic rocks. The collective results of this study provide important information to understand the formation of lithosphere and of substantial mantle heterogeneity at the mid-ocean ridges.

Keyword

Mantle heterogeneity, Mid-ocean ridge, Melt-rock interaction, Taitao ophiolite, Southern Chile

Exhumation of mantle peridotite in an embryonic oceanic basin at slow to ultraslow spreading ridge within the Dahomeyide belt in Ghana, West Africa

Daniel KWAYISI[1]*, University of Johannesburg (danielk@uj.ac.za)
Jeremie Lehmann[2], University of Johannesburg
Marlina Elburg[3], University of Johannesburg

Abstract

The occurrence of exhumed mantle peridotite, gabbro, tectono-sedimentary breccias, volcanic rocks, and marine and continental sedimentary units in the Buem structural unit (BUSU) of the Pan-African Dahomeyide belt in Ghana share similarities with typical ophiolite sequence. The BSU ophiolite complex, however, is incomplete (with the absence of sheeted dyke complex) compared to the classical Penrose ophiolite sequence, such as the Oman and Troodos ophiolite and its lithological components are in both primary and tectonic contacts. Nonetheless, the BSU is characterised by features that are consistent with ocean-continent transition ophiolites similar to those of Iberia-Newfoundland and Alpine-Apennine. In the BSU, the serpentinised peridotite dominates in terms of volume, and it is either overlain by oceanic sediments or mafic volcanic or plutonic rocks, which are subordinate. The geochemical and isotopic characteristics of the mafic volcanic and plutonic rocks associated with the BSU serpentinised peridotites are mostly similar to those of magmas formed by melting of the depleted mantle. These MORB-type rocks have been interpreted as an embryonic oceanic crust formed during the transition from rifting to seafloor spreading during the opening of the Pharusian Ocean. Slow and ultraslow spreading ridges are amagmatic with episodic magmatic activities resulting in the thin oceanic crust (<7 km); thus, the high effect of serpentinisation is due to sufficient exposure of peridotites to the ocean floor. Thus, the significant effect of serpentinisation of the BSU serpentinised peridotite may indicate exhumation in a slow to ultraslow-spreading ridge. Geochemical and geochronological data for the clastic sedimentary rocks of the BSU associated with the mafic-ultramafic rocks suggest passive margin sequences deposited during the opening of the Pharusian Ocean. Comparing the results from this study to data from the Novo Oriente Group indicates an evolution of the West Gondwana Orogen from initial mantle exhumation followed by syn-rift magmatism (Novo Oriente Group) and early stages of seafloor spreading (BSU mafic-ultramafic rocks) as has been proposed for the Alpine ophiolites. Therefore, ophiolites in the West Gondwana Orogen are of two main domains: proximal OCT of the Novo Oriente Group and distal embryonic oceanic crust of the BSU, formed during the break-up of the supercontinent Rodinia.

Keyword

Buem structural unit, Ophiolite, Peridotite, Exhumation, Sea floor spreading

Tectonomagmatic evolution of mantle complexes of the North Balkhash and Dzhalair-Naiman ophiolite zones (central and south Kazakhstan, western part of the Central Asian Orogenic Belt)

Aleksandra MILYUKOVA[1]*, Geological Institute, Russian Academy of Sciences, Pyzhevsky Lane, 7, Moscow, Russia (aleksandramilyukova@gmail.com)
Anfisa Skoblenko[2], Geological Institute, Russian Academy of Sciences, Pyzhevsky Lane, 7, Moscow, Russia
Kirill Degtyarev[3], Geological Institute, Russian Academy of Sciences, Pyzhevsky Lane, 7, Moscow, Russia

Abstract

Western segment of the Central Asian Orogenic Belt (CAOB) comprises Palaeozoic fold-and-thrust complexes of Kazakhstan, Tien Shan and Northwestern China that include island-arc and accretionary prism formations associated with dismembered fragments of ophiolites. The most complete and well-preserved mantle ophiolite suites in the west CAOB are known from the North Balkhash (NBOZ) and Dzhalair-Naiman (DNOZ) ophiolite zones of Kazakhstan.

Serpentinite mélange of the NBOZ in Central Kazakhstan contains varisized blocks of igneous and metamorphic (high-pressure) rocks, as well as slivers of volcanic-sedimentary strata. The largest igneous blocks are composed of spatially disintegrated fragments of the residual (dunite-harzburgite) and layered (dunite-wehrlite-pyroxenite-gabbro-plagiogranite) complexes, subordinate lherzolites are also found. Variably serpentinized harzburgites and dunites of the NBOZ are characterized by low Al2O3 (0.33–0.86 wt%), CaO (0.51–0.86 wt%) and Na2O (0.07–0.25 wt%) concentrations. The rocks contain high-Mg olivine (Fo91–92) and orthopyroxene (En92–93) contents, together with moderately-high spinel Cr-numbers of 63–68. The ultramafites are depleted in incompatible elements (ΣREE, Nb, Sc) and enriched in compatible elements, such as Cr (up to 2817 ppm) and Ni (up to 2327 ppm). Whole-rock compositions and primary mineral chemistry of these rocks suggest that they represent refractory mantle residues after 19–23% of partial melting to produce boninitic melts in a forearc tectonic setting. Re–Os isotope systematics (187Os/188Os = 0.1202-0.12599, 187Re/188Os = 0.230-0.316) indicates the formation of the ultramafites in two stages at ca. 1.5 Ga and ca. 668–589 Ma, as determined by the estimated TRD model ages.

The DNOZ includes deformed fragments of ophiolite suites associated with volcanic-sedimentary rocks. Plutonic parts of the ophiolite sequence comprise well-preserved dunite-harzburgite with hornblendites and dunite-wehrlite-pyroxenite-gabbro complexes. The rocks are rodingitized and serpentinized to varying degrees. The ultramafites of residual complex possess SiO2 contents < 47.7 wt.% with Mg# = 90–91, and notable Cr (<6162 ppm) with Ni (<2400 ppm) concentrations, suggesting their mantle origin and high degrees of partial melting of their mantle source of ~18–20%. Selected samples of harzburgites are notably enriched in basaltic components (Al2O3 <

3.53 wt.% and CaO < 2.55 wt.%), possibly resulting from an interaction of the rocks with Ca-Al-rich melts during serpentinization and rodingitization. Compared to DMM, the ultramafites and pyroxenites of the DNOZ demonstrate an enrichment in LILEs, U, while showing a depletion in HFSE concentrations, including Nb, Hf, REE, implying their affinity to suprasubduction zone setting and metasomatic overprinting.

This work was funded by the Russian Science Foundation (project No. 22-17-00069).

Keyword

Central Asian Orogenic Belt, Ophiolite, Peridotites

Olivine fabric and tectonic evolution of Indus-Yarlung suture zone: Insight from the Indus-Yarlung ophiolitic peridotite in the Tibetan Plateau

Yu YANG[1]*, Chinese Academy of Geological Sciences (yangyu_geo@outlook.com)
Jingsui Yang[2], Nanjing University
Weiwei Wu[3], Nanjing University
Haitao Ma[4], Nanjing University
Yun Wang[5], Nanjing University

Abstract

To advance our understanding of the deformation characteristics, rheological behaviors, and melt-rock reaction of the Indus-Yarlung suture zone (IYS) ophiolitic mantle, we analyzed mineral fabrics for ophiolitic mantle rock at multiple locations along the Indus-Yarlung suture zone, ranging from east to west. Prominent plastic deformation microstructures are observed in olivine and orthopyroxene, accompanied by significant crystallographic preferred orientations (CPOs), which suggest dislocation creep deformation. Electron backscatter diffraction measurements revealed that the D-type (characterized by a strong alignment of [100] close to the lineation and by a distribution of [010] and [001] in a girdle normal to the [100] maximum) and B-type (characterized by a point concentration of [001] axes subparallel to the lineation and of [010] axes nearly normal to the foliation plane) olivine CPOs occur in dunite samples from Luobusha (eastern part of IYZ), might formed under high stress environment. Olivine shows transitional CPO symmetry from [010]-fiber to orthogonal type (AG-type and A-type) in Sangsang (central part of IYZ), indicating a representative of the original oceanic lithosphere fabric with a low instantaneous melt/rock ratios during the impregnation process. Olivine CPO within the Xiugugabu ophilitic massif (central part of IYZ) is characterized by (100)[001] fabric (C-type), which is considered to cause by high water contents in a suprasubduction-zone setting during exhumation. Olivine in the Purang peridotite display an orthorhombic symmetry fabric, which is characterized by a point concentration of [100] axes subparallel to the lineation and of [010] axes nearly normal to the foliation plane, which is referred as A-type (Western part of IYZ) representing the remnants of the original fabric in oceanic mantle rocks formed in the spreading center of the New Tethyan ocean. Our new microstructural and fabric data, provide constrains for the tectonic evolution of the Indus-Yarlung suture zone.

Keyword

Indus-Yarlung suture, Crystallographic preferred orientations, Ophiolitic mantle

Geochemical study of ultrahigh pressure serpentinites from Chinese southwestern Tianshan and its implications

Tingting SHEN[1]*, Institute of Geology, Chinese Academy of Geological Sciences (ttshen@pku.edu.cn)
José Alberto Padrón-Navarta[2], Instituto Andaluz de Ciencias de la Tierra (IACT), CSIC-UGR
Thomas Bader[3], Ministry of Natural Resources, and Institute of Geomechanics, Chinese Academy of Geological Sciences
Tian Qiu[4], Institute of Geology, Chinese Academy of Geological Sciences
Jingsui Yang[5], Nanjing University

Abstract

Serpentinites play a crucial role in recycling of elements and volatiles in subduction zones. We studied the geochemistry of Changawuzi serpentinites from Chinese southwestern Tianshan, which underwent ultrahigh-pressure (UHP) metamorphism. The bulk-rock major and trace element compositions indicate that the Changawuzi serpentinites originated from a depleted mantle source, representing a section of the oceanic lithosphere with local occurrences of pyroxenites. The variations in major and trace elements suggest different protolith compositions and different melt-peridotite evolution before serpentinization. During the process of oceanic serpentinization, the protoliths of Changawuzi serpentinite absorbed FMEs such as B, As, and Sb from seawater, acquiring a bulk Sr isotope composition similar to that of Silurian seawater. However, the bulk Pb and Nd isotope compositions remained consistent with the depleted mantle, indicating no significant influence from sediment-derived fluids during early serpentinization or at forearc conditions. During subduction, there is a redistribution of major and trace elements among metamorphic minerals. In the early stage, most elements decrease during the transformation from lizardite to antigorite. Regarding FMEs, over 50% of B is released into the subduction zone during the lizardite-to-antigorite transformation, while Sb and As show no significant change. At peak metamorphism, minerals such as olivine, TiChn, and TiChu contain trace elements released during the antigorite partial dehydration and clinopyroxene recrystallization. Metamorphic Ti-bearing olivine and TiChu/TiChn are potential carriers of HFSE and FMEs, especially B and Li, into the deeper mantle beyond the dehydration zone of serpentinites, which may impact arc magma characteristics and global geochemical recycling. The trace element and Sr–Nd–Pb isotopic compositions of the Changawuzi serpentinite suggest that it likely resided in a slab interior setting with limited interaction with subduction zone sediment-derived fluids.

Keyword

Serpentinite, Sr-Nd-Pb isotope, Fluid-mobile elements, Ti-clinohumite and Ti-chondrodite, Southwestern Tianshan

Petrogenesis of chromitites in the Bulqiza ophiolite massif, Albania and its records of Ti metasomatism

Tian QIU[1]*, Institute of Geology, Chinese Academy of Geological Sciences (tianqiu@pku.edu.cn)
Jingsui YANG[2], School of Earth Sciences and Engineering, Nanjing University
Weiwei WU[3], School of Earth Sciences and Engineering, Nanjing University
Fahui XIONG[4], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

Podiform chromitites are one of the main sources of the key metal chromium, however the genesis of the chromitites located in crust-mantle transition zone of ophiolite has yet to be resolved. The Bulqiza ultramafic massif, which is part of the eastern Mirdita ophiolite of northern Albania, is world renowned for its high-Cr chromitite deposits hosted in the mantle section and high-Al chromitite deposits in the mantle-crust transition zone. The Cerruja high-Al podiform chromitites (Cr# of spinels varying from 0.56 to 0.58) and dunite wall-rocks (Cr# of spinels varying from 0.52 to 0.55) are widespreadly intruded by pyroxenite dikes in the crust-mantle transition zone of the Bulqiza ultramafic massif, Albania. Highly brecciated spinel and Ti-bearing mineral assemblages such as rutile, ilmenite and titanite were found in pyroxenite dike and in the interaction zone between pyroxenite dikes and high-Al chromitites. Spinels in the pyroxenite dikes and also the interaction zone between pyroxenite dikes and chromitites are characterized by obviously higher Cr# (0.72-0.83 and 0.57-0.67, respectively) than chromitites ores. Contents of TiVMnScCoZn and Ga of spinels in the interaction zone are higher with the closer distance to the pyroxenite dikes. According to the texture characteristics of spinel and the change of mineral chemical composition, we propose that the chromitites in the crust-mantle transition zone of Bulqiza massif is the result of a multi-stage process: first, high-Al chromitites are produced by the reacts between peridotites and the transition melts which has the geochemical properties both of MORB and boninitic melts during the evolution of initial subduction of the Mirdita-Pindos ocean basin (~165 Ma) ; and then, residual melts which are Ti- and Fe-rich are produced by intercumulus crystal fractionation of the MORB melt in a crystal-melt mush, penetrating into and metasomatizing extensively the surrounding chromitites during upon colling, and also crystallizing Ti-rich minerals such as rutile, ilmenite and titanite.

Keyword

Bulqiza ophiolite massif, crust-mantle transition zone, podiform chromitites, Ti-metasomatism, Rutile

A case for subduction initiation in the Proto-South China Sea? Insights from the volcanic geology, petrology, and geochemistry of the Southern Palawan ophiolite

Nikko Manaig BALANIAL[1]*, University of the Philippines - National Institute of Geological Sciences (nmbalanial@up.edu.ph)
Americus Perez[2], Philippine Nuclear Research Institute - Department of Science and Technology
Gabriel Theophilus Valera[3], University of the Philippines - National Institute of Geological Sciences
Julius Pasco[4], University of the Philippines - National Institute of Geological Sciences
Jesley Mei Dycoco[5], Energy Development Corporation
Ron Josef Magarzo[6], University of the Philippines - National Institute of Geological Sciences
Betchaida Payot[7], University of the Philippines - National Institute of Geological Sciences

Abstract

The Proto-South China Sea (PSCS) is a vanished Cretaceous to Eocene oceanic basin speculated to have existed in the location of the modern South China Sea. Details about its nature, evolution, and eventual consumption remain contentious. Ophiolites present in the southeastern margins of the South China Sea are postulated to be the only remaining vestiges of the PSCS. One of the ophiolites inferred to be associated with it is the Southern Palawan ophiolite (SPO) in the western Philippines. It is composed of dismembered outcrops of mantle peridotites, gabbros, and volcanic rocks exposed from Quezon to Balabac Island.

Field investigation of the volcanic section exposed in Quezon, Brooke's Point, Bataraza, and Balabac reveals both effusive and explosive modes of submarine volcanism. Effusive volcanism is represented by basaltic lava flows showing sheet, lobate, and pillow morphologies. On the other hand, explosive volcanism is suggested by the presence of pyroclastic breccias that unconformably overlie pillow lavas. Sub-rounded, lapilli-sized glassy clasts are embedded within pyroclastic breccias. Basalts from lava flows are generally composed of plagioclase, orthopyroxene (OPX), and clinopyroxene (CPX) grains set in a glass groundmass. The clasts in pyroclastic breccias are andesitic and composed of OPX, CPX, and plagioclase set in a groundmass of glass and feathery quenched pyroxenes. Whole-rock geochemistry suggests the existence of three main lithological groups in the SPO's volcanic section: tholeiitic, boninitic, and alkalic. Tholeiitic rocks, identified as medium-Fe basalts and basaltic andesites, are distributed in Quezon, Bataraza, and Balabac. Samples have nearly flat REE patterns comparable to normal MORB (N-MORB) except for Bataraza samples which are 1.2-2 times more depleted than N-MORB. Boninitic volcanics are observed in Quezon and co-exist with tholeiitic lavas. Boninitic samples, classified as fractionated boninite of low silica subtype, are silicic and have low TiO2 contents (0.21-0.31 wt%) albeit MgO values (4.55-7.09 wt%) are below the prescribed criteria for true boninites. Trace element signatures of both tholeiitic and boninitic lithologies (e.g., negative Nb-Ta anomaly, high Ba/Th values) indicate the incorporation of subduction-related fluids

released at shallow depths. Alkalic samples, identified as alkali basalts, are spatially constrained in Brooke's Point. The samples are notably enriched in light REE relative to middle and heavy REEs as evidenced by (La/Sm)N and (La/Yb)N values ranging from 2.86-3 and 7.37-8.04, respectively. Three samples exhibit elevated Nb (54.2-57.4 ppm), Y (42.4-46.2 ppm), Yb (3.99-4.49 ppm), and Zr (265-279 ppm) concentrations comparable to high-Nb basalts (HNB). The alkalic samples have signatures akin to enriched MORB (E-MORB) and ocean island basalt (OIB).

Although the disrupted nature of the SPO's volcanic section hindered direct stratigraphic sampling, the diverse geochemical signature of the volcanic rocks shows some similarity with forearc regions (e.g., Izu-Bonin-Mariana) and suprasubduction zone ophiolites (e.g., Zambales, Oman) intimately linked with subduction initiation (SI) processes. The presence and co-existence of geochemically varied rocks in the SPO suggest SI origins that can be linked with the initiation of subduction and eventual consumption of the PSCS. Further volcanostratigraphic and geochemical work will be done to constrain the evolution of the SPO's volcanic section.

Keyword

ophiolite, subduction initiation, volcanic rocks, Palawan, Proto-South China Sea

Juxtaposed Cenozoic and Mesozoic ophiolites in Palawan island, Philippines: Implications for the evolution of western Philippines

Betchaida PAYOT[1]*, University of the Philippines Diliman (bdpayot@up.edu.ph)
Jesley Mei Dycoco[2], Energy Development Corporation, Ortigas Avenue, Pasig City 1604, Philippines
Gabriel Theophilus Valera[3], National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City 1101, Philippines
Julius Pasco[4], National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City 1101, Philippines
Florence Annette Labis[5], Physics Department, Silliman University, Dumaguete City, Negros Oriental 6200, Philippines

Abstract

Ophiolites and ophiolitic complexes occur in western Philippines and neighboring areas such as Borneo. These fragments are believed to form part of the proto-South China Sea (proto-SCS), a fully consumed Mesozoic plate that once existed between the South China-Eurasian margin and Borneo. In the Philippines, Cretaceous and Eocene ophiolitic lithologies occur in the central and southern portions of the Palawan island. The Cretaceous Southern Palawan Ophiolite (SPO) comprises mostly of exposures of peridotites and pillow basalts. The peridotites are often cut by troctolite and olivine gabbro dikes. Isotopric olivine gabbros and biotite-bearing gabbros are also observed as float. The Eocene Central Palawan Ophiolite (CPO) is composed of mantle peridotites, isotropic and layered gabbros, and massive and pillow lavas. While a sheeted dike complex was not observed, mafic dikes with distinct bake-and-chill margins cut the CPO, from the metamorphic sole to the crustal section.

The CPO crustal rocks and mafic dikes show back-arc basin basalt affinities. Geochemical signatures of the SPO lithologies are more diverse ranging from ocean island basalt-like signatures with a mafic dike showing island arc basalt-like compositions. Radiometric dating of a plagiogranite sample from Puerto Princesa in Central Palawan yielded an Eocene age (40.01 ± 0.54 Ma), while olivine gabbro and syenite samples from Southern Palawan are determined to have a minimum age of Early Cretaceous (100.73 ± 1.07 and 102.97 ± 1.07 Ma, respectively). The geochemical and geochronological characteristics of the SPO and CPO share similarities with the Darvel Bay and Telupid Ophiolites in Borneo, which are interpreted to originate from the proto-SCS. The juxtaposition and present day configuration of the Cretaceous and Eocene ophiolites in Palawan may have been due to inception of multiple subduction and rifting events involving the proto-SCS in the past.

Keyword

palawan, Philippines, ophiolite, Proto-South china sea plate

Petrography and geochemistry of intrusive rocks in northern Zambales and Pangasinan: Constraints on the evolution of northern Luzon

Mariz Lacson ALCANCIA[1]*, UP-NIGS (mlalcancia@up.edu.ph)
Betchaida D. Payot[2], UP-NIGS
Gabriel Theophilus V. Valera[3], UP-NIGS
Jillian Aira S. Gabo-Ratio[4], UP-NIGS
Kenneth Jan F. Sangalang[5], UP-NIGS
Karl D. Jabagat[6], NCCU
Yuan-Hsi Lee[7], NCCU

Abstract

Several ophiolites and ophiolite complexes occur as basement of the Philippine archipelago. In northern Philippines, Early Miocene to Recent volcanic centers of the Luzon Arc form on top of these ophiolites. Multiple intrusive units occur in the northern Luzon segment of the arc due to the subduction of the South China Sea Basin along the Manila Trench. In particular, gabbros, diabases, and plagiogranites occur in northern Zambales and Pangasinan. These rocks possibly preserve records of the formation of the Zambales Ophiolite Complex and the inception of the Luzon Arc. This work aims to conduct petrographic, geochemical, and geochronological analyses of these intrusive rocks in northern Zambales and Pangasinan to provide new constraints on the tectonomagmatic evolution of northern Luzon.

Isotropic gabbros and associated rocks occur in the localities of northern Zambales (e.g. Sta. Cruz) and Pangasinan (e.g. Sual, Bugallon, Mabini, and Infanta). Massive isotropic gabbros are exposed in Sual, Infanta, and Sta. Cruz. Gabbros in Sual and Bugallon are cut by diabase dikes and their apophyses. A chilled margin between the contact of the diabase and gabbro was observed in Bugallon. A dunite exposure in Sta. Cruz is cut by gabbroic and plagiogranite dike swarms with prominent baked and chilled margins. Tonalites associated with isotropic gabbros are also noted in Infanta, Mabini, and Sual, Pangasinan. Isotropic gabbros in Sta. Cruz, Infanta, and Bugallon are gabbronorites that exhibit orthocumulate and sub-ophitic textures. The crystallization order is olivine → pyroxene → plagioclase → hornblende. Gabbros from Sual show orthocumulate and ophitic textures. Plagioclase formed first before clinopyroxene in the Sual gabbros. The diabases are composed of pyroxenes, plagioclases, and Fe-Ti oxides with intergranular and sub-ophitic textures. The tonalites are composed of interlocking crystals of quartz, plagioclase, amphiboles, and Fe-Ti oxides which at times show myrmekitic texture.

Whole-rock geochemical analysis of the gabbronorites, gabbros, diabases, and tonalites revealed island arc tholeiite signature. An increasing trend of TiO2 and FeO* and a decreasing trend of MgO, Cr2O3, and Ni were observed with increasing FeO*/MgO. While the tonalites have very high FeO*/MgO ratio and Na2O with very low concentrations of TiO2, Cr2O3, and Ni. Trace element concentrations of the samples revealed a slight depletion of LREEs relative to HREEs and

negative Nb, Hf, Zr, and Ti and positive Pb and Sr anomalies. U-Pb age dates of the zircon grains from an olivine-bearing gabbronorite from Bugallon and a gabbro from Sual have ages of 45.64 ± 0.97 Ma and 45.28 ± 0.30 Ma, respectively. Our results show that the intrusive rocks from northern Zambales and Pangasinan generally have island arc tholeiite affinity and were formed during the Middle Eocene.

Keyword

intrusive rocks, Zambales Ophiolite Complex, northern Luzon, Luzon Arc

Subduction initiation beneath an attenuated continental margin: Insights from the Timor ophiolite

Yu-Chin Lin[1]*, Academia Sinica, Taiwan (mollyppchin@gmail.com)
Julian Pearce[2], Cardiff University, Cardiff, UK
Akira Ishikawa[3], Tokyo Institute of Technology, Tokyo, Japan
Yannick Buret[4], Natural History Museum, London, UK
John Spratt[5], Natural History Museum, London, UK
Kuo-Lung Wang[6], Academia Sinica, Taipei, Taiwan
Shigenori Maruyama[7], Tokyo Institute of Technology, Tokyo, Japan
Ade Kadarusman[8], University of Indonesia, Jakarta, Indonesia
Sun-Lin Chung[9], Academia Sinica, Taipei, Taiwan

Abstract

Field and geochemical evidence indicate that most supra-subduction zone (SSZ) ophiolites originated by sea-floor spreading following subduction initiation. Most of our understanding of intra-oceanic subduction initiation derives from the Eocene forearc of the Western Pacific, where the locus of subduction initiation has been described as an intra-oceanic transform. Here we present a more recent example from the Miocene Timor ophiolites related to the Banda arc-basin system, where mineral and whole-rock geochemical data from boninites and peridotites demonstrate that subduction initiation took place beneath a continental margin. Specifically, the Timor peridotites include lherzolites with LREE-depleted rare earth patterns, chrome spinels with low Cr# giving oxygen fugacities close to the QFM buffer and incompatible trace element data (analyses by EMP and ICP-MS), all indicative of an origin as slightly depleted attenuated continental margin peridotite. These lherzolites are interspersed with more harzburgitic peridotites with LREE-depleted to U-shaped rare earth patterns, spinels with higher Cr# giving elevated oxygen fugacities, and elevated trace element reaction proxies. On diagnostic chrome spinel projections such as Cr# versus oxygen fugacity and Ti/FeIII versus Ga/FeIII, the data form reaction trends between continental margin lherzolites and Timor boninites that differ in detail from the abyssal peridotite- boninite trends found in Western Pacific subduction initiation systems. This emphasizes that the precise location of subduction initiation can significantly influence the petrology and geochemistry of SSZ ophiolites.

Keyword

SSZ ophiolites, Timor ophiolite, subduction initiation, continental margin peridotites, petrogenesis

The Ginebra Ophiolithic Complex: Origin and evolution of an Ophiolite in Colombia from geochemistry and U-Pb geochronology.

Jonathan Adolfo HERNANDEZ PRIETO[1]*, National University of Colombia (joahernandezpr@unal.edu.co)
Juan Carlos Molano Mendoza[2], National University of Colombia
Ana María Martínez Ardila[3], Loma Linda University

Abstract

The Ginebra Ophiolithic Complex consist of mafic to ultramafic rocks located in the department of Valle del Cauca in Colombia, on the western flank of the Central Cordillera. The study of this ophiolitic body is of great importance in the reconstruction of the geological and tectonic evolution of the Andes Mountains in the country.

The aim of this study is to reconstructs the evolution of the Ginebra Ophiolithic Complex based on the analysis and geochemical characterization of the complex, U-Pb dating of zircons from 7 samples taken throughout the study area and the compilation of geochemical data reported in other studies.

The rocks of the Ginebra Ophiolithic Complex are geochemically characterized as part of the subalkaline series and classified as gabbros, gabbroic diorites and diorites, and with a toleiitic trend. Using geotectonic discrimination diagrams and the methodology proposed by Pearce in 2014 for ophiolites, it was found that this secuence of rocks has an origin associated with MOR-type geotectonic environments, although with negative Nb anomalies, indicating additional processes in the evolution of the complex. Finally, it was determined from radiometric U-Pb dating in six zircons found in the collected samples, that this ophiolitic body has a crystallization age of 93.78 ± 1.38 M.y., age corresponding to the Turonian, within the Upper Cretaceous.

According to the data obtained for the Ginebra Ophiolithic Complex in the geochemical and geotectonic environment characterization comparing the geochemical data obtained for the complex with the geotectonic discrimination diagrams proposed by Pearce (2014), the geochronological analysis developed and the age comparison with adjacent units, is concluded that this ophiolite has a genesis independent of the Western Cretaceous Oceanic Lithospheric Province (PLOCO), which would be more related to a Mesoceanic ridge environment and its emplacement in the continent could have occurred at the beginning of the Paleogene, taking into account the temporal relationships with the intrusive bodies reported in this complex reported by Brito et al. (2010).

Keyword

Ophiolite, Geochronology, Ginebra Ophiolitic Complex, MOR, Geochemistry

[Keynote] East Asian Blocks: From Breakup of Rodinia to Assembly of Pangea

Guochun ZHAO[1]*, The University of Hong Kong (gzhao@hku.hk)

Abstract

Pangea is the youngest supercontinent in Earth's history and its main body formed by assembly of Gondwana and Laurasia about 300-250 Ma ago. As supported by voluminous evidence from reliable geological, paleomagnetic and paleontological data, configurations of major continental blocks in Pangea have been widely accepted. However, controversy has long surrounded the reconstructions of East Asian blocks in Pangea. To determine whether or not the East Asian blocks were assembled to join Pangea before its breakup, we carried out geological and paleomagnetic investigations on East Asian blocks and associated orogenic belts, supported by a NSFC Major Program entitle "Reconstructions of East Asian blocks in Pangea". Our results indicate that the breakup of Rodinia around 750 Ma ago led to the opening of the Proto-Tethys and Paleo-Asian oceans in East Asia, with the former separating the South China, North China, Alex Qaidam and Tarim blocks from other East Asian blocks at the margins of Australia and India, whereas the Paleo-Asian Ocean existed between the East Asian blocks and Siberia-Eastern Europe. The Proto-Tethys Ocean closed in the early Paleozoic (500-420 Ma), leading to the collision of South China, North China, Alex, Qaidam and Tarim with other East Asian blocks at the northern margin of Gondwana. The subduction of the Paleo-Asian Ocean formed the Central Asian Orogenic Belt, the largest accretionary orogen in Earth's history, and its closure was diachronous, with its western, central and eastern segments closing at 310-280 Ma, 280-265 Ma and 260-245 Ma, respectively, leading the Tarim, Alex and North China blocks to join Eastern Europe-Siberia as part of Pangea. During the early Devonian (420-380 ma), the East Paleo-Tethys Ocean opened with two branches, of which the north branch is called the Mianlue Ocean that separated the Tarim-Qaidam-Central Qilian-Alex and North China blocks in the north from North Qiangtang-Indochina-South China in the south, and the south branch is the stricto sensu East Paleo-Tethys Ocean that separated North Qiangtang-Indochina-South China from the Sibumasu and South Qiangtang-Lhasa blocks at the northern margin of Gondwana. In the Triassic, the East Paleo-Tethys Ocean (stricto sensu) closed along the Longmu Co – Shuanghu – Changning – Menglian – Inthanon belt, leading to the collision of North Qiangtang-Indochina-South China with Sibumasu and South Qiangtang-Lhasa, forming a single southern continent, which then collided with the Tarim-Qaidam-Central Qilian-Alex and North China blocks to form a coherent East Asian continent that had become part of Pangea by 220 Ma, when the Mianlue Ocean closed, leading to the formation of the E-W-trending Central China Orogenic System.

This research was supported by NSFC Major Program "Reconstructions of East Asian blocks in Pangea" (41190070), Hong Kong RGC GRF (17308023) and HKU Faculty Start-up Funds (000250348).

Keyword

Supercontinent, East Asia, Rodinia, Pangea, Continent

The review on the Permo-Triassic continental collision process in the Northeast Asia during the final amalgamation stage of Pangea supercontinent and the geological correlations between Korea, China, and Japan.

Chang Whan OH[1]*, Jeonbuk National University (ocwhan@jbnu.ac.kr)
Byung Choon Lee[2], Chonnam National University
Sang Bong Yi[3], Jeonbuk National University
Seung Hwan Lee[4], Korea Institute of Geoscience and Mineral Resources
Bo Young Lee[5], Korea Institute of Geoscience and Mineral Resources

Abstract

Asia is the youngest continent formed during the last stage of the amalgamation of the Pangea during Permo-Triassic period. The amalgamation of Northeast Asia began to receive much attention after discovering HP and UHP eclogites in Dabie and Sulu areas in China during the late 80s. Several tectonic models were proposed for the amalgamation of Northeast Asia, including the Korean Peninsula, China, and Japan. However, the tectonic evolution of Northeast Asia during Permo-Triassic time is still under argument. One of the leading causes of such controversy was the lack of geological information on the Korean Peninsula. Fortunately, over the past 30 years, several critical geological discoveries necessary for interpreting the Permian-Triassic tectonic evolution have been reported on the Korean Peninsula. The followings were reported as direct evidence of the continental collision. 1) The Permo-Triassic eclogite in the Hongseong area, 2) the extensive occurrences of Triassic post-collisional igneous rocks in the northern Gyeonggi Massif (GM), Imjingang Belt, and southern boundary of the Nangrim Massif which locate north of the Hongseong-Odaesan Belt, and 3) the Permo-Triassic intermediate-P/T metamorphism in the Imjingang and Okcheon Belts and the GM associated with the strongest Permo-Triassic metamorphism along the E-W trending Hongseong-Yanpyeong-Odaesan Belt locating in the middle part of the GM. Other indirect evidence for the collision were reported as follows. The Imjingang Belt was confirmed to form as the backarc basin at Devonian, and Devonian sedimentary rocks were also found in the other parts of the GM. The Honam Shear Zone was confirmed to be initiated from the early Jurassic, indicating that it can not be matched to the Tanlu Fault. These date indicate that the Qinling-Dabie-Sulu Collision Belt between the North China Craton (NCC) and South China Craton (SCC) extends not into the Imjingang Belt but into the Hongseong-Odaesan Belt within the Korean Peninsula. This tectonic interpretation is also supported by the followings. The northern and southern parts of the Gyeonggi Massif (NGM and SGM), separated by the Hongseong-Odaesan Belt, experienced different tectonic evolution during the Paleoproterozoic and Neoproterozoic. Furthermore, the Neoproterozoic igneous rocks in the NGM and SGM correlated well with those in the NCC and SCC. There is a systematic change of metamorphic age and P-T conditions along the Qinling-Dabie-Sulu-Hongseong-Odaesan Collision Belt. The Hongseong-Odeasan Belt extends into the inner part of southwest Japan and then into the Dumangang Belt in the northeast Korean Peninsula, formed by the collision between the NCC and the Khangka-Jiamusi Block. During the collision between the North Korea-China Craton

(NKC) and the South Korea-China Craton (SKC), the transition from the passive to active margin occurred with the initiation of subduction along the southern margin of the SKC from late Permian. These interpretations and data are most consistent with the tectonic model suggested by Oh and Kusky (Oh, C.W., and Kusky, T.M., 2007, The Late Permian to Triassic Hongseong–Odesan collision belt in South Korea, and its tectonic correlation with China and Japan. International Geolology Review, v. 49, pp. 639–657).

Keyword

Northeast Asia, Permo-Triassic, Hongseong-Odaesan, Dabie-Sulu, Continental Collision

Tectonic and metallogenic evolution of the North China (Sino-Korean) Craton and the connection to the East Asian Continent

Mingguo ZHAI[1]*, Institute of geology and geophysics, Chinese Academy of Science (mgzhai@mail.iggcas.ac.cn)
Ligang ZHOU[2], Institute of geology and geophysics, Chinese Academy of Science
Yanbin ZHANG[3], Institute of geology and geophysics, Chinese Academy of Science

Abstract

Ancient rocks with ages of >4.0-3.8 Ga have been determined in the North China (Sino-Korean) Craton. The diversity of magmatic and sedimentary rocks older than 3.3-3.0 Ga indicates that there were several independent ancient continental nuclei in the North China Craton (NCC). The NCC experienced large-scale growth of continental crust in 2.7-2.5 Ga and then extensively reconstructed during 2.55-2.42 Ga, ultimately forming a stable ancient continent block. The main mineral deposits are BIFs in the Archean, with a small amount of Cu-Zn sulfide massive deposits at the end of Neoarchean.

During 2.35 to 2.20 Ga, the magmatic rock assemblages in the NCC indicate the occurrence of a rift event derived by uplifted mantle during the Paleoproterozoic “quiescence”. Subsequently, subduction-collision orogeny occurred at 2.0-1.8 Ga, characterized by the appearance of a wide HTHP-HTUHT metamorphic belt, indicating the involvement of the NCC into the process of the Colombian Supercontinent. During 1.80-0.7 Ga in the Meso-Neoproterozoic, multiple extension-rifting-drifting events occurred in the NCC, with geological records of red beds, black shales, biogenic carbonates and tillite. The main minerals in this period are sulfide Pb-Cu deposits, Fe-Mg (magnesite) - B-P sedimentary deposits, and graphite deposits.

In the Paleozoic era, the NCC entered the stage of platform evolution, with the absence of strata from middle Ordovician to middle Carboniferous and with the development of coal-bearing deposits during upper Carboniferous to Jurassic. In the late Paleozoic era, strong orogeny occurred both in southern and northern margins of the NCC, leading to the convergence of the NCC with the Siberian Block, South China Block, and Tarim ancient Block, forming the basic outline of the East Asian continent. Orogenic Cu-Mo deposits were developed in the southern and northern margins of the NCC.

During the Mesozoic, the NCC was compressed by the ancient Pacific Plate and surrounding blocks, resulting in large-scale lithospheric thinning with a peak period of 130-120 Ma. In addition to the strong crustal activation, it was also marked by the large-scale gold mineralization within the continent.

As a consequence, the structural and mineralization evolution of the NCC substantially reveal the basic laws of the Earth's continental crust and material evolution.

Keyword

tectonic evolution, metallogenic evolution, North China Craton, continental crust

Early to Late Mesozoic Tectonic Evolution and Associated REE Mineralization in Southern Mongolia: A Comparative Study of the Mushgai-Khudag and Lugiin Gol REE Deposits

Otgon-Erdene DAVAASUREN[1]*, Critical Minerals Research Center, Korea Institute of Geoscience and Mineral Resources (geotec13@kigam.re.kr)
Bum Han Lee[2], Critical Minerals Research Center, Korea Institute of Geoscience and Mineral Resources
Sang-Mo Koh[3], Critical Minerals Research Center, Korea Institute of Geoscience and Mineral Resources
Namhoon Kim[4], Research Institute for Earth Resources, Kangwon National University
Chul-Ho Heo[5], Critical Minerals Research Center, Korea Institute of Geoscience and Mineral Resources

Abstract

The alkaline province in Southern Mongolia represents one of the most economically significant belts of rare-earth elements (REE) mineralization in Mongolia, featuring notable deposits such as Mushgai-Khudag and Lugiin Gol. The REE mineralization in these deposits is spatially and temporally associated with the carbonatite type. This study compares the REE mineralization characteristics of the Mushgai-Khudag and Lugiin Gol deposits. The Mushgai-Khudag carbonatite-alkaline complex is composed of sheet-like magnetite-apatite ore bodies along the contact of Jurassic syenite porphyry and the host Paleozoic sedimentary rocks. In contrast, Lugiin Gol is characterized by nepheline syenite host rocks and carbonatite dikes intruding Permian sedimentary formations. The REE ore bodies in the Mushgai-Khudag deposit are hosted by carbonatites and syenite. Major REE minerals in the Mushgai-Khudag deposit are monazite and parisite, while Lugiin Gol carbonatites comprise bastnäsite, monazite, and parisite. Considering chondrite normalized REE patterns, they exhibit similar characteristics, showing enrichment of light REE relative to heavy REE with small negative Eu anomalies. Rb-Sr results indicate that the syenite in the Lugiin Gol deposit was emplaced in the early Triassic, representing the oldest known age. On the other hand, SHRIMP dating of the carbonatite and syenite in Mushgai-Khudag suggests they were formed during the early Cretaceous, making this the youngest known alkaline carbonatite complex in southern Mongolia. Geochemical data suggest that the Mushgai-Khudag deposit originates from a lithospheric mantle source and formed in a within-plate tectonic setting associated with an extensional rift zone, consistent with the characteristics of the Lugiin Gol deposit. The emplacement ages of the studied rocks in the Mushgai-Khudag and Lugiin Gol deposits exhibit similarities to those associated with late Mesozoic alkaline–carbonatite magmatism within the Central Asian Orogenic Belt (CAOB). Specifically, these ages align with the early to late Mesozoic southern Mongolian alkaline province, which spans from 244 to 139 Ma. These rocks are also linked to alkaline magmatism involving carbonatites, implying a temporal relationship with late Mesozoic global plume activity.

Keyword

Carbonatites, REE mineralization, Mushgai-Khudag REE deposit, Lugiin Gol REE deposit, southern Mongolia

Zircon U–Pb ages and Lu–Hf isotopes of the Paleozoic Maizuru Granites, Southwest Japan: Implications for the tectonic correlation between the Proto-Japan and Northeast Asia

Kenta KAWAGUCHI[1]*, Hiroshima University (kentakawaguchi2@gmail.com)
Nobuhiko NAKANO[2], Kyushu University
Ji Wan JEONG[3], Kyushu University
Kaushik DAS[4], Hiroshima University
Sota MUROI[5], Hiroshima University
Kosuke KIMURA[6], Osaka Metropolitan University

Abstract

The "Proto-Japan" has been formed along the continental margin of Northeast Asia since the earliest Paleozoic. Recent studies have revealed that part of the "Proto-Japan" was located between the southeastern and northeastern parts of the Korean Peninsula during the Triassic to Jurassic (Kawaguchi et al., 2023a, b). However, the tectonic correlation before the Triassic is highly uncertain because of the scarce occurrence of the Paleozoic rock units in the Japanese Islands. The Maizuru Belt (MB), Southwest Japan hosts the Paleozoic plutonic rocks and can be used as a key marker to track the origin of the Paleozoic Proto-Japan. The MB is known as an island arc-back arc basin system comprising of the ophiolite with ~295–275 Ma island arc magmatism (Southern Zone) and back-arc basin formation with Permian sedimentary rocks deposited on it (Central Zone) followed by the closure of the back-arc basin, resulted in the collision of Southern and Central Zones with some unknown areas of the Northeast Asian continent (Northern Zone) (Suda et al., 2004; Mavoungou et al., 2022). In the previous studies, the Northern Zone of the MB (N-MB) is suggested to have derived from the Khanka Massif based on the commonalities of the igneous activities including Siluro–Devonian and Permo–Triassic periods (e.g., Fujii et al., 2008). In this study, we report new zircon U–Pb ages and Lu–Hf isotopes from the Paleozoic granitoids in the N-MB to reveal the crustal evolution along with further detailed tectonic correlation. Weighted mean zircon U–Pb ages of the granitoids in the N-MB can be grouped into three periods: Ordovician (463.8 ± 9.7 Ma, 453.3 ± 4.0 Ma, and 447.2 ± 3.4 Ma), Late Carboniferous (310.6 ± 5.4 Ma and 300.6 ± 2.9 Ma), and Early Permian (288.7 ± 2.4 Ma, 283.6 ± 2.6 Ma, and 280.5 ± 3.0 Ma). εHf(t) values of zircon from the Ordovician and Late Carboniferous groups are slightly positive (+0.95 to +3.05 and +0.22 to + 1.71, respectively), whereas those of the Early Permian group are mostly highly positive (+4.40 to +12.22). Granitoids of the Ordovician and Late Carboniferous groups contain ~950 Ma to ~650 Ma inherited zircon constituting up to ~35% of the analytical spots, suggesting significant input of ~950–650 Ma crustal material during the magmatism. Collating all the analytical results, granitic crusts of the N-MB were formed by the melting of Precambrian crust dominantly of Neoproterozoic ages during the Ordovician and Late Carboniferous forming ~465–445 Ma and ~310–300 Ma granitoids, whereas the input of the juvenile source such as the lithospheric mantle increased during the Early Permian, that had formed the ~290–280 Ma granitoids. Timing of magmatism and evolutional

trend of the Lu–Hf isotopes of zircon of the N-MB are consistent with those of the Khanka-Jiamusi Massif (e.g., Zhang et al., 2018) indicating the common evolutional history between them during the Paleozoic.

Keyword

Maizuru Belt, Proto-Japan, Paleozoic, Zircon U–Pb age, Zircon Lu–Hf isotope

Late Tonian (ca. 780–750 Ma) bimodal magmatism in the Ogcheon Metamorphic Belt, Korea, at the eastern margin of North China Craton

Wonseok Cheong[1], Chungbuk National University
Moonsup Cho[2]*, Seoul National University (moonsup@snu.ac.kr)

Abstract

Neoproterozoic rift-related rocks of the North China Craton (NCC), including the Korean Peninsula, provide crucial information for global supercontinent reconstruction during the Rodinia breakup and Gondwana assembly. Here, we report not only zircon and baddeleyite U-Pb ages but also zircon Hf isotopic and bulk rock compositions of amphibolites in the Ogcheon Metamorphic Belt (OMB), Korea. Zircon occurs as either primary phase or secondary one replacing igneous baddeleyite. Primary zircons analyzed from three amphibolites yielded the weighted mean 206Pb/238U ages of 755 ± 5 Ma (n = 19), 772 ± 3 Ma (n = 9), and 779 ± 13 Ma (n = 12), respectively; this result is corroborated by the baddeleyite age of ~760–745 Ma. Secondary zircons define discordia lines with lower intercepts corresponding to the Jurassic or Cretaceous age of granites emplaced adjacent to the amphibolite. In conjunction with the occurrence of coeval (ca. 762–745 Ma) metatrachytes, our result suggests that late Tonian bimodal magmatism has lasted for ~30 m.yr. in the OMB. Moreover, positive εHf(t) values (4.9–21.4) of zircon in amphibolites indicate a depleted mantle source of mafic magma, whereas trace element compositions attest to an intraplate setting for the crystallization. A compilation of Nb–Th and Zr–Zr/Y data suggests that the intraplate setting is also pertinent to ca. 950–750 Ma mafic rocks from the Gyeonggi Marginal Belt, Korea, as well as the NCC. Such a tectonomagmatic correlation is corroborated by detrital zircon age spectra of metasedimentary rocks in the OMB equivalent to those of early Tonian rocks in the NCC. In marked contrast to tectonic scenarios conjecturing a linkage between the OMB and the Nanhua rift, South China Craton, we conclude that the Ogcheon Belt provides rare geologic-geochronologic evidence for late Tonian breakup of the Rodinia supercontinent at the eastern NCC margin.

Keyword

SHRIMP zircon U-Pb ages, Tonian intraplate magmatism, detrital zircon geochronology, Ogcheon Belt, North China Craton

Petrogenesis of the circum-cratonic Triassic syenite province from the North China

Xu LIU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (liuxu@mail.iggcas.ac.cn)
Peng Peng[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Ross Nelson Mitchell[3], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Syenite and its relevant varieties are typically derived from the most metasomatized portions of the subcontinental lithospheric mantle (SCLM). Subduction-related metasomatism is identified as a key process in the replenishment of the SCLM. In return, volatile-rich syenite may provide an important link between such a deep carbon reservoir and its potential release into the atmosphere. There are multiple atmospheric CO2 pulses during the Late Triassic when the Late Triassic belt around North China craton—the only circum-cratonic syenite province in the world—was intruded. This time and this unique circum-cratonic syenite belt thus offer an opportunity to investigate the petrogenesis of extensive alkaline magmatism and its potential environmental effects. New and previous data consisting of whole-rock Sr–Nd and zircon in situ Hf–O isotopes of the syenite province indicate two distinct types of metasomatism characterized by an alteration of juvenile or ancient materials. The spatiotemporally distinct sources can be discriminated by melts from oceanic slabs subducting beneath much of the North China craton followed by deep subduction of the South China craton only to the south. The sodic intrusions, originated from metasomatization of oceanic slab, exhibit potential Nb-Zr-REE mineralization, which appear to be strongly related to hydrothermal metasomatism by halogen-CO2-rich fluid. The loss of residual fluids may thereby get released as volatiles into the atmosphere. According to our first-order calculation presented here, such craton-scale alkaline magmatism can cause significant CO2-release. Thus, multiple subduction systems surrounding North China in the Late Triassic collectively gave rise to SCLM heterogeneity, post-collisional extension inducing craton-scale alkaline magmatism, and ultimately the release of SCLM-derived carbon into the atmosphere, causing or at least contributing to the global environmental changes of the age.

Keyword

North China Craton, alkaline magmatism, SCLM, subduction metasomatism, carbon cycle

Origin and evolution of the Maizuru Belt, Southwest Japan: Implications for the crustal rearrangement tectonics along the Northeast Asian continental margin

Yasutaka HAYASAKA[1], Hiroshima University
Masahiro FUJII[2], OYO Corporation
Kosuke KIMURA[3], Osaka Metropolitan University
Kenta KAWAGUCHI[4]*, Hiroshima University (kentakawaguchi2@gmail.com)

Abstract

The Maizuru Belt (MB), Southwest Japan is a Permian island arc-back arc basin system including the exotic blocks ranging from the Archean to Paleozoic. The MB comprising of the ophiolite with ~295–275 Ma island arc magmatism (Southern Zone) and back-arc basin formation with Permian sedimentary rocks deposited on it (Central Zone) followed by the closure of the back-arc basin, resulted in the collision of Southern and Central Zones with the Northeast Asian continent (Northern Zone) (Suda et al., 2014; Mavoungou et al., 2022). The occurrence of ~2.7–2.5 Ga and ~1.90–1.83 Ga magmatic-metamorphic rocks on the western most part of the Northern Zone of the MB (N-MB) indicates their origin as the North China Craton (NCC) (Kimura et al., 2019, 2021). Whereas the coexistence of Early Paleozoic and Permian granitoids on the eastern side of the N-MB shows their commonality with the Khanka-Jiamusi Massifs (KJM) (Fujii et al., 2008; Tsutsumi et al., 2014). These contrasting tectonic correlations can be testified by the detrital zircon U–Pb age dating of the Central Zone of the MB (C-MB). Detrital zircon U–Pb ages of the Middle to Late Permian formations throughout the C-MB mostly show prominent single peak at ~270–260 Ma with minor populations at ~500–400 Ma with very minor Precambrian zircons (Type 1). Whereas those of the Triassic formations in the C-MB show two different types depend on the location; the western half shows the two major peaks at ~250 Ma and ~1.95–1.85 Ga with subordinate ~2.5–1.9 Ga zircons (Type 2), whereas the eastern half has two prominent peaks at ~280–250 Ma and ~500–440 Ma with minor populations of Neoproterozoic (Type 3). The spatial-temporal distribution of three types indicates the change of the provenances from the Permian to Triassic as follows. 1) During the Middle to Late Permian, whole MB was located along the eastern margin of the KJM where the Permian magmatism were active with subordinate ~500–400 Ma igneous-metamorphic activities with minor Precambrian crusts to have formed the type 1 sedimentary rocks. 2) During the Triassic, the hinterlands of the Triassic formations of the eastern side of the C-MB were the KJM, same as the Permian period (deposition of type 3), whereas those of the western side have been changed to the NCC based on the commonalities of the major thermal episodes of the NCC and the detrital zircon age patterns of the Type 2. These drastic changes in their provenance suggest that the MB was formed along the KJM during the Permian and moved toward the south during the Triassic to have juxtaposed the western half of the MB to the NCC. The ~2.7–2.5 and ~1.90–1.83 Ga igneous-metamorphic rocks in the western most part of the N-MB are the exotic blocks derived from the NCC during the Triassic dextral strike-slip

movement. Considering the present configuration, the MB has been moved ~500 km towered the south as a dextral strike-slip movement along the eastern margin of the Northeast Asia.

Keyword

Maizuru Belt, Khanka-Jiamusi Massif, North China Craton, Zircon U–Pb age

Paleozoic tectonic evolution of the Guryong Group from detrital zircon records: Implications for the tectonic affinity of the eastern Gyeonggi Massif, Korean Peninsula

Ji Wan JEONG[1]*, Kyushu University (jiwan314@naver.com)
Nobuhiko Nakano[2], Kyushu University
Tatsuro Adachi[3], Kyushu University
Kenta Kawaguchi[4], Kyushu University

Abstract

The Permo–Triassic Qinling-Dabie-Sulu collision belt between the North China Craton (NCC) and South China Craton (SCC) in China is suggested to be continued to the Hongseong area of the western Gyeonggi Massif (GM) in the Korean Peninsula based on the report of the eclogite facies metamorphism (Oh et al., 2005). Moreover, Oh et al. (2006) reported that the collision belt extends to the Odesan area, located at the eastern GM based on the presence of UHT metamorphism. However, the Hongseong-Odesan collision model is still under argument and more study is needed to confirm this model. The Odesan area is mainly composed of the Paleoproterozoic paragneisses, with minor Mesoproterozoic to Paleozoic units, Paleozoic Guryong Group (GG), and the Triassic plutons (Yi et al., 2016). The Paleoproterozoic paragneisses underwent Paleoproterozoic and Permo–Triassic collision-related metamorphism leading to the difficulty to evaluate the Permo–Triassic metamorphism. However, metasedimentary rock in the GG is reported to have been deposited during the Late Paleozoic (Cho et al., 2014), indicating that the GG has the potential to evaluate the timing and nature of the Permo–Triassic metamorphism along with the tectonic affinity of the GG. In this study, LA-ICP-MS zircon U-Pb age dating was performed for the metasedimentary rocks in the GG. Major peak ages and their population (%) of the detrital zircon grains from two garnet-bearing metasedimentary rocks in the southwestern GG are ~760 Ma (population; 8%), ~370 Ma (14%), 350 Ma (17%), and ~330 Ma (19%) with the youngest detrital zircon age of ~311 Ma. The detrital zircon age peaks of combining Crd-Bt-Ms gneiss and quartzite layer are ~1840 Ma (5%), ~950 Ma (9%), ~410 Ma (10%), ~390 Ma (9%), ~370 Ma (15%), and ~350 Ma (17%) with the youngest detrital zircon age of ~325 Ma, and those of three Crd-Bt-Ms gneisses are ~1830 Ma (4%), ~1160 Ma (3%), ~940 Ma (2%), ~410 Ma (8%), ~390 Ma (11%), ~370 Ma (11%), ~350 Ma (24%), and ~330 Ma (10%) with the youngest detrital zircon age of ~293 Ma. In contrast, the calc-silicate rock in eastern GG shows a different detrital zircon age pattern range between 2501 Ma and 648 Ma, with the age peaks of ~1850 Ma (16%), ~1540 Ma (12%), ~1150 Ma (12%), ~750 Ma (16%), and other two Bt gneisses show age range between 3570 Ma and 2062 Ma, with age peak of ~3290 Ma (6%), ~2640 Ma (9%), ~2590 Ma (11%), and ~2450 Ma (30%) without any Paleozoic concordant detrital zircons. Our results suggest that parts of the GG were deposited during the Paleoproterozoic similar to the paragneiss in the GM. However, the Carboniferous–Permian deposition ages have been newly identified from paragneisses in the GG.

The Carboniferous magmatism has not been reported yet, however, the Carboniferous magmatism played an important role in supplying the detrital zircon grains to the sedimentary basin during the Carboniferous–Permian. This magmatism may represent the subduction-related arc igneous activities formed along the southern margin of the NCC before the collision between NCC and SCC.

Keyword

Eastern Gyeonggi Massif, Paleozoic, Guryong Group, Permo-Triassic collision, Zircon U-Pb dating

Early Paleoproterozoic magmatism in the southern Trans-North China Orogen

Xiaoping LONG[1]*, Northwest University (longxp@nwu.edu.cn)
Jingyu WANG[2], Northwest University

Abstract

Magmatic rocks in the North China Craton (NCC) are crucial to unraveling the tectonic background during the tectono-magmatic lull (TML, 2.45–2.20 Ga) and to constraining the initiation of plate tectonics. In this study, previously published zircon U–Pb–Hf–O data and whole-rock geochemistry are collected from the early Paleoproterozoic felsic intrusive rocks in the southern Trans-North China Orogen (TNCO) and new data presented. The formation ages and petrogenesis of the early Paleoproterozoic felsic intrusive rocks in the southern TNCO are summarized to constrain the tectonic setting during the TML. Zircon U-Pb geochronology of the tonalite–trondhjemite–granodiorite (TTG) gneisses yielded intrusive ages of ~2.3 Ga and ~2.2 Ga. Geochemically, the gneisses can be classified as ~2.3 Ga high-Al and ~2.2 Ga low-Al types, and were likely derived from the partial melting of pre-existing lower crust at medium and low pressure, respectively. The heavy rare earth depletion and have high Sr/Y and La/Yb values of the ~2.3 Ga TTG gneisses indicates that they were derived from the partial melting of thickening lower crust in the garnet-hornblende phase, which is consistent with a gradual thickening of the crust. The potassic granitoids are geochemically divided into I-type and A-type granites and have early Paleoproterozoic ages at ~2.3 Ga and ~2.27 Ga. Zircon U-Pb geochronology of the dioritic gneisses yielded intrusive ages of ~2.3 Ga. These potassic granitoids and dioritic gneisses were generated by the partial melting of ancient basement rocks, with variable degrees of juvenile contributions. Considering the large variety of zircon εHf(t) values, and Sr/Y and (La/Yb)N ratios obtained for the early Paleoproterozoic felsic intrusive rocks, the crustal thickening that occurred via tectonic compression prior to ~2.3 Ga is most likely due to convergence. The high δ18O and low δ18O values in the southern TNCO may have been the result of slab subduction, which can effectively transfer surface material directly or indirectly to the lower crust, and the TTGs that formed as a result of the subsequent partial melting inherited the high δ18O characteristics to varying degrees. Glacial meltwater is an important source of low δ18O fluids and a large number of rift events developed during the 2.5–2.4 Ga interval. The resulting fractured environment provided sufficient space for the infiltration of surface water, and rocks with low δ18O characteristics are likely produced by the remelting of crustal rocks that have been thermally altered by surface water or atmospheric hydrothermal processes. Combined with evidence such as the Paleoproterozoic Alaska-type intrusive rocks, diabases, sanukitoids and sedimentary rocks, the TNCO is proposed to have been in a subduction compression setting at ~2.3 Ga. Meanwhile, the alkaline and related elements (such as Rb, Th, Ba and Nb), K2O/Na2O ratios, and zircon δ18O values of the magmatic rocks increased significantly during the TML, which indicate that plate subduction started prior to ~2.3 Ga. The difference in the intensity of the magmatism during the TML may be related to continental freeboards in different regions.

Keyword

Tectono-magmatic lull, initiation of plate tectonics, North China Craton, early Paleoproterozoic, subduction

Ages, Geochemical Characteristics and Tectonic Environment of Mesozoic Diorites in the Central Sulu Orogenic Belt

Shikuo LU[1]*, China University of Petroleum (809924204@qq.com)
Tingyue LI[2], China National Petroleum Corporation Zhejiang Oilfield Branch

Abstract

Aside from a large volumes of granites, the Mesozoic diorites, named as Liulinzhuang superunit, are also widely distributed within the Sulu orogenic belt. However, there are some controversies and disagreements on their intrusive age and genetic mechanism. This research focuses on the Mesozoic diorites distributed in the Langya area in the central part of the Sulu orogenic belt. Firstly, the intrusive age of the diorites is determined based on the zircon U-Pb dating. Then, the petrographic and geochemical characteristics of the diorites are analyzed by microscopic observation and major and trace element testing techniques, respectively. Additionally, their magma sources and genetic mechanism are discussed. The results show that the intrusion of the diorites developed during the early Cretaceous at about 119.9-124.7Ma, different from the previous understanding that they were formed in the late Triassic, suggesting that this period of intrusive rock masses were not direct products of the Triassic tectonic movement of the Sulu orogenic belt. The major element data reveals that the diorites of the Liulinzhuang superunit in Langya area are high-magnesium, alkali-calcic, metaluminous syenodiorites. The Harker diagrams and petrographic characteristics indicate that H2O was involved in the magma crystallization process. The absence of obvious Eu negative anomaly in the REE distribution patterns shows that the magmatic differentiation process was not significant during the magma evolution. The high Mg# (average value ≥58), high Cr and Ni contents and the rare earth and trace element distribution patterns of the diorites illustrate that the magma source of this suite of rock masses was an enriched lithospheric mantle. It is inferred that the enriched mantle was mainly caused by the dehydration (or melting) of the South China plate during its subduction to the North China plate in the Indosinian period and the resulting metasomatism of the overlying lithospheric mantle wedge. Summarilly, this suite of intrusive rock masses formed in a post-orogenic environment in the Cretaceous period. The magma source is deduced to be a metasomatized enriched lithospheric mantle formed during the Late Triassic continental subduction process. However, the source melting occurred in the Early Cretaceous period, which may be related to the collapse of the orogenic belt or lithospheric mantle delamination of the Sulu orogenic belt caused by the change of the tectonic movement direction or rate of the Paleo-Pacific plate.

Keyword

Sulu orogenic belt, Liulinzhuang superunit, Diorite, Geochemistry, Enriched lithospheric mantle

Cretaceous two stage extensional tectonics in Northeast Asia and its geodynamics

Wei LIN[1]*, State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences (linwei@mail.iggcas.ac.cn)
Wei Wei[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The Cretaceous tectonics of the North China Craton (NCC) and its adjacent regions were characterized by a general lithospheric extension and remarked by extensional dome structures. This makes one of the largest crustal scale extensional tectonic realm in the world. Based on our field and laboratory work, five extensional domains have been delineated, namely the Transbaikalia-Mongol-Okhotsk, the western part of NCC, the eastern part of NCC and Korea, Qinling-Dabie and its neighboring, and the interior of South China Block, respectively. These domains are featured by a NW-SE extensional direction with intensively extensional exhumation of middle to lower crust rocks to the surface along detachment faults. Two-stage extension tectonics have been suggested, which took place at ca. 130~120 Ma and ca. 118~85 Ma. The early stage constrains a narrow activity period, and the foundering of the lower part of the lithosphere could be a possible mechanism for this continent-scale extensional tectonics. This geodynamic model could help us to enhance the knowledge of the time, scale, and mechanism of the NCC destruction from the view of structural analysis. The timing of late-stage extensional tectonics is suggested by a younger trending from the northeast (Liaodong peninsula) to the southwest (Yuechengling massif in SW Hunan province). The slab roll-back of westward subducted ‘Palaeo-Pacific’ or Izanagi plate may lead to this regional extension event.

Keyword

Two-stage extensional tectonics, Cretaceous, Eastern Eurasia continent, Slab foundering, Subduction plate roll-back

Triassic tectonic response of overriding North China block to the South China block continental deep subduction

Lingtong MENG[1]*, State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences (tone18@mail.iggcas.ac.cn)
Wei Lin[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences
Zhiheng Ren[3], Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences

Abstract

During the Triassic, the South China block deeply subducted beneath the North China block, forming the Dabie-Sulu orogenic belt; the discovery of coesite and diamond indicates that low-density continental crust can subduct to mantle depths exceeding 200 km. Several studies focused on the formation and exhumation of high- to ultra-high-pressure metamorphic rocks. However, the Dabie-Sulu orogenic belt mainly records the tectonic event that is responsible for the exhumation of ultra-high pressure (UHP) rocks, in which the syn-convergence deformations were reworked by exhumation-related tectonics. Tracing the deformation events developed in the overriding plate, which are less affected by exhumation tectonics, may be an alternative and effective approach to investigating the syn-convergence processes. Furthermore, correlating the behavior of subducted and overriding plates is key to understanding the collisional orogenic belt evolution.

This work focuses on the deformations of the overriding North China block, carries out the structural analysis, and combines previous results, to understand the tectonic evolution of collision between the South China block and the North China block. Our study shows that the North China block (overriding plate) experienced Triassic NE-SW contractional tectonics, as the tectonic response to the South China subduction. The first contractional structure is characterized by Early-Middle Triassic top-to-the-NE ductile shearing and NE-directed folding and thrusting. From south to north, the ductile deformation evolves to the brittle-ductile one, and it seems that the deformation timing becomes younger. The second contractional structure is manifested by Late Triassic top-to-the-SW ductile shearing and SW-directed back-thrusting. Combined with the tectonics events developed in the Sulu orogenic belt, our new structural results allow us to build a three-stage evolution model for the continental collision between the South China block and the North China block. Our model also highlights that the flat-slab subduction of the South China block may account for the large-scale contractional tectonics developed in the overriding North China block.

Keyword

Continental deep subduction, Overriding plate, Triassic NE-SW contractional tectonics, Structural analysis, Sulu orogenic belt

lithofacies paleogeography of the Upper Cambrian-Lower Ordovician in Jiyang Sub-basin of North China Plate: An evolution driven by Huaiyuan movement, climate and see-level

Hao GUO[1]*, China University of Petroleum (East China) (794782283@qq.com)
Yanzhong Wang[2], China University of Petroleum (East China)
Yingchang Cao[3], China University of Petroleum (East China)
Chenglong Liu[4], China University of Petroleum (East China)

Abstract

Jiyang Sub-basin is a Meso-Cenozoic rifted basin superimposed on the middle of North China Craton and has an area of about 2.55×104 km2. The Huaiyuan movement is the movement of the Shangdan Ocean subduction to the North China Craton during the sedimentary period of the Zhangxia Formation in the Cambrian. The Huaiyuan movement made the Jiyang sub-basin form a pattern of high in the south and low in the north. The lithofacies paleogeography of the Late Cambian-Early Ordovician in Jiyang Sub-basin and its response to tectonic activity are studied by means of analysis of previous results, well logging data, seismic data, core data, thin section observation, geochemical test, considering the paleoenvironment, sedimentary facies markers, sedimentary facies types, sedimentary facies division of single well and cross-well profile. During the Late Cambrian-Early Ordovician, the Jiyang Sub-basin was located in the southern Hemisphere as a whole, with a latitude between 20° S-10° N and a warm and humid climate. Three types of sedimentary environment of open platform, restricted platform and evaporative platform were developed. During the depositional period of Changshan Formation of Upper Cambrian, the water body in Jiyang Sub-basin was deep and the depositional environment was mainly limited platform. During the early sedimentary period of the upper Cambrian Fengshan Formation, the Jiyang Sub-basin began to be affected by the Huaiyuan movement, and the southern area was uplifted and large-scale regression occurred. In the southwest of the Jiyang Sub-basin, the rock types were mainly crystalline dolostone and granular dolostone, and the evaporative platform developed. In the north, the crystalline limestone content gradually increased, and in the northeast of the Jiyang Sub-basin, the limited platform developed. In the middle and late sedimentary period of Fengshan Formation, Huaiyuan movement stopped temporarily and large-scale transgression occurred in Jiyang Sub-basin, the strata of middle and late sedimentary period of Fengshan Formation was mainly composed of crystalline limestone and granular limestone, with limited platform in the south of Jiyang Sub-basin and open platform in the north of Jiyang Sub-basin. During the depositional period of the Lower Ordovician Yeli Formation, the Huaiyuan movement was re-opened, and the southern area was uplifted to form an ancient land mass. The basement of Jiyang Sub-basin was high in the south and low in the north. The Yeli Formation as a whole was dominated by crystalline dolostone and granular dolostone, and the sedimentary environment were evaporative platform, with only a few limited platform and granular beach in the northern area. During the sedimentary period of the Lower Ordovician

Liangjiashan Formation, the Huaiyuan movement basically ended. Under the influence of small scale transgression, the development range of evaporative platform shrank to the south. The influence of Huai-Yuan movement on Jiyang Sub-basin lasted until the depositional period of Liangjiashan Formation, it can be inferred that the collision of Shangdan Ocean and North China Craton basically ended in the depositional period of the Liangjiashan Formation.

Keyword

Jiyang Sub-basin of North China Craton, Lithofacies paleogeography, Huaiyuan movement, Upper Cambrian-Lower Ordovician

Discovery of the Oldest Rocks in Eurasia and its Implication for the Origin of the First Crust on the Earth

Xiao-Fei Qiu[1]*, Wuhan Center, China Geological SurveyGeosciences Innovation Center of Central South China (qiuxiaofei@mail.cgs.gov.cn)
Xi-Run Tong[2], Wuhan Center, China Geological SurveyGeosciences Innovation Center of Central South China
Da Wang[3], Research Center for Planetary Science, College of Earth Sciences, Chengdu University of Technology
Shi-Wen Xie[4], Beijing SHRIMP Center, Institute of Geology, Chinese Academy of Geological Sciences
Yu-Sheng Wan[5], Beijing SHRIMP Center, Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The oldest known continental crustal materials that one could find—the Hadean to Eoarchean rocks—would provide the most direct constraints on the nature of the first crust on Earth and the magmatic process that formed it, which is of great significance for understanding the physical and chemical properties of our planet's early stage. At present, major Hadean to Eoarchean crustal blocks have only been identified in less than ten areas worldwide such as the Acasta Gneiss Complex and the Nuvvuagittuq Greenstone Belt. Limited by the scale of the rarely preserved early Archean rocks, major controversies exist on the tectonic models explaining the origin of the continental crust in the early Earth. Therefore, discovery and identification of new Eoarchean or even Hadean crustal exposures would provide new research opportunity, and will be the key for improving our understanding of the formation and evolution of early continental crust and its geodynamic driver in the early Earth.

Here, we report the new identification Eoarchean tonalitic gneisses in the Muzidian Gneiss Complex (MGC) of the northern Yangtze Craton. Zircon SHRIMP U-Pb dating of them yields ages of 3855±7 Ma and 3851±6 Ma. These granitic rocks may represent continental nuclei remnant in the Yangtze Craton, South China, and have been the oldest preserved rocks so far in Eurasia. Zircon Hf isotopic compositions indicate that the MGC gneisses were formed from remelting of pre-existing Hadean crust, suggesting early mantle differentiation and crust extraction before 4.1 Ga. These newly recognized rocks in the MGC mark an important, Hadean-crustal-derived, ancient gneiss complex, which is isotopically comparable to the Acasta Gneiss Complex in the currently established global Eoarchean geological record. Our findings provide new insights into the nature and origin of the first continental crust on the Earth and highlight the MGC as a unique natural laboratory for further exploration.

Keyword

Muzidian Gneiss Complex, Eoarchean, Zircon U-Pb dating, First continental crust, Eurasia

Geology of Northeast Asian depicted by the Tanlu fault

Peng PENG[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (pengpengwj@mail.iggcas.ac.cn)
Xu Liu[2], School of Earth and Planetary Sciences, University of Chinese Academy of Sciences
Yanbin Zhang[3], Institute of Geology and Geophysics, Chinese Academy of Sciences
Chong Wang[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Xinping Wang[5], Shanxi Normal University
Lei Zhao[6], Institute of Geology and Geophysics, Chinese Academy of Sciences
Xiaohui Zhang[7], Institute of Geology and Geophysics, Chinese Academy of Sciences
Mingguo Zhai[8], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The Tanlu fault is the largest fault in Northeast Asian and one of the largest in the world. The mechanism of its strike-slip movement has been controversial since its discovery in the 1950s. The very uncertainty lies in its timing of initiation and displacement nature of offset. It is recently proposed that the Tanlu fault was resulted from a ~16° clockwise intracratonic rotation along the fault, which has caused an offset of ~450 km within the North China craton and about half the distances in the Central Orogenic belt (Peng et al., 2022 Terra Nova 34: 381–394). This model is mainly proposed based on geology (distribution and geometry of basement, rifts/basins, large igneous provinces, plutonic suites, kimberlite/diamond fields, etc.), and is tested by paleomagnetic data. The earliest displacement was most likely happened during the collision of the North and South China cratons at the Middle Triassic – Early Jurassic. It has several implications in depicting the geological evolution of Northeast Asia, 1) shape and tectonic framework of the North China craton prior to its largest offset, as well as its configuration in historical supercontinents; 2) correlation of terranes, structural units, and mineral resources between regions west and east to the fault in Northeast Asia; 3) the effects of the fault in the forming of tectonic framework of Northeast Asia; and 4) potential roles of the fault in the Mesozoic mineralization.

Keyword

North China craton, Northeast Asia, Tanlu fault, Strike slip fault, Tectonic evolution

Oceanic isolation of the Paleo-Tethys from the Panthalassa in the leadup to the Permian mass extinction: Consistent evidence from metamorphism in East Eurasia

lei Zhao[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (zhaolei@mail.iggcas.ac.cn)
hu Tang[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Ross N. Mitchell[3], Institute of Geology and Geophysics, Chinese Academy of Sciences
Qiuli Li[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Mingguo Zhai[5], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The end-Permian mass extinction is the most devastating event in the history of the Phanerozoic biosphere and many of its paleontological records come from the Paleo-Tethys tectonic realm. Unlike the euxinic Paleo-Tethys Ocean, the much larger Panthalassa (aka paleo-Pacific) Ocean remained largely ventilated and provided potential refugia for marine taxa during the mass extinction. Distinctions exhibited by these two once-connected oceans imply that interactions between them must have been restricted and these two water bodies may have become isolated from each other shortly before the end-Permian extinction. However, detailed geological processes for the final disconnection of these two oceans, mainly due to the collision of North China and South China, is yet to be convincingly delineated. Previous geochronological studies on eclogite facies rocks in the Dabie–Sulu orogenic belt, which are the metamorphic products of the collision between North and South China, have yielded mainly Triassic metamorphic ages postdating the Permian. Nonetheless, a Permo–Triassic intracontinental orogen that developed in South China as a far-field effect of Dabie–Sulu-related stress may more closely associate this major tectonic event with the end-Permian extinction. New age dating, as well as a synthesis of recent studies on high-grade metamorphic rocks within the South China intracontinental orogen show that the onset of collisional orogenesis dates back to the Middle Permian (270–260 Ma), which is also consistent with the new geochronological results acquired on low-grade metamorphic rocks along the northern margin of the Dabie orogenic belt. We thereby provide a new tectonic model for the major continents of East Asia and their latest Paleozoic kinematics in the configuration of Pangea. Specifically, the initial collision between North and South China inferred here to have occurred during the Middle Permian should have isolated the Paleo-Tethys Ocean from the Panthalassa Ocean, facilitating the oceanographic transition of the critical Paleo-Tethys from a life-giving nutrient-rich ocean into a euxinic death trap and thereby serving as prelude to the end-Permian extinction.

Keyword

Permian mass extinction, Paleo-Tethys Ocean, Panthalassa Ocean, U–Pb geochronology, Dabie–Sulu orogenic belt

Petrogenesis and structural analysis of pillow-like metabasalt rocks in Shangying in North China Craton defines Neoarchean fore-arc ophiolitic mélange in accretional wedge

Zhiyuan CHEN[1]*, China University of Geosciences (Wuhan) (jamiechen@cug.edu.cn)
Timothy Michael Kusky[2], China University of Geosciences (Wuhan)
Lu Wang[3], China University of Geosciences (Wuhan)

Abstract

Ophiolitic mélange is one of the important hallmarks of identifying the boundaries of ancient convergent plates or accretionary terranes, recording the important geological information of the process of plate convergence. The North China Craton (NCC) is the largest craton in Northeast Asia and has experienced a protracted evolution since the Eoarchean. However, there are still many controversies about the evolution process and tectonic background of the Eastern Hebei complex. Here, we describe aspects of the Archean Shangying ophiolitic mélange in the Eastern Hebei complex, based on detailed field mapping and structural analysis of the mélange belt. We report zircon U-Pb geochronological, geochemical, and petrological analyses on the mafic blocks within the mélange. The study can provide insights into the tectonic evolution of the Eastern Hebei complex and the North China Craton at the end of the Neoarchean era and reveal aspects of the style of plate tectonics in the Neoarchean.

The Eastern Hebei Complex is located in the northern part of the North China Craton, straddling the Central Orogenic Belt and the Eastern Block of the NCC. Through decades of field geological mapping and structural analysis on the Shangying area, Eastern Hebei Complex, our group has identified a lithological association consisting of pillowed metabasalt, metapelite, and felsic volcanoclastic rocks, which outcrop as classic “block-in-matrix” mélange. Within the ophiolitic mélange belt, a series of west-northwest trending low-angle thrust faults have been identified, which sliced the mafic blocks and showed similarity to the characteristics of modern accretionary wedges. Major and trace elements of the metabasalt, metapelite, and felsic volcanic-clastic rocks show that the disrupted ophiolite sequence originated from a supra-subduction zone (SSZ) system. Zircon dating from the metabasalt blocks shows that the basalt formed at 2.54 Ga. In addition, one of the thrust faults is intruded by a granitic pegmatite. The crosscutting relationship and the age of the pegmatite (2506±20 Ma) suggest that this episode of thrust movement occurred before 2.5 Ga, which indicates that horizontal plate movement may have existed in the Shangying area before 2.5 Ga.

All these field observations, geochronology, and geochemical studies above reveal that these ultramafic-mafic blocks in the Shangying area jointly experienced the Neoarchean subduction process. The Shangying tectonic belt formed as a fore-arc accretionary wedge in a tectonic setting of a convergent margin, defining the boundary of a Neoproterozoic subduction zone. This

mélange was formed at the end of the Neoarchean, indicating that plate tectonics may have been locally initiated in the Eastern Hebei area of the North China Craton.

Keyword

Ophiolitic mélange, Accretional wedge, Structural analysis, Pillow basalt

The tectonic evolution from the Archean to Triassic in the north central Gyeonggi Massif (Hongcheon-Chuncheon area) in the Korean Peninsula, and its application to the tectonic evolution of the North China Craton

min su Kang[1]*, Chonnam National University (kms_9432@naver.com)
chang whan Oh[2], Junbuk National University
byung choon Lee[3], Chonnam National University
bo young Lee[4], Korea Insitute of Geoscience and Mineral Resources

Abstract

The Gyeonggi massif which located in the central port of the Korean Peninsula, mainly consists of the Precambrian rocks. These Precambrian rocks can provide a critical information to understand the tectonic evolution at that time. In this study, we have carried out detailed studies of the Precambrian rocks on the north central part of the Gyeonggi Massif, Hongcheon-Chuncheon areas. The Hongcheon-Chuncheon areas are composed of the Neoarchean (ca. 2.61–2.49 Ga) and milled-Paleoproterozoic (ca. 2.09 Ga) metagranitoids, the Euiam Gneiss Complex (ca. 1.89–1.87 Ga), and metasedimentary units (the Yongduri Gneiss Complex and Euiam Group). The Neoarchean metagranitoids intruded at ca. 2.61–2.49 Ga and experienced polymetamorphic events at ca. 1.92–1.87 Ga and 229 Ma. Geochemical data indicate that they were formed in the arc tectonic setting by partial melting of low-K mafic rock in the lower crust. The Paleoproterozoic metagranitoids are categorized into three types based on geochronology and geochemistry: ca. 2.09 Ga metagranitoid formed in an arc tectonic setting, ca. 1.90 Ga metagranitoid formed in a syn-collision tectonic setting, and ca. 1.89–1.87 Ga metagranitoids formed in a post-collision tectonic setting. Based on the metamorphism, the Paleoproterozoic sedimentary rocks can be subdivided into two stages; the 1st stage metasedimentary rocks (paragneisses) deposited in the Yongduri Gneiss Complex and the 2nd stage metasedimentary rocks deposited in the Euiam Group. The 1st stage metasedimentary rocks (paragneisses) were deposited after 2.05–1.95 Ga in an arc tectonic setting; they experienced intermediate-P/T metamorphism (780–860 ℃/8.7–11.0 kbar) at ca. 1.91 Ga and then low-P/T metamorphism (710−750 ℃/6.0−6.5 kbar) at ca. 1.86 Ga. The 2nd metasedimentary rocks were deposited after ca. 1.88−1.83 Ga and metamorphosed at ca. 234−230 Ma. Together with previous studies, these data imply that the Hongcheon-Chuncheon areas have Neoarchean remnants and underwent similar Paleoproterozoic tectonothermal events identified from the Jiao-Liao-Ji Belt formed by the collision between the Longgang Block of the North China Craton and the Nangrim Massif of the Korean Peninsula, suggesting that the northern Gyeonggi Massif can be correlated to the North China Craton.

Keyword

Northern Gyeonggi Massif, Neoarchean, Paleoproterozoic, Arc tectonic setting, Post-collision tectonic setting

Cenozoic intracontinental tectonics of Mongolia: A synthesized review

Ulambadrakh KHUKHUUDEI[1]*, National University of Mongolia (ulamaa.kh@gmail.com)
Tim Kusky[2], China University of Geosciences (Wuhan)
Brian Windley[3], University of Leicester
Orolzodmaa Otgonbayar[4], National University of Mongolia
Lu Wang[5], China University of Geosciences (Wuhan)
Xiao Wenjiao[6], Chinese Academy of Sciences
Nie Jungsheng[7], Lanzhou University

Abstract

Mongolia, a major world-class site of Cenozoic intracontinental tectonics, provides a key proxy for the long-term dynamics of Eurasia, but there has been considerable debate about the principal driving forces responsible for the intracontinental deformation. Here, we show that the Cenozoic tectonic development of Mongolia and surrounding regions was largely a consequence of the interaction of four factors: the India-Asia collision, extension of the Baikal Rift, mantle upwelling beneath the Khangay Dome, and Pacific subduction.

The recent tectonic development of the Mongolian and Gobi Altay, the Gobi Tianshan Mountains, and western South Mongolia were controlled by the interplay of sinistral and dextral strike-slip faults that have formed since ~5-8 Ma by intraplate transpression. The Khangay Mountains formed on a deep, slightly warmer upwelling that was derived from >80 km depth in the upper mantle. Khangay consists of many Cenozoic basalts, the origin and evolution of which are linked to thinning of the lithosphere via upwelling of a mantle plume. The Khentey Mountains were slightly rejuvenated to form an arched uplift on the final forces junction of the transpression of the India-Asia collision and Pacific subduction during Cenozoic. The Cenozoic tectonics of East Mongolia preserves a weak inheritance from Mesozoic events related to Paleo-Pacific subduction. The Sayan-Khuvsgul mountainous region formed by NS-compression against stable Siberia at ca. 1 Ma. The bulwark of the Tibetan plateau displaced atmospheric Hadley Cells northward and has acted as an orographic climate barrier against the Indian monsoon that led to aridification, lack of drainage, and to local internal erosion during the Cenozoic in Mongolia.

Keyword

Mongolia, intracontinental transpression, active faults, Cenozoic volcanism

High-temperature and high-pressure metamorphism and anatectic events in the Khondalite Belt

Shuhan PAN[1]*, Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University (panshh3@mail2.sysu.edu.cn)
Changqing YIN[2], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Shangjing WU[3], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Jiahui QIAN[4], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Deyuan CHEN[5], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University
Yao XIAO[6], Guangdong Provincial Key Laboratory of Geodynamics and Geohazards, School of Earth Sciences and Engineering, Sun Yat-sen University

Abstract

The Khondalite Belt is a newly identified Paleoproterozoic Himalayan-type continent-continent collisional orogen, located in the western part of the North China Craton. It well records the high- and ultrahigh-temperature and high-pressure metamorphic events, as well as the multi-stage anatectic events, that relate to the collision between the Yinshan Block and Ordos Block during Paleoproterozoic. In this study, the anatectic evolution of the metapelites from the Khondalite Belt is forward modelling, in which the melting reaction, melting amount and initial melt composition that involved in the anatectic process are simulated. By comparing the composition of the adjacent leucosome and the multi-stage S-type granites in the Khondalite Belt, the genetic mechanism of S-type granite is discussed, and the genetic relationship among the three is established. The results show that during the prograde metamorphic stage, the metapelites in the Khondalite Belt experienced water-saturated melting (WM), muscovite-dehydration melting (MM) and biotite-dehydration melting (BM), successively. Subsequently, in the near-isothermal decompression process, the main reaction is K-feldspar-garnet melting (KGM), while briefly occurred. The melt composition varies depending on different melting reaction that occurs. The early melt formed by WM and MM is similar to the composition of weakly peraluminous monzonitic granite, while the melt produced by BM is equivalent to the composition of moyite. Moreover, the melt produced by KGM is similar to the peraluminous-potassic granitic composition. Comparing the composition of the initial melt, the measured leucosome and the multi-stage S-type granites from the Paleoproterozoic Khondalite Belt, both the composition of initial melt and the measured leucosome can roughly fall within the range of the S-type granites of the 1.93-1.90 Ga and ~1.95 Ga from the Khondalite Belt. The result indicates that they do have a certain genetic relationship, which further supports that the S-type granites from the Khondalite Belt are produced by partial melting of metapelites. Additionally, by comparing the Rb/Sr ratio of the initial melt and the measured leucosome, and the relationship with the content of Ba and Sr, respectively, it is found that the composition of the melt produced at 50% and 60% melting (corresponding to 850℃/8.1

kbar and 850℃/6.5 kbar, respectively) during the decompression stage is similar to that of the measured leucosome. Coincidently, the high content of biotite in the metapelite, as well as the pervasive existence of the peritectic cordierite in the leucosome, together indicates that the melting process is dominated by BM and KGM. These melts are vital sources of the S-type granites of the 1.93-1.90 Ga and ~1.95 Ga in the Khondalite Belt. Combined with previous data, it is shown that the Khondalite Belt experienced a long period (100 Ma) of metamorphic-anatectic evolution, that related to the collision between the Yinshan Block and Ordos Block.

Keyword

high-temperature and high-pressure metamorphism, phase equilibrium modelling, anatexis, S-type granite, the Khondalite Belt

Petrogenesis of Paleoproterozoic granitic gneiss in the Geumsan area, Korea, and its tectonic implications for Northeast Asia

Kenichiro IWAMIZU[1]*, University of Toyama (ken-iwamizu@outlook.jp)
Ji-Hoon KANG[2], Andong National University

Abstract

We studied a Paleoproterozoic granitic gneiss body in the Geumsan area (36°03'27.2"N, 127°28'58.3"E) near the boundary between the Gyeonggi and Yeongnam massifs in Korea to clarify its petrogenesis and tectonic implications in Northeast Asia.

CL images of zircons from the granitic gneiss revealed three domains: an inherited detrital core, an anatectic mantle, and a metamorphic overgrowth rim.

Most (> 90%) zircons contained an inherited detrital core of ca. 3480–2100 Ma with relatively high Th/U ratios (0.016–4.137) and positive Ce anomalies (5.274–184.947), mainly suggesting a magmatic origin. Trace element compositions of ca. 2.5 Ga cores are plotted in the post-collisional field of the Hf vs. U/Yb diagram [1], indicating a North China Craton provenance [2].

U-Pb isotopic data from the anatectic mantle formed a discordia line on the concordia diagram with the upper and lower intercept ages of ca. 1.9 Ga and 283 Ma, respectively, indicating the ages of granite emplacement and metamorphism. The mantle data had low Th/U ratios (< 0.1) and Ce anomalies (< 2.9), suggesting a paragenesis with monazite. The emplacement age and low zircon Th/U ratios are compatible with the leucogranites in the Yeongnam Massif [references in 3].

The metamorphic overgrowth rim had U–Pb ages of ca. 227 Ma and 176 Ma, low Th/U ratios (< 0.1), and Ce anomalies (< 2.2), indicating a paragenesis with monazite.

Monazites from the granitic gneiss yielded Triassic–Jurassic Th–U–total Pb ages with the highest peak at ca. 173 Ma. One monazite grain exceptionally had a wide range of ages from ca. 1845 to 158 Ma, possibly suggesting that the monazite crystallized at ca. 1.9 Ga and reset their ages during later metamorphism. Widespread Triassic–Jurassic magmatism in Korea may have been the heat source for the metamorphism.

Whole-rock geochemistry of seven samples from the granitic gneiss indicates that partial melting of peraluminous psammite and mica-rich pelite produced their source anatectic magma. The zircon saturation temperature [4] of the magma was 713–629 °C. These geochemical and geothermal features and the abundance (> 90%) of inherited zircons in the granitic gneiss indicate the pressure condition of 0.6–0.45 GPa [5]. The ca. 1.9 Ga P-T conditions are compatible with the Yeongnam Massif but incompatible with the Gyeonggi Massif [3].

The whole-rock chemical compositions of the granitic gneiss in this study and the coeval leucogranites in the Yeongnam Massif [3] indicate the syn-collisional setting in the Rb-Hf-Ta diagram [6], whereas those of the coeval granites in the Gyeonggi Massif [3] indicate the volcanic arc setting.

From the above discussion, we suggest that the ca. 1.9 Ga granitic gneiss in the Geumsan area belongs to the Yeongnam Massif and originated from the North China Craton.

References

[1] Gao et al. (2013) Chem. Geol., 360–361, 41–53.
[2] Zhou & Zhai (2022) Earth Sci. Rev., 230, 104060.
[3] Oh et al. (2019) Precambrian Res., 326, 344–362.
[4] Watson & Harrison (1983) Earth Planet. Sci. Lett., 64, 295–304.
[5] Bea et al. (2021) Contrib. Mineral. Petrol., 176, 18.
[6] Harris et al. (1986) Geol. Soc., London, Spec. Publ., 19, 67–81.

Keyword

Granitic gneiss, Zircon, Monazite, Whole-rock geochemistry

Geochronological and geochemical evidence of the Ordovician magmatism in the Lake Zone, Western Mongolia

Batkhishig Bayaraa[1]*, Mongolian University of Science and Technology (bkhishig@must.edu.mn)
Chimedtseren Anaad[2], Geoscience Center, MUST
Munkhtsengel Baatar[3], Mongolian University of Science and Technology

Abstract

The Namir Formation and Togtokhiinshil Complex rocks are representatives of the Ordovician magmatism developed in the Lake Zone, Western Mongolia.

In 1991, L.V.Chistoedov first discovered the volcanogenic-sedimentary rocks, whose actual thickness is not known, and any fossils and fauna were not identified, and it is distributed mainly along the Tsagaanshuvuut fault that separates the Hovd and Nuur zones. Later on, Minjin et al. classified it into the Namir Formation (Minjin, 2006) and now it is mapped as (O1-2nm) on the 1:200000 scale geological map of Mongolia.

The rocks of the Namir Formation are overlying the Togtokhiinshil complex and are cut by granitoids of the Ordovician Turgengol Complex, and an angular unconformity overlies the lower-middle Silurian Chargat Formation (Samozvantsev et al., 1982).

The Namir Formation, mainly andesite and dacite in composition, consists of brown-green lava breccia, red-brown colored mindal-textured lava, tuff conglomerate, course-grained tuff sandstone, gravellite, conglomerate, siltstone, and brownish-pink colored andesite-dacite lava, lava breccia and their tuffs.

Geochemically, the rocks of the Namir Formation are andesite and rhyolite by the classification of TAS, with SiO_2=57.07-71.46%; Na_2O+K_2O=4.89-8.77% calc-alkaline series, metaluminous, SiO_2<70, #Fe>0.6 which indicates the type of magnesian rock.

The primitive mantle normalized trace element spider diagram shows enrichment of LILE relative to LREE, and well developed Nb-depletion and Pb-enriched, whereas HFSE depleted. The total REE content is 64.97-101.47 ppm, and the LREE/HREE differentiation is slightly low; the ratios are $(La/Yb)_N$=1.95-5.66, $(La/Sm)_N$=1.16-2.26, and $(Gd/Yb)_N$=1.04-1.79. The chondrite-normalized REE diagram shows subparallel REE patterns with a weak negative Eu anomaly.

In this research, two andesite samples from the Namir Formation were selected for the absolute age dating by the LA-ICPMS zircon U-Pb method. The results show that 453±4.1 and 453.4±3.2 Ma which we interpreted as the time of emplacement of the andesitic magma.

All these data and the petrological characteristics of the Namir Formation rocks suggest that active continental margin arc magmatism developed in the Lake Zone. This research result confirms the Late Ordovician age of the Namir Formation and is important for explaining the geodynamic settings of the Lake Zone, western Mongolia.

Keyword

Namir Formation, arc-magmatism, Ordovician, absolute age dating

Reporting the geochronology of the igneous rocks of the southern Jeonju area, located in the southwestern part of the Okcheon metamorphic belt, Korea

Hawon YUN[1]*, Department of Environment and Energy, Jeonbuk National University (yunhawon@jbnu.ac.kr)
Jinhyeok CHOI[2], Department of Earth and Environmental Sciences, Jeonbuk National University
Chang Whan OH[3], Department of Earth and Environmental Sciences, Jeonbuk National University

Abstract

The Jeonju area, located in the southwestern Okcheon metamorphic belt (OMB), South Korea, was reported to be composed of Cretaceous igneous and meta-sedimentary in the Jeonju Geological Map published in 1924. However, no evidence, such as age-dating analyses, supported the geological information in the Jeonju Geological Map. Previous studies reported the Precambrian, Triassic, and Jurassic intrusive igneous rocks from the Gimje, Sunchang, and Jeongeup areas near the Jeonju area. Furthermore, the meta-sedimentary rocks of the OMB have been reported to be depositional from the Neoproterozoic to the Paleozoic. These results suggest that the igneous and meta-sedimentary rocks in the Jeonju area were likely formed before the Cretaceous. In this study, the age-dating analyses on the igneous rocks of the southern part of the Jeonju area were carried out using SHRIMP and LA-ICP-MS at the Korea Basic Science Institute. This study confirms that the southern part of the Jeonju area is composed of Archean or Paleoproterozoic gneiss, Paleoproterozoic and Neoproterozoic foliated igneous rocks, Triassic foliated granite, Jurassic foliated granite, and granite porphyry. The gneiss, which may have intruded at ca. 2.5 Ga, underwent two metamorphisms during the Paleoproterozoic (1882±14Ma) and Triassic times. The Paleoproterozoic and Neoproterozoic igneous rocks intruded at 1889±10 Ma and 740±8 Ma, then underwent metamorphism. The intrusive ages at 211±3 Ma and 173-171 Ma from the Triassic foliated igneous rock and Jurassic granites, representing the Honam shear zone, implicate that the Honam shear zone occurred between ca. 211-173 Ma. These results indicate that the southern Jeonju area has experienced Archean, Paleoproterozoic, Triassic, and Jurassic igneous and metamorphic events and are well correlated with previous studies on the areas near the Jeonju area.

Keyword

Jeonju, Okcheon metamorphic belt, Korean Peninsula, geochronology

Six subduction-accretionary mafic zones identified in the Altai orogenic belt, Xinjiang, China

Liu YONG[1]*, Chinese Academy of Geological Sciences (CAGS) (liuyongfirst@163.com)

Abstract

China, Russia and Mongolia have been carrying out an international Greater Altai mapping and synthesis project since 2022 to carry out an international comparative study of the Greater Altai orogenic belt. To this end, the project is unifying the study of the Altai orogenic belt from the point of view of plate tectonics and oceanic plate geology. Oceanic plate geology is a sub-discipline of plate tectonics, which is a method of studying the oceans from mid-oceanic ridge tension to trench subduction closure. It is developed on the basis of oceanic plate stratigraphy, and the study includes oceanic plate stratigraphy, rocks (ophiolite, magma rock, sedimentary rock, metamorphic rock), tectonic deformation, and regional tectonic evolution. At present, the project team has preliminarily established the research framework of oceanic plate geology, and has sequentially defined the Chinese Altai orogenic belt from north to south as Algdai-Kurti-Burgan-Mayin Ebo (Erqis) (S-C), Kujibai-Hongguleng (∈-C), Zaheba-Alman (∈-C), Tangbal-Mayil-Baluk (O-S), and Tangbale-Mayil-Baluk (∈-S). Barruk (O-S), Dalbut (D-C) and Karamari (D-C) six subduction accretionary mafic belts. They consist of a series of ophiolites, ophiolite-green mélange, intra-oceanic arcs, and oceanic islands and seamounts of retrograde stacking tectonics, which record the complex subduction-collision orogenic process of the Tethys Ocean. Among them, the North Junggar intra-oceanic arc consists of edakite, niobium-rich basalt, boenite, boninite, bitter olivine, and pyroxene-rich olivine basalt, etc. It represents the Early Devonian to Early Paleolithic period. They represent the products of the northward subduction of the Erqis Minor Ocean Basin from the Early Devonian to the Early Carboniferous.

Acknowledgments
I sincerely want to express my deepest gratitude to all the participants, contributors, guides, and supporters of the comprehensive geological survey of the geological background of copper nickel gold mineralization in the northern edge of Junggar, Xinjiang (DD20242127). This project is not only a geological academic challenge, but also a process of team collaboration, intellectual collision, and passionate burning. Let's work together to create a more brilliant future!

Keyword

Greater Altai, oceanic plate geology, accretionary wedge, ophiolite mélange

Petrology and Geochemical Studies of late Cenozoic basic-intermediate volcanic rocks Southwest of Ghezel- Ozan (NW Iran)

Hamoon MEMARIAN[1]*, Research Institute for Earth Sciences (RIES)
(Hamoonmemarian@yahoo.com)
Elnaz Aghaali[2], Research Institute for Earth Sciences, Geological Survey of Iran
Nima Banar[3], Research Institute for Earth Sciences, Geological Survey of Iran

Abstract

The studied area, located in Hashtjin 1:100,000 geological sheets, in Azerbaijan province (Northwestern Iran). The study area restricted in 48 ˚30′ to 48 ˚00′ E longitude and 37 ˚30′ to 37 ˚00′ N latitude. Based on our field investigation, the studied area comprise of intermediate to acidic volcanic rocks. Trackyandesite to trachyte and tuffs alternatively extend through the quadrilateral. Based on lava the field studies and previous geological map indicate that the volcanic succession formed in Oligocene period. Petrography studies revealed the evidences of magma mixing and mingling including basic enclaves inside acidic groundmass sieve texture and in plagioclase phenocrysts and quartz xenocrysts with pyroxene reaction margins. The samples selected for analysis are healthy and intact samples, and this analysis was carried out on some samples in the Geology and Mineral Exploration Organization of the country.

Interpretation of the geochemical diagrams indicates calc-alkaline and high potassium calc-alkaline magmatic trends. In the tectonomagmatic diagrams normalized by primitive mantle values, they display enrichment of LILE and LREE in relative to HREE and depletion in HFSE that comparison with subduction- related magmatism. The geochemical evidence indicate that the source of the lherzolite. These evidences show that volcanism in the study area has occurred in a tensile envelope associated with collision or post collision.

Keyword

trackyandesite, magma mixing, calc- alkaline, Hashtjin

Carbonatization and silicification of ophiolitic ultramafic rocks and formation of gold-bearing listvenites in the Arabian-Nubian Shield

Mokhles Kamal AZER[1]*, National Research Centre (mokhles72@yahoo.com)
Amany Seddik [2], New Valley University
Bassam Abuamarah[3], King Saud University
Simon Wilde[4], Curtin University
Mahmoud H. Darwish [5], New Valley University

Abstract

Listvenite bodies of various compositions are present in the Al-Barramiya District in the northwestern corner of the Arabian-Nubian Shield (ANS), associated with serpentinites and talc-carbonate rocks. Here, a late Neoproterozoic mantle section in the Gabal Al-Barramiya area contains variably serpentinized peridotites that are highly altered along shear zones and thrust planes to form gold-bearing listvenites. The latter occur as lenses and dyke-like bodies that vary in color from yellowish brown to reddish brown to greyish. They can be categorized into carbonate listvenite, silica-carbonate listvenite and silica listvenite (birbirite). Carbonate listvenite is composed mainly of carbonate minerals (70-85%), quartz (15-20%), sulphides, Cr-spinel and rare gold. Silica-carbonate listvenite consists mainly of quartz (45-60%) and carbonates (40-50%) in varying proportions, with minor amounts of serpentine, chlorite, Cr-muscovite (fuchsite), sulphides, goethite, Cr-spinel and gold. Silica listvenite consists mainly of quartz (˃80 %) with lesser amounts of carbonates and minor Cr-spinel, sulphides and gold. Carbonate listvenite is characterized by the presence of schistosity and deformation fabrics similar to the host serpentinites, but such fabrics are absent in the silica-carbonate and silica listvenites, suggesting that this postdates carbonate listvenite and serpentinization. The presence of listvenites along shear zones and the presence of relics of serpentine and Cr-spinel reflects their formation through metasomatism of ultramafic rocks by hydrothermal fluids circulating along the thrust faults. All three varieties of listvenites show relative enrichment in Ni (623-1876 ppm) and Cr (517-1828 ppm). In addition, silica-carbonate listvenite is characterized by the presence of fuchsite and is enriched in Zn, Pb, Cu, Ag, and Au; this enrichment is correlated with SiO2 and Au content. The enrichment in these elements can be related to fluid-rock interaction and their addition through hydrothermal solutions. This is supported by the presence of granitic intrusions in the study area which led to enrichment of specific elements. Rare earth element (REE) contents differ between the studied listvenites. Silica -carbonate listvenite has the lowest total REE (∑=0.98-2.56 ppm), whereas the silica listvenite contains the highest total of REE (∑ = 15.70-21.42 ppm). Based on the above, carbonate listvenite is the earliest to form by the infiltration of CO2–bearing fluids released during serpentinization of the original fore-arc peridotite slab, followed by formation of silica-carbonate listvenite due to the activities of SiO2–saturation and CO2-bearing fluids released during ophiolite obduction. Fuchsite in silica-carbonate listvenite formed as a result of metasomatic reactions of Si- and K-rich fluids with Cr-spinel due to hydrothermal alteration of

serpentinized peridotite. Silica listvenite formed at the final stage by the silicification of the early formed silica-carbonate listvenite. Listvenitization of the mantle section of the Al-Barramiya ophiolite led to concentration of Au, Pb, Zn, Cu and Ag. The silica-carbonate listvenite contains higher concentration of gold (899-2199 ppb) than the carbonate listvenite (119-191 ppb) and silica listvenite (156-233 ppb).

Keyword

Arabian-Nubian Shield, Al-Barramiya ophiolite, listvenites, fuchsite, sulfides, gold

Signature of Himalayan Orogenesis in Quaternary Sediments, Lalmonirhat District, Bangladesh: Evidence from Petrography and Mineral Chemistry

ISMAIL HOSSAIN[1]*, University of Rajshahi (ismail_gm@ru.ac.bd)
KARIMA SULTANA[2], University of Rajshahi
PRADIP KUMAR BISWAS[3], Institute of Mining, Mineralogy and Metallurgy (IMMM)

Abstract

The present study describes the petrography and chemical characterization of minerals in the Quaternary sediments at Patgram upazila, Lalmonirhat district, NW Bangladesh. The borehole sediments have been investigated vigilantly to classify the sediment types and to ascertain their possible provenance and genesis. The petrographic data reveal that sediments hold mostly monocrystalline quartz, K-feldspar, lithic grains, mica, rutile, zircon and some opaque minerals. The sediments show predominantly sub-angular to sub-rounded, coarse to medium-grained, consisting of quartz (avg. 63 %), feldspar (avg. 11 %), micas (avg. 10 %) and lithic fragments (avg. 9 %). Overall, these data demonstrate sub-arkose and sub-litharenite equivalent rock types which also exemplify that these sediments were derived from plutonic granitic protolith source (or felsic source) within the tectonogenetic suites of recycled orogens, transitional continental blocks of the craton interiors.

Mineralogical analyses of biotite, Fe-Ti oxide, magnetite, rutile and zircon by SEM-EDX method provide consistent mineral characteristics to the Lesser Himalayan sequences in Sikkim and Darjeeling areas. For example, most of the biotites are compositionally annitic, while a few eastonitic in nature and their FeO*/MgO ratios fluctuate from 1.07 to 1.38 with an average of 1.27, which typically resembles biotites crystallized in a calc-alkaline (subduction-related) suite. Higher concentrations of Ti (0.21–0.37) in biotite mainly indicate primary magmatic sources resemble chemically consistent with those rocks belonging to low-grade metamorphic terrains rocks. From the studied biotite, the calibrated oxygen fugacity is about 10-12.4 and 10-12.9 within the temperature ranges from 850°C to 900°C, respectively. These data suggest that the studied biotites were formed comparatively at higher temperatures. The BSE images of the Ti-rich magnetite display textures of granular (30%), sandwich (50%), and trellis-type (20%) ilmenite lamellae where magnetite indicates the genesis of a dissected arc, whereas ilmenite indicates the formation of a recycled orogen or continental block. This studied ilmenite lamellae had lower TiO2 levels (43.6–49.4 wt.%) than pure ilmenite (52.6 wt.%). Ilmenite contains up to 4% Fe2O3 and relatively low MgO and MnO where the Fe2O3 level is similar to that of Brahmaputra River bar sediments. Temperature and less than 5% MnO indicate the gabbroic type magmatic protolith. On the other hand, the temperatures estimated from the study of the magnetite-ilmenite assemblage vary between 540 and 575°C, and the fO2 fluctuates between 10-21.4 and 10-22.1 and these findings are compatible with magnetite-ilmenite in Brahmaputra River bar sediments, with temperatures ranging from 548 to 558°C and fO2 values ranging from 10-21.4 to 10-21.7 and inconsistent with Cox's Bazar beach sands, which showed temperatures ranging from 625 to

850°C and fO2 values ranging from 10-12 to 10-21. The calibrated temperature and oxygen fugacity of the studied minerals, Brahmaputra bar sediments and Cox's Bazar beach sands equilibrated in a T-fO2 field extremely close to the FMQ buffer curve, indicating a crustal source. So, overall isogradic and tectonogenic signatures suggest that most of the sediments in the study area are very similar to the Lesser Himalayan Sequences in Sikkim Himalaya of the Sikkim-Darjeeling section.

Keyword

Orogenesis, magnetite-ilmenite assemblage, oxygen fugacity, Lesser Himalayan Sequence, Bangladesh

Carbonatite, ultramafic breccia, syenite, and alkaline basalts from the igneous and sedimentary association of the Bolivian rift

Ramiro Matos[1]*, Universidad Mayor de San Andrés (rmatoss@yahoo.com)

Abstract

The Upper Permian-Lower Cretaceous period of Eastern Cordillera in the Central Andes of Bolivia is characterized by continental environment basins characterized by shallow and sporadic marine ingressions that deposited chemical sediments with limestone and chert. This rock group forms a volcano-sedimentary association resulting from lithospheric thinning that led to the formation of a rift that was subsequently aborted. The igneous association is made up of subvolcanic, shallow plutonic bodies, lava flows, stocks, dikes, and sills of mafic-ultramafic of alkaline composition. During the Cenozoic, due to a tectonic inversion process, these basins suffered shortening that led to the formation of a steep relief of regional anticlines and synclines associated with reverse and strike-slip faults. Mapping work, satellite images, igneous and sedimentary petrography, mineral chemistry, isotopic data, and whole rock led to the discovery of a carbonatite the first identified in the Bolivian Andes, intruded into Ordovician metasedimentary rocks. The carbonatite is 1200 meters long and 500 meters wide, it consists of a ferrocarbonatite and a magnesium carbonatite or beforsite with low levels of bastnaesite, accompanied by pyrochlore and monazite as accessory minerals. The most significant feature is the anomalous content of Zn, Pb, and Mo. The carbonatite is associated with syenite rocks containing sodalite, ankerite, barite dyke, ultramafic breccia bodies, and alkaline basalt dykes and sills. The ultramafic breccia contains mantle xenoliths of olivine, pyroxene, and garnet of the melanite variety and subordinate amounts of nepheline, sodalite, apatite, serpentine, phlogopite, pyrite, sphalerite, hematite, and chalcopyrite. K-Ar dating on ultramafic breccia phlogopite and lamprophyre yielded 101 to 99 Ma. Alkaline breccia bodies are exposed, constituting subcircular protuberances that protrude into the landscape. The fragments of the breccia are of supporting matrix of variable size, shape, composition, and color. In composition, they are clasts of nepheline syenite, alkaline gabbro or theralite, pyroxenite, ijolite, and hornfels. The objective focuses on the igneous and sedimentary association of the rift and the structural style shown on the maps. The region is of special interest due to the complexity of alkaline rocks, and the folds, faults, and the close relationship between stratigraphy and structure.

Keyword

Eastern Cordillera, Central Andes, Bolivia

Pb isotope disequilibrium in metasediment-derived granitic melts

Lingsen ZENG[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(lzeng1970@163.com)
Li-E Gao[2], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

Radiogenic isotope compositions of magmatic rocks have been widely used to infer the nature of their sources. However, updated studies have demonstrated that crustal derived granites can carry a large magnitude of isotope (Sr, Nd, and Hf) disequilibrium which could be used to infer the melting reactions as well as the nature of sources. The Himalayan Cenozoic granites are typical products from melting of crustal sources. Experimental results and theoretical calculations suggest that the Himalayan leucogranites are characterized by Sr, Nd, Hf isotope disequilibrium. Exception for the reported trace element compositions and ratios and the initial Sr isotopic ratios, radiogenic Hf and Pb isotopic ratios are heterogeneity. Leucogranites from Malashan-Gyirong area consist of two groups of granites formed fluid-absent melting of muscovite (Group-A) and fluid-fluxed melting of muscovite (Group-B), respectively. Except for substantial differences in key trace element compositions and their ratios, and Sr isotope compositions, follow-up studies show that as compared to Group-A granites, Group-B granites have much higher Th, Th/U, and 208Pb/204Pb ratios. However, their 206Pb/204Pb and 207Pb/204Pb ratios are similar. Such characteristics could be explained by enhanced solubility of monazite (high Th/U and 208Pb/204Pb phase) relative to zircon during fluid-fluxed melting of metasedimentary rocks. Our findings suggest that zircon and monazite play an critical role in shaping Pb isotope systematics in crustal-derived melts.

Keyword

isotope disequilibrium,, zircon, monazite, leucogranite, crustal anatexis

Chronology and geochemistry of Triassic sanukitoids in Funing area, South China: Implications for petrogenesis and geodynamic processes

Zhenglin LI[1]*, Guilin University of technology (lizhenglin@glut.edu.cn)
Xijun Liu[2], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resource, Guilin University of Technology, Guilin 541004, China

Abstract

The Nanpanjiang Basin, located at the southern margin of the South China block, is interpreted as either a back-arc foreland basin resulting from the subduction of the Paleo-Pacific plate or a peripheral foreland basin associated with the closure of the Paleo-Tethys ocean and continental collision during the Indosinian orogeny. Abundant igneous rocks, such as arc-like intrusion and volcanic rocks, indicate subduction processes in the basin. However, the genesis of the magmatism remains controversial, with different tectonic models proposed:(1)Subduction of the Paleo-Pacific plate; (2)Intraplate tectonic activity related to Emeishan mantle plumb; (3)Subduction of the Paleo-Tethys plate beneath the South China block;(4)Joint subduction by both the Paleo-Tethys and Paleo-Pacific plates.

High-Mg andesites have generally been produced at convergent plate margins, especially where young or hot plate subduction occurs, and have become an important indicator of the evolution of the lithospheric mantle at convergent plate margins, detailed isotopic and chronological studies will be valuable in determining the mantle source and the tectonic evolution of Nanpanjiang Basin and South China. In this study, we present new geochronological, geochemical, and Sr-Nd-Pb isotopic data of Early Triassic sanukitoids from the Funing area. Our findings aim to explain the origin of these magmatic rocks and reveal the characteristics of the lithospheric mantle in the region.

Our new zircon U-Pb dating results show that these sanukitoids have a weighted mean 206Pb/238U age of approximately 250 Ma. They are calc-alkaline rocks characterized by moderate SiO2 contents (51.62-54.44 wt%) and high MgO contents (4.52-10.22 wt%) and Mg# values (59-75). These sanukitoids are enriched in large ion lithophile elements (LILEs) and depleted in Nb and Ta, resembling typical arc magma. The sanukitoids also have relatively medium to high initial 87Sr/86Sr ratios (0.7016 to 0.7129), negative whole-rock εNd(t) values (–6.2 to −9.8), and zircon εHf(t) values (−0.4 to −8.6), as well as extremely high initial Pb isotopic ratios [(206Pb/204Pb)i = 18.486–18.760, (207Pb/204Pb)i = 15.760–15.777 , and (208Pb/204Pb)i = 38.904–39.319]. Our new data, combined with previous studies on Permian to Triassic magmatism in the Nanpanjiang basin, suggest that the Triassic sanukitoids in the Funing area primarily originated from an enriched lithospheric mantle that underwent metasomatism during the subduction process, involving slab fluids and sediment melts. The extremely high initial Pb isotopic ratios of the sanukitoids cannot be explained by the subduction of Paleo-Tethys and Paleo-Pacific plates, which have low initial Pb isotopic ratios. Instead, they may be attributed to the emeishan mantle plume and lithospheric mantle beneath South China.

We proposed that the formation of Early Triassic sanukitoids in the Nanpanjiang Basin was influenced by the extensional setting during oceanic subduction, which was caused by the roll-back of the Paleo-Tethys oceanic lithosphere around 250 Ma. This provides potential insights into the interaction between Paleo-Tethys, the Emeishan mantle plume, and the lithospheric mantle beneath South China.

Keyword

sanukitoids, Emeishan mantle plume, Funing area, South China, Paleo-Tethys

The significance of isotopic decoupling in the mafic-ultramafic layered sequence of the Bushveld Complex, South Africa

Peace ZOWA[1]*, University of the Witwatersrand (2399607@students.wits.ac.za)
Ben Hayes[2], University of the Witwatersrand
Grant Michael Bybee[3], University of the Witwatersrand

Abstract

The mode of emplacement, magma source(s) and the metallogenesis of the Rustenburg Layered Suite (RLS) of the Bushveld Complex remains controversial despite decades of research. There is an agreement, however, that the RLS was formed through (1) the mixing of multiple pulses of magma in a chemically evolving magma chamber and (2) there was significant pre-emplacement crustal and/or lithospheric mantle contamination of the parent magmas. This is evident in bulk rock variations in Sr-Nd isotopes. On the other hand, Lu-Hf isotopes of accessory zircon show a limited range in εHf (at 2.06 Ga) of -8.6 ± 1.2 throughout the entire RLS. The homogenous zircon Hf isotopic values indicate that there is decoupling between the major rock-forming silicates and the accessory minerals. The bulk rock Sr-Nd isotopic data only, therefore provide a partial story about the solidification history of the RLS. Competing models have been suggested for the origin of the homogeneous εHf isotopic signature, including melting/contamination of asthenosphere-derived Bushveld magmas by the sub-continental lithospheric mantle and high-level crustal contamination of the RLS by fluids derived from the Transvaal Supergroup during crystallisation. In this study, we analysed Sr-Nd isotopes in apatite, which is also an accessory mineral in the RLS, that crystallised in close association with zircon. Our new Sr-Nd isotopes measured using LA-MC-ICP-MS show that apatite records homogeneous isotopic compositions (average initial 87Sr/86Sr of 0.7088 and εNd of ~-7 ± 1.4 at 2.06 Ga). Additionally, we show that apatite in the Phalaborwa Complex (coeval to the Bushveld Complex) has similar Sr-Nd isotopic values to the RLS (average initial 87Sr/86Sr of 0.7107 and εNd of ~-8 ± 0.8 at 2.06 Ga). Samples from the Main Zone and Upper Zone of the RLS and the Phalaborwa Complex predominantly contain F-rich apatite, while in contrast, the pyroxenites in the PGE-Cr mineralised Critical Zone contain Cl-rich apatite. Norites in the Tennis Ball Marker are distinct as they contain both F-rich and Cl-rich apatite, which may reflect an influx of chemically distinct hydrothermal fluids and/or melts in a chemically evolving magma chamber. Our new Sr-Nd isotopic data in apatite corroborate the existence of isotopic decoupling in the cumulates of the RLS. We speculate on the origin of this isotopic decoupling with hypotheses including (i) melt percolation in the crystal mush that led to isotopic homogenisation of the trapped melt from which zircon and apatite crystallised and (ii) the emplacement of isotopically distinct cargoes of silicate crystals in an isotopically homogeneous carrier liquid during the emplacement of magmas into the RLS chamber. We provide new isotopic insights into the magmatic processes involved in forming the RLS, advancing the current understanding of the existing models.

Keyword

Bushveld, Apatite, LA-MC-ICP-MS, Homogeneous, Isotopes

Determination of low-content Ti in zircon by LA-ICP-MS/MS

junlong NIU[1]*, +8615321376370 (junlongniu@hotmail.com)
shitou WU[2], +8613521286485
yueheng YANG[3], +8613651212376

Abstract

Ti-in-Zircon thermometer provides temperature constrains for various geological settings. However, accurate determination of Ti content in zircon is the prerequisite for the effective use of this thermometer. Zircon commonly contains trace-level Ti (< 10ug g-1), and Ti determination by traditional LA-ICP-MS is a challenge due to the critical interferences of isobaric and double charged ions. In this study, triple quadrupole mass spectrometry (LA-ICP-MS/MS) was investigated to eliminate the interferences of 48Ca+, 96Zr2+ on 48Ti+. The results indicated that using NH3 as the reaction gas could effectively remove the 48Ca+ and 96Zr2+ interferences on 48Ti+ with analysis reaction product 48Ti(14N1H3)4(14N1H)+(mass shift +83). We also found that a small amount of N2 could improve the signal intensity by ~2 fold. Moreover, the LA-ICP-MS/MS will undergo initial mass screening at Q1 (First quadrupole), followed by collision reactions at Qcell (Collision reaction pool), resulting in mass shift. Therefore, the background value of this technique is very low (<10cps).The precision and accuracy of this new technique are verified by analysis of various zircon reference materials. This study has demonstrated that LA-ICP-MS/MS has the capability of precise determination of low-content Ti (<10 ug g-1) in zircon at high spatial resolution (< 30um), which has significant effect on Ti-in-zircon thermometer.

Keyword

Ti-in-Zircon thermometer, in situ analysis, LA-ICP-MS/MS

(Withdrawn) Controlling Factors of Granite Chemical Diversity and Implications for Early Crustal Evolution: Migmatites from the Southwestern Daqingshan Complex, North China Craton

Xingzhou JIANG[1]*, Guilin University of Technology (304588685@qq.com)
Shengyao Yu[2], Ocean University of China
Xijun Liu[3], Guilin University of Technology

Abstract

Crustal evolution and the genesis of granite are closely linked to anatexis in the lower or middle crust, followed by the ascent of granitic magmas to the upper crust. The Daqingshan complex in the North China Craton is characterized by the extensive development of Precambrian migmatites and granites resulting from crustal anatexis. Understanding the controls on the geochemical diversity of these granitic magmas during their formation and extraction would enhance our understanding of crustal evolution from the late Neoarchean to early Proterozoic. In this study, we investigated the diverse types of migmatite and felsic–granitic rock related to partial melting in the Daqingshan complex using systematic petrographic, whole-rock geochemical and Sr–Nd isotope, and zircon U–Pb–Hf isotope analyses. Our new results, combined with data from the literature, allow reconstruction of the complete process of magma formation, extraction, and evolution for migmatites in the study area. The following new insights are obtained. (1) The Daqingshan migmatites record two main periods of metamorphism (at ~2.45 and ~2.37 Ga) and one period of anatexis (at ~2.37 Ga). (2) The migmatites originated from the Daqingshan supracrustal rocks via Bt-dehydration melting. (3) During magma extraction, decomposition of the magma was controlled predominantly by the entrainment of residuum; incongruent melting of plagioclase and its early-stage crystallization and compaction led to the fractionation of plagioclase and K-feldspar within the in situ to semi in situ magmatic accumulation site. (4) Factors such as protolith composition, rock and mineral melting mechanisms, residuum entrainment, fractional crystallization, compaction, and the assimilation of surrounding rocks played crucial roles from initial melting to magmatic evolution, and collectively contributed to the chemical diversity of migmatites and granitoids in the southwestern margin of the Daqingshan complex. (5) From the late Neoarchean to early Paleoproterozoic, substantial fractionation of plagioclase and K-feldspar during Bt-dehydration melting of metasedimentary rocks may have resulted in the extensive migration of K-rich melt from the anatectic source.

Keyword

Bt-dehydration melting, Migmatite, Granite, Anatexis, North China Craton

Early-mid Cenozoic extensional arc volcanism of the North Patagonian and the Southern Central Andes (33-43°S)

Lucia FERNANDEZ PAZ[1]*, Instituto de Estudios Andinos "Don Pablo Groeber" (UBA-CONICET) (luciafernandezpaz.gl@gmail.com)
Sofia IANNELLI[2], Instituto de Estudios Andinos "Don Pablo Groeber" (UBA-CONICET)
Vanesa LITVAK[3], Instituto de Estudios Andinos "Don Pablo Groeber" (UBA-CONICET)

Abstract

The volcanic arc of the Southern Central and Northern Patagonian Andes (33-43°S; Chile and Argentina) in the early to middle Cenozoic exhibits distinctive features that shed light on the dynamics of subduction-related volcanic activity in extensional tectonic settings. The late Eocene to early Miocene interval is particularly significant in the Andes, as it records a widespread extensional regime leading to the opening of forearc, intra-arc, and backarc basins, accompanied by prolific volcanism. This period precedes the final major uplift phase of the Andes. It is hypothesized that this extensional event occurred in two phases, associated with changes in the geometry of the subducting slab: i) oblique convergence at low rates during the late Eocene to early Oligocene, and ii) orthogonal convergence at high rates during the late Oligocene to early Miocene. This study presents new field, petrographic, geochemical, and isotopic data from volcanic sequences in the Northern Patagonian Andes, along with an extensive compilation of geochemical data from the Southern Central Andes, aiming to analyze petrogenetic processes at different stages of arc evolution.

During the late Eocene to early Oligocene, subduction-related volcanism manifests in two parallel belts located 100 and 300 km from the trench. In this period, both belts exhibit intermediate composition and a relatively homogeneous geochemical signature, transitioning between tholeiitic and calc-alkaline series. Multi-element patterns show enrichment in mobile elements (Rb, Sr, Ba, Th, U, Pb) compared to high field-strength elements and rare earth elements. Moreover, Sr and Nd isotopes indicate a derivation from depleted mantle sources with limited crustal contributions. Trace element ratios used as tectonic discriminants (Ba/Ta, La/Ta, Th/Yb, among others) suggest development in a subduction environment with contributions from fluids derived from the subducting slab. In contrast, the record of volcanic activity during the late Oligocene to early Miocene, at the peak of the extensional regime, displays significant geochemical differences along the Andes. In the Southern Central Andes, volcanism displays more basic compositions and less influence from the subducting slab. Conversely, in the Northern Patagonian Andes, subaerial and subaqueous lava flows intercalate with marine deposits, indicating a regime of rapid subsidence. These rocks exhibit geochemical signatures both transitional to arc, E-MORB, and even OIB. These geochemical singularities suggest a genesis primarily dominated by decompression melting of a heterogeneous mantle wedge.

In summary, this study emphasizes how tectonic conditions play a fundamental role in the magmatic response of subduction-associated volcanism in the Southern Central Andes and

Northern Patagonian Andes. The geological and geochemical evidence presented reveals that the stress conditions of the margin significantly influence the composition, distribution, and evolution of magmatic manifestations in these volcanic arcs, highlighting the complexity and sensitivity of these systems to tectonic conditions.

Keyword

subduction magmatism, extensional tectonics, geochemistry, South America, Nd and Sr isotopes

Petrological characteristics of the volcanic rocks of the Pugo Formation and Zigzag Formation: Insights on the arc evolution of the Central Cordillera, Philippines

ARA JOY APONGAN ABATAYO[1]*, National Institute of Geological Sciences, University of the Philippines Diliman (aaabatayo@up.edu.ph)
Betchaida Payot[2], National Institute of Geological Science, University of the Philippines Diliman
Gabriel Theophilus Valera[3], National Institute of Geological Science, University of the Philippines Diliman

Abstract

Island arcs are tectonically active belts of intense seismic activity and magmatism. The Philippine island arc system is ideal for studies focusing on the evolution and formation of island arcs. The Central Cordillera in northern Luzon partly defines the principal magmatic arc of the current subduction zone system. It corresponds to the uplifted and tectonized magmatic arc associated with the subduction of South China Sea along the Manila Trench. The Central Cordillera is floored by the Late Cretaceous to Eocene Pugo Formation. The Pugo Formation is composed of basaltic to andesitic volcanic rocks with minor interbeds of sandstone, argillites, cherts and pyroclastic rocks. Low-grade metamorphism is evident in some places. Overlying the Pugo Formation is the Oligocene Zigzag Formation. The Zigzag Formation is a sequence of conglomerates, shales, andesitic lavas and tuffs. Despite the similarities in the stratigraphic units, the ages of the formations vary which suggests that each formation records the petrological characteristics of a distinct magmatic episode. This work aims to determine the petrographic and geochemical analyses of the volcanic rocks of the Pugo and Zigzag Formations and how they correlate to the evolution of the Central Cordillera.

Exposures of pillow basalts belonging to the Pugo Formation occur in Sabangan, Mountain Province while those of the Zigzag Formation were encountered in Suyo, Ilocos Sur. Petrographic analyses of representative volcanic rocks of the Pugo and Zigzag Formations reveal that these rocks mostly consist of plagioclase and clinopyroxene phenocrysts with volcanic glass, plagioclase laths, and clinopyroxene micrograins groundmass. The Pugo Formation volcanic rocks exhibit sub-trachytic texture while Zigzag Formation volcanic rocks show felty texture. In general, the Zigzag Formations samples have larger mineral grains than the Pugo Formation. Epidote-calcite-chlorite replacement minerals are also more evident in the Pugo Formation samples.

Geochemical analyses of representative volcanic rocks reveal that the Pugo Formation volcanic rocks are mostly basalts while samples from Zigzag Formation are mostly basaltic andesite. The Pugo Formation volcanic rocks are tholeiitic while those of the Zigzag Formation are calc-alkaline signature. The Pugo Formation volcanic rocks exhibit positive trend of FeO* and negative trends of MgO, Cr with increasing FeO*/MgO. Meanwhile, the Zigzag Formation volcanic rocks show negative trends of FeO*, MgO with increasing FeO*/MgO. In general, the Zigzag Formation

basaltic andesites exhibit higher FeO*/MgO and lower concentrations of MgO, TiO2, Cr, and Ni relative to the Pugo Formation basalts. Trace element concentrations reveal that both formations have enriched LILE, LREE and depleted HFSE. Pronounced negative Nb-Ta-Ti anomalies which are typical of arc volcanic rocks are also observed. The Zigzag Formation volcanic rocks have enriched Sr, Ba and Pb relative to the LREEs while the Pugo Formation volcanic rocks have depleted Sr and Ba. The results suggest that the Pugo and Zigzag Formation volcanic rocks possibly record the evolution of an island arc from inception to maturity.

Keyword

Pugo Formation, Zigzag Formation, volcanic rocks, northern Luzon, Central Cordillera

A tale of two metamorphic belts in eastern Taiwan: petrological characteristics

Chin-Ho TSAI[1]*, National Dong Hwa University (tsaich@mail.ndhu.edu.tw)

Abstract

The eastern Central Range of Taiwan is traditionally divided into two elongated metamorphic terranes, the Tailuko belt in the west and the Yuli belt in the east. Differences between the two belts are mainly in rock type, age, and peak pressure-temperature (P-T) condition. These two belts are separated by a shear zone. Both belts are dominated by pelitic-psammitic schists but these rocks' P-T conditions are difficult to constrain unless garnet is present. Metacarbonate and metagranitoid are absent from the Yuli belt, but abundant in the Tailuko belt. By contrast, metaserpentinite is a characteristic rock type of the Yuli belt, but rare in the Tailuko belt. Metabasite occurs in both belts. The Tailuko belt is subjected to polymetamorphism, with metamorphic records in Jurassic, Cretaceous, and late Cenozoic. The Yuli belt is essentially late Cenozoic. Amphibole compositions of representative rock types from the Tailuko belt are all calcic, whereas those from the Yuli belt are in the range of calcic, sodic-calcic, and sodic. Calculated amphibole formulas show significant differences between the two belts. Amphibole unit formulas from the Tailuko belt are intermediate to low in [B]Na (< 0.448), whereas those from the Yuli belt are high in [B]Na (up to 1.498; excluding sodic amphibole). On [B]Na vs. [IV]Al plot, the Tailuko belt's amphibole data show flat and low-angle slopes but the Yuli belt's data mostly show steep slopes with complex scattering. The amphibole compositions indicate that metamorphism of the Tailuko belt includes intermediate and low P/T types, and metamorphism of the Yuli belt is high P/T type.

Keyword

amphibole, metabasite, Tailuko belt, Yuli belt, metamorphism

Petrological and geochemical characteristicsof a suite of calc-alkaline granite from Mercara Shear Zone, West Dharwar Craton, India: Implications for tectono-magmatic process from a paleo continental arc setting & evidence of deep crustal melting.

Rigzin NORBOO[1]*, Geological Survey of India, India (rigzin.norboo@gsi.gov.in)
Prantick Santra[2], Geological Survey of India
Anindya Bhattacharya[3], Geological Survey of India

Abstract

Mercara Shear Zone (MSZ) is an intensely deformed, curvilinear shear zone presents in between Western Dharwar Craton (WDC) at the north, north-east and the Coorg Block (CB) at the south and south-western direction. The MSZ exposes numerous bands and enclaves of granulite grade meta-supracrustals and mafic granulites hosted in charnockite or felsic orthogneiss (retrogressed charnockite) and is intruded by granite along the mid axis of the shear zone that bears no signature of metamorphism. Several contradictory views regarding the evolution of the rocks from the MSZ exists and the unmetamorphosed suite of granite has not been studied in detail to understand the evolutionary history of the terrain. To address this issue, we investigated the field disposition, petrography and bulk rock geochemistry of the suite of unmetamorphosed granites from the MSZ. The rock is leucocratic, coarse grained contain biotite and epidote as mafic minerals. Microscopic study shows presence of quartz, K-feldspar and plagioclase as major minerals. Normalised volume percentage of quartz, K-feldspar and plagioclase are as 19-40% (avg~29%), 22-41%(avg~30%) and 28-49% (avg~41%) respectively. Petrological study shows presence of magmatic epidote along with sphene, apatite, monazite, zircon, magnetite as common accessory phases. Absence of hornblende is noted from the intrusive. Geochemical data of the studied sample indicates an I-type affinity and a similar to the trend of Cordilleran granitoids and the I-type granitoids of Lachlan Fold Belts. Trace and rare earth element pattern suggest evolution in a continental magmatic arc setting. The rocks are calc-alkaline, REE pattern is fractionated (La/Yb) CN ≈ 12.62–56.29; average 30.42), enriched in Ba, Sr, Pb, Th and depleted in high field strength elements(HFSE) like Nb, Ta, Ti with almost no significant negative Eu anomaly (Eu/Eu* ≈0.91–1.09). These characteristics indicate dominance of crustal involvement over mantle in the generation of melt. Studied rock sample shows an ‘adakite-like’ geochemical features (high Sr/Y, La/Yb) but are not product of a typical slab melting. Our study indicates that the granites were derived by partial melting of a thick crustal source in an oxidised condition (fO2 between NNO and HM buffer) at 941–987oC and 10–12.5 kbar pressure (corresponding to 30–40 km depth).

Keyword

Mercara, petrological, geochemical, granite, crustal melting

Petrogenesis of the Early to Middle Miocene Mafic Volcanism of the Huantraico Sequence, Argentina

Carina Liliana GRECO[1]*, Universidad de Buenos Aires (cari_greco@hotmail.com)
Sofía Iannelli[2], Universidad de Buenos Aires - CONICET
Vanesa Dafne Litvak[3], Universidad de Buenos Aires - CONICET
Silvia Leonor Lagorio[4], SEGEMAR

Abstract

The Huantraico sequence (Early – Middle Miocene) is located in the present-day Andean back-arc between 37°10'S - 37°40'S and 69°44'W - 69°30'W in Argentina. It is composed of basaltic to andesitic lava flows interbedded with thick pyroclastic rocks, such as crystal and lithic tuffs. Geochemical and petrological studies characterize the volcanic rocks of the Huantraico sequence to evaluate the ancient subduction zone configuration in the Andean margin. In the lower stratigraphic sections, up to 30 m thick tuffs predominate, alternating with aphanitic basalts. These pyroclastic rocks are associated with a ferriferous mineralization that consists of pure magnetite with apatite gangue, occurring as centimetre-mantles, veins, and veinlets. Towards the upper stratigraphic levels, lava flows predominate with minor breccias and pyroclastic rocks intercalations. In thin section, the basaltic flows exhibit a porphyritic texture with phenocrysts of plagioclase, olivine, and clinopyroxene phenocrysts embedded in an intergranular to pilotaxitic groundmass in the more andesitic varieties. The pyroclastic rocks are composed of plagioclase and quartz fragments, and porphyritic volcanic rocks lithoclasts immersed in a pyroclastic matrix with devitrification textures. The main pyroclasts are pumice fragments and shards with triaxone shapes. Geochemically, the rocks are transitional to alkaline basalts, trachybasalts, trachyandesitic basalts, and trachyandesites (45.7 - 63.6% SiO2). The La/Ta (~12 - 26), Ba/Ta (~191 - 398), and Ba/La (~9-33) ratios indicate a slight influence of slab fluids in the mantle source. The HFSE ratios, such as Th/Hf, Ta/Hf, and Nb/Y (0.53 - 1.5, 0.27-0.38, 0.6 - 1.5, respectively), suggest an enriched intraplate-like source. Multielement diagrams show minor positive anomalies of Sr and LILE and negative anomalies of Ti. The geochemical signature of this volcanism is associated with a transitional composition between intraplate and arc-like rocks in a back-arc environment within an extensional setting. A new U-Pb age from a crystalline tuff yielded an age of 20.9 ± 0.4 Ma for the lower sections of the sequence. The current hypothesis regarding the evolution of the Huantraico magmatic sequence is associated with changes in slab geometry and upper plate configuration through time. In the Middle Miocene (~ 18 Ma), a shallow subduction regimen named "Payenia shallow subduction zone" was installed between ~ 34° 30´S and ~ 38° S in the Southern Central Andes (Argentina) and consequently arc-like magmatism migrated towards the east. Then, by the Latest Miocene – Early Pliocene, the Nazca plate destabilized and re-steepened, allowing an asthenospheric upwelling and the development of intraplate-like volcanism in the back-arc area. As the Huantraico sequence is the first magmatic eruption that exhibits a weak but increasing arc signature towards the younger levels, it would represent the earliest evidence of the

development of the Middle to Late Miocene Payenia shallow subduction zone, thus constituting an essential record for understanding the Miocene magmatic evolution of the Southern Central Andes. The new U-Pb age provides precise constraints of the Huantraico sequence pyroclastic activity linked to the magmatic arc expansion.

Keyword

Andes, magmatism, geochemistry, back-arc, basalt

An improved Faraday cup configuration for Sr isotopic analysis using LA-MC-ICP-MS and its applying on rich-REE apatite

Xirun Tong[1]*, Wuhan Center, China Geological SurveyGeosciences Innovation Center of Central South China (tongxirun@mail.cgs.gov.cn)
Qiu Xiaofei[2], Wuhan Center, China Geological SurveyGeosciences Innovation Center of Central South China
Lu Shansong[3], Wuhan Center, China Geological SurveyGeosciences Innovation Center of Central South China

Abstract

Correction of the interference of REE2+ in Sr isotopic analysis using LA-MC-ICP-MS remains challenging. In this study, we addressed this issue by employing the Peak Stripping Method (PSM) combined with an Improved Faraday Cup Configuration (IFCC) of MC-ICP-MS, which allows for synchronous detection of REE2+. Our evaluation of IFCC revealed that no decoupling of REE2+ signals was observed, indicating that IFCC is well-suited for use with PSM to correct the interference of REE2+. The measured ratios of Er2+ and Yb2+ signals (r: 166, 168, 170Er2+/167Er2+ and 170, 172, 174, 176Yb2+/173Yb2+) are approximately equal to the natural isotopic abundance ratios of Er and Yb (R: 166, 168, 170Er/167Er and 170, 172, 174, 176Yb/173Yb). This property allows PSM to accurately correct the interference of REE2+ with R and the measured signals of 167Er2+ and 173Yb2+. We also determined the Sr isotopic compositions of the Er and Yb-spiked 0.1μg/g NBS987 Sr solutions using SN-MC-ICP-MS with IFCC, and the results indicate that PSM can correct the interference of REE2+ in solutions with Sr/Er > 3, while the Enhanced Peak Stripping Method (EPSM) can correct the interference in solutions with Sr/Er > 1, where a measured r is used as the interference correction factor. The Sr isotopic compositions of two rich-REE apatite reference materials (Durango with Sr/Er = 7.4, and UWA-1 with Sr/Er = 2.8) were determined using LA-MC-ICP-MS with IFCC, and the determined 87Sr/86Sr of the two apatites are 0.70627 ± 0.00014 (2SD, n = 19) and 0.70476 ± 0.00019 (2SD, n = 20), respectively. Both well agree with previously published data (determined by TIMS or MC-ICP-MS) within uncertainties.

Keyword

Sr isotopic analysis, LA-MC-ICP-MS, Double-charged ions of REE (REE2+), Rich-REE apatite

Updates on the IUGS Task Force on classification and nomenclature of igneous rocks

Michele LUSTRINO[1]*, Sapienza University of Rome (michele.lustrino@uniroma1.it)
Bernard Bonin[2], Université Paris-Saclay, France
James Day[3], University of California at San Diego, USA
Anna Doroshkevich[4], Sobolev Institute of Geology and Mineralogy, Russia
Zhengfu Guo[5], IGGCAS Beijing, China
Monica Heilbron[6], Rio de Janeiro State University, Brazil
Alexei Ivanov[7], Institute of the Earth's Crust SB RAS Irkutsk, Russia
Andrew Kerr[8], University of Cardiff, UK
Roger Mitchell[9], Lakehead University, Thunder Bay, Canada
Mitsuhiro Nakagawa[10], Hokkaido University, Japan
James H. Natland[11], University of Miami, USA
Julian Pearce[12], University of Cardiff, UK
Barbara Scott Smith[13], Scott Smith Petrology Inc., Canada
Rajesh K. Srivastava[14], Banaras Hindu University, India
Sebastian Tappe[15], Arctic University of Norway
Marjorie Wilson[16], University of Leeds, UK
Georg Zellmer[17], Massey University, New Zealand

Abstract

Earth and other terrestrial planets are characterised by complex evolutionary stages reflected in the formation of a large variety of igneous rocks. During the last fifty years, IUGS has led the efforts of groups of petrologists in proposing widely accepted and easy-to-use tools to classify igneous rocks providing updated approaches based on mineralogy, petrography and geochemistry. Igneous rock classification was unwieldy by the 1980s, riddled with type locality nomenclature that obstructed recognition of significant geological processes and often referring to similar rock types with different local names.

Concerted efforts by an IUGS Subcommission on the Systematics of Igneous Rocks led to unified classification that has been fully adopted by the geoscientific community [1, 2]. These efforts reduced igneous rock nomenclature from over 1000 names to less than 350 endorsed terms of global significance. Despite these improvements, problems remain with classification schemes, and new issues emerge after more than two decades from the last edition of the IUGS book. For example, widely used concepts (e.g., the distinction between tholeiitic and calc-alkaline rock series or the tools to distinguish sodic to potassic and ultrapotassic variants) are not fully treated if not completely avoided in the 2002 IUGS edition [2]. In addition, the definition of "subalkaline" rocks (actually "subalkali" rocks) is reported as "rocks that are not alkaline in character", but not indication of the essential features of alkaline rocks is reported. To continue, the classification and nomenclature of potassic and ultrapotassic rocks (e.g., kalsilite-bearing rocks, kimberlites, lamproites, lamprophyres), as well as other relatively common (e.g., MgO-rich volcanic rocks) and rare lithologies (e.g., carbonatites) needs profound revisions.

In 2021, a new IUGS task group was created aiming to solve the problems with igneous rock

classification systems and to work towards solutions in aid of petrogenetic studies. Extraterrestrial magmatic rocks will be included for the first time into classification schemes to capture progress made in planetary studies. Geochemical data platforms, such as GEOROC and PetDB, use the vocabularies recommended by disciplines that generate the data, but often new challenges are created along the way. In this contribution we provide an update on the latest efforts to further improve igneous rock classification, to stimulate cross-disciplinary discussions about how to make magmatic petrology and geochemistry fit for the future.

1 Le Maitre et al., 1989. Blackwell Scientific Publications, Oxford, 193 pp.
2 Le Maitre et al., 2002. Cambridge University Press, Cambridge, 236 pp.

Keyword

Igneous rocks, Classification, IUGS

Revisiting the crustal growth of the eastern Central Asian Orogenic Belt: Insights from the Erguna Massif and Duobaoshan area

Chenyang SUN[1]*, Northwest University (chenyang.sun@nwu.edu.cn)

Abstract

The Central Asian Orogenic Belt (CAOB), as the largest accretionary orogenic belt on Earth, provides a natural laboratory in which to understand the crustal evolution history. Crustal growth within the eastern CAOB was previously thought to be occurred mainly during the Phanerozoic, as inferred from the highly positive εNd(t) values and low initial 87Sr/86Sr values of granitoids in the belt. Increasing evidence suggests that this phase of crustal growth may has been overestimated. Taking the Erguna Massif and the Duobaoshan arc as examples, we summarize the data from our team in recent years and combine them with other studies to establish the regional crustal evolution history.

A crustal growth curve for the Erguna Massif was established based on the calculation formula proposed by Belousova et al. (2010). The growth curve indicates that the proto-crust of the Erguna Massif formed in the Mesoproterozoic, and shows an episodic feature with three growth periods at 2.9-2.7, 2.1-1.9, and 1.7-0.5 Ga. Moreover, these three growth stages are closely related to the evolution of three supercontinents, indicating lateral crustal growth induced by their convergence. The calculated crustal reworking ratio and established reworking curve indicate that significant inhibition of crustal growth rates occurred during four crustal reworking periods. Crustal reworking is regarded as an important factor contributing to the crustal heterogeneity of the Erguna Massif.

Detrital zircons from river sediments provide large-scale geological records. We reanalyzed the detrital zircon data obtained from modern rivers in NE China and further established the crustal growth curve of the eastern CAOB. The curve exhibits a typical three-phase crustal growth similar to that of the Erguna Massif, demonstrating that the crust of the eastern CAOB reached a volume comparable to that of the present crust by the late Precambrian.

However, it should be emphasized that the crustal growth during the Phanerozoic in the eastern CAOB did not entirely cease. Based on our detailed study of the Duobaoshan arc, formed during the accretionary process of the Xing'an and Songnen massifs, the crust in the Duobaoshan area exhibits characteristics of early Paleozoic neogenesis, resulting from the closure of the Paleo-Asian Ocean branch, the Nenjiang Ocean. Subsequent granitoids in this area all have Paleozoic model ages, indicating the reworking of early Paleozoic crust.

In summary, the microcontinents in the eastern CAOB contain Precambrian basements. Previous studies have to some extent overlooked the Precambrian crustal evolution. However, it cannot be denied that areas represented by Duobaoshan continental arc still exhibit unique Phanerozoic crustal growth.

This study was financially supported by the National Natural Science Foundation of China (Grant

No. 42202050; 41772047).

Keyword

Eastern Central Asian Orogenic Belt, Crustal growth, Erguna Massif, Duobaoshan arc

Chromite formation during 0.3 GPa crystallisation of magmas produced by peritectic orthopyroxene entrainment during incongruent melting of garnet + clinopyroxene + olivine assemblages in the upper mantle: An experimental investigation

Tahnee OTTO[1]*, Stellenbosch University (tahneeotto@sun.ac.za)
Gary STEVENS[2], Stellenbosch University

Abstract

The Rustenburg Layered Suite (Bushveld Complex, South Africa) is uniquely enriched in chromium (Cr), hosting several laterally continuous chromitite layers. The two main requirements for the formation of the chromitites: 1) Unusually Cr-enriched magma, and 2) a period of chromite only crystallisation at emplacement conditions. Several models exist that attempt to explain both caveats, involving mechanisms such as magma mixing, changes in pressure or oxygen fugacity (fO2), water addition, etc. Using a phase-equilibrium modelling approach, Otto et al. (2024) recently proposed that the chromitite and silicate layering of the suite formed due to processes occurring in the mantle source, where the entrainment of Cr-bearing peritectic orthopyroxene to the magma during the partial melting of peridotite results in a MgO- and Cr2O3-rich magma composition, 'A4', that produces chromite saturated crystal-melt slurries during magma emplacement.

Using a 19 mm non-end-loaded piston-cylinder apparatus, we experimentally investigated the crystallisation behaviour of model magma A4, assessing the potential of Cr to crystallise independently of other silicates by exploring the assemblages that form close to the liquidus at 0.3 GPa. The solubility of Cr in melt is strongly dependent on fO2, with more reducing systems favouring higher solubility. By using graphite-lined Pt capsules, the experiments were locked into the graphite-buffered range of fO2 values. The high MgO content of A4 made synthesising a crystal-free glass at 1 atm impossible. Thus, the starting material was prepared as an anhydrous glass, synthesised at 1400 ºC and 1 atm in a CO2-CO atmosphere, mixed with 20 wt.% dry MgO to produce the desired composition. In addition, 3 wt.% H2O was added to the starting material, as the presence of water has been shown to depress the crystallisation of silicate minerals (Veksler & Hou, 2020).

The results show that magmas with compositions consistent with formation by peritectic orthopyroxene entrainment, in the presence of water and when buffered to fO2 values below QFM, encounter the 0.3 GPa liquidus at between 1250 ºC and 1300 ºC. Olivine or chromite may define the liquidus, as the 1250 ºC run product contained both olivine and chromite in addition to quenched melt. The Cr2O3 contents in the melts are in good agreement with the work by Poustovetov & Roeder (2000), highlighting the control fO2 exerts on the solubility of Cr in the melt. With only chromite and olivine present with melt in all experiments below the liquidus, the

effect of water has been to supress the crystallisation of pyroxene to a greater degree than olivine.

The experiments demonstrate that mantle-derived magmas of low fO2 will intrude at crustal pressures with a potentially high content of dissolved Cr. The interaction of this high-Cr magma with small amounts of Transvaal Supergroup derived metamorphic fluids may result in a more oxidised, volatile-bearing magma, which may trigger chromite saturation whilst depressing the silicate solidus. Thus, chromitite layers may form as cumulates, even in hot magma able to thermally corrode the cumulate pile, with chromite formation principally driven by an increase in oxygen fugacity.

Keyword

peritectic, chromitites, experimental petrology, Rustenburg Layered Suite, orthopyroxene

Geochemistry and petrogenesis of Janga Iron-Copper skarn deposit, Kerman province

Maliheh NAZARI[1]*, PNU (nazarimaliheh100@yahoo.com)
Shohre Hassanpour[2], PNU

Abstract

The Kerman magmatic belt is located in the southern part of the Urmia-Dokhtar magmatic arc (UDMA) and consists of various intrusive and volcanic-sedimentary rocks. This belt was formed due to the closure of the Neo-Tethys and the subduction of the oceanic crust beneath central Iran in an arc-continent collision environment. Magmatism in this region is believed to have started during the Oligocene period. Skarn mineralization occurred in the area adjacent to the Cretaceous limestone, with a range of minerals including garnet, clinopyroxene, epidote, and other minerals such as chlorite, tourmaline, actinolite, quartz, and calcite. Additionally, there were ore minerals such as pyrite, chalcopyrite, pyrrhotite, and minor amounts of sphalerite and magnetite. The abundance of magnesium-bearing minerals like diopside and calcium-bearing minerals such as garnet and epidote in the host rock suggests a calcitic-dolomitic type. Two principal types of garnet were identified in the skarn zones: (I) weakly-altered euhedral coarse-grained isotropic garnet exhibits minor variation in the overall composition (And25.95–39.41 Grs54.95–62.25 Alm + Sps + Py5.39–13.04); (II) strongly-altered anhedral to subhedral isotropic to anisotropic garnet shows a wide variation in the overall range of composition (And25.91–55.25 Grs41.37–61.15 Alm + Sps + Py1.48–12.85) in which FeOt increases, whereas Al2O3 decreases rimward. The formation of skarn and mineralization in this region is believed to have occurred in three stages. During the first stage, anhydrous minerals such as garnet and grossular diopside were formed at high temperatures. The second stage was marked by the formation of andradite. In the third stage, anhydrous minerals were replaced by hydrous minerals at lower temperatures, resulting in the formation of minerals like epidote, chlorite, and tourmaline.

Keyword

Skarn, Jiroft, Eocene, Janga

Eoarchean crustal evolution of the North China Craton revealed by U-Pb ages, trace elements and Hf-O isotopes of detrital zircons from the Caozhuang quartzite

Hao WANG[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (wanghao@mail.iggcas.ac.cn)
Jin-Hui Yang[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Earth has undergone irreversible geodynamic evolution from magmatic ocean, though some unknown tectonic modes (possibly stagnant or sluggish lid), to modern-style plate tectonics due to secular cooling of Earth's interior. The exact timing and mechanisms controlling the transitions between different tectonic modes from one to another continue to attract controversy, and this bears on the fundamental question of when the modern-style plate tectonics started. The modern-style plate tectonics is characterized by a global network of plate boundaries, and thus any indicators for the operation of plate tectonics on early Earth should be globally synchronous. However, the rock records for the early Earth are very sparse, which limits our exploration for the global simultaneity of geodynamic transitions. Zircon has strong resistance to physical and chemical changes and can be survived from multiple sedimentary and metamorphic cycles, so continued records from Hadean to present can be retrieved from zircon. Studies on detrital zircons from several ancient cratons (e.g., the Yilgarn and Singhbhum cratons) revealed obvious shift of detrital zircon trace elemental and Hf-O isotopic evolutions during Eoarchean, which was suggested to witness the onset of modern-style plate tectonics during Eoarchean. Here, we explore the possible Eoarchean geodynamic transitions from the perspective of the Caozhuang quartzite of the North China Craton. The Caozhuang quartzite had the youngest concordant age cluster for detrital zircons at 3.55 Ga and underwent high-grade metamorphism at 3.5 Ga, which makes the Caozhuang quartzite among the oldest clastic sedimentary rocks around the world. The detrital zircons were euhedral or subhedral in shape, indicating they were of local provenance. The detrital zircon U-Pb age spectra of the Caozhuang quartzite show continued records from 3.89 Ga to 3.55 Ga with two main peaks at 3.80 and 3.68 Ga, which resemble those of the Anshan gneissic complex. In addition, the concordant detrital zircons in the Caozhuang quartzite show variable $\delta^{18}O$ (mainly from 3.37 to 8.12) and $\varepsilon Hf(t)$ (mainly from -4 to +4) values, which are also comparable with those of the Anshan gneissic complex. Accordingly, the Anshan gneissic complex was the most probable source rocks for the Eoarchean to early Paleoarchean zircons in the Caozhuang quartzite. Most importantly, the Caozhuang detrital zircons show continuous and smooth evolution trends without obvious shift for $\varepsilon Hf(t)$, $\delta^{18}O$, Ti-in-zircon temperatures, oxygen fugacity, Eu/Eu*, Th/Nb, and the inferred SiO_2 contents of their host rocks. This indicates the lack of global simultaneity of geodynamic transitions during Eoarchean, and thus the proposal that modern-style plate tectonics started during Eoarchean is not supported by the study presented here. The binned averages of $\varepsilon Hf(t)$ values for every 20 m.y. interval decrease monotonically from

+1 at 3870 Ma to -2 at 3570 Ma, and binned average δ18O values are elevated in relative to the normal mantle zircon and fall in a narrow range of 6 to 7. These isotopic characteristics indicated that the Eoarchean felsic continental crust of the North China Craton formed by partial melting of mafic rocks that underwent low-temperature water-rock interaction after separation from chondritic mantle source.

Keyword

Early Earth, North China Craton, Detrital zircon, Caozhuang quarzite, Hf-O isotopes

Petrological and geochronological characteristics of the Bargilt Fe deposit in Mongolia

OYUNGEREL SODNOM[1]*, National University of Mongolia (soyungerel@num.edu.mn)
YEONGMIN Kim[2], Korea Basic Science Institute
ALIMAA Damdinsuren[3], Mongolrostsvetmet SOE Co., LTD
BATBOLD Dorlig[4], Mongolrostsvetmet SOE Co., LTD
MUNGUNTULGA Purevsuren[5], National University of Mongolia
BAIGALMAA Norov[6], National University of Mongolia

Abstract

The Bargilt iron deposit is located in the Bor-Undur ore district in the South Kherlen-Buyant metallogenic belt of the Central-Eastern Mongolia metallogenic province The host rocks of the deposit are schist, biotite gneiss, biotite-amphibolite gneiss, limestone and quartzite. Some of their ages has been on the assumption as the Neoproterozoic unclassified metamorphic complex and acidic volcanic rocks of the Lower-Middle Permian Burentsogt formation, Quaternary sediments the Paleozoic unnamed intrusive complex, the Middle Permian Burentsogt intrusive complex and the Late Triassic-Early Jurassic Bor-Undur intrusive complex. However, there has been few reports on the constraints of the absolute age of them including U-Pb geochronology. Here we report the description of whole rocks petrography and zircon U-Pb age results of the deposit. Based on petrographical observation, the major host rocks distributed in the open pit of the Bargilt deposit were classified into quartzdiorite gneiss, fine-medium grained hornblende-biotite plagiogranite gneiss, subalkaline granite gneiss, irregular grained leucocratic granosyenite, fine to medium-grained biotite bearing granite and rhyolite. Zircon grains from seven samples were separated from the Bargilt iron deposit and the U–Pb isotopic analyses were conducted using a SHRIMP IIe at KBSI, South Korea. In this deposit, there are different ages rocks distributed such as Neoproterozoic, Cambrian, Devonian, Permian (Guadalupian and Lopingian). These various age range of the rocks in the Bargilt deposit indicate the occurrence of the complex and multiple intrusion events in the study area.

Keyword

Petrography, Host rocks, Zircon U-Pb age, Bargilt iron deposit, Mongolia

Petrography and Geochemistry of Metamorphic Rocks in Logbadjeck Quarries (Littoral Region, Cameroon): Environmental Impact

Nkeng Enstein FORCHENALLAH [1]*, Ministry of Mines Industry and Technological Development (nkengenstein8@gmail.com)
Tiabou Feudjio Anicet[2], University of Buea

Abstract

*This work presents principally the textural and mineralogical characteristics of metamorphic rocks mined as aggregates for construction materials and the environmental impact of blasting in Logbadjeck quarries located between latitudes N*3°54'-3°60' *and longitudes E*10°01'-10°10' *in the Nyong Series, which form part of the Congo Craton in Cameroon. Thin sections of selected samples were described under a petrographic microscope. These samples were further analyzed by XRF and ICP-MS methods for major and trace elements respectively. Preliminary results show that, the main rock types in the study area are biotite gneiss which exhibit a granoblastic microstructure made up of quartz* (40-45%), *plagioclase* (<21%), *biotite* (20-25%), *amphibole* (1-2%), *and opaque minerals* (5%) *as accessory minerals and amphibolite showing a granoblastic microstructure consisting of amphibole* (60-70%), *quartz* (~5%), *plagioclase* (~5%), *biotite* (15%), *zircon* (~2%) *and opaque minerals* (~3%). *The paragenesis of these rocks indicate that they were metamorphosed under greenschist and amphibolite facies respectively. The mineral assemblages and geochemistry suggest that biotite gneiss* (*SiO*2: 64-72%) *is tholeiitic, peraluminous with S-type composition and plots in the igneous protolith. Amphibolite* (*SiO*2: 39-48%) *is tholeiitic, metaluminous with I-type composition and also plots in the igneous protolith. Both rock types display negative correlation of major oxides and trace elements against SiO*2 *with some exceptions. Their REE pattern show negative Eu anomaly which is an indication of LREE enrichment over HREE and a plagioclase fractionation during partial melting. Multi-element normalized diagrams possess Ba, Nb, Sr, and P anomalies which are characteristics of crustal source. In the study area, the rocks examined are blasted to aggregates of different sizes* (0-5 *mm*, 4-6 *mm*, 5-15 *mm*, 6-10 *mm*, 10-14 *mm*, *and* 15-25 *mm*) *and rubble. These aggregates are sold to individuals and professionals for construction purposes including the fabrication of building blocks and road constructions* (0-5 *mm*), *the construction of roads and bridges* (4-6 *mm*, 6-10 *mm*, *and* 10-14 *mm*), *the construction of houses, roads, reinforcement of concretes, driveways, decoration and recreation* (5-15 *mm*) *and the construction of road pavements and floor tiles* (15-

25 *mm*). *The rubble is used for the construction of walls and building demolition in mortars. In this area, the environmental impact of blasting include induced ground vibrations, air blast, flyrock, blasting fumes, dust and water pollution.*

Keyword

Petrography, Geochemistry, Protolith, Aggregate, Blasting

Syn-collisional crust-mantle interaction in Himalayan passive continental margin: a response to lithospheric flexure

Lin MA[1]*, Guangzhou Institute of Geochemistry Chinese Academy of Sciences (malin@gig.ac.cn)
Qiang Wang[2], Guangzhou Institute of Geochemistry Chinese Academy of Sciences
Andrew Kerr[3], Cardiff University
Zheng-Xiang Li[4], Curtin University
Wei Dan[5], Guangzhou Institute of Geochemistry Chinese Academy of Sciences

Abstract

More than 95% of global magmatism occurs in mid-ocean ridges and subduction zones. In addition, except for oceanic plateaus and large igneous provinces, other intra-plate magmatism, especially in passive continental margins, is very rare and provides a crucial window for probing the composition of mantle and deep processes.

The Himalaya belt is the most active collisional orogen in the world and has a profound impact on the Asian geomorphology and climate during Cenozoic. Generally, collisional orogenic zones are considered to be unfavorable to formation of magmatic rock. However, in Himalaya orogen, the syn-collisional magmatism occurred on both sides of the suture zone with different features. The southern margin of the Asian plate above subduction-collision zone is characterized by thickened juvenile crust and a relatively high crustal thermal state. In contrast, the northern edge of the Indian plate is marked by a thickened ancient crust with a moderate geothermal gradient during the early stage of collision. The 48–35 Ma Tethyan Himalaya magmatism, consisting of high Sr/Y granitoids within gneiss domes and coeval gabbro and mafic dike, is slightly younger than the magmatic peak in the Lhasa block (southern margin of the Asian plate) (51 ± 3 Ma). However, the generation mechanism and dynamics of syn-collisional magmatism is poorly understood due to the lack of critical evidence.

Here, based on our study of newly found Eocene Himalaya OIB-like mafic dykes and existing evidence of magmatism, metamorphism and tectonic, a new model is proposed to understand the mechanisms of magma generation and orogenic evolution within the lower-plate (a previous passive margin) side of a convergent orogen.

During early continental collision, break-off of the Neo-Tethyan oceanic slab and/or lithospheric delamination of the southern Lhasa terrane caused melting to produce the ca. 51 Ma magmatism in the southern Lhasa block along the suture zone. After the 51 Ma magmatic event, lithospheric flexure formed along the northern Indian continent parallel to the suture, causing brittle cracking (i.e., bending-induced faults) and the 48–45 Ma melting in the northern Himalaya. The melts derived by decompression melting of the lithosphere-asthenosphere boundary intruded to shallow levels of the lithosphere along extensional fractures below a neutral plane of downwarped lithosphere. Emplacement of these mafic magmas likely provided the heat source for the formation of coeval (51–40 Ma) orogen-parallel crustal anatexis, and thus the orogen-parallel gneiss domes. This study may provide new insight into generation of syn-collisional granitoids.

Keyword

Syn-collisional, crust-mantle interaction, passive continental margin, Himalayan orogrn, lithospheric flexure

Late Ediacaran Magmatic Activity in the Southern Dom Feliciano Belt (Northeastern Uruguay): Insights from U-Pb Zircon Dating and Hf Isotopic Composition of Dikes

Elena Peel[1]*, Faculty of Science - UDELAR (elena@fcien.edu.uy)
Belén Viera[2], PEDECIBA - Geociencias (UDELAR)
Rossana Muzio[3], Faculty of Science - UDELAR
Lucía Olivera[4], Faculty of Science - UDELAR
Santiago Fort[5], Faculty of Science - UDELAR

Abstract

This study presents an integrated geochronologic and isotopic analysis of two sets of dikes intruding the Pelotas Batholith in northeastern Uruguay. The aim is to contribute to unraveling the petrogenetic processes and tectonic evolution of the Dom Feliciano Belt during the late Ediacaran, related to the waning stages of the Brasiliano-Pan-African orogenic cycle. One set of dikes comprises acidic rocks, primarily porphyritic rhyolites, characterized chemically as slightly peraluminous with a high-K calc-alkaline affinity. The other set includes basic dikes corresponding to microgabbros, known as the Corral de Piedra dike swarm, which exhibit a tholeiitic affinity and metaluminous nature. Until now, no ages were available for either type of dike.

The methodology employed in the study involved the separation of zircon crystals, followed by their analysis using LA-ICP-MS to provide U-Pb ages and Hf isotopic compositions. Zircons from two samples, representative of each dike swarm, were analyzed at the Arizona LaserChron Center (USA). The U-Pb data were obtained using a Nu Plasma HR ICP-MS coupled to a New Wave 193 nm ArF laser ablation system equipped with a New Wave SuperCell. Hf isotope analyses were performed using a Nu HR ICP-MS connected to a Photon Machines Analyte G2 excimer laser. Standards were used for fractionation correction and to ensure the accuracy of the results. Cathodoluminescence images were utilized to ensure that the ablation pits did not overlap multiple age domains or inclusions.

The results reveal very similar crystallization ages of 573.3 ± 4.2 Ma for the rhyolitic dikes and 571.7 ± 5.4 Ma for the microgabbro dikes, placing them in the late Ediacaran period. Furthermore, the initial εHf values obtained range from -12.6 to -1.18 for the acidic dikes and from -11.1 to +0.42 for the basic dikes, indicating significant crustal involvement in the magma genesis of both dike swarms. Hf T_DM ages spanning from 1.96 to 1.34 Ga for the acidic dikes and from 1.98 to 1.45 Ga for the basic dikes suggest the participation of older crustal components in the magma source.

Based on these results, the acidic dikes can be assigned to the Sierra de los Ríos Formation, a unit that occurs in the area and comprises rhyolitic and ignimbritic flows with similar ages. Additionally, in southern Brazil, acidic and basic dikes, as well as volcanic and subvolcanic rocks, are described in association with the post-collisional stage of the Dom Feliciano Belt. Notably, similar ages have been determined for the acidic volcanic rocks in that region, suggesting a

synchronous magmatic framework during the Late Ediacaran that spans northern Uruguay and southern Brazil.
In conclusion, the results indicate coeval basic and acidic magmatic activity, implying a complex evolution in the region during the late Ediacaran. This highlights the intricate nature of post-collisional magmatism and provides evidence supporting the involvement of both crustal reworking and potential mantle contributions, thus reflecting the dynamic geological processes during the late stages of the Brasiliano-Pan-African orogeny.

Keyword

bimodal dikes, Dom Feliciano Belt, Ediacaran, Uruguay

A Preliminary Study of the Geostandards of the Granites and Obsidians using Neutron Activation Analysis and Electron Probe Micro Analysis

JIN MI-EUN[1]*, HANARO Utilization Division, Korea Atomic Energy Research Institute (jin4860228@gmail.com)
Sun Gwang-Min[2], HANARO Utilization Division, Korea Atomic Energy Research Institute
Dasari Kishore Babu[3], Department of Geology, Gyeongsang National University
Jwa Yong-Joo[4], Department of Geology, Gyeongsang National University

Abstract

Geostandards, pivotal in geoanalytical research, enable the acquisition of precise geochemical data and the refinement of analytical techniques. Despite the increasing demand, the development of Korean geostandards ceased in the 1990s. This study endeavors to lay the foundation for new Korean geostandards by selecting representative granites and Baekdusan obsidians. Neutron Activation Analysis (NAA) and Electron Probe Micro Analysis (EPMA) were utilized to determine major/minor/trace element concentrations. Selections for reference material candidates needed to meet specific criteria: representing typical Korean rock types, showcasing homogeneous chemical compositions, free from structural irregularities like fissures or folds, and available in significant fresh rock volumes. Hence, two Jurassic granites and one Cretaceous granite, emblematic of Korean granite rocks, were chosen. While synthetic glass reference materials are prevalent in microanalysis, they may introduce a matrix effect due to differing compositions from geological samples. To address this, we chose to establish a glass geostandard sample. Consequently, we prepared glassy rocks (obsidian), specifically selecting Baekdusan obsidian devoid of inclusions such as microlites. We evaluated the precision and accuracy of our analytical techniques using reference materials from the USGS and GSJ. Subsequently, we determined the chemical composition concentrations within granite rocks. The potential for development as a Korean Geostandard will be assessed by comparing our analysis results with those from other analytical institutions and establishing reference values. We anticipate these reference materials will serve various purposes across research institutes, universities, laboratories, and analytical institutions supporting geoanalytical studies.

Keyword

NAA, Geostandatds, Granite, Obsidian, EPMA

Episodic continental evolution of the paleo-Pacfic margin along East Gondwana

Giun HAN[1]*, Chungbuk national univercity (giun@cbnu.ac.kr)
Yoonsup Kim[2], Department Earth and Environmenal Sciences, Chungbuk National University
Youn-joong Jeong[3], Research Center of Earth and Environmental Sciences, Korea Basic Science Institute, Republic of Korea
Yuyoung Lee[4], Research Center of Earth and Environmental Sciences, Korea Basic Science Institute, Republic of Korea
Jusun Woo[5], School of Earth and Environmental Sciences, Seoul National University

Abstract

The formation and evolution of supercontinents has been one of the main research topics in geological community over the past few decades, and detrital zircon is useful for the study particularly in area of limited access or rare outcrops. In order to constrain the crustal evolution of the paleo-Pacific margins of East Gondwana, the U¬–Pb-O-Hf isotopic compositions of detrital zircon from metasedimentary rocks in the Wilson and Bowers Terrane, northern Victoria Land, Antarctica, were measured. The former terrane is a continental arc complex primarily composed of metasedimentary rocks and arc-related plutons whereas the latter one comprises weakly metamorphosed marine sediments intercalated with oceanic arc/back-arc volcanic rocks of Cambrian age, and molasse-type shallow marine to deltaic siliciclastic rocks of Late Cambrian to Early Ordovician age. All samples analyzed in the study yield large U–Pb age population of zircon at 1200–1000 Ma and 600–470 Ma without significant isotopic variations in Hf and O. Two major groups of detrital zircon at ~600 Ma and ~1200 Ma show the average δ18O values of 7.5‰ and 6.5‰, respectively. In addition, at all the analytic spots the δ18O values increase with decreasing ages after 2.6 Ga. The εHf(t) regression line, defined by the low δ18O (~4.5–6.5 ‰) zircon, shows that primary magma were extracted from the depleted mantle mainly at either ~1.4 Ga or ~3.4 Ga. Taken together, the formation and evolution of the paleo-Pacific margin of East Gondwana was driven by at least two main pulses of basaltic magma from the depleted mantle, and the differentiation of the primary magma was accompanied by the crustal reworking in the continental lithosphere.

Keyword

detrital zircon, zircon U-Pb-O-Hf isotopes, Gondwana supercontinent, Antarctica

Sr–Nd–Hf isotope and trace-element constraints on the origin of the HIMU reservoir of mafic-ultra mafic intrusions, Pechenga Greenstone Belt: A Potential mantle plume source in the asthenosphere

Sakine MORADI[1]*, State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China (sakinemoradi2017@gmail.com)
Lie-Meng Chen[2], State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences, Guiyang 550081, China

Abstract

Extensive Precambrian Ni–Cu sulfide-bearing mafic–ultramafic complexes within the Pechenga Greenstone Belt (PGB), northwestern Russia, provide an excellent opportunity to assess the mantle characteristics in the back-arc related magmatism. Despite numerous studies conducted on the genesis of sulfide ore deposits in the Pilgujarvi Formation, the source, enrichment processes, and geodynamic evolution of the host intrusion complexes remain widely debated. Therefore, we present new geochemical and Sr–Nd–Hf isotopic data for Ni-Cu-bearing mafic–ultramafic intrusions located in east and west of the Pilgujarvi formation, combining them with previously published data from coeval intrusive rocks in the Kola Peninsula, to constrain the formation of these complexes and associated world-class Cu–Ni oxide deposits. These intrusions are containing three different magmatic rock contain gabbro, pyroxenite, and wehrlite.

Gabbroic samples exhibit higher trace element and REE contents, overlapping with the OIB-like patterns. In contrast, peridotite, and pyroxenite samples are characterized by depletion in the LILEs (e.g., K, Ba, and Sr) but moderately enriched in the HFSEs (e.g., Nb, Ta, P, and Ti) similar to gabbroic rocks. All samples with display low initial 87Sr/86Sr ratios (0.7006–0.7042), un-radiogenic to radiogenic εNd (− 4.7 to 3.4) and εHf (− 10 to 8.7) values, demonstrate the mantle sources beneath the Pechenga are heterogeneous compositionally. The isotope compositions of these rocks plot along a mixing line between HIMU and DMM mantle end-members in isotopic diagrams, with a minor contribution from an EM component and minor decoupling observed between Nd and Hf isotopic compositions. These characteristics resembling the “HIMU”-like component that was derived from mixing between a peridotite and the depleted component (depleted MORB) that is known by pyroxenite from recycled young oceanic crust. Trace-major and isotope modelling also indicating that a pyroxenite mantle type for all type of rocks. Thus, the chemical and isotopic-compositions of the Pechenga mafic-ultramafic rocks are the best explained by decompression partial melting of an ancient and hybrid asthenospheric source. This source likely contains residual garnet within upwelling plume that had previously undergone modification through interactions with subducted Pacific oceanic lithospheric slabs and overlying marine sediments. This scenario can answer the observed slightly enriched Sr–Nd–Hf isotopic compositions, as well as the decoupling between Nd and Hf isotopic compositions in these samples. Our findings are providing a new perspective on the evolution of magmatism in the Pechenga region that have important global implications for understanding the nature, age, and

evolution of the HIMU mantle source in the extensional setting within back-arc basins.

Keyword

Pechenga green stone belt, Sr-Nd-Hf isotopes, Mantle plume, HIMU-like mantle, Back-arc basin

Protolith and metamorphic ages of eclogites from the Eastern Alps

Ruihong Chang[1]*, University of HongKong (changrh@hku.hk)

Abstract

The Austroalpine mega-unit contains the type locality of eclogites (Haüy, 1822) but their protolith age is largely unknown except that of the Permian Bärofen eclogite, for which three Sm-Nd ages between 275 ± 18 and 275 ± 18 Ma have been reported (Thöni & Jagoutz, 1993, Geochim. Cosmochim. Acta 56, 347–368; Miller & Thöni, 1997, Chem. Geol. 137, 283–310). Therefore, we studied the non-gabbroic eclogites from the Saualpe-Koralpe and Sieggraben Complexes, which are considered to represent a previously coherent subducted and then exhumed fragment of a continental rift, which led to the formation of the late Middle Triassic Meliata oceanic basin. A combined zircon U–Pb and Hf isotopic study, whole rock geochemistry of two complexes revealed a protolith age of 242.3 ± 2.6 Ma (Middle Triassic) in the Sieggraben Complex, and 283 ± 5 Ma, 255 ± 3 Ma (Early and Late Permian), 251 ± 3 Ma, and 241 ± 3 Ma (Early to Middle Triassic) in the Saualpe-Koralpe Complex. Magmatic zircons from the Sieggraben eclogites have 176Hf/177Hf ratios of 0.283067–0.283174, εHf(t) values of +15.7 to +19.4, and that from Saualpe-Koralpe eclogite have 176Hf/177Hf ratios of εHf(t) 0.282935–0.283090, εHf(t) values of +10 to +17.4 showing their juvenile mantle source rather than significant crustal assimilation. In both complexes, N-MORB geochemical characteristics are established. Associated ultramafic rocks of Sieggraben eclogites as part of oceanic or Permian subcontinental mantle lithosphere suggest a depleted mantle source and a deep subduction environment. Two zircon grains of Sieggraben eclogites with low Th/U ratios yield ages of 113 ± 2 Ma and 86 ± 4 Ma and represent the approximate age of eclogite metamorphism during Cretaceous. A trondhjemite dike cutting through the eclogite gives a crystallization age of 82.19 ± 0.4 Ma and is formed by partial melting of likely eclogite during decompression. The host metasedimentary rocks of Sieggraben and Saualpe-Koralpe Complexes are interpreted as old continental crust close to the margin of the Meliata basin and were affected by Permian migmatitic metamorphism. Metamorphic zircons of one eclogite from the Saualpe-Koralpe Complex give an age of 87–93 Ma (peak at 91 ± 1.2 Ma). The results of this study combined with previous results are used to present a new model for the tectonic evolution of the distal Austroalpine unit associated with the Meliata Ocean in a Wilson cycle: The Austroalpine Sieggraben and Saualpe-Koralpe Complexes represent a location on the distal continental margin during Permian to Middle Triassic rifting. The mafic rocks are associated with numerous Permian and potential Triassic acidic pegmatites, whereas structurally separated thick Triassic sedimentary cover successions lack any magmatism, likely excluding the present-day eclogite-bearing units as Triassic basement of the sedimentary cover successions.

The now eclogite-bearing piece of continental crust was adjacent to the Meliata oceanic lithosphere subducted during Early Cretaceous times to mantle depth. The subducted continental crust was then exhumed incorporating even ultramafic mantle rocks. During exhumation and decompression of mafic rocks, partial melting took place forming the trondhjemite dike in Late

Cretaceous times.

Keyword

eclogites, Protolith, metamorphic, partial melting, Meliata Ocean

Proterozoic Zircons in Neogene Semporna Peninsula volcanic rocks and its indication of ancient continental crust in Northeastern Borneo

Elvaene JAMES[1]*, Universiti Malaysia Kelantan (elvaene@umk.edu.my)
Azman Abdul Ghani[2], Universiti Malaya
Chung Sun Ling[3], National Taiwan University

Abstract

Volcanic activity was active during Miocene after the subduction in Semporna Peninsula, Northeastern Borneo, Malaysia. However, the volcanic activity started to terminate following the arc-continental collision after the Proto-South China Sea. The timing of magmatism in Miocene implying the major events of Miocene subduction in Southeast Sabah. The Semporna Peninsula is dominantly composed of mafic to felsic volcanic rocks of subalkaline/tholeiitic series ranging from basalt, basaltic andesite,
andesite, dacite and rhyolite. This study reports a study of zircon U-Pb geochronology for Miocene intermediate and felsic volcanic rocks from Semporna Peninsula, Northeastern Borneo. Based on the concordia plot, the age indicates Proterozoic xenocrystic zircons ranging from 0.6 to 2.0 Ga are incorporated within the Miocene Semporna Peninsula volcanic rocks. Not to mention the Th/U ratios suggest the zircon grains for Miocene volcanic rocks showing magmatic origin with combination of mafic and felsic melts. The result from zircon U-Pb for Miocene volcanic rocks suggests that some part of fragment from Western Australia might drifted to Northeastern Borneo. Based on the Lu-Hf isotope data, it can be further suggest that the Semporna Peninsula basements are heterogeneous sources and dominantly in Proterozoic. The zircon U-Pb data provide new insight on the Precambrian evolution history in Semporna Peninsula area.

Keyword

Semporna Peninsula volcanic rocks, Northeastern Borneo, zircon U-Pb, xenocrystic zircons

Age and Petrogenesis of appinite suites and high Ba-Sr granites in Chuncheon at the central Gyeonggi Massif, Korea

In-Hye MOON[1]*, Kangwon National University (mih@kangwon.ac.kr)
Young-Rok PARK[2], Kangwon National University
Kideok D. KWON[3], Kangwon National University

Abstract

There are coeval appinite suites and granites in the Chugokri area in Chuncheon at the central Gyeonggi massif. Appinite suites consist of hornblendite, hornblende gabbro, quartz hornblende gabbro, pegmatitic gabbro, diorite, which all contain hornblende as dominant mafic mineral. Granites are composed of major porphyritic biotite granite and minor equigranular biotite granite, and are classified into high Ba-Sr granite. At the boundary between granites and appinite suites, evidence of magma mingling and mixing are observed. We measured LA-MC-ICP-MS zircon U-Pb dating of the hornblende gabbro, pegmatitic gabbro, and porphyritic biotite granite, and the results are 184.3±0.36 Ma, 184.3±0.37 Ma, and 185.3±0.64 Ma, respectively. This indicates that appinite suites-granite complex formed penecontemporaneously at Early Jurassic Pliensbachian. Geochemical data and modelling result indicate that appinite suites originated from a single magma derived by partial melting of metasomatized mantle peridotite through assimilation and fractional crystallization (AFC) process, and granites adjacent to appinite suites formed from distinct felsic magmas derived through partial melting of continental crustal rocks by crustal anatexis process, which triggered by heat addition from mafic magma producing appinite suites. Geochemical features such as spider diagram, rare earth element pattern, geotectonic discrimination diagram, and predominance of hydrous mafic mineral of amphibole in appinite suites suggest that appinite suites and granitoid in the study area were generated at subduction zone. The igneous activity occurred in association with the Early to Middle Jurassic igneous activity (about 200-164 Ma) of the Korean peninsula.

Keyword

Gyeonggi massif, Pliensbachian, Appinite suites, Granite, Subduction zone

Role of basement tectonics and structural features in the seepage potential at the Cham –e Shir dam site, SW Iran

Arash Barjasteh[1]*, Khuzestan Water & Power Authority (KWPA) (barjasteh@hotmail.com)

Abstract

Cham-e Shir RCC dam was constructed over Zohreh River in the southwest of Iran. This article aims at explaining the role of basement tectonics and structural elements on possible seepage through the dam site and quality decrease of the river based on the data obtained from the previous reports, field surveys, satellite images and aerial photos. The dam site is located in a NW-SE trending highly fractured synclinal growth structure composed of marlstones and limy marlstones of Miocene Age with evidence of karstification. The region is in the Zagros Active Fold Belt of Iran with several faults cutting the area including Cham-e Shir normal fault perpendicular to dam axis and N-S trending dextral basement fault i.e., Kharg-Mish Fault. The longitudinal profile of the river shows a knickpoint with 100 m length at the dam axis. The dam reservoir area is mostly underlain by Oligo-Miocene Evaporates. The study showed that the minimum length of seepage path at the site is about 180m regarding to the fracture spacing and opening that is about 40m and 0.5m, respectively on average. The TDS of the river changes from 5000 to 650 mgrs /lit upstream and at the dam axis due to high permeability and opening of the fracture system which indicates high leakage through the rocks. Due to dam site fracturing especially in the right abutment, 36 percent of Lugeon tests show very high permeability. The estimated 320000 m^3/day possible seepage through the site can be reduced to 21000 m^3/day by establishing a grout curtain.

Keyword

Cham-e Shir dam, basement tectonics, geologic structure, seepage

Research on Key Technologies of 3D Geological Model Rendering in Cloud Environment

Yue SONG[1]*, Natural Resources Comprehensive Survey Command Center, China Geological Survey (sally_syue@qq.com)
Zhenji Gao[2], Natural Resources Comprehensive Survey Command Center, China Geological Survey

Abstract

3D model is a 3D digital representation of objective things, which has been widely applied in fields like urban construction, disaster prevention and mitigation, medical research, biological science, industrial manufacturing, agricultural production, etc. As a special 3D model, 3D geological model possesses the characteristics of 3D model and plays a fundamental role in geological survey, mineral exploitation, underground engineering and smart city construction.

With the development of intelligent sensing technology and 3D geological modeling technology, the scale of 3D geological model data increases exponentially. Meanwhile, with the pace of large-scale underground engineering and smart city continuing to increase, 3D geological model with fine large scenes is being eagerly required. The rapid growth of data and the refinement of large application scenes bring new challenges to the real-time dynamic visualization of 3D geological models.

This paper studies the above issues and puts forward the corresponding solutions. The validity of the technology has been proved by the simulation test of cluster cloud environment consisting of 5 computers. The technique has been applied in the construction of 3D geological information and visualization system in transparent Xiong'an.

(1)The distributed storage mode of 3D geological model is established to improve the efficiency of data access.

(2) The efficient rendering optimization strategy of single node 3D geological model is designed to improve the rendering efficiency of 3D geological model.

(3) A texture mapping method of 3D geological model based on machine learning is proposed to improve the texture mapping effect of 3D geological model.

(4) A cloud-based 3D geological model visualization platform based on Spark big data technology was built to provide support for large-scale 3D geological model visualization.

From the experimental data, the node invocation optimization strategy with "GPU+CPU" can ensure that the frame rate of the four rendering nodes and the end-user scene in the cloud environment is stable at about 35 frames per second, and can achieve satisfactory cluster load balancing effect.

Keyword

cloud environment, cloud environment, 3D visualization, visual framework, distributed rendering

Good Practices and Current Challenges of 3D Geological Modelling at the Czech Geological Survey

Ondřej ŠVAGERA[1]*, Czech Geological Survey (ondrej.svagera@geology.cz)
Jan Franěk[2], Czech Geological Survey
Jan Jelínek[3], Czech Geological Survey
Jakub Kryl[4], Czech Geological Survey
Jan Jelének[5], Czech Geological Survey
Otmar Petyniak[6], Czech Geological Survey
Zita Bukovská[7], Czech Geological Survey

Abstract

Although the Czech Republic is situated in Central Europe and, from a geological standpoint, occupies a stable position, its geological history has been dynamic over geological time. This has resulted in a complex and interconnected geological and structural landscape encompassing everything from unmetamorphosed Paleozoic sediments to remnants of the Variscan orogeny in the form of crystalline complexes, overlaid by well-preserved Cretaceous sedimentary basins, later punctuated by Cenozoic volcanism.

Detailed geological and geophysical mapping conducted over the past century, combined with modern geological databases, forms the foundation of the 3D geological models currently being produced at the Czech Geological Survey (CGS). These models have primarily been created on-demand, serving as frameworks for infrastructure projects such as railroads or highways, deep geological repositories, or the reevaluation of natural resources. According to collaboration with various stakeholders from both the public and private sectors, there is an increasing demand for 3D geological models.

Given the geological heterogeneity mentioned earlier, our 3D models are now being created as watertight meshes representing prevalent geological bodies and structures. Key data sources for these models include detailed digital elevation models, geophysical profiles or grids, large-scale geological maps, and newly acquired or revalidated borehole data. The scale of the models produced varies from a few hundred cubic meters, such as visualizing joint systems for experimental niches in underground laboratories, to tens of cubic kilometers, encompassing projected deep geological repositories for radioactive waste.

With growing interest in subsurface utilization across various branches of the geosciences, engineering, urban planning, and computational science, collaboration is essential. In recent years, a functional chain of data transfer from geological models to hydraulic, discrete fracture network (DFN), or geomechanical models has been established. However, seamless portability remains a significant challenge. Given the multitude of modeling software available, each discipline requires an individualized approach to data transfer. Another critical milestone to address is presenting data validity to a broader audience through uncertainty assessment and visualization, acknowledging the inherent uncertainties in 3D geological models. The CGS is continually working on both of these aforementioned challenges.

Keyword

3D geological model, DFN, Uncertainty, Infrastructure

Construction of jurisdictional, federal, and multinational 3D geology to facilitate digital twins needed to address societal needs

Leonard Harvey Thorleifson[1]*, University of Minnesota (thorleif@umn.edu)

Abstract

The UN Sustainable Development Goals outline aspirations regarding health, safety, and prosperity, along with respect for our human and natural heritage. Among the requirements needed for fulfillment of these human aspirations are energy, infrastructure, minerals, security, and water, while research underpins everything that we know. In turn, geoscience is essential for fulfillment of all of these requirements, as conceptual research, spatial mapping, temporal monitoring, and dynamic modeling to guide decisions. Observational data and multi-resolution 3D geological mapping now enable digital twins - sustained dynamic models that include a framework, monitoring, and management outputs. This digital twin approach is well known in the atmospheric sciences of meteorology and climatology, and there is growing implementation in fields such as soils and the marine. This approach is well implemented at local scales, and is now needed at subnational, national, and multinational scales, for example to help ensure groundwater sustainability. The requirement includes a global solid earth digital twin, needed for study of earth material and history, resources such as geothermal and groundwater, and hazards such as earthquakes. The purpose of global resolution is to support global analyses, and to establish protocols that will guide continental, national, regional, and local levels of resolution. Also, the global solid earth digital twin will stimulate coordination in transitioning the geological mapping paradigm from a focus on publications, to concurrent seamless evergreen databases. The observations and inferences needed to enable this apparatus are built and maintained for countries by national geological surveys, as well as by subnational surveys in federal nations. We rely on the Commission for the Geological Map of the World (CGMW) to provide leadership in publication of geological maps for the world, for continents, and for multinational regions. Users demand standardization that also allows efficiency, so needed geoscience information standards are maintained by the Commission for Geoscience Information (CGI). OneGeology (1G) is an international initiative of the world's geological surveys and partners that is focused on accessibility of global geoscience data via standardized web services. CGMW, CGI, and 1G therefore are in a position to play coordinated roles in solid earth digital twin modeling by making available the framework geology that will be required by all.

Keyword

3D, geological, mapping, digital, twin

The Loop Project - an open-source platform for 3D geological modelling: towards better management of underground resources

Laurent AILLERES[1]*, Monash University (laurent.ailleres@monash.edu)
Lachlan Grose[2], Monash University
Roy Thomson[3], Monash University
Noelle Cheng[4], Monash University
Mark Jessell[5], University of Western Australia
Rabii Chaarani[6], Monash University
Angela Rodrigues[7], Monash University

Abstract

Loop is a OneGeology initiative, initiated by Geoscience Australia and funded by Australian Territory, State and Federal Geological Surveys, the Australian Research Council and the MinEx CRC. The project is led by Monash University and involves research groups from the University of Western Australia, the RING consortium at the Universite de Lorraine, Nancy, France and RWTH Aachen in Germany. In-kind research is also provided by Natural Resources Canada (Geological Survey of Canada), Geoscience Australia and the British Geological Survey. Other partners include AuScope and the USGS.

A socially-licensed greener future depends on improving our ability to predict subsurface geology and better manage our underground resources: water, critical metals. The mine of the future must have a reduced footprint and economic, socially-accepted mineral resource discoveries and extraction activities will depend on how well we are able to map the subsurface geology, including the ability to generate models of physical and geochemical properties in mineralized systems while estimating and mapping associated uncertainties. This requires the ability to probabilistically forecast geology, allowing for rapid model updates.
We present the current state of the Loop project, an open-source interoperable, integrative, probabilistic 3D geological modelling platform. The platform consists mainly of two libraries in an attempt to automate the model building process from geological observations reported as maps and along drill holes. The map2loop library automatically augments geological information from maps and generates parameters for the modelling library. In LoopStructural, we have defined a parameterisation of 3D geological models in a forward modelling sense. LoopStructural is based on the concept of the structural frame: a coordinate system defined for each object (faults, intrusions) or geological events (folding). These coordinate systems consist of 3 perpendicular scalar fields that are interpolated and fitted to data in 3D and then combined according to the geological history. The structural frames are conformable to layering throughout the models. We present the concept for LoopResources, our proposed property modelling library. Using this deformed cartesian coordinate system, we propose to adapt geostatistical and interpolation methods to curvilinear coordinate systems using classical XYZ-UVW transformations. This will ensure that lithological anisotropies are enforced during resource estimation and property

modelling to provide better digital twins of the subsurface and characterize geological uncertainty throughout the entire workflow. We present a webapp which allows users to automatically analyze map information and generate summarized outcomes of map2loop for user confirmation, e.g., a stratigraphic or lithological column, the fault topological relationships with themselves and the stratigraphy, the geometrical characteristics of the lithologies. The outcome of map2loop are valuable in a sense that they allow the user to better understand the geological map and check the 3D modelling input before proceeding with structural interpolations to generate the 3D models.

Keyword

3D structural modelling, open-source, One Geology, automated map analysis

LoopResources: Using structural frames for geostatistical simulations of geological resources.

Lachlan GROSE[1]*, Monash University (lachlan.grose@monash.edu)
Laurent Ailleres[2], Monash University
Angela Alfonso Rodrigues[3], Monash University
Rabii Chaarani[4], Monash University

Abstract

The transition from fossil fuels to renewable electric technologies will require a significant increase in discoveries of natural resources such as critical metals, base metals, and water. To facilitate the increased demand we need to improve our ability to find new resources and improve our abilities to extract existing resources reducing environmental impacts. To do this we need to be able to predict and estimate the distribution of these properties in the subsurface from limited observations (surface, drillhole, geophysics). We need to build tools that are capable of propagating uncertainties throughout the mining value chain allowing for informed decision-making to be made throughout the process. One of the challenges facing this workflow is our ability to automatically integrate geological uncertainties into the tools and techniques used to build resource models. In a standard workflow, the geological integration within a resource model is defined by assigning domains with different geostatistical models. This approach can be subjective and difficult to automate, meaning that any uncertainties are only associated with the geostatistical model and not the geology.

We use the open-source 3D modelling library, LoopStructural, to build a geological model of the geological features of interest. For each geological feature in the model (fault, conformable series, foliation) a curvilinear coordinate system aligned to the feature of interest is built. The structural frame coordinates are aligned with the major structural feature (fault surface, fold axial surface, or foliation), the structural direction (fold axis, fault lineation, or other lineations), and an intermediate direction. The structural frame can be used to calculate a distance within a geological feature conformable to geological anisotropies. Using the structural frame distance standard geostatistical tools can be applied, for example, calculating an experimental variogram to analyze the distribution of a property within the structural frame coordinates. We apply this approach to a synthetic proof of concept model of a refolded fold and compare the results to geostatistical simulations in cartesian space.

Keyword

loop, geomodelling, structural geology, geostatistics

Geomodelling in Europe: Sharing practices and open-sourcing tools among Geological Surveys

Laure PIZZELLA[1]*, BRGM (l.pizzella@brgm.fr)
Nicolas Clausolles[2], BRGM
Christian Brogaard Pedersen[3], GEUS
Philippe Calcagno[4], BRGM
Montse Colomer[5], ICGC
Chiara d'Ambrogi[6], ISPRA
Timothy Kearsey[7], BGS
Chris Heerema[8], TNO
Ignasi Herms[9], ICGC
Monika Hölzel[10], Geosphere
Simon Lopez[11], BRGM
Carlos Marín-Lechado[12], IGME
Marton Palotai[13], SZTFH
Timo Spoerlein[14], LFU
Jan Stafleu[15], TNO
Urszula STĘPIEŃ[16], PGI
Ondrej SVAGERA[17], CGS
Ewa Szynkaruk[18], PGI
Ricky Terrington[19], BGS
Mariane Wiese[20], GEUS

Abstract

The Geological Service for Europe (GSEU) project is a 5-year EU funded project bringing together 35 geological surveys and 13 additional partners to deliver a cooperative and comprehensive information and communication campaign about the subsurface. The key focusses are critical raw materials, geothermal energy resource and storage and groundwater management. It started in September 2022 and is anchored on the European Geological Data Infrastructure (EGDI) platform, where all subsurface data collected before or during the project is shared with a broad audience. Notably, the platform serves as a dynamic central repository of various 3D geological models.

Within GSEU Task 6.3, we aim to pool tools and best practices related to the conception and visualization of these 3D geological models. Our work involves identifying these tools, assessing their use, documenting them, and providing expert insights to aid in the creation of shareable models. We also discuss common limitations, individual strengths, and collectively desired developments for the future. The initiation of this output involved compiling an inventory of practices from different geological surveys, sharing in-house tools, and conducting a series of open-tool webinars, all aimed at fostering transparent and constructive discussions on 3D geological modeling tools and practices. The overarching goals of this task include formulating a conclusive deliverable that compiles best practices and documentation on presently available open-source tools within the scientific community. Furthermore, it extends to the establishment of

a sustainable network of experts in 3D geological modeling across European geological surveys.

Keyword

geomodelling, 3D, visualization, open-source, Europe

3D Geological Modeling at BRGM (French Geological Survey)

François PROGNON[1]*, BRGM (f.prognon@brgm.fr)
Simon Lopez[2], BRGM
Philippe Calcagno[3], BRGM
Nicolas Clausolles[4], BRGM
Laure Pizzella[5], BRGM

Abstract

3D modeling has become a major asset for the understanding and quantitative characterization of subsurface geology. With the advent of new acquisition techniques, a large amount of heterogeneous measurements, over a wide range of scales, now complement the traditional field mapping activities with comparatively scarce observations. Delivering relevant subsurface models and maintaining reference databases to store them and disseminate geological knowledge need joint interpretations to deliver so-called shared earth models. This talk aims at giving an overview of the current practices and tools used at BRGM and the practical challenges to achieve such integration in 3D geological modeling.

Along with the use of many commercial software, BRGM has been developing several geological data management and modeling tools as well as collaborations at different levels (eurogeosurveys...) to overcome these challenges. The theoretical framework of the tools strongly relies on geostatistical techniques and efficient interpolation algorithms adapted to geological field data. Intuitive and meaningful rules to describe geological architecture must complement them to assemble interpolated surfaces into complex geological structures. The extension of such formalism to describe all observed architectures is still a field of research as well as interpolation techniques that can exploit all available observations. As regards technology, our current goal is the progressive structuration of an open geological modeling platform with the use of smaller modular interconnected tools and services along with a web frontend to share both produced models and modeling methods. Finally, the analysis of practices stresses the value of geological modeling as a unifying link and the need to change traditional linear workflows to include trans-disciplinary interactions.

Keyword

geological modeling, modeling tools, data management

[Keynote] Geomodelling by geological survey organisations: game changers, perspectives and challenges

Michiel Jan VAN DER MEULEN[1]*, TNO, Geological Survey of the Netherlands
(michiel.vandermeulen@tno.nl)
Florian WELLMANN[2], RWTH Aachen University
Denise MALJERS[3], TNO, Geological Survey of the Netherlands

Abstract

Since the turn of the 21st century, geomodelling, i.e. mapping the subsurface three-dimensionally, has been taken up by several geological survey organisations worldwide as an addition to, and in few cases replacement of, national geological mapping. Spearheaded by a group of early adopters, geomodelling is coming of age as a systematic effort, the results of which are finding their way to end users ever more seamlessly.

In terms of practical use and impact, geomodelling has seen its biggest successes in the geotechnical, hydrogeological and geo-energy application domains. In geological terms, the greatest successes are in mildly to undeformed sedimentary basins (as opposed to strongly tectonised, metamorphic or magmatic terrains). Applications and associated geological settings are reflected in common modelling concepts and tools, which have mostly been developed by and for the hydrocarbon, water and engineering sectors.

The related energy and materials transitions will change the game of geomodelling by geological survey organisations fundamentally. When it comes to geothermal energy and geological storage, the frontrunners will be able to satisfy much of the information needs with existing geomodelling approaches, often by revisiting the same basins. However, decarbonisation also raises the demand for minerals, supplies of which have come to be considered critical. The exploration for such minerals requires our community to step up in different, more complex, geological settings. Additionally, a better appraisal of uncertainties and related exploration risks requires an investigation of suitable geomodelling tools on all scales. This means that geomodelling needs a boost, i.e. higher investment levels in research, skills and tools, as well as in their deployment in new approaches and workflows.

Keyword

Geomodelling, Energy transition, Materials transition, Exploration, Critical raw materials

Heterogeneous internal architecture and engineering properties in an exhumed crustal scale strike-slip fault zone

Namgwon KIM[1]*, University of Strathclyde (namgwon.kim@strath.ac.uk)
Zoe K Shipton[2], University of Strathclyde
Yannick Kremer[3], University of Strathclyde
Christopher D Jack[4], COWI

Abstract

In subsurface engineering projects, understanding ground conditions and their uncertainties is essential to reduce the risk of cost and time overruns. At the initial stages of a project, accurate forecasting of the rock mass properties in 3D geological models is challenging due to the limited data available. Fault zones, especially, are characterized by complex internal architecture, exhibiting structural and lithological heterogeneities governed by various factors. Fault zone architecture can control rock mass strength and, therefore, must be considered in geological engineering projects. Here, we demonstrate a workflow to continuously refine 3D fault zone models using additional information acquired during progressive stages of infrastructure project development.

The case study area is a crustal scale strike-slip fault with several hundreds of kilometres of displacement, exhumed from the elastic-frictional regime. It is characterized by a complex internal architecture resulting from host-rock heterogeneities, multiple episodes of reactivation, igneous intrusion, and exhumation.

We built a prototype 3D fault zone model from pre-existing geological maps and well-established scaling relationships of fracture attributes. We then refined the fault zone model to incorporate geologic and engineering elements measured during a major subsurface infrastructure project. The ground investigation data from the infrastructure project enables detailed mapping of the structural geological and rock mass properties, particularly within a focussed transect perpendicular to the fault. The structural geological and rock mass property mapping shows that the fault zone comprises numerous foliated cataclasites, intrusions, lenses of protolith, and fractured wall rock with variable structural, hydrological, and engineering properties. Within the fault core, minor faults filed with clay gouge tend to be less predominant than calcite and quartz veins toward the damage zone. Several structural domains can be defined: characterized by sets of structural discontinuities based on geometry, spacing, persistence, and infilling materials. These domains are mainly bounded by narrow zones rich in faults and fractures filled with clay gouge and/or calcite and quartz. Rock mass Q-values are highly variable but are largely controlled by the structural domains. Local large increases in Q-value are observed in areas of weak foliation, wall rock lenses, and near dyke-rich zones. Structural domains showing fluctuating Q-values are typically accompanied by groundwater seepage along the structural discontinuities.

The continuously refined 3D fault zone model reveals complex spatial patterns in structural geological and rock mass heterogeneities. The complex heterogeneities across the fault zone

highlight the need to integrate structural geological analysis into engineering workflows. We argue that this will yield more robust forecasting of hydro-mechanical engineering properties within and around fault zones and contribute to reducing geotechnical risks.

Keyword

Fault zone model, Exhumed strike-slip fault, Geological engineering Structural domain, Engineering heterogeneities

Germany 3D - Overview of 3D modelling activities of the German geological survey BGR

Stephan Steuer[1]*, Federal Institute for Geosciences and Natural Resources (stephan.steuer@bgr.de)

Abstract

The Federal Institute for Geosciences and Natural Resources (BGR) is the central geoscientific authority providing advice to the German Federal Government in all geo-relevant questions. It is subordinate to the Federal Ministry for Economic Affairs and Climate Action (BMWK) and therefore obligated to provide neutral and independent advice and information related to all aspects on geoscientific and natural resources. In particular, the following fields of scientific research are included: energy resources, mineral resources, groundwater, soil, deep subsurface use, geological disposal of radioactive waste, and geohazard assessment. In all of these fields, static and dynamic 3D-modlling is conducted at different scales.

We will provide examples of various 3D-models ranging from basin-wide to very small. The largest model presented is a 3D-model of the North German Basin that was created in close collaboration with the State Geological Services of the German federal states. Comprising of 13 horizons, 273 complex salt structures, 5,300 faults and covering an area of around 170,000 km^2, this model is one of the largest 3D-models worldwide. Smaller presented models are reservoir models, groundwater and geophysical 3D-models and a very detailed model of a repository site for nuclear waste. The smallest model is the model of a single fracture, created in a geothermal well.

BGR is not only conducting various kinds of 3D-modellling, we are also working on new ways of communicating the outcomes of the modelling to the public (e.g. VR/AR, Gamification,…) and to provide information about uncertainties of a model.

Keyword

3D-modelling, structural modelling, groundwater modelling, geophysical modelling, public relations

Context is Everything: Leveraging a Common Reference Geological Model to Enhance Modeling Efficacy and Accuracy – A Case Study from Poland.

Zbigniew MALOLEPSZY[1]*, Polish Geological Institute (zbigniew.malolepszy@pgi.gov.pl)
Ewa Szynkaruk[2], Polish Geological Institute

Abstract

The Polish Geological Survey has recently completed the construction of a country-wide Framework geological model of Poland. This model provides a comprehensive, albeit generalized, overview of Poland's geology, capturing its intrinsic complexity and offering numerous possibilities for further structural modeling and parameterization. Equally important, it provides a contextual framework for the development of more detailed, regional models, which form the cornerstone of our understanding of the subsurface and our ability to utilize it effectively. As articulated by one of our most experienced geologists: "I prefer to work on basin-scale models as this is where the data points are truly related and these relations can be unpicked and interpreted most clearly."

Prior to completing the Framework geological model of Poland, we developed two basin-scale structural and parametric models from scratch, based on all available and meticulously integrated data. Now, as we embark on the construction of a third model, the difference that having a general model provides is already apparent: sharing it with our team of interpreters specializing in regional geology ignites an overwhelming urge to check, repair, detail, and test different interpretations. The motivational impact of having a pre-existing model cannot be overstated. Importantly, providing this model can be done without the use of complex software not everyone can operate. The model is served on the web using the Geo3D viewer, significantly enlarging the area of impact and accessibility of the model's context. Link: https://geo3d.pgi.gov.pl/model_Poland/index.html

The broader-scale model allows us to contextualize our new interpretations from the very beginning, potentially leading to more rigorous and coherent outcomes across different, more detailed works. It can also be manipulated beforehand (e.g., balanced) to guide new interpretations and, when combined with pre-collated data, serves as a springboard to significantly streamline our work processes. Furthermore, it establishes a benchmark that distinctly delineates the extent of our learning. Moreover, it serves as a general reference in cases of contradictions or problems beyond our current scope, providing a reliable fallback option.

This approach, while demonstrated in the context of Poland's geology, holds promise for geological surveys in other countries. By adopting similar methodologies and tools, local geological surveys worldwide can enhance their modeling efficacy and accuracy, ultimately leading to a more comprehensive understanding of their respective geological landscapes. The

common reference model coupled with Geo3D viewer has the potential to significantly improve geological modeling practices on a global scale, facilitating collaboration, knowledge sharing, and informed decision-making in the field of geosciences.

Keyword

3D geological mapping, geomodelling, framework geomodels, country-wide geological models, visualisation of geological models

Key Technologies for Geologic Modeling of Complex Fault Block Oil Reservoir

Xing DENG[1]*, China University of Petroleum (East China (892583840@qq.com)
Chengyan LIN[2], China University of Petroleum (East China

Abstract

Fault block oil reservoir features an important reservoir type in the Shengli Oilfield, accounting for 32.4% of its mining-employed reserves. The distribution of reserves in complex fault block oil reservoir varies widely with small scale, posing challenges in achieving high-efficient development. A fine characterization of the fault system and reservoir in complex fault block oil reservoir, alongside the establishment of a geological model that aligns with both geological and developmental understandings, is vital for enhancing oil recovery in the complex fault block oil reservoir. During the geological modeling process of complex fault block oil reservoir, there are internal synsedimentary faults that control the reservoir's sedimentary architecture. Different developmental types of synsedimentary faults and their combined forms determine the distribution range and scale of the reservoir. The generation, migration, and accumulation of oil and gas are closely related to sedimentary filling and tectonics. Additionally, during the pressure-driven displacement process in complex fault block oil reservoir, excessive pressure can lead to fault juxtaposition. Therefore, it is necessary to conduct modeling research on fault sealing and fracture distribution. This paper takes complex fault block oil reservoirs such as the Pan 40-80 and Zhan 27 as examples, and establishes three different sedimentary distribution models of sand bodies under the control of the synsedimentary faults at different activity intensities. It provides technical guidance for the fine characterization of reservoir geological modeling in complex fault block oil reservoir. Additionally, it combines the fault zone coring data and fracture pressure tests to model and calculate the structural characteristics inside the fault zones and the displacement pressure difference of fracture filling, which helps to guide the vertical and lateral sealing evaluation of the fault zones. The application of the above two key technologies for geologic modeling of complex fault block oil reservoir provides a clear direction for improving oil recovery through complex fault block geological drilling and pressure-driven displacement schemes.

Keyword

complex fault block, synsedimentary fault, fine characterization of reservoir, fault sealing, geological modeling

Syn-kinematic granite emplacement in a transpressional corridor and its influence on the formation of dome-and-basin fold interference patterns

Gideon Rosenbaum[1]*, The University of Queensland (g.rosenbaum@uq.edu.au)
Alana Barrett[2], The University of Queensland
Raiza Toledo Rodrigues[3], The University of Queensland
Charlotte M Allen[4], Queensland University of Techonology
Roberto F Weinberg[5], Monash University

Abstract

Folding of layered sequences is influenced by the presence of igneous intrusions, which form competent bodies that control fold distribution and geometry. We show an example from the Broken River Province (northeastern Australia), where macroscopic folding affected sedimentary rocks and felsic intrusions, forming a dome-and-basin pattern. Field relations indicate syn-kinematic emplacement of the granitic intrusions, which occur as folded sill-like microgranitic bodies, mildly deformed stocks at structural domes, and undeformed granite that cuts across the folded sedimentary sequence. U-Pb zircon ages from the various intrusions yielded an age range of 335–320 Ma, thus constraining the timing of folding. The deformed zone is restricted to a ~30 km wide corridor bounded by two crustal-scale shear zones. Kinematic indicators show that folding was generated by dextral transpression, giving rise to the dominant orientation of folds. Domes and basins are generally concentrated in the proximity of the granitic intrusions, indicating that their development was likely controlled by the syn-kinematic emplacement of these plutons. The added volume of granite to the exposed section could have altered the local strain regime, switching the horizontal stretching direction during transpression to a shortening direction. We therefore suggest that forced intrusion of syn-kinematic plutons into a confined transpressional zone (dominated by flattening strain) can create local constrictional strain where shortening occurs in two broadly orthogonal horizontal directions. The results demonstrate a link between Carboniferous granitic dome-and-basin patterns and syn-transpressional magmatism. It is plausible that similar processes involving constrictional strain were responsible for the development of granitic dome-and-basin patterns in Archean terranes.

Keyword

transpression, granite emplacement, Fold interference patterns, Mossman Orogen, Australia

Stages of Shear Zone Evolution in an Isotropic Medium: An Account of Fluid Induced Rheological Transformation in ~2.6 Ga Bundelkhand Granitoids of India

SAYAN MAITY[1]*, Banaras Hindu University (maity21s.geo@bhu.ac.in)
Sayandeep Banerjee[2], Banaras Hindu University

Abstract

Shear zones are sheet-like planar to curviplanar zones where the localization of deformation is notably higher relative to the surrounding low-strain or undeformed region. A plethora of existing studies have discussed the nucleation and widening of shear zones in response to progressive deformation. It is believed that nucleation of shear zones in an isotropic medium often needs a pre-existing mechanical or compositional heterogeneity e.g., pre-existing brittle fractures, along with the influence of many other intrinsic and extrinsic factors. However, the evolution of ductile shear zones (DSZs) from a nascent stage to a well-developed broad one in an isotropic medium like that of granitoids is still debated due to the lack of preservation of the intermediate stages. It is reported by many workers that the fluids in and around granites play a key role both in nucleation and widening of the DSZs. However, very few studies have been done so far taking the mineralogical, textural, and chemical changes from core to boundary and low-strain hosts into consideration. Also, the exact mechanism(s) of fluid-rock interaction and the role of fluid prompting and driving the progressive change from undeformed host to intensely deformed core of DSZs still remain ambiguous. The Archean (~2.6 Ga) granitoids of Bundelkhand Craton (BuC) preserve excellent exposures of DSZs with varying thickness and grade of deformation in meso-scale. In the field as well as under a microscope, the transition from apparently undeformed host granites to intensely deformed ultramylonites with/without the development of proto- and meso-mylonites are recorded. The change in mineralogy, texture, and petrofabric studied across the DSZs clearly indicates a gradual increase in grain size reduction, ductile behavior of minerals showing preferred orientation in the trend of the shear zone, and increase in porosity as well as secondary epidote-rich material towards the core, where strain localization is maximum. The contact between brittle with plastic deformation, along with the preserved brittle-ductile in between indicate that the widening of DSZ has started from the core first and then gradually engulfed the wall rock i.e. the host granitoids. So, from field, microstructural, and mineralogical investigations we suggest that the DSZs evolved along the pre-existing fractures in the presence of an epidote-rich aqueous fluid by the process of hydrolytic and reaction-driven weakening. We also show evidence of intermediate brittle-ductile transition structures as well as different stages of evolution of DSZs that are present at several locations across the craton. Finally, through this study, we propose a model for the evolution of the DSZs in Archean Bundelkhand granitoids based on field, textural, and mineralogical data.

Keyword

Ductile shear zones, Nucleation, Isotropic medium, Bundelkhand granitoids, Rheological transformation

Structural investigation in the Madurai Block of Southern Granulite Terrane, India: Insights from Shear Zones

JOHN DSOUZA[1]*, Department of Geology, St.Xavier's College, Mumbai, India 400001 and Department of Geology, Savitribai Phule Pune University, Pune, India 411007 (john.dsouza@xaviers.edu)
DURGA PRASANNA MOHANTY[2], Department of Geology, Savitribai Phule Pune University, Pune 411007

Abstract

Southern Granulite Terrane (SGT) of granulite facies rocks lying south of the granite-greenstone terrane of the Dharwar Craton is separated by the Fermor Line. SGT is also recognized for comprising various crustal blocks amalgamated along subduction and collision zones. Situated south of the granite-greenstone terrane of the Dharwar Craton, the Southern Granulite Terrane primarily comprises granulite facies rocks. The SGT is also recognized for consisting of several crustal blocks combined along subduction and collision zones. The Palghat-Cauvery Shear Zone and the Achankovil Shear Zone split the Southern Granulite Terrane into three sub-divisions: the Madurai Block, the Trivandrum Block, and the Nilgiri-Namakkal Blocks. The evolution of the SGT across the Archean-Proterozoic boundary involves a complex history of magmatic, sedimentation, and metamorphic events. The terrane has experienced multiple tectonothermal events, including subduction-related granitoid magmatism. The shared Ediacaran-Cambrian metamorphism between the SGT, the basement rocks of Madagascar, and the Precambrian rocks of Sri Lanka suggests that these regions may have been part of a coherent landmass before the late Archean. Karur-Kambam-Painavu-Trichur shear zone (KKPTSZ) of SGT has been identified in the Madurai block as a V-shaped Neoproterozoic ductile shear zone with deformation of an early and a later phase ranging from 700-550 Ma. Several workers have identified another major shear zone as Suruli Shear Zone (SSZ) Madurai block, also reported as an S-W extension of the Theni-Madurai Shear Zone (TMSZ). The Kambam Ultra High-Temperature Belt (KUHTB) is one of the SGT's ultra-high temperature belts identified in the Madurai Block, which coincides with the alignment of the SSZ. The present investigation of structural data gathered from the SSZ demonstrates a clear foliation orientation of NE-SW along the Kambam-Theni transect, which begins to deviate towards NNE-SSW in the Theni area with its south-easterly dip direction. Interference folding with differing intensity is observed in the parts of the SSZ. The structural features, the mafic granulites, sillimanite-garnet-biotite gneisses, calc-granulite gneisses, and quartzites, are preserved throughout the Madurai block. Enclaves or raft-like structures are also common within the mafic granulites. The southern part of the SSZ calc-granulites shows intensive folding along with the σ-type clasts and asymmetric shear-related minor folds within sillimanite gneisses. These calc-granulites also show distinct development of the simple non-cylindrical hook-shaped folds throughout the southern extension. This structural investigation intends to look at the association between SSZ and KKPTSZ in the context of the tectonic evolution of SGT.

Keyword

Southern Granulite Terrane (SGT), Tectonic Evolution, Shear Zones, Deformation, Structural Investigation

Shear Zones of Southern Granulite Terrane, India: Networks and complications

Durga Prasanna Prasanna MOHANTY[1]*, Savitribai Phule Pune University (durgaiitb@gmail.com)

Abstract

Southern Granulite Terrane (SGT), India, is the host to rocks of Neoarchean to Neoproterozoic age with granulite to ultra-high temperature grade metamorphic rocks with granitic, mafic and ultramafic intrusions. SGT is separated into various blocks by crustal-scale shear zone networks. East-West trending Cauvery Shear Zone System (CSZS), which is a wide zone of 400 km in length and 60-70 km in width. Thee SZS includes various shear zone networks like Kasargod-Mercara Shear Zone (KMSZ), Moyer Shear Zone (MoSZ), Bhavani Shear Zone (BSZ), Salem Attur Shear Zone (SASZ), Palghat Cauvery Shear Zone (PCSZ) etc. The CSZS, as a major tectonic unit, divides the SGT Northern Granulite Block (NGB) to its north and Madurai Granulite Block (MGB/MB) to its south. The CSZ has its western extension to the Madagascar as Betsimisaraka Shear/Suture Zone and Shear Zone to the east exposed in the Antarctica continent. The Madurai Granulite Block (MGB) is again separated from the southern tip od the India i.e. Trivandrum Bock, by means of Achan-Kovil Shear Zone, whose western and eastern extension is mapped in Madagascar (Ranotsara Shear Zone) and Sri Lanka respectively. Each of these shear zones have their unique structural deformation patterns which are well exposed in the out-crop scale. CSZS has also been reported to be the host to several dismembered ophiolites of Neo-Archean and Neo-Proterozoic age. This adds complications to the interpretations of the entire SGT with respect to setting up its regional stratigraphy, deformational history in connection to the multi-phase metamorphism reported by various researchers. Presence of Ultra High Temperature metamorphic rocks in the MGB has become a very interesting topic for the workers in that particular domain. MGB again has been subdivided into Northern Madurai Block and Southern Madurai Block by some workers where as some have different opinions as the divisions are Eastern Madurai Block and Western Madurai Block.

Keyword

Southern Granulite Terrane India, Shear Zone, Suture Zone, Deformation, Tectonics

Kinematic vorticity and deformation thermometry analyses of the exhumed mylonites from the Xiaohe ductile shear zone in the sourthern Xiaoqinling gold province, North China

Hui-Min MA[1]*, China University of Geosciences (Wuhan) (mahm0821@163.com)
Shao-Yong Jiang[2], China University of Geosciences (Wuhan)
De-Liang Liu[3], China University of Geosciences (Wuhan)
Ying Ma[4], China University of Geosciences (Wuhan)
Wen-Tian Li[5], China University of Geosciences (Wuhan)

Abstract

Quantitative determination of kinematic vorticity analyses and temperature conditions of the mylonites provide significant information regarding the kinematic characteristics and deformation mechanisms. The Xiaohe shear zone located in the southern section of the Xiaoqinling gold province on the southern margin of North China, extends ~80 km from east to west, and is characterized by well-developed SE-dipping mylonites in the east and S-dipping mylonites in the west. The shear zone exhibits a top-to-the-SE or top-to-the-S sense of extensional ductile shearing deformation, as indicated by several kinematic indicators, such as S-C fabric, extensional folds, and σ- and δ-type porphyroclasts. The vorticity of flow (Wm) along the sear zone is estimated using the Wallis plot, Rigid Grain Net (RGN) plot and oblique-grain-shape/quartz c-axis fabric. The corresponding Wm values range from 0.49 to 0.58, 0.47 to 0.58, and 0.59 to 0.83, respectively, suggesting that pure shear dominated the deformation. Integration of strain and vorticity analyses revealed a shortening of 8-11% perpendicular to the Xiaohe shear zone and an extension of 8-13% (assuming plane strain deformation) measured parallel to the flow plane-transport direction. The quartz lattice-preferred orientation (LPO) patterns also indicate extensional shearing deformation, and the opening angles of the quartz c-axis fabric show deformation temperatures ranging between 500 °C and 600 °C. A Ti-in-quartz (TitaniQ) geothermometer was also applied to assess the deformation temperature during mylonitization in the Xiaohe shear zone. In the mylonite samples from the Xiaohe shear zone, cathodoluminescence (CL) images of the quartz ribbons show no clear zonation, and back-scattered electron (BSE) images of the samples show the presence of rutile, suggesting a TiO2 activity value of 1.0. Based on the known pressure of 5.7 kbar, the deformation temperatures calculated via TitaniQ geothermometry (four methods) range from 507 °C to 603 °C, 450 °C to 561 °C, 565 °C to 704 °C, and 476 °C to 611 °C, with concentrated values ranging between 475 °C and 650 °C. Therefore, the Xiaohe shear zone records extensional ductile shear deformation, which possibly resulted from back-arc extension induced by rollback of the subducted Paleo-Pacific Plate during the Early Cretaceous when gold mineralization occurred in this region.

Keyword

Kinematic vorticity, TitaniQ geothermometer, Extensional deformation, Xiaohe shear zone,

Xiaoqinling gold province

Deep crustal expressions of exhumed continental-scale fault zone systems: Shear zone nucleation and initiation on rheological boundaries

Shuyun CAO[1]*, China University of Geosciences, Wuhan 430074, China (shuyun.cao@cug.edu.cn)
Franz Neubauer[2], Dept. of Geography and Geology, Paris-Lodron-University of Salzburg, Hellbrunnerstr. 34, A-5020 Salzburg, Austria
Wenyuan Li[3], School of Earth Sciences, China University of Geosciences, Wuhan 430074, China

Abstract

The formation and evolution of major continental-scale exhumed strike-slip faults represent one of the most important dynamic processes affecting the evolution of the Earth's lithosphere. Detailed studies and models of the potential initiation and driving mechanism, their properties and architecture of orogen-scale exhumed strike-slip faults are rare. Here, we present an integrated study of tectono-metamorphism, anatexis and deformation in the strike-slip shear zones. We propose the nucleation and initiation of shear zone is at depth, where temperature-controlled rheological weakening mechanisms play the essential role localizing future strike-slip faults. We highlight that in pluton and metamorphic core complex (MCC)-controlled tectonic settings, as end-members, the initiation of strike-slip faults occurs by rheological weakening along hot-to-cold contacts deep within the crust and mantle lithosphere, respectively. These endmember processes are potential mechanisms for the initiation of orogen-scale exhumed strike-slip faults at depth result in a specific thermal and structural architecture (Cao and Neubauer, 2016). A major aspect of many exhumed strike-slip faults is their lateral thermal gradient induced by the lateral juxtaposition of hot and cold levels of the crust controlling relevant properties of such fault zones, and thus the overall fault architecture (e.g., fault core, damage zone, shear lenses, fault rocks) and its thermal structure. Finally, we integrate all available data with crustal evolution and develop a comprehensive model for the progression of tectonic evolution in fault zone systems.

Keyword

deep-seated shear zone, nucleation and initiation, rheological weakening

Polyphase deformation derived from meso- and microstructural observations along the brittle-viscous shear zone in the Hamyang, Korea

Sang Yeol Bae[1]*, Pukyong National University (teriousbae8@gmail.com)
Jin Hyun So[2], Pukyong National University
Young-Seog Kim[3], Pukyong National University

Abstract

Shear zones can generally be classified depending on their dominant deformation mechanisms. The deformation mechanism strongly depends on the temperature and pressure, relying on the depth. In this study, we conducted a meso- and microstructural analysis based on geometry, kinematics and deformation mechanism of NE-SW trending brittle-viscous shear zones which are located in Gyeonsangnam-do, Hamyang-gun. The geology in the vicinity of the study area consists of Triassic foliated porphyritic granites which are may related to post-collisional igneous activities triggered by slab roll-back and/or crustal delamination in subduction zone. Primary foliations, Interbedding of alternating biotite-and feldspar-rich layers, are influenced by segregation. On the other hand, mylonite zone is characterized by steeply plunging stretching lineations and asymmetric geometry, indicative of a top-to-the-southeast sense of shear. The dominant deformation mechanisms of both quartz and feldspar in the viscous shear zone are interpreted as dynamic recrystallization (bulging and subgrain rotation), indicative of the medium-grade mylonites. The subsequently developed brittle-viscous shear zones, characterized by deformation localized in narrow ultramylonite zone with horizontally plunging stretching lineations, indicate dextral sense of shear. The latest stage of deformations at the study area are sinistral shearing which is locally reactivated as flanking structures or deformed mafic dikes. These changes in deformation mechanism can contribute to deciphering the tectonic evolution of Korean Peninsula.

Keyword

Shear zone, Mylonite, Shear fracture, SC-fabric, Deformation history

Importance of Mechanical Anisotropy on Strain Partitioning across a Transpressional Shear Zone (Okdong Fault) in Korea

Jinhyeon SO[1]*, Pukyong National University (so1005kr@pukyong.ac.kr)
Yeoeun SEO[2], Pukyong National University
Jinhyun LEE[3], Pukyong National University
Sangyeol BAE[4], Pukyong National University
Young-Seog KIM[5], Pukyong National University

Abstract

Strain partitioning is one of the important mechanisms, explaining the deformation patterns across transpressional shear zones. The imposed strain across the shear zone is partitioned into pure shear (contractional deformation) and simple shear (shear deformation) domains by strain partitioning. The deformation patterns in each domain may vary depending on the mechanical properties of the rocks, where mechanical anisotropy such as foliation and bedding is a significant controlling factor. The studied Okdong Fault located in Danyang, the central part of the Korean Peninsula, shows how mechanical anisotropy accommodates deformation within the shear zone. Based on the the C' shear bands from analyzed and mapped deformation structures we calculated the kinematic vorticity number (Wm). The result of this research suggests that contractional deformation predominantly occurs in the zones far from the Okdong Fault, while shear deformation dominates in zones close to the fault. The Wm derived from C' shear bands exhibits a decreasing trend with the distance from the Okdong Fault. This indicates that local strain partitioning is due to rotation of mechanical anisotropy associated with folding or thrusting. Furthermore, these variations in deformation style across the Okdong Fault indicate regional scale strain partitioning. This study give insight into the importance of mechanical anisotropy for understanding the deformation patterns associated with shear zones in other similar tectonic settings.

This research was supported by a grant(2022-MOIS62-001(RS-2022-ND640011)) of National Disaster Risk Analysis and Management Technology in Earthquake funded by Ministry of Interior and Safety(MOIS, Korea).

Keyword

Mechanical Anisotropy, Strain Partitioning, Transpression, Kinematic Vorticity Number, Okdong Fault

Strain partitioning and Construction of Wuliangshan Coherent Fault System in Biluoxueshan-Chongshan shear zone, SW Yunnan in China

QIANQIAN GUO[1]*, College of Earth and Planetary Sciences, University of Chinese Academy of Sciences (guoqqyj@ucas.ac.cn)
QUANLIN Hou[2], College of Earth and Planetary Sciences, University of Chinese Academy of Sciences
CAIBO HU[3], College of Earth and Planetary Sciences, University of Chinese Academy of Sciences
NANNAN CHENG[4], School of Resources and Environment, Henan Polytechnic University
QIZHI CHEN[5], College of Earth and Planetary Sciences, University of Chinese Academy of Sciences
MENGYAN SHI[6], School of Resources and Environment, Henan Polytechnic University
DALAI ZHONG[7], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics

Abstract

Foliations and lineations with different directions and the superpositions among them have long been used to distinguish deformational phases. However, this standard procedure, involving the identification and description of geometric and kinematic relationships among tectonic structures and structure hierarchization, presented amazing short-lived polyphase deformations and frequently changing stress fields even within a hundred million years. Over the past few decades, advances in strain analysis have shed new light on understanding the heterogeneity and localization of the deformation in noncoaxial viscous flow. This study presents coaxial and non-coaxial deformation structural data on the Wuliangshan transpression zone in the Biluoxueshan-Chongshan shear zone. The Wuliangshan transpression zone comprises three units: the northern unit of southward thrust faults, the middle unit of sinistral strike-slip shear zone, and the southern unit of extension joints. Structural analysis was presented on three cross sections, two across the shear zone and one across the thrust fault. Three deformation sequences (S1, S2, and S3) are distinguished. The S1 is characterized by the penetrative foliation (S1) defined by oriented muscovite. The S2 altered the S1 and is marked by small- and medium-scale compressional structures approximately E-W-oriented. A nearly N-S-striking anticlinorium with a steep axial plane was developed during the S2 accompanied by brittle faults. The S3 defined by the N-S-trending strike-slip shearing and west-verging thrusting, altered the existing S1 and axial plane. Of the S3, the maximum principal stress ($\sigma 1$) oriented approximately NE50°-SW230° in the middle unit of the shear zone, NW330°-SE150°-oriented in the northern unit of the thrust zone, and NNW-SSE-oriented in the southern unit of extension zone. The ductile deformation is weaker in both the northern and southern units relative to the middle unit. Finite strain measurement and principal stress analysis performed on the S3 confined the coherence between the thrust faults and the strike-slip fault. To test this understanding, we also constructed a 3D finite element model with elastoplastic rheology. This analog modeling developed structures and stress fields in good agreement with the Wuliangshan coherent fault system (WCFS). This suggests that the structural styles around fault tips in nature are more complicated than predicted. The correlation of WCFS

with regional strike-slip faults reveals that the Biluoxueshan-Chongshan shear zone could not extend southward into the Lanping-Simao Basin, and the Ailaoshan shear zone was still active during the Miocene. Combined with research in strain partition, we provide a possible explanation that the flatting deformation and simple shearing in perpendicular directions may be the results of strain partition instead of multiple episodes of deformation. This is consistent with the long-lived oblique convergence by the India-Asia collision.

Keyword

coherent fault system, ductile shear zone, strain partitioning, elastoplastic rheology, fault interaction

The role of long-lived shear zones in reconstructing the tectonic and deformational history of ancient active margin systems – the case of the Clarke River Shear Zone (NE Australia)

Raiza Toledo Rodrigues[1]*, University of Queensland (raizatoledo.r@gmail.com)
Gideon Rosenbaum[2], University of Queensland
Rashed Abdullah[3], Department for Energy and Mining, Geological Survey of South Australia, Adelaide

Abstract

Shear zones can provide crucial information on orogenic systems, including the timing of deformation and the strain distribution. The Clarke River Shear Zone, located in northeastern Australia, is an example of a long-lived structure that was active during the development of the active margin of eastern Gondwana (northern Tasmanides). Situated in northeastern Queensland, the Clarke River Shear Zone marks the boundary between two distinct components of the Tasmanides, the Thomson and Mossman orogens. To reconstruct the evolution of the Clarke River Shear Zone, we conducted field investigations, aeromagnetic data interpretation, microstructural analysis, and zircon U-Pb dating. Our results reveal that the shear zone was reactivated at least three times during the Palaeozoic. Evidence of the early phase of activity along the shear zone is characterized by gently plunging stretching lineation and sinistral kinematic indicators, including asymmetric porphyroclasts, and steeply plunging asymmetric folds, suggesting sinistral strike-slip ductile shearing. Subsequent pure-shear deformation is inferred from the presence of S-tectonites, symmetric porphyroclasts, and kinematic indicators showing both sinistral and dextral shear senses. These structures formed concurrently with the syn-tectonic emplacement of the Craigie Tonalite, for which we obtained a new zircon U-Pb crystallization age of 410.3 ± 1 Ma. Later reactivation, evidenced by cataclasite zones and chlorite-epidote alteration, occurred under brittle conditions. Considering our findings and regional information on the tectono-magmatic evolution of the northeastern Tasmanides, we propose that the shear zone acted as a sinistral transform fault during its early stages of development, in the Silurian. During the Devonian, this structure segmented the orogenic system, conditioning its architecture and magmatic activity. Increased trench retreat rates south of the Clarke River Shear Zone potentially caused counterclockwise rotations of crustal blocks, leading to oroclinal bending and pure shear deformation along the shear zone. Finally, during the Carboniferous, brittle deformation, possibly associated with dextral transpression, marked the final phase of activity along the Clarke River Shear Zone.

Keyword

Tasmanides, Eastern Gondwana, Trench mobility, Active margin, Shear Zones

Delineation of a new Crustal-Scale Shear Zone in the Northern Bundelkhand Craton: The ~E-W trending Datia Shear Zone

AISHWARYA MOHAN[1]*, BANARAS HINDU UNIVERSITY (amohan.geo@bhu.ac.in)
SAYANDEEP BANERJEE[2], BANARAS HINDU UNIVERSITY

Abstract

The Bundelkhand Craton is an Archean craton which is located in North-Central part of the peninsular India and is infringed on Western, Southern and Eastern part by Vindhyan Supergroup of rocks and its extent is delimited on the Northern and North-Eastern side by the Ganga alluvium. The aerial extend of the BuC is around 29,000 km2 and over 90% of this area is occupied by K-rich granitoids which showcase a wide variety of chemical compositions comprising of syeno- to monzo-granites, granodiorites, and diorites which date back to the Neoarchean time; collectively referred to as Bundelkhand Granitoids. The Bundelkhand Craton houses fantastic primary and secondary structural features and elements comprising of magmatic foliations and lineations, prominent shear fractures, intra terrane shear zones, crustal scale shear zones, small scale faults, etc. Till now, there are three established Crustal-scale shear zones viz. Raksha Shear Zone (RSZ), Bundelkhand Tectonic Zone (BTZ) and Madawara Shear Zone (MSZ) trending in ~E-W direction and these are the zones of mylonitised and ultramylonitised granitoids.

In the present study, we have conducted extensive field studies throughout the craton and we have encountered the presence of a ductile shear zone in the northern extremity of the presently established boundary of the Bundelkhand Craton. This ductile shear zone trends ~085 and exhibits a ~200 metres thick zone of ultramylonitised and mylonitised granitoids. This ductile shear zone extends throughout the archean crust of the Bundelkhand Craton and hence can be termed as a crustal scale shear zone. The name being assigned to this shear zone is Datia Shear Zone due to the presence of the exposures representing the core of the shear zone in proximity to the city of Datia, Madhya Pradesh, India.

The Datia Shear Zone (DtSZ) has characteristically outcrops of two major lithologies viz. Bundelkhand granites and Tonalite-Trondjemite-Granodiorite Gneisses, which show signatures of shearing under macro-, meso- and micro-scale observation. From the satellite imageries we have observed that rivers Betwa and Sindh follow the trend of the DtSZ showcasing sharp bending from their normal flow directions in the area towards the eastern and western ends of the DtSZ, which is a geomorphological expression of the presence of the DtSZ. Through detailed field-work, we have confirmed the extent of this DtSZ in the eastern, western, and central part of the northern BuC, and hence, presume that this DtSZ extends throughout the BuC. Evidences of Pegmatite vein intrusions along the ~E-W direction are common in the outcrops of the DtSZ which often show displacements and dragging across the shear fractures. A few younger shear zones (mainly trending in ~NE-SW and ~N-S directions) also dissect the ultramylonitic core of the identified shear zone at several occasions indicating that the ~E-W trending Datia Shear Zone was developed prior to the formation of the other intra-terrane shear zones in the Bundelkhand Craton.

Keyword

Bundelkhand Craton, Crustal Scale Shear Zone, Microstructures, Granitoid Deformation

Middle-lower crustal flow response to the India-Eurasia collision: structural evidence from the Chong Shan tectonic belt within the Sundaland block

Xiaoyu Chen[1]*, China University of Geosciences (Beijing) (xiaoyuchen@cugb.edu.cn)
Junlai Liu[2], China University of Geosciences (Beijing)
Yinchun Qi[3], China University of Geosciences (Beijing)

Abstract

The India-Eurasia collision since about 55Ma and the subsequent post-collision process have an important impact on the middle and lower crust activities, the formation and evolution of the crust structure in the Tibetan Plateau and its periphery. The lateral flow of the middle and lower crustal material in the Sundaland block has been widely accepted, but the characteristics, and mechanism of the crustal material flow are still widely disputed. Several models have been proposed to explain the response of the lateral collision zone in southeast Tibet, such as rigid block extrusion, middle and lower crust channel flow, and crust thickening. At the edge of the Sundaland block, there are several metamorphic complexes with Precambrian basement, most of which are developed along the ductile high strain zone. At the same time, the existence of metamorphic complexes in the Sundaland block, such as Ximeng, Bu Khang and Chong Shan complex, provides new important clues to explain the flow pattern of materials in Southeast Tibet during the Indo-Eurasian collision.

The Chong Shan complex is composed of A-type dome structure, the core of which is composed of deformed proterozoic high-grade metamorphic rocks, and the mantle of which is composed of Paleozoic and Mesozoic low-grade metamorphic rocks. The kinematic analysis reveals that the mantle rocks move in southeast relative to the core rocks.

The Chong Shan complex experienced three stages of progressive shear deformation in Cenozoic. The first stage was characterized by pure shear deformation accompanied by metamorphism, mainly by growth lineation and metamorphic foliation. The second stage of deformation is mainly simple shear related to the middle and lower crust flow, and is characterized by the development and formation of NW-SE stretching lineation, mylonitic foliation and A-type folding. The third stage of deformation was dominated by NE-SW shortening, accompanied by dome uplift and exhumation. The chronological data of the synshear granitic dike reveal that the shear occurred at 29-19Ma. During the extrusion of the Sundaland block from Oligocene to Miocene, the ductile deformation is not confined to the high strain zone at the boundary of the block, but also occurs in the interior of the block. We believe that the extrusion of Sundaland block is the result of the interaction of viscous flow and channel flow along the high strain zone.

Keyword

Chong Shan belt, dome, structural analysis, southeast Tibetan Plateau

Structural analysis of Riedel synthetic shears influenced by the thickness of the brittle layers: the lesson from analog modeling with PIV technique

Marilia Barbosa VENÂNCIO[1]*, UFRN (mariliavenancio@gmail.com)
Fernando César Alves da Silva[2], UFRN

Abstract

A strike-slip fault zone can develop subsidiary structures such as the Riedel shears. This study investigates the influence of stratigraphic layer thickness on the geometry and spatial arrangement of synthetic Riedel shears (R) within a strike-slip fault zone. Analog experiments were carried out in a sandbox apparatus with two stratigraphic layers, each made of materials with different rheological behaviors: a basal layer of quartz sand (QS) and a top layer of plaster powder (PP). While maintaining a constant stratigraphic package size (2.5 cm), experiments varied the thickness ratio of QS and PP layers (i – 2.3 and 0.2 cm; ii – 2.0 and 0.5 cm; and iii – 1.5 and 1.0 cm, respectively). The Particle Image Velocimetry (PIV) technique was employed to analyze the strain patterns and displacement on the surface. Results indicate that the thickness proportion of the layers controls structural architecture, influencing R-shears geometry. Using a displacement of 0.5 cm as a reference point, the experiment with a thin plaster powder layer (i) resulted in numerous synthetic R-shears, while thicker layers (ii and iii) resulted in fewer R fractures. The spacing between R-fractures was narrower in the experiment with a thin plaster powder layer (ranging from 0.2 cm to 2.4 cm) than those with thicker layers (ranging from 1.6 cm to 4.6 cm). The experiment with a thin plaster powder layer developed shorter R-shears, mainly measuring between 0.6 cm and 3.4 cm, whereas those with thicker layers produced longer ones, ranging from 3.9 cm to 15.6 cm. With further displacement (d = 1.0 to 1.5 cm), P-shears developed in experiments with a thicker PP layer, while R′ shears were well formed in the experiments, being more numerous and smaller in the model with a thin PP layer. The results emphasize that not only is the rheology a controlling factor in the fault zone architecture but also the proportion of the thickness of the brittle layers, which can shape the geometry and spatial arrangement of Riedel shears formed on a strike-slip fault zone.

Keyword

Strike-slip faults, Riedel synthetic shears, layer thickness, analog modeling, PIV

Southern West African Craton Strain Field derived from integrated structural mapping approach : tectonic and kinematic significance of shear zones

Kalidou TRAORE[1]*, USTTB (kalidoutraore@yahoo.fr)
Dominique Chardon[2], GET, UPS, IRD
Séta Naba[3], UJKZ
Ousmane Wane[4], USTTB

Abstract

We have developed a mapping protocol to characterize the strain field of the Eburnean accretionary orogen (2.2-2.0 Ga) at the scale of the southern West African craton. Our approach combines field structural measurements extracted from geological maps and photointerpretation in order to map the regional tectonic fabric - an approximation of strain trajectories - and derive the mapping of shear zones.

The shear zones form an anastomosed fractal network, preferentially symmetrical over scales of tens to hundreds of km, which is indicative of dominant coaxial deformation regimes. Deformation is heterogeneous, transpressive and partitioned at all scales. Despite the documented deformation gradients, very large displacements (of several hundred km) appear to be lesser within the orogen. Overall, the strain field reflects the first-order lateral escape of the orogen in response to its collision with the adjoining Archean craton. The craton was largely deformed as a consequence of its thermal softening at the contact with the accretionary orogen, which may be explained by the delamination of its lithospheric mantle at the collision zone.

Structural mapping applied at the scale of Precambrian orogens as implemented in this work provides a relevant kinematic interpretation tool. It also shows that a characterization of the orogenic-scale shear zone network, completed by a limited number of field observations, allows constraining deformation-displacement relationships within and at the boundaries of the orogens and evaluating their significance in a global tectonic framework.

Keyword

sWAC, accretionary/collision orogen, paleoproterozoic/birimian/eburnean, shear zones mapping, transpression

EXTERNAL VS. INTERNAL REFERENCES FOR KINEMATIC ANALYSIS OF A TRANSPRESSIVE SHEAR ZONE

SUSHMITA BHATTACHARJEE[1]*, GAUHATI UNIVERSITY, ASSAM, INDIA
(bhattacharjeesushmita98@gmail.com)
VASHKAR JIT MAHANTA[2], GAUHATI UNIVERSITY, ASSAM, INDIA
SURAJIT MISRA[3], GAUHATI UNIVERSITY, ASSAM, INDIA

Abstract

The kinematics of a shear zone is a primary requirement to study the deformational history of any terrane. Generally, kinematic study is done considering the external reference frame. However, there is some ambiguity when only an external reference frame is considered because the geometry of the deformed rocks is influenced by internally induced shears and material flows, considering the internal reference frame. Hence, vorticity and kinematics studied from internal reference frame is more suitable. A shear zone can be defined by external reference frames with the X, Y, and Z directions, where ‘X’ is the movement direction, ‘XY’ is the shear plane, and ‘Z’ is across the shear zone. Internally, the maximum elongation of any stretching or mineral lineation indicates the ‘X'’ axis of a strain ellipsoid, whereas ‘Y'’ is the intermediate, and ‘Z'’ is the shortening axis.

The present study focuses on the Barapani Shear Zone (BSZ), an intraterrane, multiply deformed shear zone present within the Meso-Proterozoic Shillong Group (SG) of rocks, located within the Shillong Plateau. The primary objective of this research is to study the asymmetric structures associated with the shear zone to comprehend the kinematics and deformational nature of the terrane. A detailed investigation reveals that the area underwent successive D1, D2, D3, and D4 events, resulting in preserved S1, S2, and S3 planar fabrics, with D4, evidenced by brittle deformation features. Generally, shear zones provide a finite kinematic and vorticity number; however, BSZ exhibits variable kinematic and vorticity numbers measured across different deformation zones. In this study both the external and internal reference frames have been considered to have better understanding about the kinematics and degree of rotation of the material lines. Subsequent analysis demonstrates that superposed transpressional tectonics dominated the D2 and D3 deformation episodes that played a significant role in the structural evolution of the plateau.

Keyword

shear zone references, transpression, kinematics, vorticity number, Shillong Plateau

Fluid flow characteristics based on topological analysis of a fracture system in Sinseondae area, Geoje Island, Korea

Goeun KIM[1]*, Pukyong National University (gone1213@pukyong.ac.kr)
Jinhyeon SO[2], Pukyong National University
Young-Seog KIM[3], Pukyong National University

Abstract

The characteristics of fluid flow within bedrocks is controlled by discontinuities (fractures and faults) as well as permeabilities of rocks. Mineral-filled fractures and faults (veins) are good indicators for paleo-fluid flow characteristics, which can be applicable to a better understanding of future fluid behavior. Furthermore, new geological structures are commonly influenced by pre-existing structures. Therefore, to understand and evaluate the characteristics of fluid flow in bedrocks, it is important to analyze pre-existing structures including veins. The study area, located on Geoje Island in the southeastern part of the Korean Peninsula, consists of Cretaceous sedimentary rocks comprising shale and sandstone layers. This region has experienced multiple fluid infiltration events, leading to the development of various types of veins. First of all, we interpreted the developing history of fractures in the study area based on fracture geometries and cross-cutting relationships. Additionally, we conducted topological analysis of fractures and vein systems respect to the distance from the main fault. Based on the data, the following fracture development history was established: (1) the development of NE-SW striking reverse faults with high dips ; (2) the development of N-S striking tension fractures ; (3) the cutting of pre-existing fractures by low-angle NNW-SSE striking normal faults developed along bedding planes; (4) the cutting of the previous fractures by NNE-SSW to NE-SW striking left-lateral normal faults . Three mineral precipitation events are identified based on the mineral filling patterns: (1) calcite precipitation between stages 1 and 2; (2) epidote precipitation between stages 2 and 3; (3) secondary precipitation of calcite after stage 4. As a result of the topological analysis, it was observed that the number of connections per branch (CB) decreases as the distance from the fault core increased, with a total CB value ($0 \leq CB \leq 2$) of 1.82, showing a relatively high degree of connectivity. It indicates that fault is an important controlling factor to fluid flow. However, fluid flow characteristics are influenced not only by discontinuities but also by other physical and chemical factors, suggesting the need for comprehensive studies of fluid flow characteristics in the future.

Keyword

Topology, Fracture network, Fault system

Analysis of Subsurface Fault Systems Using Audio-Magnetotelluric Surveys in the Western Ilan Plain of Northeast Taiwan

Ping-Yu CHANG[1]*, National Central University (pingyuc@gmail.com)

Abstract

We employed the audio magnetotelluric (AMT) method to delineate subsurface resistivity structures associated with the western Ilan Plain, which emerged from the orogenic belt in northeastern Taiwan and is believed to be influenced by the opening Okinawa Trough. Our study focuses on how the later opening of the Okinawa Trough has impacted this previously compressional region. The results of the AMT surveys indicate that the area features a series of N-S trending fracture zones, in addition to the ENE-WSW normal fault systems. Comparing the AMT data with seismic reflection profiles, we discovered that the study area consists of normal fault systems that developed on the paleo-thrust fault, thrusting the Miocene Lushan slates onto the younger rock formations of the Hsuehshan groups. The normal fault systems are truncated by young strike-slip faults, modifying the relief of the rock basement in a recent stage of formation. The western part of the study area is dominated by left-lateral strike-slip faults, while the eastern part is dominated by right-lateral strike-slip faults. Our findings from the AMT resistivity images, along with the re-interpreted seismic profiles, provide new evidence of the tectonic evolution associated with the development of the Okinawa Trough system. The influences from the arc-continent collision may have extended into the western Ilan Plain.

Keyword

Audio Magnetotelluric, Okinawa Trough, Subsurface Fault Systems

Fractured feldspar clast as paleostress marker

Tridib Kumar MONDAL[1]*, Indian Statistical Institute (tridibkumarmondal@gmail.com)
Gourav Das[2], Indian Statistical Institute
Sirshendu Kumar Biswas[3], Indian Statistical Institute
Sourav Mondal[4], Indian Institute of Technology, Kharagpur

Abstract

The estimation of paleostress conditions in any structurally deformed terrain is important to understand the evolutionary history of that area. Many paleostress markers exist in nature that provide information on late-stage brittle deformation, such as tensile fractures and conjugate fractures. We study the possibility of using fractured feldspar clasts in deformed granite as a potential paleostress marker. The feldspar clasts, found within the Closepet Granite, Eastern Dharwar Craton, India, are systematically fractured. These fractures are near vertical, sub-parallel to each other, and strictly restricted within the clasts. We use the FEM (finite element method) tool to assess the state of stresses responsible for fracturing within the clasts. It was found that the tectonic stresses enhanced inside the clasts due to their higher rigidity than the surrounding matrix. This amplification of stresses inside the clasts is responsible for the formation of clast-restricted fracturing. The clasts are also rotated with respect to the applied stress direction, and we found that, within a range of ±24°, it is possible to form tensile fractures within the clasts. All these findings, along with the field observation, provide us with an E-W-directed paleostress orientation that was active during the Neoarchean time in the Eastern Dharwar Craton. This E-W directed paleostress orientation is also in a good agreement with the state of stresses revealed from the granitic plutons adjacent to the Closepet Granite. Therefore, we infer that fractured feldspar clasts can be used as reliable paleostress markers.

Keyword

Feldspar clast, Clast-restricted fractures, Enhancement of stress, Paleostress, Closepet Granite

How good is your fracture model? Examining how interpreter experience and approaches affect fracture model variability.

Leila Evans[1]*, University of Strathclyde (leila.evans@strath.ac.uk)
Zoe Shipton[2], University of Strathclyde
Clare Bond[3], University of Aberdeen
Jen Roberts[4], University of Strathclyde
Namgwon Kim[5], University of Strathclyde

Abstract

Applied geoscience relies on a robust understanding of the structural regime and successfully developing structural models that are at the appropriate scale and level of detail for the problem at hand. But how good are we at developing structural models?

As humans, we each inherently hold different biases which are a product of our personal and professional experiences and backgrounds, areas of expertise, cognition and values. Therefore, we each bring a diversity of experience and approaches to geoscience activities such as fracture interpretation. Given that structural models form a critical part of geoscience outputs for a variety of industries across energy, resources and infrastructure, it is imperative to ensure we are generating robust interpretations. This can lead to improved safety, better decision making and ultimately helps to ensure project success.

Our study aims to characterise the variability in fracture interpretations made by geoscientists observing an aerial drone image of a fractured outcrop. We compare fracture data outputs (fracture density, network topology and orientation) from observations carried out by participants in a relatively short timeframe, to those from a more detailed set of observations. We are effectively comparing how “good” a set of observations carried out in a timeframe more closely aligned with common practice in a commercial setting are, with the outputs from a very detailed piece of mapping.

Previous experiments explored the variety of models that can be fit to a single 3D seismic image and showed that geoscientists’ experience and approaches impact the resulting structural models. Our experiment is the first to collect similar observations from outcrop data. By accounting for these biases and mitigating the uncertainties and issues generated, we can ensure positive outcomes to interpretational approaches. This can help develop better interpretation methods, inform how we arrange our teams and assurance processes and how we teach and communicate geoscience.

So, how good is your fracture model?

Keyword

fractures, interpretation, variability, uncertainty, bias

Exploring the significance of favourable and unfavourable structures in Orogenic gold deposits through a numerical modelling approach

SWARNENDU BHUYAN[1]*, IIT KHARAGPUR (sbhuyan@kgpian.iitkgp.ac.in)
Mruganka Kumar Panigrahi[2], IIT Kharagpur

Abstract

Archean greenstone-hosted lode gold deposits, referred to as mesothermal gold are popularly known as ‘orogenic gold’ and are characterized as quartz-dominated lode-type gold deposit systems where the source of ore fluid is supposed to be of metamorphogenic origin. The ‘Fault valve’ mechanism heavily rests on the metamorphogenic origin that is apparently caused by fluid pressurisation and rupture of the pre-existing fault. The fault-valve model commonly known as Sibson’s cycle needs an impervious seal referred to as the ‘seismic lid’ at the mid-crustal level and a pre-existing high-angle reverse fault that crosscuts the ‘seismic lid’ and is periodically reactivated. This high-angle reverse fault does not conform to the Andersonian theory of faulting. This study focuses on the pivotal role of fault orientation in fluid pressure evolution, introducing a distinction within structures as either 'favourable' or 'unfavourable’. The fault-valve mechanism is effective for unfavourably oriented (> 53 degree to σ1) low cohesion (0.6-0.85) faults that cause the build-up of fluid overpressure whereas a favourably oriented fault facilitates the channelization of overpressured fluids. The existence of favourable and unfavourable structures in worldwide gold deposits was validated by some gold provinces, although there has been a debate in the context of the Hutti gold deposit in the eastern Dharwar craton, S. India. To critically analyse the significance of favourable and unfavourable structures in the fault-valve model, the numerical simulation method proves to be the most effective. Among very few proposed numerical models on the fault-valve mechanism, Sheldon and Ord’s model appears to be an effective one. This model has certain limitations such as a pre-existing fault that is not exposed at the surface, a post-rupture fluid pressure value greater than the pre-rupturing value and so on. To overcome such limitations of the model, a modified 2D numerical model is implemented using COMSOL Multiphysics software with some changes including the fault being continuous and extending to the Earth's surface. Based on the simulation results, our findings indicate that fault orientation predominantly governs fluid migration rather than directly impacting fluid pressure build-up. A fault having an angle of 60 degree to σ1 may be designated as 'favourable,' while a low-angle fault with an angle of 30 degree may be labelled as an 'unfavourable' structure. The high-angle fault is not expected to be unfavourable thereby possibly preventing supralithostartic fluid pressure build-up and impeding the operation of Sibson’s cycle. Thus, the fault-valve mechanism vis-à-vis seismic pumping might not be operational, particularly for the Hutti deposit.

Keyword

Orogenic gold deposit, Fault-valve Model, Fluid pressure, Favourable and unfavourable structure

[Keynote] Illuminating fault zone structures in depth by dense seismic array

Haijiang Zhang[1]*, University of Science and Technology of China (zhang11@ustc.edu.cn)

Abstract

Fault zone structures play a very important role in controlling the rupture process of the earthquake, the propagation of seismic waves, and the distribution of local earthquakes. Therefore, it is important to illuminate detailed fault zone structures from near surface to greater depth. Here I will review the development of using local dense seismic array to determine fault zone properties and fault plane distributions.

By using surface waves extracted from continuous ambient noise data recorded by seismic array, ambient noise tomography can be used to determine three-dimensional (3D) shear wave velocity (Vs) model beneath the array. For fault zones with active seismicity, double-difference seismic tomography can be utilized to determine Vp, Vs, and Vp/Vs models of the fault zone. In addition, seismic anisotropy and attenuation models can also be determined by corresponding inversion methods. Joint inversion of body wave and surface wave data can also be used to further improve fault zone velocity models. Guided by fault surface trace, with fine velocity models we can further delineate the distribution of fault planes.

In addition to fault zone properties, we can also use seismic scattering imaging to determine the distribution of fault planes with earthquake waveforms following two strategies. The first strategy is to treat the earthquake sources as pseudo-active seismic sources with known locations and origin times. In this way, the Generalized Radon Transform can be used to determine discontinuous fault planes by using P-P or S-S scattered waves. The 2nd strategy is to use the interference between backpropagated P and S wavefields at an interface. In this way, source information is not needed.

Keyword

Seismic tomography, Seismic scattering imaging, Fault zone structure, Dense seismic array

100Ma of slip events in the core of the Highland Boundary Fault, Scotland: implications for earthquake slip.

Lucy McKay[1], University of Strathclyde (now at COWI UK)
Zoe SHIPTON[2]*, University of Strathclyde (zoe.shipton@strath.ac.uk)
Rebecca Lunn[3], University of Strathclyde
Billy Andrews[4], University of Strathclyde (now at Uni Plymouth)
Adrian Boyce[5], Scottish Universities Environmental Research Centre
Timothy Raub[6], University of St Andrews

Abstract

The Highland Boundary fault near Stonehaven, Scotland, provides a rare opportunity to study the internal fault structure of a well-exposed, along-strike section of an ancient plate boundary fault. As in many plate boundaries, serpentinite juxtaposes quartzo-feldspathic crustal rocks of distinct terranes. The Highland Boundary fault core is comprised of four structurally and chemically distinct clay-rich units that remain unmixed. Despite abundant evidence for internal strain, relatively intact clasts of wall rock and fragile microfossils are preserved within the clay gouge. The fault core clay minerology is consistent with a shallow, low-temperature authigenesis derived from shear-enhanced chemical reactions between wall rocks of contrasting chemistry during sinistral strike-slip. Using K–Ar isotopic dating of illitic fault rocks, coupled with X-ray diffraction and microstructural analyses we constrain, for the first time, timing of multiple illite-producing fault reactivation events on the HBF in the Carbniferous (348-314Ma), Permian (306-250Ma and Triassic (258-226Ma). Through detailed mapping, we demonstrate that the internal structure of the fault core varies in thickness and composition along-strike over centimetre- to metre- length scales. The observed structure is comparable to those of other major weak-cored plate boundaries (e.g. the San Andreas fault). Earthquake rupture mechanics critically depend on the physical properties of fault rock assemblages. For example, the more complex the fault geometry, the more energy has to be consumed at depth during an earthquake and the less energy reaches the surface. Therefore, models that investigate rupture propagation at active plate boundaries should incorporate, or else assess tolerance and sensitivity to, variable fault core thickness and composition.

Keyword

fault core, clay gouge, earthquake, illite dating

Quantitative evaluation of fault connectivity and its petroleum significance based on topological analysis: a case study from the well H area, southern Sichuan Basin

jingru zhao[1]*, China University of Petroleum (East China) (zhaojingru_upc@163.com)
yangwen pei[2], China University of Petroleum (East China)
Qingqi Zhao[3], China University of Petroleum (East China)
zhengshuo miao[4], China University of Petroleum (East China)

Abstract

Due to the influence of multi-stage structural superposition, a large number of medium to small scale faults were developed in deep shale gas reservoir in the southern Sichuan Basin. Quantitative analysis and evaluation of fault network structures and plane connectivity are of great significance for deep shale gas exploration and development. On the basis of detailed delineation of medium to small scale faults in deep shale gas reservoir, this study conducted topological structural analysis and connectivity evaluation of fault networks in the well H area of southern Sichuan Basin. By integrating topological quantitative evaluation with the production data of shale gas wells, the controlling effects of fault network topology and plane connectivity on shale gas accumulation were discussed. This investigation indicates three aspects of new findings. (1) High level of spatial variation was observed in the distribution of fault nodes and branches in the well H area in southern Sichuan Basin. Their NE-SW oriented distribution, being in accordance with the strikes of folds, presents high concentration in the cores of three narrow anticlines and limited distribution in the three synclines, respectively. (2) There are significant differences in fault network connectivity in different structural domains in the well H area, with better connectivity in the anticlines than the synclines. The northern portion of the western anticline, the eastern anticline and the central anticline present good, medium and poor fault connectivity, respectively. In the eastern anticline, the northern portion presents relatively higher connectivity than the southern portion. (3) There is a significant correlation between the production data of shale gas and the topological connectivity of fault networks in the well H area. With increasing fault connectivity, the production of shale gas climbs up and then falls down, indicating that neither high connectivity nor low connectivity of fault networks benefits shale gas accumulation.

Keyword

Topological structure analysis, Plane connectivity, Deep shale gas, Quantitative evaluation, Petroleum geological significance

The Role of Thermal Buoyancy on the Permeable Faults: Insights from the Lattice Boltzmann Models

Soojung AN[1]*, Kangwon national university (ansj0603@kangwon.ac.kr)
Byung-Dal SO[2], Kangwon national univeristy

Abstract

Understanding the impact of thermal buoyancy on fluid flow within permeable faults is crucial for ascertaining the dynamics of subsurface fluid transport in geological formations. In this study, we employ the Lattice Boltzmann Method (LBM) to investigate the influence of thermal anomalies on porous flow within faults, focusing on the role of Rayleigh and Prandtl numbers. We examine the influence of positive thermal anomalies on the viscous flow within permeable faults in geological formations. Through numerical simulations, we analyze the thermal effects on fluid flow within porous media by varying the Rayleigh and Prandtl numbers, which represent the ratios of buoyancy to viscous forces and the relative importance of momentum and thermal diffusivity, respectively. By systematically varying these parameters, we investigate the resulting changes in Reynolds numbers, which characterize the flow regime and provide insights into the dynamics of the porous flow under thermal gradients. Our findings reveal that the average Reynolds numbers increase with the Rayleigh number, indicating a strengthening of the convective flow component driven by thermal buoyancy. Furthermore, we observe conditional dependencies of the Reynolds number on the Prandtl number, highlighting the significance of thermal diffusivity in modulating the kinematic response of porous flow to thermal anomalies. The implications of our results are significant for understanding the role of thermal effects on fluid flow dynamics in geological formations, particularly within permeable faults. The observed increase in Reynolds numbers with higher Rayleigh numbers underscores the enhanced convective heat transfer associated with thermal anomalies, which can influence processes such as groundwater flow, hydrocarbon migration, and geothermal reservoir engineering. Overall, our study provides valuable insights into the complex interplay between thermal effects and porous flow, elucidating the mechanisms governing fluid transport in geological formations under thermal gradients. These findings contribute to a better understanding of subsurface fluid dynamics and have implications for various fields, including geology, hydrology, and energy resource management.

Keyword

Thermal buoyancy, Convective heat trasfer, Lattice Boltzmann method, Rayleigh number, Reynolds number

The Orogenesis and Metamorphic Fabrics in the Western Pacific Subduction Zones since late-Miocene, the rock recored from strike-slip to collision

Gong-Ruei HO[1]*, Department of Geology, National Museum of Natural Science
(gongruei@gmail.com)

Abstract

The arc-continent collision in Western Pacific Subduction Zones is traditionally interpreted as a relatively continuous process with an invariant plate convergence vector since late Miocene. This steady convergence and the obliquity between the subducting continental margin and the plate boundary predict a propagating collision tectonic setting with a space-time equivalence along the developing orogen. More recently, detailed plate reconstruction and structural analysis suggest that the plate convergence changed from highly oblique to nearly orthogonal in the last 2 to 1 Ma. Oblique convergence, driven primarily by the northward motion of the Philippine Sea Plate wrt Eurasian, predicts a significant component of left-lateral, strike-slip shearing through Korea, Japan, Taiwan, and Philippine orogenic belts. A comprehensive analysis of available data helps to define this previously unrecognized zone of strike-slip deformation. In this study, we start from Taiwan and attempt to address the following questions: 1) The distribution of horizontal shear throughout the Western Pacific Subduction Zone; 2) The kinematics of deformation; 3) The age of deformation, and 4) Regional consistency between geological studies and plate reconstructions. To understand the strike-slip systems in the western Pacific Subduction Zones, we aim to study the orogenic belt in the eastern Central Range of Taiwan as a pioneer research and extend to the Sambagawa belt in Japan and the Philippines mobile belt. This study integrates previous studies, and the main details are listed as follows: 1) The strike-slip deformation, which ranges from 30 km in width and extends the 200 km length of the orogen, is characterized by a history of subhorizontal shearing. Evidence for high strain includes mylonitic fabrics, rotated fold axes, sheath folds, and rotated stretching lineations; 2) Microtectonics, including S-C fabrics, strain shadows and sigmoidal structures consistently indicate left-lateral shearing in D2 and transtensional deformation in D3; and 3) The syn-kinematic veins and fabrics showed an Ar-Ar age of 2-6 Ma in D2, and 1.1-1.5 Ma in D3.

Keyword

Left-lateral shearing, Deformation fabrics, Ductile shear zone, Transpression to transtension

ROOTLESS ORE DEPOSITS OF TIEN-SHAN

GENNADY ERMOLAEV[1]*, IMR (egs25@mail.ru)

Abstract

ERM0LAEV G.S.
ROOTLESS ORE DEPOSITS OF TIEN SHAN
Rootless ore deposits have been established in well-studied ore regions of Central Asia(Northern, Central and Southern Tien Shan). In-depth structural analysis and physical-mechanical (rheological) properties of rocks identified processes not associated with folding and faulting, but representing post-Alpine discontinuous block tectonic flow of rock masses, including ore. Within the Western Tien Shan(Eastern in China) industrial sites of non-ferrous, rare, noble and radioactive metals of various genetic and industrial types are known. Except for radioactive ones, all are located in pre-Mesozoic formations. The main part is confined to the contacts of the Mesozoic-Cenozoic and pre-Mesozoic complexes (Muruntau, Vysokovoltnoye, Zarmitan, Dzhizhikrut, Khaidarkan, Chonkoy, Kochbulak, Kalmakyr, Andash, Jerooy, etc.). Ore districts containing large industrial accumulations, such as Almalyk and Kyzylkum, are located at the end junctions of the Southern and Central Tien Shan. A similar situation is typical for other regions of the world: the Urals, the Cordillera, and also South Africa, where the largest ore district is located at the continent-ocean junction. This may indicate a rupture of ore-bearing structures in places of greatest accumulation of mineral matter, which is confirmed by the widespread development of faults that supposedly “control” the placement of ore fields and deposits. In Western Uzbekistan, industrial sites of gold, tungsten and uranium (Muruntau, Ingichke, Uchkuduk, etc.) are associated with approximately equal specific gravities (19 g/cm3), as well as zero values of magnetic anomalies Δ Ta and gravity field anomalies Δ g lok.,low (up to 2000m) altitudes and “island outcrops” of pre-Mesozoic formations against the background of the Mesozoic-Cenozoic.
Detailed structural studies have established that metallic mineralization is associated with isolated, rootless blocks of hard rocks contained in a mass of plastic strata and the morphostructure of the modern relief. Rigid formations - terranes, make up predominantly elevated parts of the relief, plastic ones correlate with the leveled part of it, the ore mineral complex occupies an intermediate position, located on the boundaries of the elevated and leveled relief. These are metasomatically altered sandstones, limestones, dolomites, granitoids, mafic rocks, volcanics, which have a blocky (rootless) structure with sharply changed parameters and surface configuration (indicating rupture-extension). By acting in reverse geodynamics (under compression conditions), it is possible to assemble broken (both laterally and vertically), often ore-bearing blocks into a single whole. Siltstone-schist (black shale) plastic, dynamic (inextricable) geomass (the main distribution is deep) is the driving force. It accommodates, or underlies and moves a wide variety of block structures of different ages over significant distances both vertically and horizontally, with the advantage of the horizontal component. In the process of movement and interaction of material composition with different rheological properties, melange complexes (shale or ophiolitic) are

formed, which mainly comprise the territory of Central Asia.

The rootless deposit is the result of not only the impact of mineralization processes on rocks, but also the subsequent processes of movement of blocks of ore-bearing rocks. The role of the transporter was played by plastic, thermodynamic silt-lithic shale geomass.

Keyword

Tien Shan,, ore objects,, tectonic flow, block structures,, plastic geomass

Mapping gas hydrate and fluid flow indicators: potential linkage with the occurrence of slope instability processes in the northern Bay of Bengal, offshore Bangladesh

Vanessa MONTELEONE[1]*, National Oceanography Centre (Southampton, UK) (vanessamonteleone88@gmail.com)
Héctor Marín-Moreno[2], School of Ocean and Earth Science, University of Southampton, National Oceanography Centre Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH, UK
Gaye Bayrakci[3], National Oceanography Centre Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH, UK
Angus Best[4], National Oceanography Centre Southampton, Waterfront Campus, European Way, Southampton SO14 3ZH, UK
Farhana Shaon[5], Bangladesh Oil, Gas and Mineral Corporation (Petrobangla), Dhaka, Bangladesh
Mohammad Moinul Hossain[6], Bangladesh Petroleum Exploration and Production Company Limited (BAPEX), Dhaka, Bangladesh
Ahmad Al Karim[7], Maritime Affairs Unit, Ministry of Foreign Affairs, Dhaka-1000, Bangladesh
Md. Khurshed Alam[8], Maritime Affairs Unit, Ministry of Foreign Affairs, Dhaka-1000, Bangladesh

Abstract

The Bangladesh exclusive economic zone extends seaward into the northern portion of the Bay of Bengal, down to water depths of 2250 m. This area comprises the northern portion of the Bengal Fan, where sediment supply from the Ganges and Brahmaputra rivers has resulted in the accumulation of up to 20 km of shallow-marine, fluvio-deltaic and slope sediments during rapid tectonic subsidence since the late Miocene. The high sedimentation rates, along with the high organic matter content of the slope deposits, make this area favorable for the formation of natural gas from both microbial and thermogenic sources. Interpretation of multichannel seismic reflection profiles and modelling of the present-day gas hydrate stability zone (GHSZ) provide the first evidence for the occurrence of natural gas hydrates in this portion of the Bay of Bengal. Seismic indicators of gas hydrates, such as the Bottom-Simulating Reflectors (BSRs), and fluid flow, including seismic chimneys and other reflection anomalies, characterize the channel-levee and mass transport deposits (MTDs) sediments of the slope area. BSRs are located in water depths of 1300–1900 m and at depths below seafloor of 250–440 m. High seismic interval velocities (1920–1940 m/s) are visible above the BSRs, which can be explained by the presence of gas hydrate filling the pore space of shallow marine sediments. The theoretical base of the gas (methane) hydrate stability zone (BGHSZ) seems to lie at approximately the same depth as the observed BSRs. Some of the observed offsets between the BSR and the calculated BGHSZ may be explained by fluid flow through faults/fractures, causing localized heat-flow perturbations and/or changes in the hydrate-forming gas composition. In shallower areas, where the seafloor depth corresponds to the feather edge of the GHSZ, irregular BSRs and evidence for fluid flow correlates with the presence of MTDs (slumps), associated with recent events generating seafloor topography; here, the base GHSZ lies within tens of meters of seafloor and is considered to be

more sensitive to climate-driven factors that may change stability conditions, such as sea level variations and sedimentation rates. In such a setting, the excess pore-pressure caused by gas hydrate dissociation could have had a role in slope failure events.

Keyword

Bengal Fan, Gas Hydrate, Offshore Bangladesh, Seismic Reflection Data, Geohazard

Microstructure of the fault rock drill cuttings from the enhanced geothermal system site in Pohang, South Korea: evidence of frictional melting

Sejin JUNG[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul (shazabi7@snu.ac.kr)
Ji-Hoon Kang[2], Department of Earth and Environmental Sciences, Andong National University, Andong, Republic of Korea
Youngwoo Kil[3], Department of Energy and Resources Engineering, Chonnam National University, Gwangju, Republic of Korea
Haemyeong Jung[4], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea

Abstract

The 5.5 magnitude (Mw) earthquake in Pohang, South Korea in 2017 was one of the largest triggered earthquakes at an enhanced geothermal system (EGS) site. Faults that ruptured in Pohang were not identified by preliminary geological investigations or geophysical surveys, and the subsequent study of the fault rocks at the Pohang EGS site was limited to depths of 3790–3816 m. In this study, we present new observations of fault rocks from drill cuttings retrieved from the Pohang EGS. The drill cuttings obtained from 3256 to 3911 m contained “mud balls,” which showed a clay matrix with foliation and a cataclastic texture, indicating a typical fault gouge or breccia. Furthermore, the mud ball samples retrieved from depths of 3256 m and 3260 m contained black fragments. Scanning and transmission electron microscopy revealed that the black fragments consisted of glass-like material, which is indicative of frictional melting during coseismic slip (Jung et al., 2023). The presence of these black fragments suggests that at least one seismic event had occurred at the Pohang EGS site prior to the hydraulic stimulation test.

Jung, S., J. -H. Kang, Y. Kil and H. Jung, 2023, Evidence of frictional melting in fault rock drill cuttings from the enhanced geothermal system site in Pohang, South Korea. Tectonophysics, 862, 229964.

Keyword

fault gouge, frictional melting, coseismic slip, microstructure, Pohang EGS site

Investigation of seismic and aseismic slip behavior of large thrust and strike-slip faults through the integration of structural mapping, microstructural characterization, thermometric and stable isotopic analyses and numerical simulations (Ligurian Alps, Italy; Carg Project)

Silvio SENO[1]*, University of Pavia, Department of Earth and Envinronmental Science (silvio.seno@unipv.it)
Matteo Maino[2], University of Pavia, Department of Earth and Envinronmental Science
Michele Perozzo[3], University of Pavia, Department of Earth and Envinronmental Science
Ludovico Manna[4], University of Pavia, Department of Earth and Envinronmental Science
Leonardo Casini[5], Department of Chemistry, Physics, Mathematics and Natural Sciences, University of Sassari

Abstract

We present the structural architecture and evolution of two main fault zones, which drove the formation of the southern part of the Alpine orogen (Ligurian Alps). The two fault zones encompass both the largest thrust (Monte Frontè thrust) and strike-slip (Horse Head Fault Zone) faults detected in this sector of the Alps. Faults have been studied through detailed structural mapping merging classic field-based survey (in the frame of the Albenga and Ormea sheets of the Carg projects) and Unmanned Aerial Vehicle (UAV)-based Digital Outcrop Model. Fault rocks have been characterized in terms of meso- and microstructure, texture, kinematics. The Monter Frontè thrust has been also characterized through thermometric measurements (synkinematic chlorite geothermometer and illite crystallinity index plus stable isotope and fluid inclusion microthemometry from calcite- and quarz-veins) and numerical simulations with the aim to investigate the thermal evolution during the deformation. Fault activity is dated in the Oligocene through the combination of thermochronometry (zircon (U-Th)/He dating) and stratigraphic relationships. Both fault system are part of a mega-shear zone with left lateral kinematics leading the bending of the the Ligurian Alps as part of the Western Alpine arc as accomplished through two consecutive, Late Oligocene and Early Miocene, stages driven by the combination of Adria rotation and the rollback of the Apennine subduction. Moreover, the thermal signature of the thrust zone (Monte Frontè thrust) indicates that the fault zone attained temperature higher than the wall rocks, with a ΔT of ~50 °C but with local input up to 150 °C. Isotopic signal of fluids indicates a local, proximal source localized in the wall rocks, rather than deep exotic fluids. We simulated the geological evolution with a suite of elasto-visco-plastic thermomechanical models using a 2-D finite difference code that reproduces the stress, strain, temperature, and pressure variations occurring within the thrust zone. Results indicate that shear heating during distributed cataclastic flow account for a moderate and persistent temperature increment (ΔT 5–30 °C), while transient higher temperature pulses (50–90 °C) are reproduced simulating coseismic slip along narrow slip planes. Integration of analytical data and numerical results supports the slow creeping frictional-viscous deformation as effective mechanism explaining the low-T part of the thermal history, whereas seismic deformation equivalent to moment magnitude Mw > 6.5–7.0 earthquakes

is required to fully account for the thermal signal, including the extreme peak temperature.

Keyword

Fault, Coseismic slip, Thermochronometry, Modelling, Alps

Heterogeneity of burial-related fracture networks and its effect on strata permeability: Insights from a volcano-sedimentary sequence in Wido Island, Korea

Sodam PARK[1]*, Department of Geology, Kyungpook National University (dami1030@naver.com)
Chae-Eun Park[2], Department of Geology, Kyungpook National University
Kang Hyeon Lee[3], Department of Geology, Kyungpook National University
Yujung Kwak[4], Department of Geology, Kyungpook National University
Seung-Ik Park[5], Department of Geology, Kyungpook National University

Abstract

This study aims to understand how heterogeneous spatial distribution of burial-related fracture networks controls strata permeability within a sedimentary basin. For this purpose, we examined a natural laboratory on the northern coast of Wido Island, Yellow Sea, where a Cretaceous lacustrine volcano-sedimentary sequence shows complex strata-bound fracture networks. We sampled the fracture networks on well-exposed low-angle bedding planes using the circular scanline method and analyzed them after unfolding to obtain their geometric and topological parameters. Our results show that the strata-bound fracture networks mainly consist of closely spaced NNW–SSE and ENE–WSW trending fracture sets along with NNE–SSW and WNW–ESE trending sets. Notably, the NNE–SSW and WNW–ESE trending fracture sets are concentrated in a pyroclastic unit cut by a listric strata-bound normal fault, reflecting the fault-induced strain. The mutually orthogonal fracture sets abut each other, likely indicating a local switch of intermediate and minimum principal stress axes during burial in the basin. The combination of mutually orthogonal fracture sets leads to high hydraulic connectivity at all stratigraphic positions because of the high proportions of Y-nodes. We highlight that orientations of bed-parallel permeability ellipse axes of the fracture networks differ depending on stratigraphic positions, indicating the localized fault-induced strain accommodation in addition to background fracturing during burial. Our findings demonstrate that burial-related fracture networks can promote heterogeneous layer-parallel flow migrations that are compartmentalized by strata boundaries.

Keyword

Burial-related fracture networks, Fracture connectivity, Permeability anisotropy, Heterogeneous fluid flow

The impact of dykes and large planar surfaces in the connectivity of fractured basalts of the Paraná-Etendeka Province, Southern Brazil

Francisco Wohnrath TOGNOLI[1]*, Federal University of Rio de Janeiro
(franciscotognoli@igeo.ufrj.br)
Leonardo Campos Inocêncio[2], São Paulo State University (UNESP)
João Vitor Pavan Balbinotti[3], A&T Geotecnia
Debora Jacobs Heider[4], VizGEO Sci Data Lab.

Abstract

In the last decade, the development and popularization of remotely piloted aircraft systems (RPAS), digital photogrametric techniques and sensors for high-resolution mapping contributed to consolidate digital outcrop models (DOM) as part of the workflow in many geological studies. In the field of structural geology, there are many examples approaching geometric aspects and orientation of ruptile and ductile of geological structures and automatized extraction of discontinuities for rock mass quality (e.g., joints, faults, deformation bands). More recently, high-resolution images has permitted visualization and demarcation of discrete features directly on the DOMs. This scenario has opened new possibilities in the field of dynamic and kynematic analysis and in the understanding of stress-strain in the core and damage zones of fault systems. Topologic analysis derived from DOMs provides a unique opportunity to analyse fracture networks with the high sampling representativity necessary to unveil controls in the fluid flow of granular and fractured media. This case study presents results of a topological analysis performed in basalts from the Paraná-Etendeka Province at Southern Brazil. In this area, the lowermost basaltic lava flows constitute the Serra Geral Aquifer System (SGAS), that directly overlies aeolian sandstones that constitutes the Guarani Aquifer System (GAS). Almost 60% of the municipalities in the Rio Grande do Sul state, southern Brazil, has groundwater as the main water supply for human, industrial and agricultural uses. The water storage in basalts occurs in joints associated with fault zones and dykes. Large planes of joints were also analysed. Therefore, the quantitative analysis of patterns and behavior of the fractures can be of interest to integrate hydrogeological controls and groundwater productivity. This study used a basalt open-pit cut by two basaltic dykes to perform the data acquisition, which provided high-resolution pictures to generate a 3D digital outcrop model and orthophotos. Five sampling areas were used to perform a quantitative assessment of the nodes and branches to determine the degree of connectivity of the fracture system in the scope of topological analysis. Results showed that the rock mass presents dominance of the Y-type and X-type nodes and C-C branches. Connections per branch indicated high degree of connectivity with values ranging from 1.79 to 1.86. This scenario is favorable to fluid flow, if analysed independently. However, the topological pattern changes abruptly in the borders of dykes, where I-type and Y-type nodes and I-I and I-C branches dominate, becoming these zones potential flow barriers.

Keyword

Topologic analysis, Digital Outcrop Model, Quantitative Geology, Serra Geral Aquifer System, Fluid flow

Damage Asymmetry and Earthquake Rupture Propagation

Young-Seog KIM[1]*, Pukyong University (ysk7909@pknu.ac.kr)
Jin-Hyuck Choi[2], Korea Institute of Geoscience and Mineral Resources
Kwangmin Jin[3], Korea Institute of Geoscience and Mineral Resources

Abstract

Fault damage zones composed of secondary deformation structures have helpfully been used to understand 3D fault architectures, fault behavior characteristics and fault evolutions. Damage zones divided into three main categories depending on purpose and concern of analysis; cross-fault damages, along-fault damages and around-tip damages. Detailed analyses of these fault damage zones with displacement distribution can contribute to understand fault scale, fault geometry, evolution pattern and fluid flow characteristics around natural faults. Thus, it has intensively studied for exploration and evaluation of potential water or oil reservoirs and mineral deposits.

However, recently, we are now applying the advanced knowledge about the fault damage zones to active fault evolution such as rupture propagation. The 2016 M L=5.8 Gyeongju, Korea, earthquake, the 1999 ML=7.3 Chi-Chi earthquake, Taiwan and the 2016 MW=7.8 Kaikoura, New Zealand, earthquake are good examples to apply these models. Although the Gyeongju earthquake did not generate any surface rupture, it is interpreted as the rupture on the linking fault between two main fault-segments along the Yangsan fault zone. For the Chi-Chi earthquake, along-strike variations in coseismic offsets along the Chelungpu fault also clearly displays the linkage relations of two fault segments. Although the rupture propagation pattern along the Hope fault and Kekerengu fault associated with the Kaikoura earthquake is much more complex, it clearly shows linkage pattern between two separated fault segments. Thus, if we carefully analyze the rupture propagation pattern and slip distribution along the fault ruptures, we could understand the characteristics of fault growth and evolution. This kind of study could contribute to assessing earthquake hazards and predicting the next potential ruptures.

Keyword

Fault, Damage Zones, Earthquake Rupture, Fault Evolution

Architecture and properties of active faults, insights from active faults in southern Spain

Anita Torabi[1]*, University of Oslo (anita.torabi@geo.uio.no)
Juan Jiménez-Millán[2], University of Jaen
Rosario Jiménez-Espinosa[3], University of Jaen
Francisco Juan García-Tortosa[4], University of Jaen
Behzad Alaei[5], University of Oslo
Abhisek Basa[6], University of Oslo

Abstract

Unique exposures of active faults in Andalucía, southern Spain cutting through a variety of rock types and sediments provides a natural laboratory to study the interplay between fault geometry, active tectonic and host rock properties. We have studied the architecture and properties of three active faults in southern Spain, namely Padul, Baza, and Galera faults. Padul Fault is located in Granada Basin, while Baza and Galera faults are located in Gaudix-Baza basin. We have conducted several seasons of fieldwork, drone imaging, and in-situ and laboratory measurements of petrophysical and mechanical properties of host and fault rocks. The petrophysical and mechanical analyses include XRD and thin section studies, permeability, and elastic properties measurements. We have investigated both fault core and damage zone of these faults depending on the availability of outcrops in vertical (along fault height) and horizontal sections (along fault length). Our results show that the host rock mineral composition and properties influence the seismic behavior of faults and therefore their architecture and kinematics. This has significance for the fluid flow behavior of faults during the seismic cycles, which in turn results in diagenetic reactions between minerals within the fault zone and nearby host rock. The result of this study has implication for predicting the future earthquakes associated with these active faults in the studied area.

Keyword

active fault, damage zone, fault architecture, fault properties, fluid flow

[Keynote] Fossil traces of co-seismic fluid flow in seismically active fault zones: studying the past to understand the present and possibly predict the future.

Luca SMERAGLIA[1]*, Consiglio Nazionale delle Ricerce, CNR-IGAG (luca.smeraglia@cnr.it)
Stefano M. Bernasconi[2], Geological Institute, ETH Zürich, Sonneggstrasse 5, 8092 Zürich, Switzerland
Andrea Billi[3], Consiglio Nazionale delle Ricerche, CNR-IGAG, Rome, Italy
Chiara Boschi[4], Consiglio Nazionale delle Ricerche, CNR-IGG, Pisa, Italy
Antonio Caracausi[5], Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Palermo, Via Ugo La Malfa 153, 90146 Palermo, Italy
Eugenio Carminati[6], Dipartimento di Scienze della Terra, Sapienza Università di Roma, Rome, Italy
Manuel Curzi[7], Dipartimento di Scienze della Terra, Sapienza Università di Roma, Rome, Italy
Carlo Doglioni[8], Istituto Nazionale di Geofisica e Vulcanologia, sede di Roma, Via di Vigna Murata 605, 00143 Roma, Italy

Abstract

This keynote presents a comprehensive summary of five years of research focusing on earthquake-related fault-fluid interactions in the Central Apennines, Italy, which are characterized by seismically active faults within an extensional tectonic setting. Our investigation employed a multidisciplinary and multiscale approach, integrating field and microstructural studies with analyses of carbon and oxygen stable isotopes, carbonate clumped isotopes, fluid inclusions, whole rock geochemistry, and U-Pb and U-Th dating. This approach aimed to elucidate the geochemical signature of syn-tectonic calcite mineralizations obtained from active normal faults. These mineralizations can be considered as fossil traces of past fluid flow in active faults. The examined faults include: (a) the Tre Monti Fault, potentially active during the 1915 Avezzano earthquake; (b) the Mt. Gorzano Fault, responsible for the 2016-2017 Amatrice earthquake; (c) the Val Roveto Fault, the most extensive fault in the central Apennines of Italy; and (d) the hydrocarbon-bearing Trisulti Fault. Our findings indicate that during seismic events, overpressured fluids were squeezed along the principal fault plane and its damage zones, likely facilitating fault slip. Co-seismic dilatancy facilitated the mixing of fluids from two primary crustal reservoirs: shallow meteoric-derived fluids and deep hydrothermal fluids. The results from the study mineralizations in active faults are compared with current geochemical monitoring of springs and groundwater before, during, and after earthquakes in the same region, to validate groundwater monitoring as a tool for earthquake prediction. Notably, the post-earthquake increase in fluid discharge is consistent with geological evidence suggesting the presence of co-seismically overpressured fluids within active faults and the upward migration of deep hydrothermal fluids towards shallower crustal levels. Future investigations will entail a detailed comparison of geochemical analyses of fault-related mineralizations with observed hydrochemical changes in groundwater to determine if the chemical changes observed presently in groundwater also manifested during past seismic events.

Keyword

Fault fluid interaction, earthquakes, seismic precursors

Geometric characterization of Baza and Galera active faults, Baza Basin, southern Spain

Ofelia Soledad SILIO[1]*, University of Oslo (ofelias@uio.no)
Anita Torabi[2], University of Oslo
Juan Francisco García Tortosa[3], Universidad de Jaén
Luc Girod[4], University of Oslo

Abstract

Fault geometric characterisation involves the study of attributes such as displacement, segment length, core thickness and damage zone width. These are used in scaling laws to predict fault growth and mechanics. However, there are challenges related to (i) limitations to access fault 3D structures; (ii) resolution limits of datasets; (iii) uncertainties and constrains of methodologies used to study faults and (iv) existence of specific-scale gaps in the fault global dataset. Moreover, there are less data available from active faults, although scaling laws for individual ruptures have been studied before. The objective of this work is to use drone imaging techniques to extend the visualization scope and approach 3D fault characterization in locations unreachable with conventional outcrop analysis.

The study area encompasses Baza and Galera faults, Granada Province, southern Spain. These two active faults are mainly normal and strike-slip faults, respectively, which extend along tens of kilometers. They originated in the basement and propagated through the poorly consolidated Miocene to Pliocene sedimentary rocks, representing a unique case study for the geometric analysis of modern faults.

Outcrop descriptions and structural measurements were carried out, together with drone imagery acquisition. Photos were processed using AGISoft Metashape Professional photogrammetry software. Field data were used as calibration points and faults were mapped based on color changes, strata dip changes, topographic features, fluvial channels distributions, rock alteration, among others. When possible, geometric attributes including strike, dip, length, displacement, fault core thickness and damage zone thickness, were measured on the virtual outcrop models with VRGeosciences software.

To the north, Baza fault core is formed by a single plane with a thicker clay smear. To the central and southern zone, displacement of the Baza fault is distributed among different splays and fault cores become narrower with a decreased proportion of clay smear. The strike of Baza fault is north-south in the northern and central segment and northwest-southeast along the southern sector. Inclinations are predominant to the east-northeast, ranging from 60° to 85°. Displacement measurements vary between a couple of centimetres to tens of metres offset across the fault planes. Fault core thickness range from 1cm for discrete planes to 8m for complex and clay-smear

structures.

In most localities, Galera fault exhibit striation that indicates sub-horizontal strike-slip displacement, affecting undeformed sub-parallel modern sediments. Strikes are scattered into two main families, one northeast-southwest and a second northwest-southeast oriented. Dip angles varies from 45° to 85°. When Galera fault experiments along-strike bending, it is possible to observe positive and negative flower structures, as a result of localized compression and extension, respectively. Fault zone thickness is delimited by flower structures, with scales varying from centimeters to decameters.

The application of drones allowed extending the scope of view of outcrop studies, therefore, increasing the accessibility. Drone imagery offers a bridge between conventional on-site outcrop survey that have limits in their reach, and satellite studies that suffer from relatively low resolution. The scope of the studies can therefore be extended, and features of different scales integrated in a single analysis.

Keyword

Active, Galera Baza, Scaling laws, Geometric attributes, Drone

Architecture of active and fossil fault zones in sedimentary rocks: Lessons from integrated structural, geomechanical and mineralogical analyses

Abhisek BASA[1]*, University of Oslo (abhisek.basa@geo.uio.no)
Anita Torabi[2], University of Oslo
Behzad Alaei[3], Earth Science Analytics & University of Oslo
Juan Jiménez Millán[4], University of Jaén
Francisco Juan García Tortosa[5], University of Jaén
David Lino Vasconcelos[6], Federal University of Campina Grande
Francisco H.R. Bezerra[7], Federal University of Rio Grande do Norte
Francisco C.C. Nogueira[8], Federal University of Campina Grande

Abstract

Complexity in the spatial organization of fault zone architecture, involving the fault core and the adjacent damage zones can influence the variation of mechanical properties along and across its strike. In this study, we integrate results from the investigations of excellent fault zone outcrops along scanlines from two separate basins. The first part involves active faulting in carbonate, evaporites and siliciclastic host rocks along ~30 km long Galera Fault (left-lateral normal fault) within Guadix-Baza Basin, SE Spain. The second part utilizes an almost continuous outcrop stretch of ~1500 m x ~350 m areal extent in Rio do Peixe Basin, NE Brazil. This outcrop exposes two major sets of deformation band (DB) fault zones oriented perpendicular to each other. The host rock in this outcrop comprises of siliciclastic braided-river system deposits, which was affected by rifting events during the Cretaceous.

Samples collected from active fault zone outcrops in SE Spain show that calcite cementation enhances the elastic behaviour, while increase in phyllosilicate content reduces the elastic property estimates relative to the adjacent host rocks. This has important implications in governing the locations of stable and unstable segments along the fault length in the subsequent earthquake cycles. In the siliciclastic outcrops of NE Brazil, fault zones are defined by the presence of high frequency of DBs. These DBs are more prevalent in the coarse-grained host rocks (which also show higher porosity)and show higher values of Young's Modulus and P-wave velocity (Vp). On the other hand, the less porous medium to fine-grained host rocks deform by forming fractures and constitute the damage zone of the fault. Apart from the grain-size distribution of the host rocks, the interaction of fault zones of various orientations also plays a crucial role in governing its overall architecture. Outcrops in SE Spain exhibiting fault sets of multiple orientations, display a comparatively wider damage zone. The interaction of the two perpendicular DB fault zones in NE Brazil influences the geomechanical property distribution of the fault and the host rocks. The modified estimate of Brittleness Index used in this study from samples collected in SE Spain, shows a direct relationship with the Vp of both the fault and the host rocks, revealing that the mineral assemblage of the fault as well as the adjacent host rocks controls the release of elastic strain during faulting.

Our results demonstrate that detailed outcrop investigations integrating structural, geomechanical and mineralogical analyses can help in delineating the multitude of factors influencing the geomechanical property distribution in fault zones. Insights from such outcrop studies can aid in better prediction of rock properties in active and fossil fault zones in the subsurface.

Keyword

Active and fossil faults, Fault interaction, Geomechanics, Mineralogy

The Dauki fault zone architecture and its implications for the evolution of the Shillong Plateau, Meghalaya

Vinee SRIVASTAVA[1]*, IISER Bhopal (vinee@iiserb.ac.in)
Rikalave Raman Chabukdhara[2], IISER Bhopal

Abstract

The Dauki fault plays a crucial role in the Shillong Plateau uplift in the North-Eastern Himalaya based on previous tectonic-climate coupling studies. The upliftment of the Shillong Plateau commenced in Miocene and has been explained by various mechanisms. The most prevalent model of the Shillong uplift is that of a continental basement pop-up structure along two seismically active steep-reverse faults along its southern and northern edges by Bilham and England, (2001). As suggested the Shillong Plateau is separated from foredeep basin in south and bounded by the E-W trending Dauki Fault and the WNW-ESE trending Oldham Fault to the north. Geophysical and geomorphic based extensive studies have suggested strike-slip, normal as well as a reverse/thrust fault kinematics for the Dauki fault. However, the existing literature lacks structural and field evidences essential to constrain geometry and kinematics of the Dauki fault. Therefore, structural field mapping based on contemporary fault zone conceptual model was used to work out the geometry and kinematics of the Dauki fault. The Dauki fault was mapped along seven strike-perpendicular N-S transects along the frontal Shillong Plateau. Field observations indicates a partially preserved Dauki fault core and hanging wall damage zones in all seven traverses varying in thickness from ~1-3 km from east to west respectively. The Dauki hanging wall damage zone consists highly fractured and deformed sandstone, shale, and mafic Cretaceous rocks. The Dauki fault core preserved the highly pulverized gouge of same parent rocks. Footwall damage zone is either not exposed or preserved in patches along the six transects along the frontal Shillong Plateau. However, in the easternmost transect running parallel to N-S trending Umngot River section massive cross-bedded sandstones of Oligocene age Simsang Formation was exposed. Older Cretaceous rocks over younger Oligocene age Simsang Formation rock sequence confirms reverse sense of shear on the Dauki fault. In the absence of any displacement marker horizons and the diffused nature of the fault, it is difficult to conclude whether it is reverse or a thrust fault. However, based on the ~3 km width of outcrop of the fault zone we interpret it to be a gently-dipping, thrust fault. This is also consistent with the observations of uplifted terraces and growth of frontal topography south of the Shillong Plateau main topographic front. Our field observations are, however, not consistent with the pop-up hypothesis of the origin of the Shillong Plateau as that requires a Pre-Cambrian basement over Cenozoic fault contact along the Dauki reverse fault. It also suggests that more detailed structural work is required to constrain the deformation in the Shillong Plateau to constrain the models of its evolution.

Keyword

Dauki Fault, Shillong Plateau, Fault zone architecture

The western central African passive margin seismicity

Hardy NKODIA[1]*, Marien Ngouabi (nkodiahardy@gmail.com)
Timothée Miyouna[2], Marien Ngouabi University
Folarin Kolawole[3], Lamont-Doherty Earth Observatory, Columbia University,
Florent Boudzoumou[4], Marien Ngouabi University
Delvaux Damien[5], Department of Geology, Royal Museum for Central Africa

Abstract

The Congo basin and its surrounding orogens in the western Central African region had been experiencing several earthquakes, even though quite few studies had attempted to explain their occurrences. The link between the recent seismicity and known faults does not look straightforward. The analysis of seismic history of the onshore and offshore areas revealed that the earthquakes are occurring on pre-existing fault systems of the Congo Basin, its surroundings units, and along near-shore extensions of the oceanic transform faults. In addition, the western Central African passive margin is undergoing two principal stress regime, one which is a ENE-NE trending horizontal compression in a thrust regime, and the other which is a normal faulting regime. Using the slip tendency method, the application of these present stress regimes on the mapped pre-existing fault systems which are mostly high-angle strike-slip faults systems, suggest that it is difficult to reactivate these faults under a thrust faulting stress regime, but more easily in a normal faulting stress regime. As most of the earthquakes occur at upper-crustal depths, we propose three hypotheses: 1.) there might be a brittle shear zone at depth that is accommodating tectonic reactivation leading to seismogenic rupture, which could be achieved by landward stress transmission by oceanic transform faults; 2.) these earthquakes might be generated by plate uplift and gravitational collapse; 3.) some of the events may have been triggered by local anthropogenic stress perturbation. The second hypothesis is quite probable as the western Central African margin has experienced repeated episodes of tectonic uplift in the Cenozoic as recorded in the Congo Basin. A thorough seismic analysis of the western Central African margin would provide more insight into the most probable causative mechanism for the earthquakes.

Keyword

Tectonic stress, Intraplate seismicity, Central Africa, Slip tendency

Multidimensional structural analysis of the reservoir-scale fault damage zones flanking the eastern side of the High-Agri-Valley Basin, southern Italy

Fabrizio AGOSTA[1]*, University of Basilicata (fabrizio.agosta@unibas.it)
Ian Bala Abdallah[2], University of Basilicata
Canio Manniello[3], University of Basilicata
Giacomo Prosser[4], University of Basilicata

Abstract

Faults are known to have a profound influence on both migration and storage of geofluids in the shallow crust. Due to their conducive, sealing, and/or combined barrier-conduct hydraulic behaviour, faults impact the modalities of fluid flow and accumulation according to the processes associated to their nucleation and growth, the geometry of the interacting fault segments, the strain rates they solve, the tectonic environment/s in which they form, and their diagenetic history. In this study, we carry out a structural survey on several 100's m- high cliffs exposing Jurassic – Cretaceous platform carbonates crosscut by WNW-striking, high-angle transtensional faults bounding the High Agri Valley Basin, eastward. This work involves the combination of field and digital outcrop structural analysis techniques to assess the variation of geometry, distribution, density, and intensity of both fractures and faults according to the host rock lithology and distance from the basin. Furthermore, we compute their multiscale length and height properties to obtain the input data for DFN modelling. Finally, we build multiple stochastic models of fracture networks at bed package (height: 5m), outcrop (height:50m) and reservoir scales (height: 500m). The goal is the assessment of variations of both fracture porosity and permeability, as well as the scaling factors for the horizontal permeability ellipses.

The results show a scale dependency of fracture and fault geometry over 3-order magnitude for the Cretaceous carbonates, and a scale independent geometry for the Jurassic carbonates. Data are interpreted according to the stratigraphic architecture of the carbonates, and hence the role exerted by efficient mechanical interfaces such as bed and bed-packages interfaces on the vertical propagation of fractures and small faults. The fracture stratigraphy exhibited in the field by the carbonates supports this interpretation. In fact, results of field circular scanline measurements are consistent with both fracture density, P20, and intensity, P21, characterized by similar trends in the Jurassic carbonates. Here the aforementioned mechanical interfaces promoted the vertical fault growth by linkage of pre-existing fractures, originally compartmentalized within single bed-packages, by localizing jointing at their extensional quadrants. Differently, contrasting results are achieved for the massive Cretaceous carbonates due to pronounced bed amalgamation. Furthermore, away from faults, the grain-supported carbonates such as grainstones and packstones show the highest P20 and P21 values due to the calcite rims coating the grains, which formed in marine-phreatic environments, and to the pervasive blocky cements that filled the pore space and formed in shallow freshwater-phreatic environment. In terms of fluid storage and migration properties, results after DFN modelling show the profound contribution provided by both strata-

bound and non-strata-bound fractures to fracture porosity, and by faults, to fracture permeability. Most of the DFN models show near isotropic horizontal permeability ellipses, which is consistent with the fractured and faulted carbonates behaving such as a porous-like medium for horizontal fluid flow. We note that the fault-parallel dominated flow tendencies are exhibited by geocellular volumes representative of the main basin-bounding fault zones.

Keyword

fracture porosity, fracture permeability, platform carbonates, DFN modelling, scaling properties

Characteristics of fault zone structure and the relationship with hydrocarbon migration and accumulation: a case study of Qiongdongnan Basin, South China Sea

Yannan DU[1]*, China University of Petroleum (East China) (b20010011@s.upc.edu.cn)
Kongyou WU[2], China University of Petroleum (East China)
Yanying LI[3], China University of Petroleum (East China)

Abstract

Qiongdongnan Basin is a Cenozoic petroliferous basin in the northern South China Sea. Because it is located at the junction of the Eurasian plate, the Pacific Plate plate and the India Australia plate, it is jointly affected by multiphase stress, and a large number of extensional faults are developed. Faults are important elements that transport natural gas and form structural traps. A fault is a three-dimensional geological body with a certain width, and its internal structure has strong heterogeneity. This research is based on core characteristics and logging curve response characteristics to carry out structural identification and division of fault zone. The structural development model of fault zone is established. Through experimental testing of fault rock samples, the physical characteristics and diagenetic cementation were analyzed. The structural characteristics of fault zone in Qiongdongnan basin and its relationship with hydrocarbon migration and accumulation are discussed. The results show that: (1) Fault zone can be divided into fault core and damage zone, and deep and shallow resistivity, caliper, porosity logging curves have good response characteristics to the structural division of fault zone; (2) The structure of fault zone is not necessarily well developed, and its development degree is greatly affected by the lithology of country rock, structural stress and fault activity. The structural characteristics of the same fault are heterogeneous; (3) The transmission and sealing of fault zone to oil and gas depend on the development degree of each structural unit of the fault, physical property conditions, diagenesis and the "time-space" matching relationship. The incomplete structure of the fault zone is a transport type fault zone, and the transmission capacity is controlled by the fracture density and connectivity. The complete structure of the fault zone is a sealed fault zone, and the transmission capacity depends on the matching relationship between diagenesis, main generation and expulsion periods and fault activity periods.

Keyword

Fault zone structure, Diagenesis, Logging identification, Fault controlled reservoir

Brittle Deformation History based on Kinematic Analysis in Igidae, SE Korea

[1]*, Pukyong National University. Geologic Structures and Geohazard Research group (eu1451@gmail.com)
[2], Pukyong National University. Division of Earth and Environmental System Sciences.

Abstract

The southeastern part of the Gyeongsang Basin in korea, composed of volcano sedimentary rocks of Cretaceous Yucheon Group, is characterized by the presence of several large faults on the Korean Peninsula including the Yangsan, Ulsan, Ilkwang, and Dongnae Faults. Understanding the characteristics and history of brittle deformation in the area is crucial for neotectonics and seismic hazard assessment. The kinematic analysis of faults, veins and dikes offers valuable insights into the deformation history and fault evolution of the area. Igidae area in Busan is one of the best place to understand the brittle deformation history and its relationship with large faults and regional tectonics. We collected structural dats through field surveys. Deformation events were analyzed from crosscutting relationship and kinematics of faults and fractures. The results indicate that the deformation history in Igidae is dominated by normal faulting with joints, veins, and dikes followed by multiple strike-slip events. Those multiple events were distinguished and analyzed based on fault geometry, fault connection, and fault displacement. The deformation events in the study area suggest that the normal faults with joints reactivated to strike-slip faults in the study area. The reactivation is mainly controlled by fault geometry, fault zone material and the orientation of stress. This will help to understand the overall tectonics of the area.

This research was supported by a grant(2022-MOIS62-001(RS-2022-ND640011)) of National Disaster Risk Analysis and Management Technology in Earthquake funded by Ministry of Interior and Safety(MOIS, Korea)

Keyword

Deformation history, fault evolution, Igidae, Kinematics, Volcano rocks

Fault reactivation and vein localization along dikes in granitic rock, Gyeongju, Southeast Korea

Sehyeon GWON[1]*, Korea Hydro & Nuclear Power Co., LTD. Central Research Institude
(sehyeon.gwon81@gmail.com)
Sambit Prasanajit Naik[2], Pukyong Nation University
Young-Seog Kim[3], Pukyong Nation University

Abstract

Veins associated with fault zones provide essential information on pore-fluid pressure and stress conditions at the time of vein formation. This study describes quartz-mineralized and fault gouge-infilled veins formed along the Cheongun fault segment in the Late Cretaceous to Early Paleogene granitic rocks, Gyeongju, Southeast Korea. We excavated two trenches across NNE-SSW-striking faults. In both trenches, the vertical separation of the unconformity between the granitic rocks and the Quaternary sediments and the observed striations on the fault planes indicate transpressional deformation along a reverse skrike-slip fault. Interestingly, vein networks are localized within the dikes along which the faults are reactivated with reverse-slip sense. Quartz veins are characterized by intense fracture networks within an andesitic dike. Fault gouge injection within a felsic dike shows that granular gouge materials are injected into fractures off the fault surface. The observed gouge injection and vein localization may imply fluid overpressure involved fracture propagation in the dikes and injection of the mineralized fluids or fluidized fault gouge from the fault zone. The structural analysis of the vein system indicates that the veins are formed under NE-SW-oriented maximum horizontal stress and NW-SE-oriented minimum horizontal stress. This study indicates that statistical analysis and 3D Mohr-circle reconstruction on fractures and veins can provide useful information to determine the magnitude of pore-fluid pressure and stress states associated with localized veins within dikes.

Keyword

Veins, fault gouge injection, fluid pressure, fault zone, fracture

Structural heterogeneities in exhumed fault core: result from Great Glen Fault, Scotland

Namgwon KIM[1]*, University of Strathclyde (namgwon.kim@strath.ac.uk)
Zoe K Shipton[2], University of Strathclyde
Yannick Kremer[3], University of Strathclyde
Christopher D Jack[4], COWI

Abstract

A fault core accommodates most of the displacement within the fault zone, resulting in heterogeneous internal architecture governed by various geological factors. Heterogeneity in brittle structural discontinuities, including faults, fractures, and veins, will control the hydro-mechanical properties of the fault core that need to be considered for surface or near-surface engineering purposes. We use detailed structural and topological maps for the fault core of the Great Glen Fault (GGF) to elucidate the internal architecture and spatial relationships between fault core elements and brittle structural discontinuities controlling engineering properties. The GGF is one of the major NE–SW trending strike-slip faults in Scotland and cuts foliated protoliths. It exhibits a complex internal architecture developed through the multiple reactivation events and exhumation from the elastic-frictional regime. The fault core of GGF is exposed at the Torcastle area showing micaceous shear zones, faults and local dykes cutting foliated psammitic–pelitic gneiss and quartzite. The heterogeneous patterns of structural elements at the Torcastle outcrops define several fault-bounded structural domains. In several domains, NE–SW trending regional foliations are locally rotated by up to 90°. The faults and dykes tend to be subparallel to the adjacent foliations. The geometrical properties of fractures are highly variable, with local quartz and calcite infills, but they clearly relate to the local foliation trend and dyke distribution in each domain. The fractures can be subdivided into six types based on the distribution pattern and geometrical relationships with local faults and foliations. The distribution of X and Y node density indicates that a zone of highly rotated local foliations, and hence higher variability in fracture orientation and connectivity, is likely to represent a zone of lower mechanical stability. The results of this study highlight the structural heterogeneity related to the brittle deformation in the fault core and its relationships with pre-existing anisotropies, which have a predictable control on hydro-mechanical engineering properties.

Keyword

Structural discontinuity, Topological map, Structural domain

Controls of deep strike-slip fault on fractures in the Tarim Basin, Northwest China: Insight from finite element numerical simulation

Yichen SONG[1]*, College of Geoscience, China University of Petroleum (Beijing)
(songyichen828@126.com)
Lianbo ZENG[2], College of Geoscience, China University of Petroleum (Beijing)

Abstract

The carbonate fractured-vuggy reservoir controlled by strike-slip faults is the main target for ultra-deep carbonate oil and gas exploration in the Tarim Basin, China. It is crucial to clarify the fault-related fracture distribution within the damage zone for guiding the exploration and development of ultra-deep oil and gas. In this study, a finite element numerical simulation method was employed to investigate the characteristics and development patterns of fault-related fractures in the fault damage zone with different structural styles in the Shunbei Oilfield, Tarim Basin. The simulation results were compared and validated with well-logging interpretations. In areas with multiple faults, fault stepovers exhibit the highest fracture density and widest damage zone. Within the pop-up structures of restraining stepovers, the fractures are concentrated near the sidewall reverse faults and the central uplift zone. Analysis of the stress state of rock fracturing reveals that these fractures belong to shear fractures, intersecting with the direction of the boundary faults at small angles (20-30°). In the pull-apart structures of releasing stepovers, the fractures are concentrated near the intersection of sidewall normal faults and opposite master faults, with the secondary concentration near the sidewall normal faults. These fractures are extensional fractures that intersect with the direction of the boundary faults at larger angles. In areas where a single fault is present, the fractures are shear fractures that intersect with the fault direction at small angles (20-30°). The highest fracture density occurs at the fault bend, followed by the fault tip. The simulated fracture density curve along the wellbore significantly correlates with conventional and gas-logging curves, confirming the accuracy of the simulation results. The research findings provide valuable reference for optimal well placement and fracturing operations in ultra-deep carbonate reservoirs within the Tarim Basin.

Keyword

Strike-slip fault, Fault-related fracture, Fracture density, Stepover, Finite element

Quantitative characterization method of ultra-deep strike-slip fault damage zone based on facies-controlled seismic inversion

Lu LIU[1]*, China University of Petroleum(Beijing) (1789098232@qq.com)
Lianbo Zeng[2], China University of Petroleum(Beijing)

Abstract

The ultra-deep fault-controlled strike-slip fault damage zones are formed by fluid migration and dissolution along the fault-fracture system, which have the potential to bacome favorable reservoirs for oil and gas. The characterization of the spatial distribution and internal structure of the fault damage zones is of great significance for the screening of exploration targets. This study focuses on the ultra-deep strike-slip faults in carbonate formations with an average buried depth of more than 7500m in Fuman area of Tarim Basin. The drilling data indicates that there is a good correlation between P-wave impedance and porosity of fault damage zones in the study area, so a quantitative characterization method is established to calculate the porosity data volume by obtaining P-wave impedance data volume by facies-controlled seismic inversion. Firstly, using the constrained sparse spike inversion method, the first P-wave impedance seismic inversion is carried out based on the variation trend of P-wave impedance in multiple wells. This P-wave impedance data volume has the characteristics of longitudinal wave impedance variation which is consistent with that of the well, but lacks the trend of lateral variation. Three kinds of data volume are calibrated their threshold values from the drilling data and chosen to describe different components of the damage zone: the difference between the original seismic data and the median filtered seismic is used to describe the boundary of the whole damage zone, the fault distribution data obtained by CNN method is used to describe the fault and fracture system, and the residual impedance attribute is used to describe the shape of caves in the damage zone. We call these three data volumes facies and in each facies the P-wave impedance volume obtained from the first inversion is numerically replaced by the real impedance form wells. In this way, a facies-controlled low-frequency model is established through the combination of wells and seismic data. Finally, the model is used to constrain the second P-wave impedance inversion, and a new P-wave impedance data volume is obtained. Then the porosity volume is calculated through the fitting P-wave impedance-porosity calculation formula, which not only characterizes the structure of the strike-slip fault damage zone but also shows the porosity variation of different structures.

Keyword

ultra-deep strike-slip fault, fault damage zone, seismic inversion

Structural characteristics of thrust system in the piedmont zone of middle part of Longmen Mountains during the Indosinian period

Na ZHENG[1]*, China University of Geosciences, Beijing (zhengna1999@163.com)
Fa Deng HE[2], China University of Geosciences, Beijing

Abstract

The Longmen Mountains tectonic belt is located at the boundary between the southeastern margin of the Qinghai-Tibet Plateau and the Sichuan Basin, and is divided into north, middle and south sections with Wolong-Huaiyuan and Beichuan-Anxian boundaries. Among them, the middle section of Longmen Mountains has the greatest variation of topographic gradient, which is one of the best places to reveal the geological structure of Longmen Mountains. During the Late Triassic Indosinian movement in Longmen Mountain, the preexisting normal faults in Longmen Mountain area reversed. In order to determine the Indosinian thrust system in the front and middle section of Longmen Mountain, the structure of the Indosinian thrust system in the piedmont zone middle section of Longmen Mountain was determined through field geological observation, combined with digital elevation and 3D seismic data, and a 3D geological model of the Indosinian thrust system was constructed. The results show that the Indosinian thrusts in the piedmont zone of middle part of Longmen Mountain are a series of reverse faults that tend to the NW and converge over the coal bearing strata of Xujiahe Formation. The front edge of the thrust belt is mainly involved in the deformation of the second and third members of the Xujiahe Formation, and the hanging wall of the fault develops into the Middle and Lower Triassic series. In addition, the thrust system of Longmen Mountain piedmont zone in the Indosinian period has a tendency to transfer from north to south, and the thrust table of imbricated thrust belt gradually decreases from north to south.

Keyword

Longmen Mountain, piedmont belt, Indosinian, imbricated thrust structure, three-dimensional geological model

Earthquakes and neotectonics in cratonic Australia

Haibin YANG[1]*, Zhejiang University (haibin.yang@zju.edu.cn)
Mark Quigley[2], Melbourne Univerity
Schirin Sellmann[3], Melbourne University
Tamarah King[4], Geoscience Australia

Abstract

Australia is one of the most stable continents around the world with few earthquaekes. However, analysis of high-resolution digital elevation models indicates neotectonic fault-propagation fold traces on the nearly flat karst landscape that locally extend to lengths of >100 km, suggesting potential for hosting large (>7.3–7.5) moment magnitude earthquakes. Along-strike maximum displacements are not proportional to neotectonic fold surface trace length but are spatially associated with crust-scale electrical conductors identified in magnetotelluric surveys. Two major conductors penetrate from the upper crust to the uppermost mantle (at depths < 60 km) along crustal scale shear zones. Conductivity in the uppermost mantle shear zones is higher than conductivity at increased depth, suggesting fluid-enhanced enrichment with hydrogen and/or carbon. Lithospheric fluid localization associated with ancient slab subduction and/or hydrothermal alteration may have weakened pre-existing faults and enhanced neotectonic faulting in the Nullarbor Plain in South-Central Australia.

We further analyzed surface ruptures for 11 historical (1968–2018) moment magnitude (Mw) 4.7–6.6 reverse earthquakes in Australia using statistical techniques and compare their characteristics with magnetic, gravity, and stress trajectory data sets. Of the total combined (summative) length of all surface ruptures (~148 km), 133 km (90%) to 145 km (98%) align with the geophysical structure in the host basement rocks. Surface rupture length (SRL), maximum displacement (MD), and probability of surface rupture at a specified Mw are high compared with equivalent Mw earthquakes globally. This is attributed to (1) a steep cratonic crustal strength gradient at shallow depths, promoting shallow hypocenters (~1–6 km) and limiting downdip rupture widths (~1–8.5 km), and (2) favorably aligned crustal anisotropies (e.g., bedrock foliations, faults, fault intersections) that enhanced lateral rupture propagation and/or surface displacements. Combined (modeled and observed) MDs are in the middle third of the SRL with 68% probability and either the ≤33rd or ≥66th percentiles of SRL with 16% probability. MD occurs proximate to or directly within zones of enhanced fault geometric complexity (as evidenced from surface ruptures) in 8 of 11 earthquakes (73%). MD is approximated by 3.3 ± 1.6 (1σ) × AD (average displacement). S-transform analyses indicates that high-frequency slip maxima also coincide with fault geometric complexities, consistent with stress amplifications and enhanced slip variability due to geometric and kinematic interactions with neighboring faults. Rupture slip taper angles exhibit large variations (−90% to +380% with respect to the mean value) toward rupture termini and are steepest where ruptures terminate at obliquely oriented magnetic

lineaments and/or lithology changes. Incremental slip approximates AD between the 10th and 90th percentiles of the SRL. The average static stress drop of the studied earthquakes is 4.8 ± 2.8 MPa. A surface rupture classification scheme for cratonic stable regions is presented to describe the prevailing characteristics of intraplate earthquakes across diverse crustal structural-geophysical settings. New scaling relationships and suggestions for logic tree weights are provided to enhance probabilistic fault displacement hazard analyses for bedrock-dominated intraplate continental regions.

Keyword

cratonic earthquakes, neotectonics, rupture complexity, fault reactivation

Active Son-Narmada-South Fault as major threat to dams in central India

VAIBHAVA SRIVASTAVA[1]*, Banaras Hindu University (vsrivastavabhu@gmail.com)

Abstract

The Son-Narmada-South Fault (SNSF) demarcates the southern limits of the Paleoproterozoic Mahakoshal Group of rocks in the Son river valley region of central India. Here, the two multi-phase deformed rock units namely the Mahakoshal Group and Archean Chhotanagpur Granite-Gneiss Complex (CGGC) rocks are at tectonic contact along the SNSF. The northern limit of the Mahakoshal Group is also at tectonic contact with the Middle- to Late- Proterozoic Vindhyan Supergroup. The Upper Vindhyans have remained practically undeformed and hence it is thought that this region of central India has not experienced tectonic disturbances since Late- Proterozoic therefore attained a tectonic stability. The myth was broken by 1997 Jabalpur earthquake in the vicinity of the SNSF and thereafter the studies carried out in the region started giving indications of the active tectonics prevalent in vicinity of SNSF. Using the structural analyses techniques the present study finds that the deformation patterns of the Precambrian rocks across the SNSF are not same even the two studied units namely Mahakoshal Group and the CGGC are located side-by-side in the Son valley region. This indicates that the two concerned rock units have been deformed elsewhere and now juxtaposed together along the SNSF suggesting huge strike-slip movements. The movement is still going on and hence posing a threat of possible earthquake in near future again along the SNSF. There are operational and upcoming dams and large reservoirs for hydropower generation lying close the SNSF hence the tectonic instability may affect them most and further intensify the possibility of severe disasters. Timely actions are therefore very much required for the greater safety.

Keyword

Active Tectonics, Mahakoshal, CGGC, Deformation, Son valley

Multi-phase non-coaxial orogenic growth: propagation of the Longmen Shan thrust belt on the eastern margin of the Tibetan Plateau

Zhicheng ZHOU[1]*, China University of Geosciences (Beijing) (zzcgeology@126.com)
Dan-ping Yan[2], China University of Geosciences (Beijing)
Liang Qiu[3], China University of Geosciences (Beijing)
Ruoyan Kong[4], China University of Geosciences (Beijing)
Huajie Song[5], China University of Geosciences (Beijing)
Dongzhi Xiao[6], China University of Geosciences (Beijing)
Xiaohan Lin[7], China University of Geosciences (Beijing)
Chao Du[8], China University of Geosciences (Beijing)
Fei Kong[9], China University of Geosciences (Beijing)

Abstract

Reconstructing the deformation sequence and strain history of the Longmen Shan thrust belt (LSTB) has significant implications for the growths of the SW Qinling orogenic belt and the Tibetan Plateau. However, the Mesozoic–Cenozoic propagation of the LSTB remains poorly understood owing to weak constraints on strain variations. We conducted a comprehensive structural investigation and made measurements of anisotropy of magnetic susceptibility along the entire LSTB. Magnetic fabrics are represented by prevalent layer-parallel shortening (LPS) fabrics, intersection lineation fabrics, and folding fabrics with magnetic lineations trending NE–SW, WSW–ENE, NW–SE, and N–S, corresponding to four compressional deformations. AMS results and structural analyses, revealed four phases of deformation (D1, D2, D3, and D4) that were characterized respectively by top-to-the-SSE thrusting in the northern LSTB at >219–164 Ma, top-to-the-SW thrusting in the central-northern LSTB at >201–164 Ma, top-to-the-SE thrusting of the LSTB at 125–5 Ma, and top-to-the-east thrusting at 5–0 Ma in the LSTB. D1, D3, and D4 LPS fabrics exhibit a strain evolution that progressed from incipient deformation to pencil structure to cleavage fabrics, corresponding to moderately oblate, prolate, and oblate strain ellipsoids, respectively. The intersection lineation fabrics imply a hinterland-ward progression from LPS fabrics to cleavage-controlled fabrics and non-coaxial superimposition of D2 on D1. Therefore, the early Mesozoic LSTB developed owing to the superimposition of D2 on D1 being non-coaxial, likely suggesting southward growth of the SW Qinling orogenic belt, whereas the modern LSTB was formed by the superimposition of D4 on D3, implying non-coaxial eastward growth of the Tibetan Plateau.

Keyword

structural analysis, magnetic fabric, finite strain, Longmen Shan thrust belt, eastern Tibetan Plateau

[Keynote] Surface Ruptures of the February 6, 2023 Earthquake Sequence, eastern Türkiye

Tim Kusky[1]*, China University of Geosciences, Wuhan (tkusky@gmail.com)
Jiannan Meng[2], China University of Geosciences, Wuhan
Walter Mooney[3], U.S. Geological Survey
Erdin Bozkurt[4], Middle East Technical University
Lu Wang[5], China University of Geosciences, Wihan

Abstract

Two powerful earthquakes struck eastern Türkiye on February 6th 2023, rupturing three active fault systems, including the Dead Sea fault zone (DSFZ), the East Anatolian fault zone (EAFZ) and the Çardak-Sürgü fault (Ç-SF). The DSFZ is the transform plate boundary between the Arabian and African plates, whereas the EAFZ is the transform plate boundary between the Arabian and Anatolian plates. The Feb. 6 2023 earthquake sequence activated both plate boundaries, providing a natural laboratory to study how fault ruptures are propagated from one plate boundary to another at triple junctions, and offering insight to how plates interact.

We present our first-hand field measurements of ground offsets and high resolution (centimeter level) drone-mapped determinations of surface ruptures taken 10-30 days after the first shock. The surface ruptures, liquefactions, massive landslides and dammed lakes caused by these earthquakes were clearly documented during our field work, and now available as public open-access databases (Meng et al., 2024 (10.1126/science.adj3770; doi.org/10.6084/m9.figshare.24872043). We present our data in raw form, and as vector files showing the new fault ruptures, but we refrain from classifying the fault systems into classical Riedel or other standard forms, as complimentary seismological studies. Ren et al., 2024 (10.1126/science.adi1519) show that some of the ruptures were super-shear, others sub-shear, and we do not wish to impose century-old assumptions of plane strain, homogenous isotropic media, and Andersonian stress fields to interpret this new data set. The geophysical, structural geology, and imaging communities can use these data to formulate new concepts in surface rupture in complex media during large earthquake events and their rupture properties and results through variable media with emerging concepts and technologies.

The initial rupture was on the Dead Sea fault zone (DSFZ), while the maximum displacements (around 47.5 kilometers away from the epicenter at the junction of the DSFZ and the EAFZ) and energy release (Mw 7.8) occurred 24 sec later when rupture transferred to the East Anatolian fault zone (EAFZ). Seven hours later, a Mw 4.5 aftershock at the junction of the EAFZ with the east-west striking Çardak-Sürgü fault (Ç-SF), was followed soon-after by the second large (Mw 7.5) earthquake, hinting at a possible causal relationship.

Our observations provide important data on surface deformation during large continental strike-slip earthquakes, rupture propagation mechanisms, and how slip may be transferred between complex fault systems. We also provide insight into how slip along linked fault systems accommodates global plate motions.

Keyword

Turkiye, earthquake, Kahramanmaras, rupture, drone

Hunting for an invisible Holocene fault beneath an urban region using historic aerial photos

Junjie REN[1]*, School of Earth Sciences and Resources, China University of Geosciences, Beijing (renjunjie@cugb.edu.cn)
Fei Guo[2], China Earthquake Networks Center
Kang Li[3], National Institute of Natural Hazards, Ministry of Emergency Management of China
Xiwei Xu[4], School of Earth Sciences and Resources, China University of Geosciences, Beijing

Abstract

A large earthquake in a city always causes a huge loss in the economy and big casualties. This type of large earthquake is related to Holocene faults generally with displaced landforms. Therefore, finding active faults beneath a city will be essential for disaster prevention and mitigation. In the urban active fault surveying project, the popular techniques are seismic reflection exploration and drilling which are expensive and time-consuming but include big uncertainties. In the middle part of the Datong Basin, the Shuiyu fault crosses the Yudong District of Datong City, north China. Urbanization in the past 20 years brought about dense buildings and cement roads that have erased the origin landforms and made the possibly visible fault trace invisible. Although the seismic reflection results show evidence of a potentially active fault beneath the Yudong District, the fault trace is hard to accurately determine, and the late Quaternary activity of the fault remains unclear. Here, we introduce the sterophotographic technique of old aerial photos taken in the1960s to reconstruct the original DEM data along the fault. We use trenching and radiocarbon dating to recover the paleoearthquake in the late Quaternary. Trenching results show at least five normal surface-rupturing events occurred in the late Quaternary along the Shuiyu fault, and the original DEM data indicate two or three clear scarps along the strike of the Shuiyu fault. The fault exposures in the foundation excavation of the buildings validate that the scarps are related to displaced terrace T3 by the Shuiyu fault. The height of the scarp and dating of terrace T3 indicates that the Shuiyu fault has a normal slip rate of about 0.12-0.21 mm/yr. Given the elapsed time of ~10 ka, the Shuiyu fault beneath the Yudong District will increase the risk of a large earthquake in the future. Besides, the old aerial photos before urbanization can provide unique clues for active faults beneath a city and make the invisible fault visible. With the development of urbanization, however, the potential earthquake will pose a high seismic risk to citizens and basic infrastructures.

Keyword

invisible Holocene fault, urban region, historic aerial photos, sterophotographic technique, Datong Basin

[Keynote] Progress of active fault surveying and its frontier problems in China

Xiwei XU[1]*, School of Earth Sciences and Resources, China University of Geoscience, Beijing 100083 (xiweixu@vip.sina.com)
Feng LI[2], China Earthquake Disaster Prevention Center, Beijing 100029
Jia CHENG[3], School of Earth Sciences and Resources, China University of Geoscience, Beijing 100083
Baojin LIU[4], Geophysical Exploration Center, China Earthquake Administration, Zhengzhou 450002, China
Guihua CHEN[5], Institute of Geology, China Earthquake Administration, Beijing 100029, China
Kang LI[6], National Institute of Natural Hazards, MEMC, Beijing 100085, China
Junjie REN[7], School of Earth Sciences and Resources, China University of Geoscience, Beijing 100083
Qichao JIA[8], School of Earth Sciences and Resources, China University of Geoscience, Beijing 100083

Abstract

This report reviews, first, the challenges or opportunities brought by occurrence of extremely large earthquake events, the historical background of the approvals, funding status of relevant Chinese governmental departments, and also the main research contents for the projects of the urban active fault surveying, the large-scale mapping plan of active faults, the seismic risk assessment of active faults in the key earthquake monitoring and preventing areas, as well as the scientific investigations of the earthquake surface rupture zones of the major earthquakes occurred in past 20 years. Then, the significant progresses have been achieved since the implementation of those projects in the hidden active fault surveying and positioning technology under strong noise and weak signal conditions, fault-activity quantitative identifying technology, earthquake hazard assessment theory and method, multi-source data managing technology of active faults and a series of technical standards for active fault surveying. New theories, new methods and new concepts have also been established in the faulting behavior and great earthquake origin, the active fault avoidance, earthquake hazards prevention, earthquake monitoring and predicting, and they are the new dynamic uplifting model of the Qinghai-Tibet Plateau, multiple fault-segments-cascading rupture mechanism, earthquake rupturing localization characteristics and avoidance theory, and seismo-geological signatures for identifying M≧7.0 earthquake risk areas and their application in zoning an earthquake risk area. Finally, some scientific questions and problems that urgently need to be solved are put forward in active fault surveying and research, such as uncertainty of quantitative parameters of fault activity, multiple fault-segments-cascading rupture conditions and prediction of large/great earthquake magnitude, quantitative evolution process of the seismo-geological signatures for identifying M≧7.0 earthquake risk areas, simulation of strong ground motion and related earthquake disaster prediction based on 3D active fault model, and faulting resistance of major projects across active faults.

Keyword

active fault, surveying technique, earthquake rupturing localization, research progress, scientific problem

Anatomy of intracratonic Gondwana rift basins of Peninsular India: An integrated gravity, magnetic and remote sensing approach

SWARNAPRIYA CHOWDARI[1]*, CSIR-NGRI (swarnapriya.ngri@gmail.com)

Abstract

The Gondwana rift basins of Peninsular India are situated close and parallel to the junctions in the suture zones between the Archean cratons such as Dharwar, Bastar, and Singbhum. There are four Gondwana rift basins of India represented by the E-W trending Satpura & Damodar Basins and NW-SE trending Pranhita-Godavari & Son-Mahanadi Basins. A combined analysis of gravity, magnetic, and Remote Sensing techniques to delineate the subsurface structures to trace the tectonic evolution of the basin. Landsat Remote sensing data, ground gravity, and Emag2 magnetic data were used to understand the surface and subsurface structures.

The Bouguer gravity anomaly map of the Gondwana rift basins of India and its adjoining area depicts prominent linear gravity low of 50mGal negative anomalies due to lower density Gondwana sediments. It shows a total anomaly variation of 148 mGal with a relative gravity low of 111 mGal and a high of 37 mGal. The EMAG2 magnetic anomaly map of the study area shows a variation of about 1773 nT with a low of -795 nT and a high of 978 nT. Landsat 8 Operational Land Imager (OLI) and Thermal Infrared Sensor (TIRS) C2 Level 1 Data of 30m resolution used for integration purposes.

The major structural trends show NNW–SSE from Pranhita-Godavari basin, ENE-WSW, and NW-SE from the Son-Mahanadi basin, NE–SW from the Satpura basin and it appears the different basins of the Damodar valley along with an E–W trending structures characterized by NW–SE Karanpura–Bokaro, NW–SE to NNE–SSW Jharia basin, NNW–SSE, and NNE–SSW Ranigunj basin.

Keyword

Gondwana basins, remote sensing, gravity, magnetic, structures

Probabilities Seismic Hazard Modeling inferred from the newest fault slip rates and its effect on the Landslide Risks in the Eastern Tibet Region

Jia CHENG[1]*, China University of Geosciences, Beijing (jiacheng@cugb.edu.cn)
Xiwei Xu[2], China University of Geosciences, Beijing
Chong Xu[3], National Institute of Natural Hazards, Ministry of Emergency Management of China

Abstract

The Eastern Tibet Region (ETR) stands in the region where the crustal eastward extrusion of the Tibetan Plateau occurs. Tens of active strike-slip faults behave with high strike-slip rates to adjust this eastward extrusion of the crust. These active faults consist of the Xianshuihe fault zone, Litang fault zone, Lancangjiang fault zone, Baqing-Leiwuqi fault, Nujiang fault, Bianba-Luolong fault, Jiali fault, and other large strike-slip fault zones. Strong historical earthquakes frequently struck this region . These large-scale strike-slip faults all have earthquake risks of M7+. How to build a scientific and reasonable seismic hazard model for the eastern Tibetan Plateau is of great significance to the safety of both the local people and the major projects under construction and already constructed in western China.

In this study, we constructed a new seismic hazard model for the eastern Tibetan Plateau using the newest fault slip rates and considering the multi-segment possibilities and probabilities. First, we collected and analyzed the newest slip rate results from field works for the faults in the eastern Tibetan Plateau. Then, we built segmentation models for these faults according to DEM data and historical rupture behaviors. According to historical seismicity distribution and fault slip behaviors, we divided the ETR into eight seismic zones to obtain the Magnitude-Frequency Distribution (MFD) for different earthquake magnitudes in each zone. We also considered the multi-segment possibilities and probabilities for the active faults with clear segmentation and historical earthquake data in this region in the seismic hazard models. After that, we applied the taper Gutenberg-Richter distribution to convert the geodetic strain rates and the fault slip rates into fault seismic activity rates and background seismic activity rates. We calculated the Peak Ground-motion Acceleration (PGA) values for the ETA. Finally, we also predicted the landslide risks in the ETA in the PGA field.

Our results show that the PGA value is relatively lower around the middle section of the Xiaojiang fault, which is agree with the historical earthquakes occurrence pattern. The high probabilities of the multi-segment rupturing for the Xiaojiang fault are determined by the fault segment distribution based on the new geological mapping results. We obtained four fault areas with high risks of potential M7+ earthquake in the ETR, i.e., the Xianshuihe fault, the Jiali fault, the Jinshajiang fault, and the Litang fault. The predicted landslide risks show the high values occurring around the Jiali fault and the Xianshuihe fault.

Our results will enhance the application of regional geological field studies in earthquake risk analysis, and provide the preparedness for renew of the seismic hazard models.

Keyword

Eastern Tibet Region, Strike-slip faults, Seismic Hazard Modeling, Multi-segment rupturing, Landslide Risks

Irregular Earthquake Recurrence of the Northern Kongur Shan Extensional System, NE Pamir: Constraints from Multiple Paleoseismic Methods

Jin GE[1]*, Zhejiang University (gejin97@gmail.com)
Xuhua Shi[2], Zhejiang University
Hanlin Chen[3], Zhejiang University
Ray Weldon[4], University of Oregon
Richard Walker[5], University of Oxford
Tao Li[6], Institute of Geology, China Earthquake Administration
Huili Yang[7], Institute of Geology, China Earthquake Administration
Jie Chen[8], Institute of Geology, China Earthquake Administration
Feng Li[9], Zhejiang University
Xiaochun Wei[10], Zhejiang University
Xiao Yang[11], Zhejiang University
Zhuona Bai[12], Zhejiang University
Yuqing Zhang[13], Research Institute of Petroleum Exploration and Development, PetroChina
Yuanhai Shu[14], Zhejiang University
Xin Liu[15], Zhejiang University
Yixi Yan[16], Zhejiang University

Abstract

The Kongur Shan Extensional System (KSES), the largest E-W extensional system in the Pamir, is tectonically active with high rates of instrumental seismicity. However, its earthquake recurrence remains largely unknown, hampering the comprehensive understanding of regional seismic hazard and crustal kinematics. Here we investigate three paleoseismic sites in the northern KSES, including lacustrine seismites in the Muji Basin, surface ruptures of the Kongur Shan Fault, and an exposure of the eastern Muji Fault. Using multiple paleoseismic methods, we constrain recurrence intervals of Mw 6.5 ± 0.2 earthquakes at these sites. The seismites, as a regional record, indicate an aperiodic earthquake recurrence pattern, with two paleoearthquakes occurring over the past ~1000 years, at 720–683 and 1025–936 cal yr BP. The other two sites, with records spanning ~4800 and ~2700 years, reveal average intervals of 1400 ± 278 and 1125 ± 248 years on the Kongur Shan Fault and eastern Muji Fault, respectively. The long recurrence intervals contradict ~80–230 years estimated from slip rates of the two faults over a longer time span, which are ~2.2 and ~6.3 mm/yr, respectively. This inconsistency suggests irregular seismic recurrence behaviors of the two individual fault segments. Such irregular seismic recurrence behaviors, on both regional and individual fault scales, are potentially related to the low maturity and complex fault geometry of the northern KSES, as well as changes in surface loads in the region.

Keyword

Northeastern Pamir, Kongur Shan Extensional System, Paleoseismology, Irregular earthquake recurrence

Paleoseismic investigating understanding “Whether the historical 1505 central Himalaya earthquake produced surface rupture??”

Shreya Arora[1]*, Bates College (sarora@bates.edu)
Natalie Meenan[2], Bates College
Drew Cochran[3], Department of Earth and Climate Sciences, Bates College
Eshaan Srivastava[4], Indian Institute of Technology, Kanpur
Alana Williams[5], School of Earth and Space Exploration, Arizona State University
Mitthu Dhali[6], ndian Institute of Technology, Kanpur
Ramon Arrowsmith[7], School of Earth and Space Exploration, Arizona State University
Javed Malik[8], Indian Institute of Technology, Kanpur
Hisao Kondo[9], Active Fault Research Center, ASIT, Geological Survey of Japan, Tsukuba Japan

Abstract

Variability in earthquake-generating ruptures results in different seismic hazard implications and offers crucial insights into understanding causative factors such as fault geometry, the presence or absence of barriers restricting ruptures, time since the last earthquake, and the periodicity of seismic events. To comprehend the rupture variability, it is important to generate the past earthquake chronologies-data spanning for a longer duration which can assist in discerning the repeatability or randomness of the ruptures along individual faults. This study focused on two notables Himalayan earthquakes, the AD 1505 central Himalaya earthquake, and the AD1803 Gharwal earthquake, both pre-instrumental earthquakes, that occurred along the Central Seismic Gap (CSG)- a region believed to be seismically silent for hundreds of years. The long seismic quiescence in this region has led to the anticipation of a great earthquake in the near future. Despite the significance of the location of the AD1505 and AD1803 events in the CSG, there remains a lack of knowledge of its surface rupture extents, and thus in turn its magnitude. We excavated two paleoseismic trenches approximately 80 km apart in Gharwal Himalaya to establish earthquake chronology. Based on the preliminary earthquake chronology data from our trenches, and the correlation of probability density graphs of event chronologies from previous published trenches, we suggest a surface rupture of at least 110 km for the AD1505 earthquake and at least 98 km for the potential AD1803 event within the Delhi- Haridwar segment boundary.

Keyword

Active Faults, Paleoseismology, Gharwal Himalaya, AD1505 earthquake

Transient response of semi-elliptical hill with an elliptical tunnel under blasting and seismic loading

Hao Luo[1]*, School of Resources and Safety Engineering, Central South University (mingtao@csu.edu.cn)
Luo Hao[2], School of Resources and Safety Engineering, Central South University
Zhao Rui[3], School of Resources and Safety Engineering, Central South University
Xiang Gongliang[4], School of Resources and Safety Engineering, Central South University

Abstract

With the propagation of blasting and seismic stress waves, the structural discontinuities from the hill and the tunnel led to stress wave scattering, inducing dynamic stress concentration around the tunnel and surface displacement amplification effects of the hill. The focus of this study was the hitherto unexplored comparative analysis of transient response under blasting and seismic disturbances, which optimized the existing equivalent blasting wave to accurately characterize the engineering blasting stress wave, and the Ricker wavelet was introduced to characterize the seismic loading. The wave function expansion method based on the Mathieu function and angular Mathieu function half-range expansion method was jointly employed to obtain the exact mathematical solution for the steady-state response of the hill and tunnel. Subsequently, the Fourier transform and Duhamel integral were combined to derive the transient surface displacement of the hill and the transient dynamic stress concentration factor (DSCF) of the tunnel under the blasting and seismic loading. The differences in the transient response of the hill and tunnel under two types of loading were compared, and the effects of incident angle, the type and duration of loading, and the axis ratio of the hill and tunnel on transient DSCF and surface displacement were analyzed. The numerical results indicated that the spatial distribution of DSCF and surface displacement was mainly determined by the combination of the incident angle and axis ratio of the hill and tunnel, while the values of DSCF and surface displacement were mainly determined by the combination of duration and type of loading. Furthermore, earthquakes were prone to induce structural damage and exhibited a higher destructive capacity compared to blasting.

Keyword

Transient response, Hill tunnel, Blasting and seismic loading, DSCF, Surface displacement

Morphotectonic studies and identification of active faults in Qazvin city up to a radius of 50 km from its center.

Maliheh Norouzi[1]*, Geological Survey and Mineral Exploration of Iran
(malihenorouzi0@gmail.com)

Abstract

Earthquakes that occur in densely populated cities are among the most dangerous natural disasters with potentially devastating effects on society and infrastructure across the globe. To better understand earthquakes, research in active tectonics aims at quantifying crustal deformation throughout the active fault's earthquake cycles by studying morphotectonics and stratigraphic evidence of recent and past earthquakes.

The underlying assumption in this approach is that a fault's current and previous seismic behavior is representative of its future behavior. Faults are seldom present in outcrops. However, even when they are, their occurrence is often limited to a cross-section, or the surface of the fault itself. Furthermore, such outcrops are commonly only exposed in either quarries or areas of high erosion or high seismic activity. On the contrary, in urban areas and intra-plate regions, the societal relevance of understanding the faults is higher; faults very rarely outcrop. This is where morphotectonics can play an important role. Constraining a fault's seismic behavior in such a manner requires high-resolution morphotectonics and stratigraphic records that enable us to resolve the spatial and temporal characteristics of co-, post-, and interseismic phases, ideally over multiple earthquake cycles. In this research, remote sensing studies and fieldwork led to the identification of active faults around the city. Also, the morphotectonics evidence indicates the existence of hidden faults in the city of Qazvin.

In the geological maps that have been published until today, no faults have been identified on the surface of Qazvin City, but this research indicates the existence of several active and young fault branches on the surface of Qazvin City.

Clastic dikes are the primary source of data used for paleoseismic interpretations. This research found clastic dikes several meters high related to historical earthquakes. This was while it is not seen in any article or scientific reference in Iran that a researcher has observed clastic dikes in Iran. This research has new results from the active tectonic knowledge of Qazvin City, which will be beneficial for future urban development and the preservation of the human and financial capital of this city.

Keyword

active fault, morphotectonic, earthquake, urban, Qazvin

New insight into the mechanism and evolution of HorseTail splay folds: A case study from the Huayingshan fold belt(South China)

Zhang-peng LIU[1]*, State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China (thatjohnliu3390@gmail.com)
Liang Qiu[2], State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China
Dan-Ping Yan[3], State Key Laboratory of Geological Processes and Mineral Resources, School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China

Abstract

As the seismogenic fault of the Ms6.0 earthquake in Luxian County, China. the Huayingshan Fault bears great significance in seismic prevention due to the presence of the large urban area of Chongqing nearby. Analyzing its lithospheric structure and evolutionary formation mechanism is crucial in clarifying the tectonic history of the eastern Sichuan region. Many studies indicate that the Huayingshan fold belt is a typical Jura-type thin-skinned tectonic belt.

The fold-thrust belts are also considered closely associated with active tectonic earthquakes. The horsetail splay folds in research of the central-southern part of the Huayingshan fold belt have attracted widespread attention, and similar landforms are widely distributed in multiple countries. However, research on their formation mechanisms remains relatively weak. To better understand the mechanism evolution of the present-day landform of the Huayingshan horsetail splay folds. We utilize discrete element numerical simulation in the PFC2D software, based on the inferred regional geological structure of the Mesozoic and Cenozoic. We set the slope angle of the ramp and the depth of the detachment layer as variables, along with reasonable geological parameters. We obtained an extension sequence similar to the chronological results and profile fold topography results highly consistent with the actual geological background, We used the theory of fold linkage and combined it with the historical tectonic background to provide a reasonable explanation for the mechanism evolution of horsetail splay folds plane landforms. We hope that by studying the horsetail splay folds in Huayingshan as an example, we can provide important insights and new approaches into lithospheric structure and tectonic evolution processes for researchers in regions with similar landform units, contributing to global seismic research and disaster prevention efforts.

Keyword

Fold-thrust belt, Horsetail splay, Numerical simulation, DEM, PFC2D

Bonded nanoparticles restrengthen faults during earthquake slip

Jianhua HUANG[1]*, Peking University (huangjianhua1002@126.com)
Bo ZHANG[2], Peking University
Wanrui HU[3], Department of civil engineering, Monash University
Junjie ZOU[4], Institute of Geology, China Earthquake Administration
Honglin HE[5], Institute of Geology, China Earthquake Administration
Jiaxiang DANG[6], Institute of Geology, China Earthquake Administration

Abstract

Faults are the most important sources of seismicity worldwide, while the research on the recovery mechanisms of slip-surface strength or fault healing is scarce. We investigated the microstructures and nanostructures in fault rock of a seismogenic normal fault, hosted in chert-banded dolostones, from the Yuguang Basin South Margin Fault (YBSMF), northeast of the Shanxi graben system, North China. Also, high velocity shear experiments were conducted on the quartz-bearing dolomite fault gouge taken from the YBSMF. The behavior and its effects of nanoparticles during high-speed slipping are simulated by discrete element method (DEM). The fault slip surface exhibits a range of slip-related structures, including slickenlines, truncated clasts and nanoparticles/fragments. These nanoparticles are shaped into two forms, single spherulitic nanoparticles (size ranges from 50 to 300 nm) and agglomerated nanoparticles (size ranges from 300 to 500 nm). The textures of the gouge from high velocity experiments are characterized by grain comminution, R shear planes and localized deformation zone in the friction weakening stage. The slip surfaces of the gauge are characterized by mirror-like smooth surface and nanoparticle aggregates. Theoretical calculation results show that the temperature inside the gauge layer did not exceed 300 °C during the experiments. However, the microstructures present that the dolomite experienced thermal decomposition, indicating that the temperature at the asperity exceeds 550 ℃. Our microstructural investigations suggest the single spherulitic nanoparticles can be the result of thermal decomposition of dolomite along the major slip surface of the normal fault. Numerical simulation results from DEM present that the shear strength surges exponentially with the increasing volume percent of bonded nanoparticles. We suggest that the transformation from single spherulitic nanoparticles to agglomerated/bonded nanoparticles by sintering can result in the recovery of friction strength at the fault plane. The post-seismic strength recovery can partly attribute to formation of agglomerated nanoparticles.

Keyword

Nanoparticle, Carbonate fault rock, Fault recovery, Earthquake slip

Seismogenic structures of the 2022 M6.1 Lushan earthquake and M6.0 Maerkang earthquake sequence in western Sichuan, China

Chuanyou LI[1]*, Institute of Geology, China Earthquake Administration (chuanyou@ies.ac.cn)
Kai Sun[2], Institute of Geology, China Earthquake Administration
Junjie Li[3], Institute of Geology, China Earthquake Administration

Abstract

Both the Lushan Ms6.1 earthquake on June 1 and the Maerkang M6.0 earthquake swarms on June 10, 2022 occurred in the the eastern part of Bayan Har block west of Sichuan Province, where the NE-trending faults have dominated, and the structures are relatively complex. Among them, the Lushan Ms 6.1 magnitude earthquake occurred in the southwest section of the Longmenshan fault zone. Whether it was an aftershock of the 2013 Lushan magnitude 7.0 earthquake and whether it occurred in a seismic gap are the main points of contention. The Maerkang earthquake sequence occurred in the northwestern section of the Songgang fault. This fault has received little attention and been not well studied, therefore no consensus on its activity. In order to understand the cause of these two earthquakea, determine the seismogenic structure of the earthquake, and determine the future seismic trend, we conducted a field investigation of the geological structures, surface deformations and disaster distribution characteristics around the epicenter. The field observations of the Lushan M6.1 earthquake show that on the southeast side of the epicenter, the distribution of earthquake disasters including landslides and rockfalls were scattered and the sizes of landslides were also relatively small; whereas on the north west side of the epicenter the landslides and other earthquake disasters were densely distributed and showed big sizes, especially along the belt from north of Baoxing county to the east of Yanjing township. The field investigation combined with the results of the focal mechanism solution and the relocation of aftershocks, suggest that the seismogenic structure of this earthquake is a northwest-trending thrust fault between the Yanjing-Wulong fault and the Shuangshi-Dachuan fault, which is a small, secondary fault. The field investigation of the M6.0 earthquake sequence in Maerkang showed that the earthquake occurred in the northwestern section of the Songgang fault, which was an immature section with a complex structure. The surface deformation caused by the earthquake, such as building damage, ground fissures and landslides, is not distributed along the main fault showing a linear characteristics, but is arranged in a row along a belt located on the east side of the main fault and nearly parallel to it. Combined with the analysis of the results of relocation of aftershocks and focal mechanism solution, it can be concluded that the earthquake rupture did not occur along the main Songgang fault, but along the branch fault on the east. Above studies show that the Lushan M6.1 and Maerkang M6.0 earthquakes both occurred on secondary faults, which were the results of the unified movement of the Bayan Har block in the same tectonic environment.

Keyword

Lushan M6.1 earthquake, Maerkang M6.0 earthquake swarm, Seismogenic structures, the Longmen Shan fault zone, the Songgang fault

3D modeling and seismic capablity assessment of the east margin fault of Daxing uplift in North China Plain

Zhengfang LI[1]*, Institute of Geology, China Earthquake Administration (lizhengfang07@163.com)
Bengang zhou[2], Institute of Geology,China Earthquake Administration
Yajing Zhang[3], Institute of Geology,China Earthquake Administration

Abstract

The east margin fault of Daxing Uplift is an important boundary fault in the North China Plain, which controls the development of Langgu secondary depression under the extensional tectonic background. The latest shallow seismic reflection profile and borehole data have found evidence of Holocene activity in the eastern margin of the Daxing Bulge, which has changed the conclusion in recent decades that there has been no activity since the late Quaternary, and has important application value for the seismic hazard risk survey in Beijing, and also poses a new challenge to the assessment of the upper limit of the maximum potential magnitude of the eastern margin of the Daxing Bulge. In this research, by collecting and organizing several shallow seismic geophysical profiles and deep seismic reflection profiles, a 3D model of the east margin fault of Daxing Uplift is constructed by using the 3D modeling software SKUA-GOCAD, which mainly includes: (1) 3D fault model and stratigraphic information map; (2) three-dimensional model diagram of fault distribution according to dip Angle; (3) Three-dimensional model diagram of fault distribution according to depth and three-dimensional map of small earthquake distribution. Finally, by using the structural analogy of the summer pad fault on the eastern margin of the Daxing uplift, the maximum potential magnitude induced by the Daxing fault is evaluated, and the following conclusions are drawn: (1) It is inferred in the research that the lower part of the fault on the eastern margin of the Daxing uplift is connected with the deep and shallow fault cutting the upper and lower crust interface and Moho surface, and it is a deep and shallow fault. (2) In this research, 15 shallow seismic geophysical profiles were collected and organized, and three-dimensional models of the east margin fault of Xiadian uplift according to strike, dip Angle and depth were constructed by using SKUA-GOCAD three-dimensional modeling software. (3) Based on the principle of structural analogy and the magnitude-fault rupture scale relationship obtained by predecessors for North China, this paper comprehensively estimates that strong earthquakes of magnitude M7.5 may be induced on the eastern margin of the Daxing uplift, and surmises that the eastern margin of the Daxing uplift still has the possibility of large earthquakes. This conclusion has important scientific guiding significance for earthquake disaster prevention and control in the Beijing area in North China Plain, and should be paid attention to and actively take prevention and avoidance measures.

Keyword

the east margin of the Daxing Uplift, 3D modeling, seismic reflection profiles, seismic capablity

assessment

Evidence of Quaternary surface rupturing in the southernmost end of the Yangsan fault and deterministic seismic hazard assessment in the Busan metropolitan area

Hyunjee LIM[1]*, Pusan National University (lim_hyunjee@pusan.ac.kr)
Sangmin HA[2], Korea University
Chung-Ryul RYOO[3], Korea Insttitute of Geoscience and Mineral Resources
Tae-Ho LEE[4], Korea Insttitute of Geoscience and Mineral Resources
Moon SON[5], Pusan National University

Abstract

The Gyeongju Earthquake (Mw 5.8, on September 12, 2016) and Pohang Earthquake (Mw 5.4, on November 15, 2017) had a significant impact on Korea's geological and seismological researches, producing a wealth of research results. The series of earthquakes has generated a lot of fundamental research, but not much that is directly relevant to the public. In this study, we aim to cover both basic research and application. 1) We report on the Quaternary surface rupture (Gasan) at the southernmost end of the Yangsan Fault near two cities (Busan & Yangsan) (Active faulting behavior, Field observation). Based on this surface rupture's information with geotechnical database, 2) we analyze the seismic hazard assessment in the Busan metropolitan area (Earthquake hazard zonation, Data processing). Ultimately, 3) we provide data for practical preparedness against earthquake risk (Urban prevention strategies, Scene simulation).

1) Active faulting behavior (Field observation); Yangsan Fault is a major tectonic line in the southeastern Korean Peninsula that traverses major cities in the Yeongnam region, including Busan, Yangsan, Ulsan, and Gyeongju. Previous studies have reported numerous Quaternary fault sites associated with moderate to large-magnitude earthquakes along the fault. The surface rupture trace identified in this study at Gasan-ri, Yangsan, is located at the southernmost end of the Yangsan Fault and are very close to the Busan, the second largest city in South Korea. Two northeast-striking fault planes cut the alluvial fan deposits with 1 m vertical displacement in outcrop section. The OSL dating of the unconsolidated sediments indicates that the most recent earthquakes with surface rupture occurred after 111±7 ka, the late Pleistocene.

2) Earthquake hazard zonation (Data processing); Seismic hazard assessment for the Busan metropolitan area was conducted using the surface rupture evidence and geotechnical database. The moment magnitude estimated using the vertical displacement and the maximum displacement-moment magnitude empirical equation (Wells and Coppersmith, 1994) is 6.5. Based on the surface rupture point, a radius of 30 km from the epicenter was defined as the Busan metropolitan area for deterministic seismic hazard assessment. The site classification was determined based on the Korean domestic site classification of Sun (2010) using the bedrock depth and the average shear wave velocity up to 30 m depth extracted from the borehole data.

3) Urban prevention strategies (Scene simulation); If an earthquake of magnitude 6.5 occurs in Gasan in 2024, huge damage may occur in Mulgeum of Yangsan, Eco-Delta City of Busan where more than 560,000 people live. This result of seismic hazard assessment can be utilized for

developing earthquake disaster prevention plans and strategies as one of the earthquake disaster occurrence scenarios. Future studies should include additional research considering building codes, building structure, factors of fire occurrence, and emergency response planning for further quality improvement.

Keyword

Yangsan Fault, active fault, seismic hazard assessment, geotechnical data

Mechanism analysis of underground powerhouse structure-stress-controlled collapse in fractured rock mass: microseismic monitoring and numerical investigation

Yuepeng SUN[1]*, State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University (ypsun1997@163.com)
Nuwen Xu[2], State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University
Biao Li[3], School of Geoscience and Technology, Southwest Petroleum University
Haoyu Mao[4], State Key Laboratory of Hydraulics and Mountain River Engineering, Sichuan University

Abstract

The stability of the surrounding rocks of large underground powerhouses is always emphasized during the construction process. The development of unfavorable rock mass structural planes such as fault will lead to large excavation deformation and obvious discontinuous deformation characteristics. An extremely intense collapse case observed in underground powerhouses in southwestern China was introduced as a case study. To understand the damage evolution mechanism in collapse, microscopic characterization of unloading damage evolution process of surrounding rock is carried out based on microseismic (MS) dynamic monitoring information. Second, to further reflect the characteristics of rock failure evolution and deformation response in the monitoring section, the digital panoramic borehole camera and acoustic wave test are arranged. The results show that the excavation unloading not only causes surrounding rock fracturing near the periphery of the cavern but also induces deep fracturing at a certain depth from the periphery of the cavern. Subsequently, based on numerical simulation and moment tensor inversion method, the evolution of the temporal distribution of the fine fracture type of the surrounding rock mass is clarified; For the evolution mechanism of the fault-slip collapse, many tensile fracture events occurred during the development stage, and a few shear fractures, corresponding to structure plane dislocation, occurred before the occurrence of the fault-slip collapse. The results provide a direct case history that will assist the prediction and support of fault-slip collapse disasters and contribute to excavation of deeply-buried caverns in the field.

Keyword

Underground powerhouse, MS monitoring, Numerical simulation, Gently inclined faults, Progressive failure characteristics

The Characteristics of Geostress Field and Fault reactivation analysis Assessment in the Cucumber Mountain Area, southern Sichuan Basin

Zifan Zhu[1]*, China university of petroleum (East China) (anya187346068@163.com)
YangWen Pei[2], China University of Petroleum (East China)

Abstract

Due to the complex stress field and shale gas extraction, the faults in the Huanggua Mountain area are prone to reactivation, leading to incidents such as casing deformation and microseismic events. Therefore, accurately understanding the spatial distribution pattern of the stress field and evaluating the risk of fault reactivation are crucial for shale gas extraction. By comprehensively considering seismic data, logging data, and the spatial geometry of faults, numerical simulations of the stress field were conducted to ascertain its spatial distribution pattern. Based on the numerical simulation results, a novel method for evaluating fault reactivation was proposed, which combines differential matrices with the Coulomb-Mohr rupture criterion (fR=σn /τ), revealing the spatial distribution differences of fault reactivation risk along fault attitudes. Simultaneously, through the correlation analysis of horizontal wellbore deformation and microseismic data, the impact of fault reactivation on shale gas extraction was quantitatively evaluated. The research findings reveal that: (1) The stress distribution in the Huanggua Mountain area exhibits significant spatial variations, with the stress in the syncline zone being higher than that in the anticline zone, and the stress in the southwest region being higher than that in the northeast region, with the stress in thrust and back-thrust zones being higher than that in single thrust zones. (2) The risk of fault reactivation exhibits significant spatial variations and local high-value characteristics, gradually decreasing from north to south, but showing higher risk at areas of fault strike changes, connections, and overlaps. (3) There is a significant correlation between casing deformation and microseismic events with the risk of fault reactivation and the distribution of high shear stresses. With the increase in reactivation risk and shear stress, the probability and intensity of microseismic events and casing deformations also increase.

Keyword

Shale gas, Fault Reactivation analysis, Numerical simulation, Ground stress distribution characteristics, Triaxial stress analysis

Unveiling the Hidden Dynamics: A Comprehensive Exploration of the Greater Himalayan Out-of-Sequence Thrust and Active Faults in the Sutlej River Section, India

RAJKUMAR GHOSH[1]*, DEPARTMENT OF EARTH SCIENCES, IIEST SHIBPUR, HOWRAH, WEST BENGAL, INDIA, 711103 (rajkumar.ghosh.2020@gmail.com)
ATIN KUMAR MITRA[2], DEPARTMENT OF EARTH SCIENCES, IIEST SHIBPUR, HOWRAH, WEST BENGAL, INDIA, 711103

Abstract

The Himalayan tectonics is composed of three major in-sequence foreland-propagating (southward) orogen-scale thrusts (MCT, MBT, and MFT), as well as North-to-Northeast-dipping Out-of-Sequence Thrusts (OOST) and additional back structures. Looks deeply into the unique structural pattern and intriguing dynamic tectonic setting of the Greater Himalayan Out-of-Sequence Thrust (GHOST) in the Sutlej River basin, from the Oligocene to the present. The Jhakri Thrust (JT)-Jeori Dislocation (JD)-Sarahan Thrust (ST)-Chaura Thrust (CT) system has recently been identified as a possible orogen-scale out-of-sequence thrust (OOST) in the proximal footwall of Main Central Thrust in NW Himalaya. The Jeori Dislocation (JD) and Sarahan Thrust (ST) are situated between the Main Central Thrust (MCT) and South Tibetan Detachment Zone (STDZ), but their age is similar to Himalayan Frontal Thrust (HFT) or Main Frontal Thrust (MFT) (<2.5 Ma).

Focuses on active thrust faults, including CT, which has a hanging wall exhumation rate of 4.82±0.55 mm/yr. and a footwall exhumation rate of 0.61±0.10 mm/yr. These geological data provide valuable insights into complex tectonic processes shaping Himalayan orogeny.

Emphasizes importance of understanding brittle-ductile style deformation processes, looks at multi-scale tectonics of the Greater Himalayan brittle-ductile style inside western Himalayan terrain. MCT reactivation was observed in setting of out-of-sequence faulting as late as the Pliocene. Perhaps a south-directed out-of-sequence fault disrupts upper plate of Himalayan orogen, overlapping (and cutting) pre-existing faults.

The fundamental approach includes of field observations, structural mapping, and geochronological analyses, which incorporate cutting-edge techniques spanning from outcrop-scale to microstructural analysis to provide a comprehensive picture of structural evolution. This section provides a detailed analysis of structural features of Greater Himalayan Out-of-Sequence Thrust, including fault geometry, fault-related folds (including intriguing box fold and micro-slip in the centre of box fold), and associated structures (irregular quartz vein with varying thickness) at various stages of symmetric and asymmetric shaped boudins, S-C fabrics (top-to-bottom shearing).

The emphasis is on identifying strain patterns and understanding the GHOST's kinematics. These geological correlations reconstruct tectonic history of Sutlej River segment, focusing on key episodes of deformation and metamorphism. In terms of broader implications, this section focuses

on contribution to understanding of Himalayan tectonics and potential implications for seismic hazard assessment in Jhakri (Nathpa area), Jeori, Sarahan, and Chaura regions. As a result, structural setting imposes numerous minor earthquakes (near Rampur areas) or release of stress energy in form of strain or fault-controlled hot springs over the area (along the right bank of the Sutlej river in Nathpa, near Jeori on Hindustan Tibet Road to Spiti valley) over geological time. The significance of structural pattern (box fold, kink fold, tension gases, S-C fabrics, Y-P planes, asymmetric boudins, and asymmetric quartz veins) and tectonic history of Greater Himalayan Out-of-sequence Thrust in Sutlej River section, as well as future research and exploration opportunities in this dynamic geological environment.

Keyword

Himalayan Geoscience, Greater Himalayan Sequence (GHS), Collisional Orogeny, Structural Evolution, Seismic Hazard Assessment

Deformation-Time Constraints on the South Tibetan Detachment System in the Cuona area, eastern Himalaya

Zhuo Tang[1], Institute of Geology, Chinese Academy of Geological Sciences
Hanwen DONG[2]*, Institute of Geology, Chinese Academy of Geological Sciences
(donghanwen123@126.com)
Rongze Fei[3], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The South Tibet detachment system (STDS) is a set of stretched dissociation systems developed along the Himalayan orogenic belt, and its formation process is closely related to the uplift history and evolution process of the Himalayan orogenic belt, which is an important object for studying the tectonic deformation in the process of Indo-Eurasian collision and orogeny. Cuona Detachment (CD) is a ductile shear zone several kilometers wide in which a large number of different types of leucogranites develop, and on the basis of large-scale field mapping, two phases of leucogranites are identified in CD: early syn-tectonic leucogranites and late post-tectonic leucogranites. In this paper, zircon LA MC-ICP-MS U-Pb analysis tests were performed on three early leucogranites bodies and two late leucogranites bodies. Zircon U-Pb dating results showed that CD continued to be active at 20 Ma until it stopped around 14.8-16.5Ma. At the same time, combined with the results of previous research, the evolution process of STDS in the Cuona region and its difference along the orogenic belt were further explored. Along the Himalayan orogenic belt, the activity time of STDS in different regions showed obvious differences, and this paper believes that the STDS cessation time mainly shows a trend of gradually becoming younger from the western tectonic junction to the east (such as the Cuona area).

Keyword

Himalayan orogen, STDS, Deformation, Zircon U-Pb Geochronology

Constraining the evolution of shear zones in the Himalayan mid crust in Central Nepal: implications for the exhumation of the Himalayan metamorphic core

Rodolfo CAROSI[1]*, University of Turin (rodolfo.carosi@unito.it)
Chiara Montomoli[2], University of Turin
Salvatore Iaccarino[3], University of Turin

Abstract

The mid-crust of the Himalaya is exposed in the Greater Himalayan Sequence (GHS), one of the major tectonic units of the Himalayan belt cropping out for nearly ~ 2500 km along strike. GHS is regarded as coherent tectonic unit, bounded by the South Tibetan Detachment to the top and the Main Central Thrust to the bottom. Integrated studies by different techniques allowed to recognize several high-temperature shear zones in the core of the GHS, with top-to-the S/SW sense of shear (High Himalayan Discontinuity: HHD, (Montomoli et al., 2015) U-Th-Pb in situ monazite petrochronology provides ages older than the Main Central Thrust, along the same structural profile. Data on P-T evolution testify that these shear zones, acting for ~ 5-10 Ma, affected the tectono-metamorphic history of the belt and different P-T conditions have been recorded in the hanging-wall and footwall of the HHD. Burial and prograde metamorphisms in footwall rocks were linked to thrust sense movement along the HHD, while the hanging wall rocks were retrogressed and exhumed. This shear zone, running for nealry 1000 km , is documented in several sections of the belt. We present the results of some transects of the GHS in the Annapurna-Manaslu massif (Central Nepal). Close to the transition between sillimanite-bearing gneiss and kyanite-bearing gneiss, we identified a high-temperature ductile shear zone with kinematic indicators pointing to a top-to-the S sense of shear.

In situ U-Th-Pb analysis on monazite, joined with chemical compositional maps, on samples from the shear zone and its footwall provided ages ranging from ~ 8 to 43 Ma. The age of the HHD in central Nepal is constrained between ~ 28/27 and 17 Ma, in very good agreement with the ages of the HHD detected along strike in the GHS (Carosi et al., 2018). It is notably older than the Main Central Thrust along the same section (Catlos et al., 2001; Gibson et al., 2015) constrained at ~ 17-13 Ma.

The occurrence of the HHD in Central Nepal allows us to fill a gap in the recognition of the HHD in the Himalayan belt. Thus this study is a step towards a precise identification of the burial, assembly and exhumation mechanisms of the Himalayan metamorphic core.

References

Carosi R., Montomoli C. & Iaccarino S. 2018. 20 years of geological mapping of the metamorphic core across Central and Eastern Himalayas. Earth Sci. Rev., 177, 124-138.

Catlos E.J., Harrison T.M., Kohn M.J., Grove M., Ryerson F.J., Manning C.E. & Upreti B.N. 2001. Geochronologic and thermobarometric constraints on the evolution of the Main Central

Thrust, central Nepal Himalaya. J. Geoph. Res., 106, 16177-16204.
Gibson R., Godin L., Kellett D.A., Cottle J.M. & Archibald D. 2016. Diachronous deformation along the base of the Himalayan metamorphic core, west-central Nepal. GSA Bull., 128, 860-878.
Montomoli C., Carosi R. & Iaccarino S., 2015. Tectonometamorphic discontinuities in the Greater Himalayan Sequence: a local or a regional feature? Geol. Soc., London, Sp. Publ., 412, 25–41.

Keyword

Himalaya, Exhumation, Petrochronology

[Keynote] Utilizing Multi-Mineral Multi-System Petrochronology to Unravel the Tectonic Development of the Himalaya

John COTTLE[1]*, University of California Santa Barbara (cottle@geol.ucsb.edu)
Kyle Larson[2], The University of British Columbia Okanagan

Abstract

Petrochronology, or the interpretation of isotopic dates in light of additional contextual data (e.g., microstructure, textures, trace element-, and isotope-geochemistry), is a key tool for understanding the timing and rates of orogenic events. The expansion (e.g. in situ Lu-Hf and Rb-Sr geochronology) and refinement (e.g. U-Th/Pb geochronology) of petrochronologic methods, as applied to the Himalayan orogenic system, has enabled the investigation of previously intractable geological problems, and the resolution of long-standing debates about the timing and duration of a range of geologic processes. In this presentation, some of the key recent advances in geochronologic instrumentation and analytical techniques will be highlighted, including 1) the application of in-situ Lu-Hf garnet geochronology combined with quantitative modeling to robustly interpret the geologic significance of garnet-based dates from metamorphic rocks; 2) Three-dimensional simultaneous imaging of U-Th/Pb, trace elements Sm-Nd isotopes in monazite and xenotime to unravel the complex history of melt formation and migration, and; 3) applications of a new generation of time-of-flight mass spectrometer to high-resolution (micron-scale) geochronology of a range of accessory minerals to document cryptic tectonothermal events. The presentation will conclude with a discussion of how the application of these, and other methods, has transformed our understanding of the processes that define the development of the metamorphic, magmatic, structural, and exhumation history of the Himalayan orogen.

Keyword

Petrochronology, Himalaya, Geochronology, Tectonics

The geodynamics of long-term convergence, Indian continental subduction and indentation at the India-Eurasia collision zone

Wouter Pieter SCHELLART[1]*, Vrije Universiteit Amsterdam (w.p.schellart@vu.nl)
Kai Xue[2], Vrije Universiteit Amsterdam
Arijit Laik[3], Vrije Universiteit Amsterdam
Vincent Strak[4], Vrije Universiteit Amsterdam

Abstract

Continent-continent collision is generally a relatively short-lived process, lasting up to max. several tens of Myr, as the convergence rate progressively decreases during the collision process. The short duration and decrease in convergence rate are thought to result from the reduction and eventual disappearance of the driving force during collision. The India-Eurasia collision, resulting in the largest mountain belt and plateau on Earth, the Himalaya and Tibet, respectively, are unusual in this respect, because relatively rapid India-Asia convergence (at 4-5 cm/yr) and mountain building have continued since the onset of collision at ~60-50 Ma. The collision is also unusual in that it has resulted in major indentation and northward advance of the collisional plate boundary, and major continental subduction of Indian lithosphere. Many previous studies consider an external driving force for the long-term convergence, continental subduction and Indian indentation. In this study, we investigate the mechanism(s) of the continued convergence, long-term continental subduction and long-term indentation of India into Asia using buoyancy-driven geodynamic models. We present results of time-evolving analogue experiments and numerical models performed in three-dimensional space to simulate the subduction and collision processes at the India-Eurasia-Sunda convergent boundary with different boundary conditions at the 660-km discontinuity. These include models that are confined to the upper mantle and models that incorporate a lower mantle reservoir. The results of both modelling techniques indicate that indentation and collisional plate boundary advance occur in all models, irrespective of the layering of the mantle, but is progressively enhanced for models with an increase in viscosity step at the 660 km discontinuity. Furthermore, both the analogue experiments and numerical simulations indicate that long-term convergence and continental subduction require subduction of slab material into the lower mantle, as the lower mantle slab segments provide the main drive for such convergence and continental subduction. Finally, our models suggest that the negative buoyancy force of both upper and lower mantle slab segments of the Sunda slab and the lower mantle Tethyan slab segment below the collision zone are the main driver of long-term convergence and continental subduction, while the combination of rollback-induced mantle flow of the Sunda slab and slab negative and positive buoyancy forces of the Sunda and India slabs, respectively, drives northward Indian indentation.

Keyword

collision, subduction, indentation, mantle flow, orogen

Break-up of Pangaea and Gondwana Reflected in the Tectonics of the Eastern Himalayan Syntaxis

Neptune Srimal[1]*, Florida International University (srimal@fiu.edu)
Manoj Kumar Sahoo[2], Geological Survey of India
Khrieliebeizo Sekhose[3], Geological Survey of India
Prasanta Sanyal[4], Indian Institute of Science Education and Research, Kolkata
David A Foster[5], University of Florida

Abstract

Current models of the tectonics of the Eastern Himalayan Syntaxis in the Arunachal Pradesh of NE India project the Indus -Tsangpo suture along the NW-SE trending Tiding-Mayodiya-Tuting ophiolite belt. This ophiolite belt divides the region into a northeastern Lohit Plutonic Complex and associated metasediments and the southwestern block representing the Indian plate margin. The southwestern block is composed of gneiss, schists and volcano – sedimentary sequences of Proterozoic to Eocene age herein is called the Dibang Block.

Extensive fieldwork along with U-Pb, Lu-Hf and carbon lipid profile analysis and aided by published geochemical, isotopic and detrital zircon date leads to the conclusion that:

1. The Lohit plutonic complex consists of three generation of granitic magmatism represented by a. Late Jura-Early Cretaceous Gabbro-diorite complex with positive εHf formed contemporaneous with rifting of the Lhasa terrane from the Gondwanan margin b. Trodjhemite-Granodiorite-Hornblende-Biotite Granites with positive εHf and low initial Sr ratio of largely mid to late Cretaceous age formed by far field extension by subduction pull related to the subduction of Lhasa terrane along Bangong NuJiang Suture . c. Miocene S-type Leucogranite intruding both of the above granites which we relate to the post indentation rotation, oblique-slip faulting and transpression of the Lohit terrane and the Indian plate margin.

2. All the above granites show adakitic signature which for the Cretaceous granites formed by decompression melting in an extensional setting. The Miocene leucogranites were formed by post-convergence anatexis of crustal rocks in a manner analogous to the formation of Himalayan leucogranites.

3. None of these granites represent subduction related arc magmatism or correlate with the late Cretaceous-Eocene Gangdese batholith of Tibet. In our model, the Lohit Plutonic Complex represents the Central Lhasa block. The South Lhasa block terminates at the Namche Barwa syntaxis.

The Dibang Group is composed of volcano-sedimentary strata that overlie basement of the late Paleoproterozoic Bomdilla Gneiss dated at c.1750 Ma. On the basis of lithologic mapping, detrital zircon data, carbon lipid profile and published paleomagnetic data from the interbedded metavolcanic beds, we propose the entire sequence to be time equivalent to the Permian Gondwanan formations that occurs at the southern margin of our area that were deposited in several parallel rift bound basins. during the rifting of the Qiangthang terrain from the Gondwanan

margin. This Permian sequence forms the pre-rift base for the overlying Abor Volcanics of early Cretaceous age. The volcanics are interbedded with purple and green sandstones and shales, variously named Miri Quartzite, Yinkiong Formation and Hunli Formation and represent syn-rift sedimentation and volcanism related to the rifting of India and Australia in the Cretaceous. The overlying Dalbuing Formation with Eocene plant and shallow marine micro fossils represent post-rift sediments.

Geochemically, the mafic-ultramafic rocks of the Tiding-Mayodiya-Tuting ophiolite belt represent sub continental lithospheric mantle exhumed during extension of Gondwana, and do not represent an oceanic subduction zone or suture.

The Dibang Group is correlatable with the rocks of the Shillong Plateau and not with the lesser or Higher Himalayan rocks.

Keyword

Eastern Himalayan Syntaxis, NE Himalaya, Continental Rifts

Himalayan Influence Tectonic and Exhumation history of the Shillong Plateau and Mikir Hills, NE-India: Constraints from Low-temperature Thermochronological Analysis

RAMESH CHANDRA PATEL[1]*, Department of Geology, Institute of Science, Banaras Hindu University (BHU), Varanasi -221005, INDIA (patelramesh63@bhu.ac.in)
Sanjeeb Behera[2], Department of Geology, Institute of Science, Banaras Hindu University (BHU), Varanasi-221005, INDIA
Vikas Adlakha[3], Wadia Institute of Himalayan Geology, 33, General Mahadeosingh Road, Dehradun-248001, India

Abstract

Himalayan Influence Tectonic and Exhumation history of the Shillong Plateau and Mikir Hills, NE-India: Constraints from Low-temperature Thermochronological Analysis

R.C. Patel1*, S. Behera1, V. Adlakha2

1. Department of Geology, Institute of Science, BHU, Varanasi,
2. Wadia Institute of Himalayan Geology, 33, General Mahadeo Singh Road, Dehradun

*Corresponding/Presenting author: R.C. Patel (patelramesh63@bhu.ac.in)

The Shillong - Mikir massif within the foreland of the Himalayan orogen, NE-India, is the largest active basement structure in the world. It now occupies a region which is subject to complex tectonic stress patterns on accounts of its location in the proximaty of the tri-junction of the Indian, the Eurasian, and the Burmese plates. The north-south collision between the Indian and Eurasian plates and east-west convergence between the Indian and the Burmese plates impart geologic and complex tectonic setting of the Shillong -Mikir massif. The northern part of the Shillong Plateau is overridden and compressed by the immense load of the Himalayan orogeny along the northeast dipping Main Central Thrust (MCT), Main Boundary Thrust (MBT) and Main Frontal Thrust (MFT) while its southern part is free from such compression and overridden by any load. In contrast, the Mikir Hills is overridden and compressed in the north by the enormous load of the Himalaya along the MCT, MBT and MFT while its south and southeast part is overridden and compressed by the Naga Hills along Halflong-Disang thrust. These two-block located in two such different tectonic regimes have experienced complicated tectonic regime and expected to experience different exhumation history.
To elucidate the exhumation history, Apatite Fission Track (AFT) ages were obtained for 15 samples out of which 08 ages are form Shillong Plateau and remaining 07 ages are from the Mikir Hills. Ages are analyzed combining with previously published ages. The ages in the Shillong Plataeu range between 33.7± 2.4 to 260.7 ± 38.5 Ma and in the Mikir Hills, it ranges between 64.0 ± 3.3 to 169.0 ± 8.8 Ma. Out of 08 AFT ages from the Shillong Plateau, 04 ages ranging between

33.7±2.4 and 91.4±6.2 Ma (With mean age 62.8±3.6 Ma) are from the middle of the Shillong Plateau i.e. from west of Shillong city and other four ages ranging between 119.1± 6.1 and 260.7± 38.5 Ma (With mean age 202.1 ± 22.6 Ma) are from the northern most part of the Shillong Plateau i.e north of Guwahati. In Mikir Massifs, the ages range between 64.0±3.3 and 169.0±8.8 Ma (With mean age = 104.5±9.8 Ma). Younging age pattern from northern edge (260.7 ± 38.5 Ma) to southern edge (8.6 ± 0.6 Ma) of the Shillong Plateau reflect that the southern edge was buried below closing temperature of AFT i.e. ~120 °C while the northern edge was over the 120 °C isotherm of AFT prior to Miocene time. In the other hand the Mikir Hills was exhuming slowly i.e. similar to the Guwahati region of Shillong Plateau.

Keyword

Himalayan Orogen, Shillong-Mikir massifs, Exhumation, AFT ages

Tectonic collision of Indian-Asian plates and the evolution of Himalaya foreland basin

KUN YU[1]*, China University of Mining and Technology (yukun@cumt.edu.cn)
Yiwen JU[2], University of Chinese Academy of Sciences
Bhupati Neupane[3], University of Chinese Academy of Sciences

Abstract

After continental collision of India-Asia plates in the Cenozoic, sediments deposited in the peripheral foreland basin were reworked and recycled in the southern margin of the Himalaya. A magnetostratigraphic and low-temperature thermochronology study of the post collision belt in Tansen Basin, central Himalaya was conducted to further constrain the age and evaluate the tectono-thermal history of the Himalayan fold-thrust belt in Nepal. The observed sequence of polarity zones correlates with the chron C7n1 to chron C6Bn1 in the Geomagnetic Polarity Time Scale spanning the time frame ca. 24 to 21.5 Ma. Detrital ZHe ages from the upper part of Bhainskati Formation and overlying lower to upper Dumri Formation range from ~126 to 7 Ma, with a dominant population of ~15-10 Ma in the Dumri Formation are spread across a range of eU values. This age range is younger than the proposed stratigraphic age of the host sediments and suggests substantial post-depositional Miocene thermal resetting of the ZHe system followed by relatively rapid cooling. The ZHe age pattern suggests an inverted age relationship, which is attributed to thermal metamorphism resulting from overthrusting by a hot nappe which is no longer preserved. This thermal effect however, is less apparent in outcropping coal measures of the underlying upper part of Bhainskati Formation, where vitrinite reflectance measurements suggest maximum post-depositional paleotemperatures attained were ~85-90°C. This study also indicated provenance change, after collisions of Indian-Asian plates, and exhumation history of the foreland basin in the central Himalaya since the early Miocene.

Keyword

continental collision, foreland basin, provenance, Himalaya region, tectonic evolution

COMPLEX THICK- AND THIN-SKINNED THRUSTING WITHIN THE NW QAIDAM BASIN, TIBET, CHINA – OR HOW TO SALT THE DESERT

Piotr KRZYWIEC[1]*, Institute of Geological Sciences, Polish Academy of Sciences (piotr.krzywiec@twarda.pan.pl)
Fanwei Meng[2], School of Resources and Earth Sciences, China University of Mining and Technology, Xuzhou, China
Adam Baranowski[3], Institute of Geological Sciences, Polish Academy of Sciences, Warsaw, Poland
Wenhang Liu[4], Institute of Geological Sciences, Polish Academy of Sciences, Warsaw, Poland
Stanisław Mazur[5], Institute of Geological Sciences, Polish Academy of Sciences, Kraków, Poland

Abstract

Cenozoic closure of the Tethys Ocean in central Asia was associated with formation of an extensive zone of tectonic compressional deformations reaching the N margin of the Tibetan Plateau and beyond. One of the northernmost zones of compressional deformations is known from the NW part of the Qaidam Basin, located above the Tibetan Plateau in W China. Previous structural models for this zone, either based solely on surface field data and rather conceptual, or based on 2D seismic data with limited depth imaging, have suggested the presence of a rather simple thrust fault system rooted within the pre-Cenozoic (Meso-Paleozoic) basement and associated folds developed within the Paleogene-Neogene shallow water to terrestrial sedimentary succession of the Qaidam Basin. High-quality 3D seismic data acquired above the Jandingshan, Heiliangzi i Janbei anticlines in the NW Qaidam Basin proved that a much more complex model should be used to explain the structure and evolution of this compressional belt. The new model, supported by a balanced cross-section constructed using seismic data, consists of two main components: (1) thin-skinned thrusts detached within the Eocene evaporites, and (2) thick-skinned thrusts and backthrusts developed with the Meso-Paleozoic basement. Shallow growth strata precisely imaged by seismic data indicate very recent, Pliocene – Quaternary thrusting, uplift, and localized erosion. The proposed structural model also provides new clues about the origin of present-day salinity of numerous lakes located in the Qaidam Basin. At least partly this salinity might be related to erosion and redeposition of Eocene evaporites that were transported to the surface along recently active thin-skinned thrusts.

Seismic data used in this study was kindly provided by China National Petroleum Corporation (PetroChina) which is acknowledged with many thanks. IHS Markit is thanked for providing academic license of the Kingdom seismic interpretation software. This study was supported by statutory research funds of Institute of Geological Sciences, Polish Academy of Sciences.

Keyword

Qaidam basin, Tibet, compression, salt

Wedge-scale deformation in the Himalaya through time

Malay MUKUL[1]*, IIT Bombay (malaymukul@iitb.ac.in)

Abstract

The Himalayan boundary is wedge-shaped with a basal decollement or the Main Himalayan thrust (MHT). Transfer of slip along the MHT from the wedge backstop in the hinterland to the Himalayan foreland through time is the key to understanding Himalayan deformation from geological through decadal scales. Results from the Global Positioning System (GPS) measurements indicate that slip along the MHT is highest and aseismic in the Himalayan hinterland. The slip accumulates along the MHT as it climbs up section into the brittle regime from a ductile regime and is converted into shortening in the Lesser Himalayan Duplex. This also causes the maximum vertical uplift in the Himalayan wedge near the Lesser Himalayan Duplex indicating that the Himalayan wedge is currently sub-critical. Slip has been periodically transferred along MHT to the mountain front through time whenever the Himalayan wedge becomes critical. Slip has also been transferred forelandward from the locked region in out-of-sequence deformation thrusting. Out-of-sequence thrusts also appear to have ductile deformation signatures indicating prolonged out-of-sequence deformation in the frontal Himalayan wedge and change in deformation mechanisms in these faults possibly due to overburden removal in the wedge by erosion. Channel flow activity in the Higher Himalaya also operated out-of-sequence in the wedge to build taper in the sub-critical Himalayan wedge in the hinterland. Interseismic seismicity in the Himalaya is associated with the slip accumulation zone near the Lesser Himalayan Duplex. Great earthquakes are typically expected when the Himalayan wedge becomes critical and slip is transferred to the Himalayan front as evident from multiple palaeoseismic studies in the frontal Himalaya. In the hinterland, continued normal faulting and normal fault-related seismicity indicates that the wedge hinterland has been super-critical at times too. Such wedges typically develop into salients with multiple frontal imbricates forming a frontal schuppen belt without a well-defined Main Frontal thrust. Himalayan recesses have a well-defined Main Frontal thrust and may also have a hinterland rift in some cases. This work shows that the deformation in the Himalayan wedge varies through time and space but is consistent in terms of decollement tectonics and slip transfer along the MHT.

Keyword

Himalayan Wedge, Sub-critical wedge, Out-of-sequence thrusting, Lesser Himalayan Duplex, Salient-Recess

Spatial and temporal stress variations along a continental megathrust: case study of the Himalayan Main Central Thrust

Djordje GRUJIC[1]*, Dalhousie University (dgrujic@dal.ca)
Olivia Rolfe[2], Dalhousie University
Marianne Negrini[3], University of Otago
David Prior[4], University of Otago

Abstract

We investigate the internal deformational structure of an active continental megathrust exposing a full spectrum of active fault behaviours—from aseismic creep at depth to earthquakes creating surface ruptures. Himalayan thrusts, including the Main Central thrust (MCT), have collectively operated over broad ranges of pressure, temperature, and strain rates since the early Miocene. As all these structures merge into the Himalayan basal décollement, the Main Himalayan thrust (MHT), it can be safely assumed that the rocks now at the surface were within the MHT at the time of their deformation. Hence, they offer records of different behaviours along the megathrust.

The MCT in eastern Bhutan is a ductile shear zone extending up to four kilometres into the footwall block. First, we determined the metamorphic peak temperatures across the MCT by Raman spectroscopy of carbonaceous material (RSCM). We established the deformation temperatures by Ti-in-quartz thermobarometry and quartz c-axis textures. Thermal-kinematic history along the transit, for the period of interest, was derived by inverse modelling of the thermochronological datasets obtained by 40Ar/39Ar dating of muscovite, apatite fission-track dating, and (U-Th)/He dating in apatite and zircon (Grujic et al., 2020). From the optimal model, we obtained the Pressure-Temperature histories of the individual points across the shear zone, allowing accurate calculations of the flow stresses.

Further, microstructural and textural analyses of quartz mylonites from the MCT enabled us to quantitatively assess flow stress variations triggered by exhumation-induced pressure and temperature reductions. Notably, the flow stresses at the peak deformation temperatures were the same across the shear zone, but the strain rates decreased by two orders of magnitude from the core to the shear zone boundary. By the cessation of ductile shearing, flow stresses approached approximately 110 MPa. This allowed us to calculate the conditions for frictional slip reactivation of the brittle, seismogenic part of the megathrust.

Finally, microstructural observations under the Scanning Electron Microscope provide evidence that dissolution-precipitation creep accompanied by intergranular dilatation (aka microscale cavitation) was the dominant deformation mechanism during the final stages of ductile deformation.

Grujic, D., Ashley, K. T., Coble, M. A., Coutand, I., Kellett, D. A., Larson, K. P., Whipp Jr, D. M., Gao, M., and Whynot, N. (2020): Deformational temperatures across the Lesser Himalayan Sequence in eastern Bhutan and their implications for the deformation history of the Main Central

Thrust. Tectonics https://doi.org/10.1029/2019TC005914

Keyword

quartz mylonite, flow stress, Main Central Thrust, Himalaya, brittle ductile transition

Effects of structural position on the progressive evolution of internal shear zones from the Himalaya: Insights into orogenic wedge evolution

Pritam Ghosh[1], Indian Institute of Science Education Research (IISER) Kolkata; Department of Earth Sciences, Yonsei University, Seoul, South Korea.
Kathakali BHATTACHARYYA[2]*, Indian Institute of Science Education Research (IISER) Kolkata (kathakali@iiserkol.ac.in)

Abstract

We studied two internal shear zones, the Main Central thrust (MCT) and the Pelling-Munsiari thrust (PT), from the leading-edge to address how kinematic evolutionary paths of two successive internal shear zones vary along their transport direction due to varying structural positions. The rock parcel at the leading-edge exposures lies foreword of the Lesser Himalayan duplex (LHD) and, therefore, records the deformation signatures from trailing-edge locations during its progressive deformation. Hence, these rocks record the most complex and complete progressive deformation history. Structural analysis of the MCT and the PT reveals significant variation in thicknesses, deformation mechanisms, and strain partitioning from the trailing- to the leading-edge of the orogenic wedge.

The thickness-displacement plot signifies strain softening in all the exposed thrust zones, with leading-edge exposures exhibiting additional evidence of reaction and geometric softening. This is attributed to varying deformation conditions and mechanisms along the transport direction, due to decreasing overburden conditions, fault cutting up the section and concomitant erosion. Irrespective of their structural position within the orogenic wedge, exposures of internal thrusts record a non-steady, decelerating strain path. In the leading-edge exposures, the PT with greater connectivity with the immediate footwall duplex records a higher strain, higher translation, and higher pure shear component than the overlying MCT that does not have direct connectivity with the duplex. With a more complete deformation history, the leading-edge exposures of the MCT and the PT zones record a comparatively higher simple shear component and a higher strain than the trailing-edge exposures. We explain this as a result of the dominance of the less competent mylonite domain over the more competent protomylonite domain in the leading-edge exposures. Strain partitioning due to internal structural geometry, a manifestation of the varying deformation conditions along major shear zones, also plays a critical role in their kinematic evolution. This work demonstrates that the structural and kinematic behavior of shear zones associated with orogen-scale internal thrusts are intricately linked to their structural position and connectivity to footwall structures.

Keyword

Shear zones, Kinematic evolution, Himalayan orogen

Magmatic and metamorphic evolution of the Late Cretaceous Muslim Bagh Ophiolite, western Pakistan: Implications for ridge subduction after subduction initiation

Masanari Arao[1], Tohoku University
Takeshi IMAYAMA[2]*, Okayama University of Science (t.imayama@gmail.com)
Yoshihiro Sawada[3], Shimane University
Koshi Yagi[4], Hiruzen Institute for Geology and Chronology
Rehanul Haq Siddiqui[5], Saindak Metals Limited
Dripta Dutta[6], Okayama University of Science

Abstract

The magmatic and metamorphic evolutions of the Muslim Bagh Ophiolite (MBO) can help understand the relationship among supra-subduction ophiolite, subduction initiation, and the former spreading centre in the forearc. Here, we investigated the whole-rock chemistry, mineral composition, P–T conditions, and K–Ar ages of the MBO and its associated units. The whole-rock and magmatic clinopyroxene compositions suggest that the MBO metabasites and tholeiitic basalts of the underlying Bagh Complex originated in a supra-subduction setting and mid-ocean ridges, respectively. Oceanic island basalts are also found in the Bibai Formation and the Bagh Complex. Metamorphic hornblendes in the MBO metabasites record low-pressure amphibolite-facies (partly granulite-facies) metamorphism, indicating a >50 ºC/km geothermal gradient. The K–Ar hornblende and plagioclase ages suggest contemporaneous high T/P metamorphism in the MBO and tholeiitic magmatism in the Bagh Complex at 78–77 Ma, implying that the heat source causing the high geothermal gradient could be due to orthogonal ridge subduction after subduction initiation in the forearc. Higher alkali content and Al values in the hornblende rims than in their cores suggest a pressure increase at high temperatures in a compressional setting. Our results, combined with those of the previous studies, demonstrate that the geothermal gradient in the MBO dropped from >50 ˚C/km at 80–72 Ma to 15–25 ˚C/km at approximately 65 Ma due to gradual steepening of the subducting slab, followed by the obduction of the MBO during the Late Cretaceous to Eocene period.

Keyword

Muslim Bagh Ophiolite, high geothermal gradient, supra-subduction zone, ridge subduction

Neo-Tethyan subduction records in West Sulawesi, Indonesia

Xiaoran Zhang[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (zxr627@163.com)
Shuiyue Xue[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Jinyu Xi[3], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The southeastern extension of the Neo-Tethyan arc system in SE Asia remains enigmatic mostly due to the lack of robust isotopic dating on arc magmatism in the Indonesian archipelago. Here, we report new detrital zircon U-Pb-Hf isotopic data from West Sulawesi to constrain its Cretaceous to Eocene magmatic tempo. We find that detrital zircons from West Sulawesi are dominated by ca. 105-80 Ma and ca. 70-45 Ma age populations with high positive εHf(t) values, suggesting derivation from juvenile sources with limited continental crustal contamination. Our new data, together with previous geological and geochemical investigations, support the existence of an Andean-type continental margin in West Sulawesi during mid-Cretaceous to Early Eocene times. More importantly, such a magmatic tempo of West Sulawesi and zircon Hf isotopic signatures agree well with those of Neo-Tethyan arcs in southern Lhasa and Sumatra, but contrasts with those of Paleo-Pacific subduction-related arcs in SE China, SE Vietnam, East Malaysia, and NW Borneo. Therefore, we propose that the Neo-Tethyan arc system may extend over 7500 km from southern Tibet to West Sulawesi, and that such huge an arc system with consistent magmatic flare-ups and lulls and may have played a vital role in global-scale plate reorganization and climate change.

Keyword

Detrital zircon, West Sulawesi, Neo-Tethyan arc system

Cenozoic kinematic evolution of the Qilian Shan, northern Tibetan plateau: implication for the intraplate deformation

Bing LI[1]*, Chinese Academy of Geological Sciences (libing@cags.ac.cn)
Xuanhua Chen[2], Chinese Academy of Geological Sciences
Andrew Zuza[3], Nevada Bureau of Mines and Geology, University of Nevada, Reno
Daogong Hu[4], Institute of Geomechanics, Chinese Academy of Geological Sciences
Yiping Zhang[5], Chinese Academy of Geological Sciences
Yujun Sun[6], Chinese Academy of Geological Sciences

Abstract

The Cenozoic growth of the Tibetan Plateau and the distribution of deformation across it are a consequence of India-Asia collision and continued convergence, which have implications for studies of continental intraplate deformation. The spatio-temporal development of Cenozoic deformation along the northern margin of the plateau is an important issue that can test various models of plateau growth. The northern Tibetan Plateau is bounded by the Cenozoic Qilian Shan thrust belt and the Haiyuan left-slip fault. In this study, we conducted geologic mapping, field observations, electron spin resonance dating, apatite- (U-Th)/He and fission track analysis, and analogue modelling in the Qilian Shan thrust belt to improve our understanding of the timing of brittle faulting, range exhumation, and intraplate deformation in the northern Tibetan Plateau. We document the first direct age constraints for Oligocene deformation within the central Qilian Shan via ESR dating, which correlates with AHe-AFT cooling ages in adjacent ranges. We demonstrate that the Qilian Shan thrust belt experienced Cenozoic two-phase growth history including Eocene-Oligocene fault-related uplift shortly after the India-Asia converge, and mid-Miocene regional overprinting deformation that reactivated the proximal thrust faults. This deformation pattern suggests the Qilian Shan thrust belt has experienced out-of-sequence development starting from the Eocene-Oligocene time and has persisted as the stationary northeastern boundary of the Himalayan-Tibetan Orogen throughout the Cenozoic. Analogue modelling results indicate that the Paleozoic Qilian suture systems acted as a pre-existing weakness to play a decisive role in controlling the lithospheric rheology, which therefore impacted the timing, pattern and strain distribution of Cenozoic intraplate deformation across the northern Tibetan Plateau.

Keyword

northern Tibetan Plateau, Qilian Shan, Cenozoic, Low-temperature thermochronology, analogue modelling

Kinematics and deformation conditions of the Chongshan strike-slip shear zone on the southeastern Tibetan plateau

Wenyuan LI[1]*, China University of Geosciences, Wuhan 430074, China (wenyuanli@cug.edu.cn)
Shuyun Cao[2], China University of Geosciences, Wuhan 430074, China
Yanlong Dong[3], China University of Geosciences, Wuhan 430074, China
Lefan Zhan[4], China University of Geosciences, Wuhan 430074, China
Rodolfo Carosi[5], University of Torino, 35 10125 Turin, Italy
Chiara Montomoli[6], University of Torino, 35 10125 Turin, Italy

Abstract

Strike-slip shear zones are important components in collisional orogens and play a key role in the tectonic evolution of the continental lithosphere. The Chongshan shear zone (CS-SZ) is an important hundred-kilometer-long continental scale strike-slip shear zone on the southeastern Tibetan plateau. To unravel its deformation history and processes, we examined a range of deformed rocks (e.g. granitic mylonite, mylonitic gneiss, quartz schist). The detailed field observations, microstructural, and EBSD texture analyses reveal that the CS-SZ experienced high-temperature (500–650 °C) deformation overprinted by a low-temperature (300–400 °C) deformation during the shearing and exhumation process. Kinematic vorticity data reveal that the Cenozoic ductile shearing on CS-SZ was characterized by general-shear deformation. The pure shear-dominated flow (79–55% pure shear) of the bulk deformation history has been overprinted by a later increase of simple shear up to a simple shear dominated flow (48–97% simple shear) during the latest increments of ductile deformation. The bulk strain rates of CS-SZ ranged from 3.4 × 10-16 to 3.8 × 10-12 s-1, while the northernmost region experienced higher differential stress (46 to 108 MPa) and higher strain rates (1.7 × 10-12 to 1.0 × 10-11 s-1). There are both sinistral and dextral kinematic senses in the northern segment of CS-SZ, but the southern segment is dominated by sinistral kinematics. The opposing shear senses in the northern segment could be explained by a large amount of pure shear during deformation. Our structural analyses, combined with published geochronology data, indicate that CS-SZ experienced rapid cooling between 19 Ma and 13 Ma, accompanied by the coeval exhumation of the metamorphic rocks.

Keyword

Strike-slip shear zone, Deformation condition, Rheology, Vorticity

K-Ar dating of authigenic illite-bearing fault gouge constraints on Cenozoic multiple reactivation of the Lancangjiang Fault, SE Tibetan Plateau and its Tectonic Implications

Kui TONG[1]*, State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China (t33102@sina.cn)
Zhiwu Li[2], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China
Jinxi Li[3], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China
I. Tonguç Uysal[4], School of the Environment, The University of Queensland, Brisbane, QLD 4072, Australia
Todd Andrew [5], CSIRO Energy, 26 Dick Perry Avenue, Kensington, WA 6151, Australia
Shugen Liu[6], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China

Abstract

Quantifying deformation histories of the thrust faults within the Tibetan Plateau (TP) and its periphery can provide significant insight into the geodynamic mechanism of the formation of the Plateau. The Lancangjiang fault (LCJF) outcropped mainly along the Lancang (Mekong) River and is a NNW-SSE-striking regional thrust fault in the SE TP, which may have played an important role in accommodating the differential uplift in the SE TP. However, there is, to date, no precisely temporal constrains on the activity history of the LCJF due to poorly exposed fault trace and limited technique of brittle fault dating. Recent hydropower construction and drilling along the Langcang River excellently exposed the main fault zone of the LCJF at Quzhika village, east Tibet, providing a rare opportunity to study deformation histories of the LCJF by applying K-Ar dating of authigenic illite-bearing fault gouge.

The LCJF at Quzhika village strikes NNW-SSE to closely S-N and dips 60-85° NWW and juxtaposes the Triassic granite and dacite against the Jurassic fuchsia sandstone, siltstone and mudstone. The fault zone, exposed by the tunnel and borehole, is composed of the fuchsia and white fault gouge bands that outcrop as tectonic lenses, indicating thrust kinematic character of the LCJF. Two white fault gouge samples of the LCJF were collected from the borehole for clay mineralogical analysis and K-Ar dating. Oriented X-ray diffraction (XRD) analyses show that different clay size fractions of the fault gouge consist mainly of illite with tiny kaolinite. Random powder XRD analyses suggest that each fraction is comprised of 2M1 and 1Md/1M illite polytypes. Illite polytype quantification demonstrates that the components of 2M1 polytype relative to those of 1Md/1M one decrease from 22% to 3% with fractions decreasing. These results suggest that the finest fractions (<0.1 μm) are mainly composed of authigenic 1Md/1M illite. The apparent K-Ar ages also decrease from 12.8 ± 0.3 Ma to 3.4 ± 0.3 Ma with clay fractions decreasing. We interpret that the K-Ar dates for each fraction represent mixture ages comprised of the two-end member illite polytypes. Illite age analysis extracted the K-Ar ages of the pure authigenic 1Md/1M and 2M1 illite are 2.4 ± 1.3 Ma and 51.1 ± 11.3 Ma (2σ standard

errors), respectively. Integrated with thrust kinematic character of the LCJF, the Late Pliocene to Early Pleistocene K-Ar age for authigenic 1Md/1M illite represents the timing of brittle thrust deformation along the LCJF, coinciding with the Late Cenozoic rapid incision of the Lancang River. The K-Ar age (51.1 ± 11.3 Ma) for 2M1 illite is much younger than the crystallization and sedimentary ages of the host rock, which can represent syn-kinematically crystallized components resulting from the Early Cenozoic high temperature (>280 °C) ductile faulting associated with fluid flow of the LCJF. Integrated with previously published results, this study suggests that the TP and its periphery underwent quasi-contemporaneous tectonic compression deformation during the middle Eocene, likely caused by the combination of the hard collision of the Indo-Asia plates and intra-continental subduction of the terranes within the TP.

Keyword

Southeast Tibetan Plateau, Lancangjiang fault, authigenic illite, fault gouge, K-Ar dating

Structural analysis, Geochronology and Thermochronology studies of the middle segment of the Xianshuihe-Anninghe-Xiaojiang Fault system: Implications for multiple-stage growth of the SE Tibetan Plateau margin

Zhiwu LI[1]*, State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China (lizhiwu06@cdut.edu.cn)
Kui Tong[2], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China
Shugen Liu[3], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China
I. Tonguç Uysal[4], School of the Environment, The University of Queensland, Brisbane, QLD 4072, Australia
Jinxi Li[5], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China
Wenhui Wu[6], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu 610059, China
Andrew Todd[7], CSIRO Energy, 26 Dick Perry Avenue, Kensington, WA 6151, Australia
Barry Kohn[8], School of Earth Sciences, University of Melbourne, Melbourne, Victoria 3010, Australia

Abstract

The Xianshuihe-Anninghe-Xiaojiang Fault system (XAXFS) is an important lithospheric fault at the eastern boundary of the Chuandian block that plays a crucial role in understanding intro-continental deformation and lateral growth of the Tibetan Plateau (TP). The middle segment of the XAXFS that mainly consists of the Anninghe, Zemuhe, Shimian-Zhaojue Faults is characterized by brittle faulting with poorly geochronological age constraints on the timing of deformation yet. This study presents first attempt to integrate structural analyses with brittle fault dating and low-temperature thermochronology studies of the middle segment of the XAXFS, which could provide insight into the Cenozoic multiple-stage deformation and growth of the SE TP margin.

Structural analyses suggest that the Anninghe, Zemuhe, Shimian-Zhaojue Faults has experienced early phases of thrust deformation under NE-SW and nearly EW compression, respectively, followed by NW-SE transpressional deformation and NNW-SSE compressional strike-slip deformation. Isotopic dating techniques were carried out using K-Ar dating of authigenic illite-bearing fault gouge and calcite in-situ LA-MC-ICP-MS dating. The results show that the K-Ar age and the proportions of 2M1 illite relative to those of 1M/1Md illite decrease with size fractions decreasing. K-Ar ages for different fractions are mainly impacted by the physical mixture of detrital 2M1 and authigenic 1M/1Md illite, hence representing mixture ages. Based on illite age analysis, K-Ar ages of authigenic 1M/1Md illite were determined at ~50-28 Ma for the Anninghe, Zemuhe and Shimian-Zhaojue Faults, suggesting that the NE-SW compressional thrust deformation in the study area occurred at the Late Eocene-Early Oligocene. Meanwhile, LA-MC-ICPMS dating of syn-tectonic calcite slickenfibers from the Shimian-Zhaojue Fault yielded U-Pb age of ~8-4 Ma, showing the sinistral strike-slip deformation in the study area since the Latest

Miocene.
Low-temperature thermochronology analyses combined with thermal history modeling for the elevation profile of Xiaoxiang Mountain at the hanging wall of the Anninghe Fault suggest that the Xiaoxiang Mountain has underwent an extremely rapid cooling episode at ca. ~24-20 Ma with a mean rate of ~38 °C/Ma and a relatively rapid cooling episode at ca. ~20-13 Ma (~11 °C/Ma), followed by a protracted slow cooling episode since the late Miocene.
Integrating previously published results, we reconstructed three-stage Cenozoic deformation and growth of the SE TP margin. (1) During ~50-28 Ma, the far-field compressional force of the hard collision of Indo-Asia plates resulted in NE-SW compressional fold-and-thrust deformation and slow exhumation in the SE TP margin. (2) The SE TP margin underwent intense thrust faulting and uplifting during ~28-20 Ma due to E-W compression, which was likely attributed to the lateral horizontal compressional pressure resulted from the establishment of the present high elevation and flat topography in the central TP. (3) The SE TP margin experienced two-stage extrusion deformation since the early Miocene. During ~20-10 Ma, the study area experienced NW-SE transpressional deformation with the influence of sinistral strike-slip of Xianshuihe Fault. Since ~8 Ma, with the connection of the XAXFS, the present tectonic pattern of Chuandian block was established, resulting in the sinistral strike-slip deformation in the study area under NNW-SSE compression.

Keyword

SE Tibetan Plateau margin, Xianshuihe-Anninghe-Xiaojiang Fault system, brittle fault dating, authigenic illite, tectonic evolution

Mechanism for the Uplift of Gongga Shan in the Southeastern Tibetan Plateau Constrained by 3D Magnetotelluric Data

Feng JIANG[1]*, South China Sea Institute of Oceanology at Chinese Academy of Sciences (fengj.cn9@gmail.com)
Xiaobin Chen[2], National Institute of Natural Hazards, Ministry of Emergency Management of the P.R.C
Martyn Unsworth[3], University of Alberta

Abstract

The eastern margin of the Tibetan Plateau is characterized by a number of mountain ranges that include the Longmen Shan-Jingping Shan (LMS-JPS) orogenic belt. This is located on the boundary between the Songpan-Ganzi terrane and Yangtze craton which is part of the South China block. The region is tectonically active as shown by the 2008 Mw 7.9 Wenchuan earthquake that occurred in this region. On a regional scale, the mechanisms that have caused uplift are poorly understood. Gongga Shan is the highest mountain with a rapid uplift rate on the eastern margin of the Tibetan Plateau. Its distinct geomorphic characteristics very likely indicate a key factor at work for the lithospheric deformation in the eastern Tibetan Plateau. However, the mechanism for the uplift of Gongga Shan is unclear due to a lack of detailed geophysical studies. Inversion of an array of magnetotelluric data at 120 sites produced a 3D resistivity model that revealed that the Gongga Shan massif is characterized by a high resistivity upper crust underlain by a westward dipping resistor at middle crustal depths that is interpreted as the underthrust Yangtze Craton. A thin conductive layer is sandwiched between these two zones of high resistivity. This resistivity model is inconsistent with previously published geodynamic models. The new resistivity model strongly suggests that there is significant westward underthrusting of the Yangtze Craton beneath the Songpan-Ganzi terrane. Since the Songpan-Ganzi terrane presently is being extruded to the east (Wang and Shen, 2020), this study confirms that theSongpan-Ganzi terrane has been overthrust onto the basement of the YC and is the dominant cause for the uplift of Gongga Shan. This uplift has likely been enhanced by an oblique slip on the Xianshuihe Faults (Chen et al., 2016) in the southwest Songpan-Ganzi terrane.

Keyword

eastern Tibet Plateau, orogen's uplift, Gongga Shan, magnetotelluric

(Withdrawn) Cenozoic tectonomagmatic history of South Tibetan Detachment System (STDS), Dhauliganga valley, NW Himalaya

GARGI GIRISH DESHMUKH[1]*, INDIAN INSTITUTE OF TECHNOLOGY ROORKEE (ggirishdeshmukh@es.iitr.ac.in)
Arvind Kumar Jain[2], Formerly at Department of Earth Sciences, Indian Institute of Technology Roorkee
Rahul Dixit[3], Department of Geology, University of Delhi, Delhi-110007, India
Deepak Chandra Srivastava[4], Indian Institute of Technology, Roorkee
Pulok Kumar Mukherjee[5], Formerly at Inter-University Accelerator Center, New Delhi-110067, India

Abstract

The South Tibetan Detachment System (STDS) is a well-studied peculiar syn-contractional Low Angle Normal Fault (LANF) that separates the sillimanite grade Greater Himalayan Sequence (GHS) gneiss from the low to unmetamorphosed Tethyan Himalayan Sequence. The deformation in the footwall GHS, as well as the relationship between the granitoids is well exposed along the Dhauliganga valley, NW India. Early Paleozoic gneissose granitoids intrude the high-grade mylonite-gneiss on the immediate footwall of the STDS. These granitoids possess U-Pb zircon ages ranging from 498.92 ± 2.7 Ma to 486.54 ± 1.1 Ma and are a part of an extensive Cambro–Ordovician (C–O) granite belt in the uppermost GHS straddling the STDS.

Six granitoid samples yielded Cenozoic ages and recorded zircon growths in two distinct phases: pulsative from Late Eocene to Early Oligocene, with Th/U ratios <0.045. The Upper Eocene to Lower Oligocene zircons show peaks at 33.99 ± 0.37 Ma, 30.53 ± 0.38 Ma, and 25.03 ± 0.43 Ma; and in the continuous mode from Middle Oligocene 23.68 ± 0.25 Ma to 13.30 ± 0.15 Ma in the Miocene, for nearly 10.0 myr. A few individual ages from leucosome also show growths around 36.8 Ma. Singular magmatic zircon rim growth records an age in the late Miocene 6.38 Ma (Th/U ratios 0.2). Most of these Cenozoic zircons represent typical metamorphic overgrowths on the Neoproterozoic and C–O magmatic cores portraying low Th/U ratios (0.09-0.05). These zircon growths reveal protracted Cenozoic metamorphic/magmatic activities along the STDS since the Late Eocene.

GHS granitoid along the STDS are observed to have undergone simultaneous high-grade metamorphism in the Late Eocene and Early Oligocene, leading to partial melting and various generations of leucosome. This early anatexis, in turn, might have triggered the initial reactivity of the STDS and, also consequently, led to the tectonic transition from its compressive tectonics to the extensional regime. This work attempts to constrain the tectonomagmatic activity along the STDS from the Eocene to the Miocene by correlating the deformed and undeformed leucogranitic and granitoids emplaced in the footwall of the STDS.

Keyword

South Tibetan Detachment System, Himalaya, Eocene magmatism, Leucogranite

Development Process of the West Kunlun Orogenic Belt Under the Control of Tethyan Evolution: Constraints from Detrital Zircon U-Pb Chronology of the West Kunlun Foreland Belt

Yang GAO[1]*, China University of Petroleum,Beijing (3356529159@qq.com)
Lin Jiang[2], Research Institute of Petroleum Exploration and Development
Fujie Jiang[3], China University of Petroleum,Beijing
Weiyan Chen[4], Research Institute of Petroleum Exploration and Development
Hongkui Dong[5], Research Institute of Petroleum Exploration and Development
Wen Zhao[6], Research Institute of Petroleum Exploration and Development
Tingwei Guo[7], China University of Petroleum,Beijing

Abstract

The West Kunlun orogenic belt at the convergence of the Tarim Craton and the Tibetan Plateau encapsulates a comprehensive geological history documenting the subduction of the Paleo-Tethys and Tethys Oceans and the accretion of landmass and oceanic fragments from the Early Paleozoic to the Early Mesozoic. Hindered by the formidable natural conditions along the northern edge of the Tibetan Plateau, research has been limited, leading to a dearth of subsurface stratigraphic and chronological data and significant controversy over the evolutionary timeline and initiation of the orogenic process in this region.In pursuit of resolving these uncertainties, this study zeroes in on the West Kunlun foreland belt, examining Permian cores from well T1 in the Suget structural zone and Cretaceous and Jurassic cores from wells KD5 and KD101 in the Kedong structural zone. Leveraging advanced detrital zircon U-Pb dating techniques and integrating stratigraphic data, the research reconstructs the developmental history of the West Kunlun orogenic belt against the backdrop of Tethyan tectonics. The investigation reveals a critical Triassic period when the Tethys-Himalayan-Qiangtang block merged with the West Kunlun-Tarim block, followed by rapid uplift in the West Kunlun region during the Jurassic-Cretaceous periods.

All zircon samples showed peak ages around 430 Ma and 240 Ma, respectively corresponding to the final closure times of the Paleo-Tethys and the ancient Tethys Oceans. The youngest zircon ages in the Cretaceous and Jurassic samples are all in the Triassic, indicating a lack of effective volcanic activity records in the West Kunlun and nearby regions from the Triassic onward in the Mesozoic era. Correlation tests of the data show that the chronological data of zircon samples from the Cretaceous and Permian exhibit good similarity with previous studies of the Southern and Northern Kunlun blocks. However, the Jurassic samples show less similarity with the data from the South and North Kunlun blocks, but they display better similarity with previous data from the Tethys-Himalayan-Qiangtang area. This may indicate that the final plate collision between the Tethys-Himalayan-Qiangtang block and the Songpan-Ganzi-Southern and Northern Kunlun blocks was completed in the Triassic, between the Permian and Jurassic, and that there was a period of rapid uplift in the West Kunlun orogenic belt from the late Jurassic to the early Cretaceous.

This study furnishes new chronological evidence elucidating the closure events of the Proto-

Tethys and Paleo-Tethys Oceans, as well as the early developmental history of the West Kunlun orogenic belt. It enhances the comprehension of orogenic mechanisms and holds significant prescriptive value for guiding future hydrocarbon exploration efforts in the region.

Keyword

Detrital zircon U-Pb, West Kunlun Mountains, Tibetan Plateau, Tarim Basin, Tethys

EBSD-based microstructural characterization of the (ultra-) high pressure eclogite and retrogressed amphibolite from the Tso Morari Crystalline Complex in Ladakh, India

Dripta DUTTA[1]*, Okayama University of Science (dripta.dutta@gmail.com)
Takeshi Imayama[2], Research Institute of Frontier Science and Technology, Okayama University of Science, Okayama 7000005, Japan
Dyuti Prakash Sarkar[3], Department of Earth and Planetary Systems Science, Hiroshima University, Higashi Hiroshima 7398526, Japan

Abstract

Crystallographic preferred orientations (CPOs) of minerals are being widely used to identify the orientation relationships between the parent grains and their daughter crystals. These orientation relationships are used to trace the deformation mechanisms that affected the parent grains – now retrogressed to and replaced either partly or completely by the more stable daughter grains – at peak pressure conditions. Such breakdown of peak pressure minerals is often preserved in the exhumed (ultra-) high-pressure eclogites. We studied one such eclogite sample from the Tso Morari Crystalline Complex. The eclogite preserves symplectites with the coarse and euhedral omphacite grains either replaced partially along the periphery and transgranular fractures (Site 1) or completely (Site 2) by finer amphibole and plagioclase grains. A garnet amphibolite sample from the same locality is also studied to assess the dislocation creep-mediated deformation of the amphibole grains produced at a lower pressure than those of the eclogite. Though the samples are non-oriented, the shape-preferred orientations of omphacite and amphibole grains in the eclogite and amphibolite, respectively, are conspicuous. The jadeite contents of the omphacite grains range between 43-47%. The compositions of the plagioclase grains vary from albite to oligoclase. The amphibole grains of the eclogite are higher in Mg# values and Na content than those of the garnet amphibolite. Although the omphacite, amphibole, and plagioclase grains in the eclogite exhibit strong CPOs, the grain orientation spread values of omphacite are much lower than the rest. Therefore, the oriented growth of the omphacite grains likely produced their strong CPOs. The pole figures suggest the following crystallographic relationships between the phases: <001>Omp||<001>Amp, (100)Omp||(100)Amp, (010)Omp||(010)Amp, (110)Omp 30° to (110)Amp, and <100>Omp 30° to <100>Amp||<001>Pl. The low-angle misorientation axes (LAXs) of omphacite are mostly parallel to their <001> axes, and those of the amphibole grains mainly lie on the (100) planes with two maxima sub-parallel to <001> and <010> axes. Plagioclase LAXs from Site 1 are sub-parallel to the poles of (010) and (0-10), whereas those from Site 2 are not crystallographically controlled. The higher frequencies of the neighbour-pair misorientation angle distributions of amphibole and plagioclase than their respective random-pair and theoretical distributions at lower angles (10–30°) and point distributions of their CPOs suggest that their CPOs originated by inheritance. Interphase misorientation analysis also demonstrates statistically significant differences between the neighbour- and random-pair distributions for both omphacite-amphibole and omphacite-plagioclase pairs testifying to the influence of omphacite

CPOs on those of amphibole and plagioclase. Though characterized by point and girdle distributions, the amphibole CPOs from the garnet amphibolite are much weaker than those from the eclogite. The quartz grains are few and do not exhibit any preferred orientation. The distribution of the quartz LAXs implies activity of the high-T (>600°C) {m}<c+a> slip-system. In contrast, the amphibole LAXs are mostly sub-parallel to (100) poles, suggesting the dominance of (010)<001> slip-system activity (assuming tilt boundaries) and low-T (350-450°C) deformation.

Keyword

CPO Inheritance, Phase transformation, Interphase misorientation, Symplectite, Slip systems

NanogeoscienceA developing interdisciplinary

Yiwen JU[1]*, University of Chinese Academy of Sciences (juyw03@163.com)
Hongye Feng[2], University of Chinese Academy of Sciences

Abstract

Nanogeoscience is a highly comprehensive and overlapping subject, with combination of nanotechnology and geoscience. It will be a necessary way for the development of earth scienceIts research objects mainly include nanomaterials and nanopores, which are widely distributed on the earth so as to Planet and have diverse causes and obvious scale effects. To nanomaterials, researchers use various image analysis methods to observe their shape, size and aggregation model, also investigate the crystal structure of minerals and molecular structure of organic matter through all kinds of spectroscopy methods. To nanopores, researchers use image analysis, fluid invasion combined with numerical simulation methods, to characterize pore morphology, pore size distribution, connectivity and other characteristics Its function is closely related to the earth's supergene environment and resources. On the basis and framework of traditional geoscience research, the systematic research of nanogeoscience as a discipline is to solve the scientific problems about nanomaterials and nanopores in each sphere of the earth, such as formation, migration, aggregation and existence form of nanomaterials, as well as formation and evolution of nanopores. Consequently, it deepens the cognition of nanoscale characteristics of branches like mineralogy, petrology, structural geology, geochemistry as well as resources, disasters and environment. The emergence and development of nanogeoscience have brought human beings into a new level in understanding and transforming nature. It is the inevitable way for the development of the earth and planetary sciences. Related research has provided new theoretical basis for prevention and treatment of environmental pollution and geological disaster, mineral deposit exploration, resource development, new energy utilization, etc. Therefore, nanogeoscience has immeasurable scientific significance and application values.

Keyword

Nanogeoscience, Nanomaterial, Nanopore, Nanotechnology, environment and resource effect

The effect of inherited basement strike-slip structures on rift basin architecture: insights from analog modeling and PIV analysis

Marilia Barbosa VENÂNCIO[1]*, UFRN (mariliavenancio@gmail.com)
Fernando César Alves da Silva[2], UFRN

Abstract

Preexisting basement structures create zones of mechanical weakness that can influence the structural architecture, kinematic pattern, and deformation distribution of subsequent new structures within the basin on a crustal scale. This study investigates the impact of a preexisting basement shear zone on basin structural architecture through analog modeling. Sandbox experiments simulated the effects of structures developed during an early strike-slip event (D1) on the development of an orthogonal sedimentary basin undergoing extensional deformation (D2). The Particle Image Velocimetry (PIV) technique was employed to analyze the strain distribution on the surface and the vertical displacement. During the D1 event, subsidiary structures such as Riedel shears, Y fractures, and positive and negative flower structures were formed. Subsequent extensional deformation (D2) led to normal fault development, with orientations differing inside and outside the preexisting D1-related shear zone. Faults within the shear zone exhibited NE-SW to NW-SE orientations, while those faults outside were predominantly oriented N-S; also, faults within the shear zone had lower dip angles. During the nucleation, the first faults presented less strain intensity on the preexisting shear zone and thus were less developed, segmenting the sedimentary basin into two subbasins along the preexisting basement fabric. Internal faults displayed a discontinuous nucleation throughout the shear zone region, constrained by underlying structures. The basin exhibited a narrower width and deeper depocenter outside the inherited shear zone, whereas it widened with a shallower depocenter within the shear zone region. Syn-kinematic layer thickness decreased closer to the preexisting basement structure. Although the basin perimeter expanded near the shear zone, a direct association between the basin area and the preexisting shear zone was not feasible. An orthogonal crossline revealed a synclinal structure along the inherited shear zone. Overall, the results emphasize the significant role of inherited structural architecture in controlling fracturing, fault distribution, and basin evolution during rifting processes.

Keyword

preexisting basement structures, basin evolution, analog modeling, PIV

Long-term stability of the Siberian craton: from “hot anchor” to “cold anchor”

Qin WANG[1]*, School of Earth Sciences and Engineering, Nanjing University (qwang@nju.edu.cn)
Xiaotong Gu[2], School of Earth Sciences and Engineering, Nanjing University, China
Tianlong Jin[3], School of Earth Sciences and Engineering, Nanjing University, China
Vladislav Shatsky[4], Sobolev Institute of Geology and Mineralogy SB RAS, Russia

Abstract

Because small amounts of hydrogen can significantly decrease viscosity of nominally anhydrous minerals, different rheological models of continental lithosphere have been proposed based on vertically heterogeneous water distribution in the lower crust and upper mantle. Meanwhile, temperature is the controlling parameter of viscosity and thermal states of the continental lithosphere evolve with time. To examine the rheological evolution of a stable craton, we measured water content and fabrics of garnet granulite and peridotite xenoliths from the Udachnaya pipe in the Siberian craton. Using the Fourier transform infrared spectroscopy, water content in garnet granulite xenoliths were determined with clinopyroxene (334–977 ppm), garnet (23–149 ppm), and plagioclase (157–779 ppm). Mafic garnet granulite samples experienced pressures of 0.6–1.0 GPa and temperatures of 549–800 ºC using the Grt-Cpx Fe-Mg thermometer (TK88), which are consistently lower than equilibrium temperatures of 737–899 ºC from the REE-in-Grt-Cpx thermobarometer (TREE). Compared with pseudosection calculations, our samples experienced continuous cooling since the last granulite facies metamorphism at 1.8 Ga. On the other hand, garnet lherzolite xenoliths show heterogenous water content in olivine (34–166 ppm), orthopyroxene (32–126 ppm), clinopyroxene (83–166) and garnet (7–46 ppm). The calculated equilibrium temperature and pressure of the peridotite xenoliths vary from 846 to 1276 ºC and 4.0 to 5.2 GPa. This confirms the water content variation in olivine beneath the Udachnaya pipe from previous studies: low (20 ± 15 ppm H2O) at depths <130 km, but low to high (187 ± 135 ppm H2O) at depths >130 km due to mantle metasomatism.

Electron backscatter diffraction analysis revealed weak lattice-preferred orientation in clinopyroxene and plagioclase from mafic granulite xenoliths, and A-type olivine fabric in coarse-grained or protomylonitic peridotites but E-type olivine fabric in mylonitic peridotites. Assuming a strain rate of 10^-14 s^-1, we calculated the strength profile of the Siberian craton. The results indicate that water-poor olivine at depths of 74–170 km is about two orders of magnitude stronger than water-rich olivine at depth around 200 km, which can be attributed to the water-weakening effect at the base of the lithosphere. For mafic garnet granulites, if using TREE, the water-rich lower crust has the viscosity comparable with the underlying water-poor lithospheric mantle, no matter using flow laws of wet clinopyroxene or wet anorthite. When cooling down to TK88, clinopyroxene-controlled rheology will produce a stronger lower crust than the upper mantle, whereas plagioclase-controlled rheology still facilitates the mechanical coupling. The comparable effective viscosity of Udachnaya granulite and peridotite xenoliths is different from the “crème brûlée” or “jelly sandwich” models because the weak lower crust is water-rich and the upper

lithospheric mantle is water-poor. We named this strength profile as the “hot anchor” model of the cratonic lithosphere. By contrast, the present-day cold geotherm in the Siberian craton resulted in the water-rich and strong lower crust overlying the water-poor and strong lithospheric mantle, which is inferred as the “cold anchor” model. Transition from the “hot anchor” to “cold anchor” model explains the long-term crust-mantle coupling and stability of the Anabar tectonic province since the Neoarchean.

Keyword

fabric, water content, strength profile, Siberian craton, crust-mantle coupling

Microscale to mesoscale structures to constrain shear zone kinematics, a case study from the Shillong Plateau, NE India

SURAJIT MISRA[1]*, GAUHATI UNIVERSITY (misrasurajit@gmail.com)

Abstract

The shear zone kinematics are significant to determine micro-, meso- and regional scale tectonics of any terrane. Kinematics is generally derived from dominant structural elements such as foliation and lineation. Orientations of these elements are also significant to constrain vorticity numbers and kinematics with respect to the external and internal reference frames of any shear zone. These are simply recognized from ideal coaxial and non-coaxial shears rather than the general shears. It is more complex in a multiply deformed terrane like the Barapani Shear Zone (BSZ) an intracontinental deformation zone within the Shillong plateau. The lithology of the zone is dominantly phyllite that preserved evidence of intense shearing events and quartz vein intrusions.

The BSZ had experienced D1, D2, D3, and D4 events which are recorded as S1, S2, and S3 planar fabrics. The D1 was related to the E-W compression, which was followed by the D2 an oblique-sinistral strike-slip shearing along the NE-SW direction. Further, the zone was overprinted by an oblique-dextral strike-slip shearing along the E-W direction, and finally, the D4 was elastic-plastic deformation at locals. Orientations of these deformation-related fabric elements, vorticity numbers and their kinematics considering both the external and internal reference frames of the BSZ indicate that the superposed transpressional tectonics were majorly operated during the D2 and D3 events.

Keyword

Shillong Plateau, Shear zone, Transpression, Kinematic, Vorticity

Microscopic Kinematic Indicators in the Achankovil Shear Zone, South India and its Tectonic Implications

Vikas Chandrasekharan[1], Oil & Natural Gas corporation Ltd (ONGC), KG-PG Basin, Godavari Bhavan, Rajahmundry, Andhrapradesh-533103, India.
Prasannakumar Vasudeva Kaimal[2], Department of Geology, University of Kerala, Trivandrum, Kerala- 695 581, India
Pratheesh PRABHAKARAN NAIR[3]*, Department of Geology, Central University of Kerala, Kasaragod, Kerala- 6713120, India (pratheeshp@cukerala.ac.in)

Abstract

The Achankovil shear zone (AKSZ), stretching approximately 120 km in a northwest-southeast direction across the states of Kerala and Tamil Nadu in Southern India, serves as a significant crustal boundary. It separates the Madurai block to the north, characterized by granulite facies, from the khondalite belt (Trivandrum block) to the south. A pronounced tectonic fabric oriented along the AKSZ is evident, marked by grain size reduction, enhanced flattening, elongation, and preferred orientation of constituent minerals, indicative of progressive strain. Mylonite and mylonitic patches, displaying numerous shear indicators, are prevalent along the shear zone's length. Despite significant attention to the AKSZ regarding metamorphic conditions and the correlation of Gondwanaland fragments, challenges persist in interpreting its geometry, tectono-metamorphic evolution, and movement characterization. This study aims to elucidate the geological and structural features of the AKSZ, with a focus on interpreting its kinematic and microstructural evolution through microfabric analyses. Crystallographic preferred orientation (CPO) of quartz, obtained via Electron Back Scatter Diffraction (EBSD), suggests deformation facilitated by diffusional creep, while mica, amphibole, and feldspars indicate plastic deformation via intracrystalline slip systems activation. All CPOs reflect fabric modifications due to reactivation during the tectono-thermal evolution of the AKSZ. The progressive evolution of mylonite signifies a transition in deformation mechanisms from dislocation creep to grain boundary sliding and ultimately to grain size-dependent diffusional flow in the study area. Kinematic indicators at meso- and microscopic scales predominantly indicate dextral shear sense, with a minor sinistral shearing component observed in microdomains. The occurrence of opposing shear senses is interpreted as a result of strain partitioning and/or AKSZ reactivation during the Pan-African period. Based on shear deformation characteristics, the AKSZ has been correlated with the dextral Axial shear zone of Madagascar, aiding in the correlation of Gondwanaland continental fragments. Tectonic models proposed for Pan-African orogenesis in South India must accommodate the prevalent dextral strike-slip shear movement observed throughout the AKSZ.

Keyword

Kinematic Indicators, Microstructural, Achankovil Shear Zone, Tectonics

[Keynote] Multiscale modern structural geology in metamorphic basements: exploring processes from the map to the atomic scale

Michele Zucali[1]*, Università degli Studi di Milano (michele.zucali@unimi.it)

Abstract

Basement rocks that have undergone metamorphism are known to have diverse and complex tectono-metamorphic histories. These complexities can be observed at various levels, ranging from maps to microscopic scales. The trajectory maps of the rock's foliation reflect the tracking of finite strain features and metamorphic signatures, which are indicative of the rock's history.

Rocks can change their appearance and structure when they are subjected to metamorphic and strain conditions. This can lead to the development of different fabrics that can be classified into three categories: coronite, tectonite, and mylonite (CTM). The Degree of Fabric Evolution (DFE) determines which category the fabric belongs to, while the Degree of Reaction Progress (DRP) indicates how complete the metamorphic transformation is. A simple calculation shows that permuting DFE and DRP on an isotropic rock undergoing three metamorphic stages yields a thousand rock configurations. Do they correspond to rocks in the field?
We apply a procedure that integrates structural, petrological, lithostratigraphic, and, wherever possible, geochronological data while strongly maintaining the reference to the structural framework resolved by fieldwork activity. The procedure uses the DFE and DRP strategy to map rocks from map to microscale.

Quantitative estimation of concurrent deformation and metamorphism produces a matrix of rock types expected in a metamorphic terrain, which sheds light on the tectono-metamorphic evolution (Rock Matrix).

The evolution recorded by a specific rock type (e.g., granite) is mostly controlled by the evolution in space and time of chemical, shape, and crystallographic properties, which control the production of rocks that can record strong differences in the DFE (deformation gradients) and DRP (metamorphic transformation gradients).
The interplay of DFE and DRP produces the actual rock matrix. DFE and DRP can be mapped, and such maps lead to the sampling of the "right" samples for subsequent and more resolved analyses (e.g., geochronology, strain analysis, 3D quantitative imaging).

The efficacy of the combined method has been tested on various Alpine terrains, aiming at i) exploring the influence of thermal regimes, ii) studying the influence of inherited textures, DFE, bulk rock, and mineral compositions on DRP; iii) quantifying the 3D architecture of deformation and metamorphic transformation gradients; iv) individuating the critical thresholds making “strain rate” the dominant factor over metamorphic reactions.

New and very promising digital tools have been introduced nowadays. We need to make them a real advance in understanding tectonics and geodynamics through modern, solid, and quantitative structural geology.

Keyword

rock matrix, CTM, Fabric Evolution, Reaction Progress

Influence of salt diapir on the fault activity of subsalt units in salt-bearing fold-and-thrust belts: insight from natural example and numerical simulation

Wei WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (wangwei09@outlook.com)
Hongwei Yin[2], Nanjing Univeristy
Shaowen Liu[3], Nanjing Univeristy
Dong Jia[4], Nanjing University

Abstract

Salt-bearing fold-and-thrust belts represent the deformation zone containing the salt layer, mainly between the mountain and the basin. The salt layer could make the deformation above and below it quite different, and the subsalt structure has a high risk of earthquakes and abundant potential for oil and gas. While previous studies mainly focus on the interaction between salt structures and suprasalt deformation, the relationship between salt structures and subsalt deformation is largely unrecognized. The Kuqa fold and thrust belt is associated with complex salt structures and abundant hydrocarbon sources. Changes in fold geometry and subsalt fault activity were investigated using parallel cross sections to reveal the effects of salt structures on along-strike variations in the subsalt structural wedge of the Kuqa fold-and-thrust belt. Results indicate that the pre-existing salt wall is the key factor driving along-strike variation because it acts as a weak zone influencing deformation propagation. Suprasalt structural variation results in different sediment depths which has a significant impact on subsalt fault activity. In the eastern segment, fault activity decreases from the hinterland to the basin. Conversely, due to the pre-existing salt wall and deep sedimentation near the hinterland in the western segment, the fault beneath the salt wall demonstrates maximum throw. The results reveal the connection between suprasalt and subsalt deformation and the role of a salt diapir in along-strike structural evolution variation in the subset structural wedge of the Kuqa fold and thrust belt. Then, numerical simulation is used to investigate the influence of salt structures on the evolution of salt-bearing fold-and-thrust belts, using salt diapirs as an example. A comprehensive and quantitative analysis of the relationship between salt structures with both suprasalt and subsalt deformation is presented, and the interaction between salt structures and subsalt deformation is addressed for the first time. Model results demonstrate the influence of salt diapir on the strain distribution during the deformation. The location of salt diapirs controls strain distribution during the deformation. Specifically, the salt diapir is the primary rupture surface for strain localization in the suprasalt units, and could produce two primary rupture surfaces in the subsalt units. In the suprasalt deformation, the salt diapir has a high priority to deformation as it acts as the primary rupture surface. The location of the salt diapir controls the structural geometry evolved from the salt diapir. Plug-fed thrust usually develops when the salt diapir is near the hinterland, while the source-fed thrust forms when near the foreland. Once the salt diapir initiates deformation, it tends to delay the deformation propagation to further structures in both total shortening and deformation rate. This effect fades as the distance from the salt diapir increases, and the fade rate also increase. Regarding subsalt

deformation, the salt diapir generates two primary rupture surfaces, and the distance between them could represent the impact range of the salt diapir. Faults tend to occur along the primary rupture surface. These faults have enhanced activities, while adjacent faults could be restrained.

Keyword

salt tectonics, fold-and-thrust belts, fault activity, Kuqa depression, numerical simulation

Graphitic material in fault zones: Implications for tectono-thermal evolution and carbon cycle

Shuyun CAO[1]*, China University of Geosciences, Wuhan 430074, China (shuyun.cao@cug.edu.cn)
Meixia Lyu[2], China University of Geosciences, Wuhan 430074, China

Abstract

Graphite possesses characteristic mineral properties, including a layered structure and an exceptionally low friction coefficient. The irreversible graphitization process of amorphous carbonaceous materials with increasing temperature enables graphite to record metamorphic-deformation events. However, there remains a significant gap in our understanding of the formation of naturally deformed graphite-bearing rocks and their macroscopic to microstructural characteristics related to rock and mineral deformation, as well as their rheological weakening behavior and mechanisms. In this study, we focus on various types of metamorphic-deformation rocks in the shear zone or metamorphic massif, particularly graphite-bearing rocks and minerals. Leveraging detailed field observations, we employ optical microscopy (OM), scanning electron microscopy (SEM) with electron back-scattering diffraction (EBSD), cathodoluminescence (CL), Raman spectra, and carbon isotope mass spectrometry to conduct a comprehensive analysis of deformation macro-microscopic and submicroscopic structural features, mineral lattice preferred orientation (LPO), graphite Raman spectrum temperature, and the origin of carbon material. The results reveal deformed graphitic carbon-bearing rocks have experienced strong plastic to brittle deformation in medium-to low grade metamorphic rocks, accompanied by grain-size reduction, development of LPOs and micro-shear zones and slip-planes. The LPO patterns and mechanism of graphitic carbon present dislocation varieties from creep base <a>, rhomb <a> to prism <a> slip with temperature rise. According to the graphitic slip-planes, micro-shear zones with grain-size reduction and mylonitic foliation constituted by graphitic carbon minerals, we also propose that the development of fine-grained amorphous carbon plays an important role in rheological weakening of the whole rock during progressive ductile shearing.

Keyword

graphitica materials, tectonoc-thermal evolution, rheological weakening, carbon cycle

Site investigation in a tunnel for unrevealing earthquake nucleation or "Finding the needle in the haystack"

Alba Simona ZAPPONE[1]*, ETHZ (alba.zappone@sed.ethz.ch)
Peter AchtzigerZupančič[2], Fraunhofer Research Institution for Energy Infrastructures and Geothermal Systems IEG, Aachen, Germany
Alberto Ceccato[3], Department of Earth Sciences, ETH Zurich, Switzerland
Giacomo Pozzi[4], Istituto Nazionale di Geofisica e Vulcanologia, Italy
Alexis Shakas[5], Department of Earth Sciences, ETH Zurich, Switzerland
Florian Amann[6], Department of Engineering Geology and Hydrogeology, RWTH Aachen University, Germany
Daniel Escallon[7], Department of Earth Sciences, ETH Zurich, Switzerland
Domenico Giardini[8], Department of Earth Sciences, ETH Zurich, Switzerland
Marian Hertrich[9], Department of Earth Sciences, ETH Zurich, Switzerland
Xiaodong Ma[10], Department of Earth Sciences, ETH Zurich, Switzerland
Men-Andrin Meier[11], Department of Earth Sciences, ETH Zurich, Switzerland
Stefan Wiemer[12], Department of Earth Sciences, ETH Zurich, Switzerland
Massimo Cocco[13], Istituto Nazionale di Geofisica e Vulcanologia, Italy
Julian Osten[14], Department of Engineering Geology and Hydrogeology, RWTH Aachen University, Germany
Mohammadreza Jalali[15], Department of Engineering Geology and Hydrogeology, RWTH Aachen University, Germany

Abstract

In the underground laboratory in Bedretto, an experiment is being planned to stimulate a fault zone and observe the induced seismic activity. The laboratory is located in a tunnel in the Swiss Alps and offers the possibility to access faults at a depth of c.a. 1km. This research aims to improve the understanding of earthquake processes and fault behavior. The experiment aligns with the broader goal of near-fault observatories worldwide, which aim to collect high-quality data from sensor networks placed close to active faults for a deeper understanding of earthquake mechanisms.

The success of the experiment depends on the identification and characterization of a suitable fault zone for controlled stimulation and close-up monitoring. A multidisciplinary approach has been employed to select the target fault zone. Geological mapping and remote sensing at the surface of the tunnel, borehole logging, and ground-penetrating radar in the tunnel and in boreholes have been used for data collection to assess the rock formations and identify potential faults. A specific fault zone, several meters wide has been chosen using a multi-parameter criterion. This fault is well-oriented within the existing stress field for potential reactivation. Laboratory tests on rock samples from the fault zone revealed specific properties, including a tendency to strengthening fault gouge under shearing forces and a complex flow path for injected fluids.

The comprehensive approach on fault selection addresses the heterogeneity of the rock formation within the fault zone and ensures a suitable target zone for controlled stimulation and detailed and close monitoring. The successful identification of the fault paves the way for the first experiment,

scheduled for spring 2024.

Keyword

earthquake nucleation, earthquake monitoring, induced seismicity

Geometric and kinematic characteristics of along the strike-slip fault system: An example from the Yongdong fault system in central part of the Korean Peninsula

Kim JUN-YEOP[1]*, Pukyong National University. Division of Earth and Environmental System Sciences (kar7565@naver.com)
Oh Yubi[2], Pukyong National University. Division of Earth and Environmental System Sciences
Hwang Seung-Ho[3], Pukyong National University. Division of Earth and Environmental System Sciences
Bae Sang-Yeol[4], Pukyong National University. Division of Earth and Environmental System Sciences
Kim Young-Seog[5], Pukyong National University. Division of Earth and Environmental System Sciences

Abstract

Recently, a Quarternary fault was dicovered about 2 km southeast of the previously reported Yongdong fault. The purpose of this study is to understand the spatial distribution and the geometric & kinematic characteristics of the fault systems around this Quarternary fault location.

Based on the result of lineament analysis from remote sensing data (aerial photography, DEM & LIDAR), the NE-SW direction is the most dominant one, followed by the NNW-SSE to N-S and the NW-SE direction. The result is consistent with the result from the geological ground survey.

Left-lateral movement is mainly observed along the NE-SW striking faults with slight oblique slip, perceived through the lakes of slickenline (15 ~ 25º). This oblique slip is confirmed as result of weak transtension through Frohlich Triangle diagrams of win-tensor program. In addition, some right-lateral movement is also recognized along the NE faults. Left-lateral movement of the NE faults is confirmed at both the bedrock & the basal conglomerates and the boundary between these two rocks. Also, some right-lateral movement along the NE faults is observed in the basal conglomerates. These characteristics are consistent with the previously reported deformation history of the Yongdong fault during and after the formation of the Yongdong basin.

Along the NNW-SSE to N-S faults, left-lateral movement is mainly observed with slight oblique slip, perceived through the lakes of slickenline (15 ~ 25º). This oblique slip is confirmed as result of weak transpression through Frohlich Triangle diagrams of win-tensor program. This characteristic of the N-S trending faults is confirmed in quartz porphyry known to have intruded in the Late Cretaceous Period. The NE faults with right-lateral movement are cut and displaced sinistrally by the N-S faults or the accompanying subsidiary faults (NW-SE strike faults).

The fault systems in the study area is interpreted through the geometries, movement characteristics, relationship with the stratum and cross-cutting relationships as follows: 1) The NE

faults experienced right-lateral movement after left-lateral movement concerning the behavior of the Yongdong fault in Cretaceous Period 2) The N-S faults were developed cutting the NE faults with left-lateral movement after the quartz porphyry intrusion. 3) It is speculated that only sporadic distribution of the basal conglomerates (almost in the form of breccia) in this area away from the Yongdong basin is related to the transtensional component associated with the left-lateral movement along the NE faults.

This research was supported by a grant(2022-MOIS62-001(RS-2022-ND640011)) of National Disaster Risk Analysis and Management Technology in Earthquake funded by Ministry of Interior and Safety(MOIS, Korea).

Keyword

Yongdong fault, Principal stress analysis, Kinematic analysis, Lineament

Progressive evolution of a type II shear zone: the Ferriere-Mollières Shear Zone (Argentera Massif, Western Alps, Italy)

Matteo Simonetti[1]*, Servizio Geologico d'Italia - ISPRA (matteo.simonetti@isprambiente.it)
Rodolfo Carosi[2], Università di Torino
Chiara Montomoli[3], Università di Torino

Abstract

Shear zone behavior is mainly controlled by deformation regime, temperature, strain rate and rheology of the deformed rocks. If a gradient of strain is established across a shear zone, softening phenomena can cause a progressive localization of deformation toward the core, resulting in a constant thickness of the shear zone with increasing strain. In contrast, strain hardening may induce migration of deformation into the wall-rocks, causing an increase in shear zone thickness. In the Western Alps we studied a NW-SE striking steeply dipping km-scale shear zone, the Ferriere-Mollières Shear Zone (FMSZ), that cross-cuts Variscan migmatites in the Argentera External Crystalline Massif. The shear zone is characterized by a deformation gradient (Carosi et al., 2016), with strain increasing toward the center of the shear zone due to strain softening during Variscan retro-metamorphism. By combining structural and microstructural analyses with quartz fabric analysis, quartz palaeopiezometry and petrochronology, three main stages of shear zone development are recognized (Simonetti et al., 2021). Each stage is characterized by specific age, temperature and deformation regime. Stage I occurred between ~340 Ma and ~330 Ma under a temperature range of ~610 – 590° C with a prevalent (76%–65%) component of pure shear deformation; stage II occurred between ~ 330 and 320 Ma at temperatures between ~ 530 and 480° C with a decrease in the component of pure shear (73%–49%); stage III developed from ~320 to 300 Ma under temperature conditions between ~ 500 and 420° C with a prevalent component of simple shear (pure shear of 39%– 31%). Palaeopiezometry and microstructures revealed that during stage III alternation of cycles of brittle and ductile deformation occurred and they were triggered by fluids channelized in the active core of the structure.
The FMSZ is a new example of a strain-softening and long-lasting regional-scale shear zone, useful as a natural study area for future research about the complex processes operating in large-scale shear zones.

Carosi, R., D'Addario, E., Mammoliti, E., Montomoli, C. & Simonetti, M. (2016): Geology of the northwestern portion of the ferriere-mollieres shear zone, Argentera massif, Italy. J. Maps 12, 466–475. https://doi.org/10.1080/17445647.2016.1243491.

Simonetti, M., Carosi, R., Montomoli, C., Law, R.D. & Cottle, J.M. (2021): Unravelling the development of regional-scale shear zones by a multidisciplinary approach: The case study of the Ferriere-Mollières Shear Zone (Argentera Massif, Western Alps). J. Struct. Geol., 149, 104399. https://doi.org/10.1016/j.jsg.2021.104399

Keyword

Transpression, Vorticity, Quartz fabric, Monazite petrochronology, Palaeopiezometry

Newly identified fold-and-thrust structures in the Ulsan Block of the Cretaceous Gyeongsang Basin, SE Korea, and their formation timing

Hyewon LIM[1]*, Department of Geological Sciences, Pusan National University (limhw0903@pusan.ac.kr)
Seongjun Lee[2], Active Tectonics Research Center, Korea Institute of Geoscience and Mineral resources
Min-Cheol Kim[3], Department of Earth Science Education, Pusan National University
Jong-Won Han[4], Department of Geological Sciences, Pusan National University
Sangmin Ha[5], Department of Geography Education, Korea University
Yong-Un Chae[6], Department of Geological Sciences, Pusan National University
Hee-Cheol Kang[7], Department of Geological Sciences, Pusan National University
Moon Son[8], Department of Geological Sciences, Pusan National University

Abstract

Studies on the Gyeongsang Basin, SE Korea, are crucial for understanding the complex tectonic process occurring along the subduction zone between Eurasian and (paleo-)Pacific plates at the eastern margin of Asia since the Cretaceous. The Ulsan Block, located in the southeastern part of the Gyeongsang Basin and bordered by the Yangsan Fault to the west, has undergone multiple episodes of large fault movements and subduction-related igneous activities as the tectonic setting evolved. We have newly observed contractional structures that appear at various scales in the Ulsan Block. The block can be divided into eastern and western domains based on changes in stratal attitude and these domains are bounded by the Dongnae Fault, indicating their differential deformation histories. The stratal pattern in the western domain is delineated as a map-scale anticline with sub-horizontally W-plunging axis. This pattern is similar to that in the west of the Yangsan Fault, but is displaced about 38.2 km right-laterally by the strike-slip movement of the Yangsan Fault. On the other hand, the eastern domain shows a homoclinal structure dipping toward SE, except for the adjacent areas of intrusives. At the outcrop scale, numerous E-W trending folds and thrusts were observed in the western domain. Our findings, obtained from descriptive and kinematic analyses, paleostress reconstruction, and micro-scale observation, suggest that these contractional structures were formed by flexural-slip and/or buckling mechanisms under low P-T condition in the upper crust by N-S to NNE-SSW-trending horizontal compressional stress. Based on this geometric and kinematic similarity of structures on map, outcrop, and micro scales, observed structures in this study can be interpreted as a single structural assemblage, which is referred to as the ‘Ulsan Fold-and-Thrust Structure (UFTS)’. The dextral displacement of UFTS by the Yangsan Fault indicates that its formation was before the dextral movement of the fault, which is well-known to have occurred during the late Paleogene. This interpretation is supported by the cross-cutting relationship between fold-associated faults and felsic dikes and 73.3±0.54 Ma in zircon U-Pb age of the dikes. Considering the deposition age (103.6±2.5 Ma in zircon U-Pb) of the deformed sedimentary rock together, the formation timing of UFTS is constrained between 103.6 - 73.3 Ma. However, we do not yet know exactly what

causes the stress that formed UFTS. The UFTS may have been controlled by local stress field caused by movement of large fault zones or plutonism, and may be closely related to far-field stress field caused by regional tectonic event. This question is expected to be addressed by further detailed studies of the structures like UFTS formed in other areas of the Gyeongsang Basin.

Keyword

East Aisa, Gyeongsang Basin, Ulsan Block, late Cretaceous, contractional structures

HT-LP extensional shear zones in the Metamorphic core of the Himalaya: preliminary ages, strain and P–T conditions

Salvatore IACCARINO[1]*, University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT) (salvatore.iaccarino@unito.it)
Chiara Montomoli[2], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)
Elena Pippo[3], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)
Rodolfo Carosi[4], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)
John Cottle[5], Department of Earth Science, University of California, Santa Barbara, USA

Abstract

The Greater Himalayan Sequence (GHS) represents the metamorphic core of the Himalaya. The study of the GHS is particularly interesting since, due to its good exposure, it has often seen as a proxy for the middle-lower crust in orogenic settings. For a long time, the GHS has been often regarded as coherent, single tectonic unit. Recent findings, starting from field observations, down to microscale analysis, challenges this view. Indeed, nowadays most of the focus on the tectono-metamorphic evolution of the GHS is aimed to characterize how strain is accommodated within this "composite" unit, over the time.

In this contribution we report new data, combining field observations, microtectonics analysis, with pseudosection modelling and iterative thermodynamic modelling and monazite petrochonology, on the activity of high-temperature / low-pressure ductile shear zones, affecting garnet-sillimanite and cordierite-bearing anatectic paragneisses, in Eastern Nepal.

Field and microtectonics study highlighted how these shear zones are associated to a normal (both top-to-the-S and top-to-the-N) sense of shear. Mylonites were formed under upper amphibolite facies (c. 700°C) as testified by syn-kinematic mineral assemblage as well as quartz and feldspar dynamic recrystallization microstructures. Phase equilibria modelling (i.e., with the aid of P-T-X pseudosections) as well as iterative thermodynamic modelling, highlighted how sheared rocks experienced a "peak" pre-mylonitic stage in the medium-pressure, upper amphibolite-to granulite facies, under melt-bearing, conditions. This stage is followed by the mylonitic stage, which is associated to decompression and minor cooling.

Our multidisciplinary investigation highlights how strain was progressively localized within migmatitic terrain, following melt extraction, from the Oligocene down to Miocene. Possible consequences on the role of the detected HT-LP extensional shear zones on the exhumation and thinning of the GHS are presented.

Keyword

Ductile shear zones, Himalaya, Petrochronology, forward modelling, microtectonics

Mapping polycyclic and monocyclic basement's units, and their relationships with oceanic-derived units, in the Western Alps: preliminary data from the Northern Dora Maira Massif

Salvatore IACCARINO[1]*, University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT) (salvatore.iaccarino@unito.it)
Rodolfo Carosi[2], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)
Chiara Montomoli[3], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)
Davide Dana[4], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)
Francesco de Cesari[5], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)
Alberto Corno[6], University of Turin, via Valperga Caluso, 35 - 10125 Turin (IT)

Abstract

With the discovery of coesite relicts, diagnostic mineral assemblages (e.g., pure pyrope; the coexistence of jadeite with kyanite) and peculiar rocks occurrences (e.g., pyrope-bearing quartzite and whiteschist), testifying how the continental crust could be subducted down to mantle depth at ultra-high-pressure (UHP) conditions, the Dora-Maira massif (Southern Western Alps) has become a peculiar place for the Plate Tectonics.

Despite this globally wide recognition and importance, most of the focus and of the scientific interest, has been paid to the Southern portion of the Dora-Maira massif, specifically on the Brossasco-Isasca unit (BIU), where UHP was originally documented. The remaining, but still very consistent by extent, part of the massif is still largely unexplored from the geological point of view, including updated structural-geological mapping and modern tectono-metamorphic characterization. For these reasons, by decades, the Northern portion of the Dora-Maira has been regarded as a "monotonous" portion of the Western Alps, constituted by two continental-derived tectonic units, a structurally upper (largely) polycyclic basement unit and a lower monocyclic unit, affected respectively by Alpine eclogite and blueschist facies conditions. Recent findings, specifically the occurrence of a structurally thin, garnet-chloritoid-coesite-bearing tectonic unit, sandwiched among the two aforementioned basement units, opened new scientific puzzling and challenges.

In this contribution we report new data, starting from field observations coupled with microtectonics analysis, obtained from the ongoing geological mapping, at the scale of 1:50000 (Foglio 172 - Pinerolo), within the Italian national CARG (Geological CARtography) project. This project involves the creation of a database supplying more detailed geological and geothematic maps enabling cartographic data to be used for many different purposes, including research in Tectonics and beyond.

An updated geological map, coupled with new meso-and microstuctural observations is presented with the aim of discussing the internal architecture of the Norther Dora Maira massif and its relationships with the oceanic-derived units, located tectonically above it.

This research has been supported by the funds of the CARG – Project – Geological Map of Italy

1:50,000

Keyword

geological mapping, microtectonics, Western Alps, Dora Maira massif, metamorphic basement

Crustal tectonic fabric in the Iberian Variscan slate belt: strong seismic anisotropy of slaty rocks partially preserved during homoaxial re-folding

Sergio Llana-Funez[1], Geology Department, University of Oviedo
Gabriela Fernandez-Viejo[2], Department of Geology, University of Oviedo
Victor CARDENES[3]*, Department of Geology, University of Oviedo (cardenesvictor@uniovi.es)
Marco Antonio Lopez-Sanchez[4], Department of Geology, University of Oviedo
Jorge Acevedo[5], Department of Geology, University of Oviedo
Javier Olona[6], Department of Geology, University of Oviedo
Carlos Lopez-Fernandez[7], Department of Geology, University of Oviedo

Abstract

The distal parts of the preorogenic rock sequence in the Iberian Plate before its involvement in the Variscan orogeny were dominated by fine-grained detritics and lutites. During the Variscan event, this thick and monotonous rock sequence became the “slate belt” as the rocks developed a pervasive and strong tectonic fabric in relation to recumbent folding. Ongoing convergence resulted in the upright refolding of earlier folds. These folds were homoaxial with previous structures resulting in an overall strong linear fabric with fold axes subhorizontal and perpendicular to the overall E-W shortening direction.

The development of crystallographic and well as shape fabric in dominant metapelites imposes a strong mechanical anisotropy in slaty rocks. The homoaxial refolding and crenulation of this fabric affect bulk rock anisotropy by transforming an original planar anisotropy into a linear fabric. We use direct whole-rock measurements of CPO in slates by ESBD to constrain the physical properties of mineral aggregates. In combination with the modelling of their physical properties, we determine the bulk physical properties under various arrangements of minerals and fabrics.

Present-day crustal structure in the area has been surveyed using ambient noise from a seismic network deployed in and around most of the slate belt. Cross-correlation of seismic records in station pairs by seismic interferometry theory allows the extraction of velocity data in between stations. Rayleigh and Love dispersion measurements are used in ambient noise to extract vertically (Vsv) and horizontally (Vsh) polarized shear waves. When they differ, the solid medium is regarded as radially anisotropic (Vsv>Vsh is positive, Vsv<Vsh is negative). Our results show that in the NW Iberian upper crust, a strong positive radial anisotropy is preserved in the slate belt, contrasting with negative anisotropy on tectonic units on either side, the foreland fold and thrust belt to the E, the high-grade hinterland to the W.

Despite more recent tectonic events affecting the crust in NW Iberia, such as the Mesozoic extension giving rise to the opening of the Atlantic Ocean or the more recent alpine convergence, the crustal segment in the Variscan slate belt seems to preserve a subhorizontal fabric which cannot be related to these more recent events, where fracturing tends to produce vertical anisotropies. We suggest that this crustal fabric is related to the internal structure of the slate belt

as its appearance is restricted to the exposure at the surface of heavily folded slaty rocks.

Keyword

slaty rocks, seismic anisotropy, interference folding, crustal fabric, ambient noise

Structure characteristics and its insights on shale gas exploration: an example from the Luzhou area, southern Sichuan Basin, China

zhengshuo MIAO[1]*, China University of Petroleum (East China) (miaozhengshuo@163.com)
Yangwen Pei[2], China University of Petroleum (East China)
Jingru Zhao[3], China University of Petroleum (East China)
Zifan Zhu[4], China University of Petroleum (East China)

Abstract

The southern Sichuan basin, a shale gas bearing area, presents great potential for increasing storage and production in the future. However, the structure characteristics and their control on shale reservoir quality have not been documented. Here the Luzhou area was selected as an example to study the structure characteristics and its insights on shale gas exploration in the southern Sichuan basin.

In this study, multiple methodologies, including 3D seismic interpretation, strain simulation, seismic attributes analysis, and fault system topology, were employed to investigate the fault characteristics, fault-fold spatial distribution and fault connectivity in the southern Sichuan basin. The quality and potentials of shale reservoirs were then evaluated.

In section view, different types of thrust fault were identified in the study area, including fore-thrust and back-thrust faults. Accordingly, the folds developed in the study area were divided into the anticlines in pop-up zones and the synclines in imbricate zones and stable zones. The strain simulation indicates that the fold of different types results in different level of reservoir damages, with high in the anticlines in pop-up zones, low in the synclines in stable zones, and intermediate in the synclines in imbricate zones. In plan view, two primary sets of faults, trending NNE and W-E, were interpreted based on 3D seismic attribute analysis. However, the two sets of faults present different distributions, with the NNE trending faults distributed throughout the study area and the W-E trending faults distributed primarily in the southwest portion. Based on fault topological analysis, the fault connectivity was quantitatively evaluated, demonstrating high level of variation in the study area. The anticlines in pop-up zones present high level of fault connectivity, whereas the synclines in stable zones present low level of fault connectivity. The synclines in imbricate zones present fault connectivity in between. By integrating the production data of shale gas wells in the study area, it is believed the high productive shale gas wells are primarily distributed within the synclines in imbricate zones with intermediate fault connectivity, which may provide important hints for the shale gas exploration in the Luzhou area in the future.

Keyword

Fault characterization, shale gas, strain simulation, seismic attributes analysis, fault network connectivity

Structural diagenesis of deep-buried carbonates controlled by strike-slip faults: an example from the Sinian Dengying Formation in Central Sichuan Basin

Shangzi LIANG[1]*, Petroleum Exploration and Production Research Institute, SINOPEC, Beijing, China (liangsz.syky@sinopec.com)
Zhong Li[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China

Abstract

Fault-controlled structural diagenesis of carbonates has received increasingly attention mainly owing to its promising economic prospects for oil and gas exploration. The dissolution and mineral precipitation associated with faults can alter the reservoir properties. Therefore, faults that act as fluid migration channels and the relationship between faulting and fluid diagenesis should be further investigated. The Sinian Dengying Formation in Central Sichuan Basin provides an opportunity to combine structural analysis with petrographic and geochemical data to investigate the structural diagenesis of deep carbonates and clarify the related implications for the reservoir. Through core observation, thin section examination and cathodoluminescence analysis, the different phases of fracture-filling dolomite cements associated with the strike-slip faults were identified. According to the petrographic characteristics, typical samples are selected to conduct carbon and oxygen stable isotope analyses, fluid inclusions analysis and in-situ rare earth elements analysis, revealing the properties and sources of the mineral-deposit-forming fluid. Combining the deformation style of the strike-slip faults and the paragenetic sequence, the structural-fluid evolution history is deciphered, and structural diagenesis model is established. The research shows that four phases dolomite cements were developed in the Dengying reservoir. The earliest dolomite generation may have precipitated from mixing of meteoric water and seawater. The second and third phase of dolomite cements were formed during the middle–deep burial process, generated from modified seawater. The latest episode of dolomite cementation is related to regional hydrothermal activity. Beside dissolution occurred in the penecontemporaneous and hypergene stages, two-phase burial dissolutions developed in the Dengying Formation, which were related to hydrothermal fluid and hydrocarbon injection. Based on the study of in situ fluid–rock interaction records and burial–thermal history, it is believed that the burial dissolution–cementation of the Dengying reservoir was influenced by the fluid flows that were related to the four stages activity of the strike-slip faults.

Keyword

structural diagenesis, strike-slip faults, Deep-buried carbonate reservoir, Sinian Dengying Formation,, Sichuan Basin

Permeability structures of fault zones in low porosity carbonates

Fabrizio AGOSTA[1]*, University of Basilicata (fabrizio.agosta@unibas.it)

Abstract

In the brittle regime, fault zones in low porosity carbonates are characterized by a variety of deformation mechanisms and diagenetic processes, which might determine a profound effect on the time-space evolution of mineralization and fluid pathways within fractured reservoirs. Deformation associated to faulting of pre-existing structural heterogeneities, fault growth by linkage of neighboring segments, splaying of faults, and fault intersections may form localized fluid conduits for the infiltration of meteoric waters at depth and/or the upraise of deep and warm fluids toward the Earth's surface. As a result, the ingression of externally derived fluids into the fault zones can cause localized dissolution and/or mineralization of the carbonates, and modify the diagenetic history of fault rocks and of the encompassing fractured photoliths. Fluid circulation along carbonate fault zones can therefore form mineral deposits, produce hydrothermal activity, and affect groundwater integrity. For these reasons, extensive research is currently taking place on the analysis of surface analogs of subsurface fractured carbonate reservoirs. The results of this work are applied to industrial activities related geothermal energy production, secure storage of nuclear waste in the subsurface, CO2 confinement at depth, and groundwater management. A good understanding of the permeability structure associated to carbonate fault zones might be key to safely operate during production of renewable energy, CCS activities, and all types of operations related with the drilling of fractured carbonates at depth.

The present contribution summarizes the main outcomes of field-based geological investigations of low porosity carbonates exposed in the Mediterranean area. The fluid flow behavior of the outcropping high-angle fault zones is assessed by combining the results of field structural analysis with those obtained after petrophysical, rock physical, and geochemical investigations of carbonate samples, as well as with the outcomes of discrete fracture network modeling of geocellular volumes. Data are consistent with the carbonate fault zones rarely forming barriers or baffles to fluid flow in the subsurface. The fractured rock matrices often form localized or diffuse fluid conduits enhancing the along-fault flow. However, mineralization due to the ingression of externally-derived fluids might modify the permeability associated to carbonate fault zones. This process is very rare within faults in dolostone and dolomitic-rich rocks do not include any mineralization, whereas those in limestone are very often cemented by meteoric-derived fluids. As a consequence, cementation can reduce the fault-orthogonal permeability. Of course, any possible presence of clayish smears in the fault zones drastically inhibit the fluid flow. The overall permeability ellipsoid associated to fault zones in low porosity carbonates is therefore characterized by an oblate shape that sub-parallels the faults. The longer axes of the ellipsoid represent greater values of permeability associated to the fault-parallel fluid flow, which main localizes along the main slip surfaces and within the fractured carbonate around. Differently, the shortest axis of the ellipsoid represents the less conducive fluid behavior associated to the

comminuted and, possibly, cemented fault rocks, which may reduce the cross-fault permeability.

Keyword

surface analogs, Mediterranean, high-angle faults, fractured carbonates, fault architecture

Distributed faulting and fault growth by segment linkage in stratigraphic multilayers

Rob BUTLER[1]*, University of Aberdeen (rob.butler@abdn.ac.uk)
Fracisca Robledo[2], University of Aberdeen
Phoebe Sleath[3], University of Aberdeen
Clare Bond[4], University of Aberdeen

Abstract

Starting points for understanding geomechanics and fluid-flow for faults and fault zones are clear descriptions of the geometry of these structures. But how well can we characterise geometry of faults and fault systems in the subsurface? Much of our understanding of faults, whether as individual structures or as arrays, comes from seismic imagery of structures have substantial displacements. Interpreted patterns of the displacements, charted by offsets of stratal reflectors, are widely used to test interpretations not only for the geometry and evolution of a fault but also for predicting its properties (e.g. shale-gouge ratio and derivatives thereof). This understanding is dominated by studies from normal faults – seismic imagery from thrust systems is generally poorer so that idealised conceptualisations are used to inform interpretational workflows – commonly applied to structures on regional cross-sections. These scales of application generally focus on large-displacement structures. However, when appraising candidate sites for subsurface geo-storage (e.g. for CO2 or rad waste), large faults are generally avoided. So potential risks to site integrity come from small faults. How well do we understand such structures and their geometric variability? What are the implications of different interpretations of small-displacement fault arrays for the initiation and early history of large-displacement fault systems?

Here we present combinations of, generally excellent, seismic imagery from 3D volumes, along with outcrop analogues to examine different workflows and approaches for mapping faults relevant to the scales and application to subsurface geostorage. These indicate that faults can initiate, in both extensional and contractional regimes, as distributed arrays confined to competent layers. We liken this to the patterns of fractures developed in packets of broken biscuits (crackers). All layers are faulted, but layers can have distinctly different fault patterns. The size of the early fault segments will be strongly controlled by the stratigraphic template. Deformation in incompetent layers can be distributed across shear zones and broader volumes of distributed strain/differential compaction. As recognised by others, complex localisation of faulting as they initiate and grow can result in complex architectures within fault zones. Seen in vertical profiles, as faults grow, they can link to create local segments with dip-directions counter to those on the segments within competent layers. In thrust systems, these counter-segments locally extend layering (apparent normal faulting); in normal faults the counter-segments show local reverse displacements. In plan-view, faults developed through the linkage of short segments will have sinuous traces. These results indicate that fault systems, once dismissed as being “minor

structures” in the context of regional cross-sections, can make complex patterns through stratigraphic multilayers. They precondition the geometry of large faults that may grow through further deformation, carrying the initial complexity in the architecture of larger fault zones. In recognising the likelihood of such complexity, interpreters should allow for significant uncertainty in their endeavours and for challenges in seismic interpretation, where structures, or parts thereof, may lie beyond the resolution of the imagery. Effective forecasting the complexity of fault zones may be enhanced by consideration of the stratigraphic template that host them.

Keyword

thrusts, faults, multilayer, geo-storage, interpretation

Preliminary data on fluid flow along the seismically active Yangsan fault

Luca SMERAGLIA[1]*, Consiglio Nazionale delle Ricerce, CNR-IGAG (luca.smeraglia@cnr.it)
Andrea Billi[2], Consiglio Nazionale delle Ricerce, CNR-IGAG, Rome, Italy
Chang-Min Kim[3], Department of Geology, Division of Geology and Geophysics, Kangwon National University, Chuncheon, South Korea
Youngbeom Cheon[4], Active Tectonics Research Center, Korea Institute of Geoscience and Mineral Resources, Daejeon, South Korea
Chiara Boschi[5], Consiglio Nazionale delle Ricerche, CNR-IGG, Pisa, Italy
Eugenio Carminati[6], Dipartimento di Scienze della Terra, Sapienza Università di Roma, Rome, Italy

Abstract

The NNE-striking, strike-slip Yangsan fault is one of the most seismically active faults in Korea (i.e., magnitude 5.1 and 5.8 earthquakes generated on September 12, 2016). Many past studies aimed at characterizing the structural architecture, micro- to nanostructures, and fault rock friction of the Yangsan fault; however, the origin and role of fluid circulation during the seismic cycles of this fault are still unknown. For this reason, we combined structural and microstructural analyses of calcite veins and slickenfibers sampled from three exposures along the Yangsan fault with stable carbon and oxygen isotopes to propose a first preliminary model of fluid circulation with implications on earthquake-related fault permeability. Results show that the Yangsan fault is characterized by both dextral and sinistral strike-slip kinematics, with both fault movements occurring during fluid flow within the fault zone. Slickenfibers are mostly localized along (1) the slip surfaces of competent, anastomosed rock lithons scattered within the strongly foliated clay-rich gouge in the fault cores and (2) along shear planes in the clay-rich gouge itself. Calcite veins occur within the anastomosed rock lithons in the fault core and in the fault damage zone consisting of volcanic and siliciclastic sedimentary rocks. Stable isotope data show that δ18O (VSMOW) values of both veins and slickenfibers range between +15‰ and +10‰. Both veins and slickenfibers show negative δ13C (VPDB) values. In particular, veins in the damage zone show more negative δ13C values than those of slickenfibers in the fault cores. Overall, the negative δ13C values suggest the circulation of meteoric-derived water both in the damage zone and in the fault core. Our results show that, although the low-permeability fault core is rich in sheared clays and shales, externally-derived meteoric fluids were able to circulate within it. Probably, these fluids were stored in the high-permeable (i.e., more fractured) damage zone and were further injected into slickenfibers (i.e., micro dilational jogs) during multiple seismic fault movements. Stable isotope data exclude the involvement of (1) locally derived, rock-buffered fluids, such as those from clay dehydration and (2) uprising hydrothermal fluids. We conclude that even low-permeable, clay-rich fault cores along strike-slip faults can act as conduits for the circulation of externally-derived meteoric fluids during seismic events, thus dismantling the paradigm of clay-rich gouge making faults completely impermeable to the circulation of external fluids. Further clumped stable isotope analyses are necessary to better constrain the fluid origin and validate the proposed fluid flow model and implications.

Keyword

Fault-fluid interactions, stable isotopes, earthquakes

Multistage structural controls on hydrothermal vein system development in epithermal mineral deposits: A case study of the Tieluping Ag–Pb–Zn deposit, East Qinling, China

Xinming ZHANG[1]*, China University of Geosciences (Beijing) (zhangxmcugb@qq.com)
Da Zhang[2], China University of Geosciences (Beijing)
Xuan Wang[3], MNR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, Chinese Academy of Geological Sciences
Mingjian Yang[4], China University of Geosciences (Beijing)
Bojie Hu[5], China University of Geosciences (Beijing)
Songyan Liu[6], China University of Geosciences (Beijing)

Abstract

Epithermal deposits are formed by hydrothermal vein systems controlled by complex systems of brittle fractures. The development of these ore-controlling fractures results from the dynamic interplay of various structural factors, including paleostress regimes, fluid pressures, and pre-existing mechanical anisotropies in the rock mass. However, the nature of this interplay has not previously been described in detail. The Tieluping epithermal Ag–Pb–Zn deposit is situated on the western margin of the Xiong'ershan ore-concentration area and contains two groups of fracture-controlled N- and NE-striking veins. Here we systematically investigate the structural deformation and hydromechanical development of the Tieluping deposit. Ag–Pb–Zn mineralization is characterized by the superposition of multiple generations of mineralized hydrothermal quartz–siderite–pyrite (V1), quartz–ankerite–sphalerite–galena (V2), and quartz–calcite–fluorite (V3) veins. Our analysis of structural-deformation and fault-slip data reveals that the T1 stress tensor (σ1: 003/90; σ2: 183/00; σ3: 093/00; R = 0.50) during the formation of early V1 veins was characterized by sinistral shear and hybrid kinematics of NE-striking fractures and tensional kinematics of N-striking fractures. The subsequent formation of late V2 and V3 veins, including NE-striking hybrid (dip-slip offset) and tensional structures and N-striking dextral shear and hybrid structures, were controlled by the T2 stress tensor (σ1: 045/90; σ2: 221/00; σ3: 311/00; R = 0.77). Fluid inclusion petrography and microthermometric analysis suggest that epithermal mineralization in the Tieluping deposit was caused by mixing of magmatic fluids and meteoric water under hydrostatic conditions and occurred in the distal region of a porphyry–epithermal system in the Xiong'ershan ore-concentration area. These structural and fluid inclusion data were used as a basis to construct a quantitative 3-D Mohr circle to describe the dynamic evolution of ore-controlling fractures in the deposit. The results of the 3-D Mohr circle analysis suggest that differing multistage stress regimes and variable fluid pressure governed the reactivation of pre-existing cohesionless structural planes that controlled the emplacement of epithermal veins in the Tieluping deposit. Fluid pressure favored the widespread reactivation of pre-existing structural planes and provided tensional accommodation space for fluid mixing and mineral precipitation during epithermal mineralization. The quantitative 3-D Mohr circle method used to analyze the hydromechanical evolution of the Tieluping deposit successfully describes the formation and

evolution of the ore-controlling fracture system and gives insights into the development of epithermal deposits.

Keyword

epithermal deposit, ore-controlling fracture, fault-slip, fluid inclusions, 3-D Mohr circle

Synkinematic hydrothermal silicification in active normal faults: implications on the permeability structure of silicified faults

Luigi Riccardo BERIO[1]*, Università di Parma (luigiriccardo.berio@unipr.it)
Fabrizio Balsamo[2], Università di Parma
Alessio Lucca[3], Università di Parma
Mattia Pizzati[4], Università di Parma
Fabrizio Storti[5], Università di Parma
Luca Aldega[6], Sapienza Università di Roma
Francisco Hilario Bezerra[7], Universidade Federal do Rio Grande do Norte
Anna Cipriani[8], Università degli Studi di Modena e Reggio Emilia
Federico Lugli[9], Università degli Studi di Bologna
Luciana Mantovani[10], Università di Parma
Marcos Allyson Felipe Rodrigues[11], Universidade Federal do Rio Grande do Norte
Stefano Zanchetta[12], Università degli Studi di Milano Bicocca
Giulio Viola[13], Università degli Studi di Bologna

Abstract

In upper crustal fault zones, silica-bearing hydrothermal fluids may affect petrophysical and mechanical properties of rocks by modifying their texture and mineralogy with strong implications on geofluid storage and flow potential. It is, however, extremely difficult to predict the geometry of silicified rock volumes along and around fault zones as well as their textures and petrophysical properties in the subsurface and, therefore, well exposed outcrop analogues can provide important insights. The Kornos-Aghios Ioannis Fault (KAIF) on Lemnos Island (Greece) is a silicified extensional fault system active at shallow depth (<1 km) that, well exposed over 10 km length, juxtaposes Lower Miocene volcanic rocks against Middle Eocene to Lower Miocene turbidite sandstones. The fault zone structure consists of a m-thick fault core made up of silicified breccia, cataclasite and ultracataclasite and by fractured damage zones developed in silicified turbidite sandstone. In the footwall damage zones, this pervasively silicified sandstone locally contains crackle to mosaic breccia cemented by late stage quartz. Silicified and brecciated domains extend in the footwall for a maximum of 250 m and 80 m from the master fault, respectively, but their width strongly varies along-strike, it being greater at the fault tip. Fracture density and connectivity is higher in the silicified portions of the fault. Whole-rock X-ray diffraction data of representative samples show systematic changes in quartz content from the silicified fault core to the pristine host rock with maximum values >80 wt. % near the master fault plane and values between 40 and 50 wt. % where the host rock is not affected by silicification. Quartz content is inversely correlated with feldspar content. Oxygen isotopic composition of silica cements is in the range +7.0 ‰ < δ18O V-SMOW < +12.4 ‰ and fluid inclusion data indicate that silica precipitated from hydrothermal fluids with an average temperature of 170 ± 16 °C. Fluid inclusion and isotopic data from other hydrothermal minerals sampled in fault-related veins in the hanging wall (i.e. calcite, dolomite and barite) indicate similar temperatures (166 ± 17 °C) and the δ18O V-SMOW values of hydrothermal calcite vary between + 4.0 and + 23.0 ‰. Hydrothermal calcite

exhibits high Mn, Fe and REE contents (average ΣREE 94 ppm) and pronounced positive Eu anomalies. Our data support an evolutionary scenario in which deeply circulating meteoric fluids underwent thermal equilibration and trace element enrichment through fluid-rock interaction processes. Silica precipitation possibly occurred during their upward migration along fault zones due to a progressive decrease of silica solubility during cooling. Petrophysical analyses performed with an unsteady state gas permeameter and porosimeter suggest that the process of silica precipitation can strongly impact on petrophysical properties of faulted sandstone by decreasing matrix porosity from 12-14 % to 2-4 % and permeability from 1 to 0.001 mD.

Keyword

Fault, Silicified fault, Hydrothermal, Damage zone, Permeability

Fluids and deformation processes at shallow subduction megathrust: hints from ancient analogues

Francesca REMITTI[1]*, Università di Modena e Reggio Emilia (francesca.remitti@unimore.it)

Abstract

Subduction megathrusts have been recognized for a long time as weak interplate faults that localize deformation under low shear stresses (<20 MPa) and active circulation of fluids. This is inferred from the small taper angles of overlying accretionary wedges, low surface heat flow, the distribution and nature of aftershock focal mechanisms, and geophysical measurements of high Vp/Vs. The weakness of megathrusts is ascribed to low-friction minerals and/or fluid overpressures which significantly lower the effective friction coefficient of megathrust faults. In particular, the shallow part of the subduction megathrust hosts several changes leading to progressive lithification of seafloor sediments at increasing P-T conditions, resulting in a shift from diffuse soft- sediment deformation to discrete faulting often characterized by diffuse veining. The widespread occurrence of fracture sets filled with mineral veins in ancient megathrust testifies to an active fluid circuit, cyclically subjected to pressure rises and drops and permeability changes related to fracturing and fracture healing by precipitation of hydrothermal minerals. Tectonic veins thus represent a valuable archive of information on both the stresses state and the physicochemical characteristics of fluids circulating in the fault zone through time. This presentation aims to explore two main aspects: (i) the impact of progressive lithification on deformation processes occurring in the shallow part of the megathrust, and (ii) the insights provided by tectonic veins into fluid pressure, fluid circulation, and stress distribution around shallow ancient megathrusts.

Keyword

megathrust, tectonic veins, subduction, fault

Deciphering fluid sources and pathways of hydrothermal Ba-F mineralisation in western Bastar craton, central India: Using mineral system approach by combining structure, fluid, Sr- and S-isotope geochemistry

Muduru Lachhana Dora[1]*, Geological Survey of India (muduru.dora@gsi.gov.in)
Sandip Kumar Roy[2], Geological Survey of India

Abstract

Hydrothermal vein-type Ba-F mineralization usually occurs in the vicinity of rift valleys, basement-cover unconformities, and large-scale crustal lineaments or fault systems. The study area is part of Western Bastar Craton (WBC), composed of ca. 2.5 Ga Tonalite-Trondhjemite-Granodiorite (TTG) suites, charnockite and mafic-ultramafics. These assemblages are intruded by 1.6 Ga Mul granite, overlain by Pranhita-Godavari (PG) cover sediments. Mineralization (Ba-F) is associated with numerous quartz veins along structural weak planes, i.e. faults, hosted in Mul granite. We combined field and laboratory studies using structural mapping, geochemistry, fluid inclusion, Sulfur, and Sr-Isotope geochemistry to characterize ore-forming processes and their pathways.

The regional NW-SE trending PG rifting provided pathways for fluid flow and ore formation along faults/fracture systems (F2 and F3 fault systems) in the host Mul granite of WBC. The F2 fault system, sympathetic to the PG rift, is deep-seated and contains mainly barites of magmatic origin besides the minor marine signature. The F3 cross faults, developed across the gneissic foliation of TTG gneisses and charnockites, can be traced to the PG basin's younger marine sediments, host barites of marine signature.

Petrography studies show barite is accompanied by galena, pyrite, fluorine and chalcopyrite. Sulfide-free (Brt-I), sulfide-bearing (Brt-II), and fluorite-associated barites (Brt-III) were observed in different assemblages. The fluid inclusion homogenization temperature (Th) ranges from 152°C to 310°C with a mean Th value of 201°C. Fluid inclusion and Sr-S isotope data suggest a bimodal evolution of the brine viz. the oxidative source forms sulfide-free high-salinity brine and reductive low-salinity sulfide-bearing aqueous fluid formed by interaction with reducing agent causing hydrothermal Ba-mineralization. The source for hydrotherms responsible for the formation of barite and galena in association with the quartz-barite vein is granitic magma. The 87Sr/86Sr isotopic ratios display two distinct arrays; one with lower 87Sr/86Sr of 0.706075-0.707791, having lower salinity, suggests the influence of Mesoproterozoic seawater. The second one, with higher 87Sr/86Sr of 0.71561-0.719785 and relatively higher salinity, indicates mixing hydrothermal solutions with the fluids formed in the continental areas generated in the rift valley. The combined 87Sr/86Sr and δ34S‰ data suggest mixing fluids from diverse sources, including magmatic, marine, and crustal fluids. Low 87Sr/86Sr (10‰) are indicative of alteration products of granite that were subsequently mixed with submarine hydrothermal fluid mobilized through the Mesoproterozoic PG rift system. The epigenetic-submarine hydrothermal vein-type barite

mineralization hosted in granite, WBC differs from VMS, Sedex, Carlin, or Orogenic-type barite deposits. The Ba ± F mineralization in the study area is a perspective for regional exploration and elsewhere in a similar geological milieu.

Keyword

Hydrothermal Barite, 87Sr/86Sr, Fluid Inclusion, Bastar Craton, Central India

[Keynote] Reconstructing past fluid migrations in fold-and-thrust belts and forelands using geochemistry

Nicolas E Beaudoin[1]*, Université de Pau et des Pays de l'Adour (nicolas.beaudoin@univ-pau.fr)

Abstract

Orogenic forelands, either flexural foreland or broken foreland in style, host interactions between deformation and static or migrating fluids. Given their accessibility and dimensions, these areas are not only historic landmarks for structural geology, but they are also areas of prime interest for georesource exploration and geological storage, and loci of potential geohazards. Geochemical techniques applied on synkinematic mineralization in tectonic structures, along with direct measurements in fluid trapped in the crystals, can constrain the temperature, pressure, origin and pathways of fluids during deformation and allow the characterization of the past fluid system. This talk attempts at summarizing, through some selected studies of past fluid systems reconstructed at the scale of the orogenic foreland, the evolution of the fluids involved during deformation, with regards to the structural style. At first order, the past fluid system evolves in a similar way with respect to the considered stage of deformation, being rather closed to external fluids when deformation is bounded to mesoscale structure development, and opening to vertical flow when thrust and folds develop. In a more detailed view, it seems that the past fluid system evolves and distributes under the influence of the structural style, of the geometry of the major faults, and of the lithology of the sedimentary succession. The concept of geochemistry-assisted structural geology will be discussed through some cases studies where geochemistry of calcite veins helped refine sub-surface geometries and structural developments in orogenic forelands.

Keyword

Fluid flow, Geochemistry, Fold and thrust belt, forelands, calcite

Scale-dependent fracture patterns and flow in low-enthalpy geothermal targets: the role of diagenesis and contingent nodes

Stephen Ernest Laubach[1]*, The University of Texas at Austin (steve.laubach@beg.utexas.edu)
Stephanie Forstner[2], The University of Texas at Austin

Abstract

Fracture patterns in rock strongly affect directions, magnitudes, and heterogeneities of both fluid flow and rock strength. Accurate and testable predictions of patterns are essential for understanding many societally important processes in the Earth and for effectively managing subsurface engineering operations. Chemical processes play a larger role in opening-mode fracture pattern development than has hitherto been appreciated. For fractures formed at depths of ~1–10 km and temperatures of 50–200 °C, new evidence shows chemical reactions are common and more diverse than previously recognized. We describe how viewing fracture formation and evolution from a chemical perspective helps to solve problems in fracture pattern analysis. We outline the main impediments to subsurface fracture pattern measurement and interpretation, assess implications of recent discoveries in fracture history reconstruction for process-based models of fracture and cement accumulation, review models of fracture cementation and chemically assisted fracture growth, and discuss promising paths for future work. Potential exists for basic scientific investigations to lead to progress on what has been one of the most refractory practical problems in subsurface science. Results suggest that progress in fracture interpretation and prediction can be made using observational, experimental, modeling, and theoretical approaches that view fracture patterns as the result of coupled mechanical and chemical processes. Developments have application for the energy transition.

Keyword

fracture, scaling, geothermal, network, connectivity

Infiltration of illuvial clays along the near-surface slip zone

Youngbeom CHEON[1]*, Active Tectonics Research Center, Korea Institute of Geoscience and Mineral Resources (cheonyb@kigam.re.kr)
Hakyung LEE[2], Department of Geology and Research Institute of Natural Science, Gyeongsang National University
Chang-Min KIM[3], Department of Geology, Division of Geology and Geophysics
Raehee HAN[4], Department of Geology and Research Institute of Natural Science, Gyeongsang National University

Abstract

Illuvial clays are generally regarded as very fine deposit materials, which vertically migrate in water and accumulate in pore-like spaces without significant chemical and physical alteration. Here we present the nature of illuvial clays observed along paleoearthquake slip zones in near-surface regions, South Korea, based on outcrop to microscale structural observations and mineralogical investigations. Paleoearthquake ruptures distributed throughout the Korean peninsula are mainly characterized by a narrow slip zone (<3-cm-wide) in the basement depths, which branched into several narrower splays showing a bifurcation geometry within the overlying unconsolidated sedimentary strata. At the three studied sites (Oebuk, Songhak, and Geumam sites in the NNE−SSW-striking Gongju Fault Zone, central Korea), the specific slip zone in the basement rocks (granitic rocks) is mainly composed of the fault rocks (fault gouge and/or microbreccia), whereas the branched slip zones in the unconsolidated strata are expressed as the infiltration of illuvial clays without fault rocks. However, it is noted that the uppermost part of the slip zones in the basement rocks also contains the illuvial clays, which are intercalated within the fault rocks, showing a downward tapering geometry. Our structural and mineralogical findings show that the illuvial clays have a distinct texture and color but also mineralogy compared to the fault rocks. These features present that the narrow seismic slip zone propagated in near-surface regions, primarily showing a deformation mechanism of granular flow, can be an important permeability zone due to its dilation. We further need to consider the influence of infiltrating materials on subsequent earthquake slip events based on their mineralogical characteristics.

Keyword

Illuvial clay, Earthquake slip zone, Near-surface region, Infiltration, Permeability zone

The mechanism and its geological significance of Mesozoic red sandstone bleaching in Luxi block, North China Craton

Li LI[1]*, China University of Petroleum (East China) (lili@upc.edu.cn)

Abstract

Red sandstone bleaching is of great significance for tracing the origin of reducing fluids and the fluid-rock interaction with subsurface sediments in the process of fluid escape. Based on the fieldwork data, XRD test and carbon and oxygen isotope test, this research systematic revealed the characteristics, mechanism and geological significance of bleached sandstone in Luxi block, North China Craton. Field observations found that the bleaching sandstone occurred along bed parallel layers and fractures in the Jurassic and Triassic red sandstone. The former is planar and diffuse along the layer and the latter is linear, branch shape, etc. along the fracture strike and planar on the profile. The XRD tests found that the mineral compositions of calcite and hematite in the Jurassic and Triassic bleached sandstones are different. The former has a high content of calcite and no hematite, while the latter has a low content of calcite and hematite. The mineral edge of the red sandstone is covered with a hematite coating in section, while the red coating on the mineral edge dissolved and partially dissolved after bleaching. Carbon and oxygen isotope tests show that the average value of δ13C in the Jurassic bleached sandstone is -4.04‰, and the average value of δ18O is -10.15‰. Although the carbon isotope values far from the fault are smaller than those near the fault, both of them are products of mantle-derived CO2 fluids reduction. While the average value of δ13C and δ18O of the Triassic bleached sandstone is of -2.70‰ and -13.64‰, respectively, heavy δ13C and light δ18O compared to the Jurassic bleached sandstone, indicating that the Triassic red sandstone is the reduction of hydrocarbon fluid. The fault is an important channel for the Mesozoic red bed bleaching and reducing fluids migration of the Luxi block. The Tan-Lu fault zone, the crustal detachment surface and the NW-trending detachment fault control the migration of the mantle-derived CO2 upward to the shallow surface, and the CO2 gas diffused along the bed parallel slipping surface and fractures produced by the NW trending detachment during the same period and reduced the Fe3+to Fe2+, resulting in the fluid-red sandstone interaction to bleach the Jurassic red sandstones. The Cicun fault is a channel for hydrocarbon migration from the Dongying sag, Bohai Bay Basin to the Luxi block, which led to the bleaching of the Triassic red sandstone by reducing the Fe3+to Fe2+. The geo-geochemical study reveals that there are two type of bleaching mechanism by reducing Fe3+to Fe2+ during mantle derived CO2- rock interaction and hydrocarbon- rock interaction in Mesozoic red sandstone of the Luxi block. The reducing fluid originates from the mantle and hydrocarbon in the Dongying sag, respectively, and the activities of the Tan-Lu fault zone and the regional faults in the Luxi block are closely related to the bleaching of red beds. The research implied that the northern part of Luxi block is a potential oil and gas exploration area.

Keyword

Bleaching sandstone, Mechanism, Mesozoic, Luxi block, North China Craton

Identification of fault that triggered the 2017 Mw 5.4 Pohang Earthquake using the geothermal borehole (PX-2) cuttings

Hyunjee LIM[1]*, Pusan National University (lim_hyunjee@pusan.ac.kr)
Toshihiko SHIMAMOTO[2], Shimamoto Earth & Environment Laboratory Ltd.
Chang-Min KIM[3], Kangwon National University
Jong Ok JEONG[4], Gyeongsang National University
Sangmin HA[5], Korea Univeristy
Seongjun LEE[6], Korea Institute of Geosciences and Mineral Resrouces
Min-Cheol KIM[7], Pusan National University
Hee-Cheol KANG[8], Pusan National University
Moon SON[9], Pusan National University

Abstract

The Pohang earthquake (Mw 5.4) on November 15, 2017, caused significant property damage in Korea. The Korean Government Commission reported that the stimulation process of the Pohang Enhanced Geothermal System (EGS) project directly triggered the Pohang earthquake. The earthquake occurred when water was injected into PX-2 among two boreholes operated in the EGS project. The spatial distribution of aftershocks and foreshocks of the earthquake (Kim et al., 2018) indicates that the Pohang earthquake fault (the fault triggering the main shock) intersects the PX-2 borehole at a depth of approximately 3,800 m. The faulting event did not cause any surface rupture. This study aims to directly identify the fault that caused the earthquake by analyzing the cuttings retrieved from the PX-2.

The cuttings at depths between 3750 m and 3815 m of PX-2 contain an average of 60% mud balls. Mud balls are unconsolidated rock fragments that are wrapped in a thin layer of drilling mud and have a rounded shape. The cores of all the mud balls were identified to be composed of fault gouge or fault breccia fragments coated with drilling mud. Under polarized microscopy, the commonly observed clay-rich fault gouges show unique microstructural features formed in the brittle regime. At high magnification, mineral fragments are mainly composed of quartz, feldspar, and mafic minerals derived from granodiorite, the host rocks, with some minerals such as calcite and chlorite inferred to have been made during or after fault activities. In the matrix, alternating and distinctively separating bands, composed of dark brown to light brown and green clay mineral (probably mostly chlorite) layer and mafic mineral layer in thickness of tens of micrometers, form a unique foliation under open nicols. The foliation is regularly arranged as a whole, but the direction is rotated around large mineral fragments as a cataclastic flow. Based on these observations, it is concluded that the Pohang Earthquake occurred due to the reactivation of a large mature fault zone that has experienced repeated fault movements and injection of hydrothermal fluids during or after fault activity.

Keyword

Pohang Earthquake, EGS, fault internal structure, fault materials, microstructure

Pseudotachylytes in Gyeongju City, Jiri Mountain, and Maemul Island of Southeastern Korea: Its Occurrence and Characteristics

Hee-Cheol KANG[1]*, Department of Geological Sciences and Institute of Geohazard Research, Pusan National University (kanghc@pusan.ac.kr)
Raehee Han[2], Department of Geology and Research Institute of Natural Science, Gyeongsang National University
Dohee Gu[3], Department of Geology, Natural Science, Gyeongsang National University
Chang-Min Kim[4], Division of Geology and Geophysics, Kangwon National University
Moon Son[5], Department of Geological Sciences, Pusan National University
Min-Cheol Kim[6], Department of Earth Science Education, Pusan National University

Abstract

Pseudotachylyte (PST), produced by frictional heating during seismic slip, provides information that is critical to understanding the physics of earthquakes. We present the results of occurrence, structural characteristics, scanning electron microscopic observation, geochemical and geochronological analysis of PSTs. The host rocks of these PSTs are granodiorite (Gyeongju, SHRIMP U-Pb zircon age, 75.0±1.5 Ma), biotite granite (Gyeonyju, SHRIMP U-Pb zircon age, 58.4±1.1 Ma; Maemul island, SHRIMP U-Pb zircon age, 68.1±1.2 Ma), and granitic gneiss (Jiri mountain, metamorphism age 1,860-1,900 Ma). These PSTs are presumed to have formed during the Eocene-Late Cretaceous. In these areas, PSTs and cataclasite, which are the products of brittle deformation under the shear stress regime, occur together along the fault zone. Cataclastic rocks are classified into non-foliated clast-supported and foliated clast-supported to matrix-supported cataclastite. PSTs are identified into four types based on the thickness and morphology in the field: single dike-, fault vein-, injection vein-, and brecciated-type PST. The single dyke-type PST, exposed on the coast of Gyeongju city, shows a variation of thickness from 15-40 centimeters along its strike and has an average thickness of 21 cm, which is the largest in the world, as far as we know. At a first glance it looks like a mafic dike, but it has a chemical composition almost identical to the wall rock of granodiorite. Also, it has many subrounded clasts which consist predominantly of quartz and feldspar and newly crystallized tiny grains (submicrometers to several micrometers in size). The feldspars and biotite are euhedral and some plagioclase grains show zoning. Flow structures and embayed clasts are also observed. The single dyke-type PST-bearing fault zone can be traced continuously over at least 1.5 km based on the data from the drilling sites and other outcrops. The fault vein-type PSTs, which is the most frequently produced in all study areas, occur as thin (as thick as 0.5-2 cm) layers generated on the fault surface, Embayed clasts, phenocryst with reaction rim, oxide droplets, amygdules, and flow structures are also observed. The smaller injection vein-type PSTs are also found along the fault vein-type PSTs in all study areas, and appear in a variety of shapes (bleb, lens, sigmoid, network, and breccia) based on field occurrence and vein geometry. The brecciated-type PST (1.2 m wide, >5 m long), which are much larger in width than single dyke-type PST, develop on the dilational jog of the dyke-type PST-bearing fault in the Gyeongju. The breccia and matrix components are the same as

the dyke-type PST, and characteristically, the chilled margin develops as the zone at the edge of the breccia. These breccias are similar to the autobrecciated rocks that often develop in highly viscous lava flows. All of these observations indicate the PSTs formed due to frictional melting of the wall rock minerals during fault slip related to strong seismic faulting events in the shallow depth of low temperature-low pressure. Further studies will be conducted to determine the age and mechanical aspect of the PSTs formation.

Keyword

pseudotachylyte, single dyke-type, fault vein-type, injection vein-type, seismic faulting

Determining the timing of fault activity using fluid behavior characteristics

TAE-HO LEE[1]*, Korea institute of Geoscience and mineral resources (thlee80@kigam.re.kr)
Youngbeom Cheon[2], Korea Institute of Geoscience and Mineral Resources
Jin-Hyuck Choi[3], Korea Institute of Geoscience and Mineral Resources
Shinae Lee[4], Korea Basic Science Institute
Keewook Yi[5], Korea Basic Science Institute

Abstract

A fault is a deformation structure where the both sides of a rock are displaced relative to each other due to slipping (shearing), and the area involving displacement develops structures through fracturing or pulverization. In the case of large-scale fault zones, they exhibit complex internal structures, which can serve as pathways or barriers for fluid movement. Generally, the influx and release of fluids within a fault zone can either cause repeated slipping during the seismic cycle or result from such slipping. Therefore, from a geological timescale, the movement and development of faults can be considered contemporaneous with fluid influx and specific stages of deformation. At this time, since the fluids entering the fault zone contain a significant amount of common lead, it is judged that utilizing this can constrain the timing of common lead influx, namely the movement timing of the fault. In this study, zircons were separated from the parent rock and fault gouge at major fault locations within the Korean Peninsula, and U-Pb dating was conducted. Before the U-Pb dating analysis, backscattered electron imaging and cathodoluminescence imaging were obtained to select appropriate analysis points and observe changes in the internal structure of zircons due to fluids. Observations of the internal structure of zircons revealed that zircons from fresh parent rocks showed oscillatory zoning structures typical of igneous rocks. However, zircons separated from the fault gouge showed the development of numerous microfractures due to fluid influx, along which formed or infiltrated microinclusions were observed. The U-Pb dating results for zircons from the unaffected parent rock mostly aligned on the concordia curve, indicating the crystallization age of the zircons. In contrast, U-Pb dating results for zircons separated from the fault gouge were characterized by discordant ages due to the influx of common lead. Utilizing these discordant ages caused by common lead is expected to be useful in constraining the timing of movement in basement faults in future studies.

Keyword

U-Pb age, common lead, zircon, fluid, fault activity

Pressurization and injection of fault materials and fluids during the long-term seismic cycle, the intraplate Yangsan fault, SE Korea

Chang-Min KIM[1]*, Kangwon Nationl University (cmkim@kangwon.ac.kr)
Raehee HAN[2], Department of Geology and Research Institute of Natural Science, Gyeongsang National University
Sangwoo WOO[3], Institute of Geohazard Research, Pusan National University
Hee-Cheol KANG[4], Department of Geological Sciences, Pusan National University

Abstract

Fault zone processes during long-term cycles of seismicity in fault zones can provide key information for mitigating earthquake hazards in intraplate regions. To understand the fault zone processes during long-term seismic cycles in a granitic fault zone in SE Korea, we conducted an integrated methodological study combined with multiscale observations and analyses of the mineralogical properties of fault rocks, along with low- to high-velocity shear tests. A strike-slip fault zone that branches out from the main strand of the Yangsan Fault bounds Triassic and Jurassic granites. The fault zone consists of a <35 m-thick fault damage zone that is developed around a <1 m-thick fault core. The fault core contains breccia and clay-rich foliated gouge zones, which contain 43 wt.% clay minerals, including smectite (13.3 wt.%), illite (21.2 wt.%), and kaolinite (8.5 wt.%). The low- and high-velocity shear tests using foliated gouge taken from an outcrop show a low friction coefficient ($0.13 < \mu ss < 0.17$) and flash dilation of gouge material. Cross-cutting relationships among microstructures in the fault zone indicate the following sequence of events. (1) Pressurized fluid was vigorously injected along the fault zone. Notably, fluids from the wall rock invaded the densely packed, low-permeability gouge. (2) Fibrous calcite veins, which are perpendicular to the Y-shear direction of the fault, formed along foliation planes in the gouge. (3) Fluidized gouge material was injected into the damaged wall rock. These observations indicate the occurrence of cyclic coseismic and aseismic faulting during long-term seismic cycles in the intraplate granitic fault zone after the low-temperature formation of expanding clay minerals. Moreover, the shear tests show that mixed smectite/illite gouge can dilate instantaneously at a seismic slip rate (1.3 m/s) if the total displacement exceeds ~5 m. Our findings suggest that intraplate fault zones can behave unstably due to the cycle of long-term seismic events and the dynamic properties of fault core materials.

Keyword

fault zone process, fluid injcetion, gouge injection, seismic slip, Yangsan Fault

Three-dimensional structural and parametric models focused on finding the leads for different applications connected with energy acquisition in NW part of Poland.

Rafał Laskowicz[1]*, Polish Geological Institute – National Research Institute (PGI-NRI) (rlas@pgi.gov.pl)
Marcin Bolek[2], Polish Geological Institute – National Research Institute (PGI-NRI)
Jerzy Hadro[3], Polish Geological Institute – National Research Institute (PGI-NRI)
Jarosław Zacharski[4], Polish Geological Institute – National Research Institute (PGI-NRI)

Abstract

In the south-eastern part of the Central European Permian–Mesozoic Basins a 3D model was made covering an area of 27,000 km2 in the NW part of Poland. Data derived from 103 deep boreholes, 781 surface 2D seismic surveys and 3 3D images were used, as well as archival maps. Coverage of the area by geophysical and seismic surveys is uneven. Geophysical reconnaissance is concentrated around reservoir zones leaving other parts of the area only partially recognized. This results in holes that are difficult to interpret. Due to the large number of studies stored in analog phaorma, in order not to lose a large number of data contained in them, a method of recovering seismic data from paper printouts was tested and applied. These data were scanned and, after appropriate graphic processing, imported into the interpretation project in the form of 2D seismic profiles (SGY format) - this enabled the seismic interpretation from the southern part of the area to be completed. In the course of analyzing the thickness distribution of the basic elements of the separated petroleum systems, verification of information from deep boreholes was performed for consistency of stratigraphy in individual boreholes. Consolidation of scattered data in a single platform gave the opportunity to verify data originally prepared in different standards, from different sources and from different period. Interpretations in the time domain were carried out and the results were converted into depth obtaining the final models in the depth domain. Preparation of a consistent fault model verified by images from selected seismic materials mainly in 2D and the course of fault traces on archival maps led to an unambiguous three-dimensional image of dislocation sequences. The deep geological structure was detailed and hydrocarbon prospective horizons were selected for which structural and thickness models were prepared. Spatial models of the distribution of selected lithological, petrophysical and geochemical parameters on the lithostratigraphic framework (porosity, Vshale, TOC) were developed. A preliminary quantitative assessment of Carboniferous, Red Bedrock, Main Dolomite and Lower Jurassic petroleum systems was performed.

The compiled data integration originally focused on identifying hydrocarbon prospects. Due to the wide range of analyses performed and the integration of all the data produced so far, it allows the analysis of structures in terms of the multifaceted use of deep structures for substance storage and energy extraction.

Keyword

Central European Permian–Mesozoic Basins, Poland, hydrocarbon prospects, petroleum systems, 3D model

Landform Evolution of the Brahmaputra, Padma and Meghna interfluve, Bengal Basin, Bangladesh – A Pedological Approach

Zahidul BARI[1], Jahangirnagar University
Md. Sharif Hossain KHAN[2]*, Jahangirnagar University (sha@juniv.edu)
Khalil R. CHOWDHURY[3], Jahangirnagar University

Abstract

Soil archives the changes since the deposition of its parent materials, hence pedological study is very important to assess the soil-landform evolution of an area. The capital city Dhaka lies within the central part of the Bengal Basin, which hosts the Quaternary Madhapur Tract, is an interfluve of Brahmaputra, Padma, and Meghna rivers. A comprehensive landform evolution of Madhupur Tract is yet to be done. Hence a pedological approach in conjunction with alluvial/fluvial morphology has been employed to assess the soil-landform evolution in the central part of the Bengal Basin. The study is based on soil-geomorphic map, detailed field investigation, and soil-chronoassociation. A soil-geomorphic map has been prepared using soil resource maps, toposheets and satellite images, delineating thirteen (13) distinct soil-geomorphic units within the research area. Based on pedogenic characteristics, particularly solum thickness, ped development, and cutan development in the B-horizons of soil profiles across various soil-geomorphic units, as well as considering the ages of the soils and published proxy ages from the area, a five-membered soil chronoassociation (QGSD1 to QGSD5) has been developed to elucidate the evolution of the soils and the concurrent development of the landform in the area under investigation. The tentative assigned ages of the soil chronoassociation (QGSD1 to QGSD5) are <500 yr., 0.5-3 ka, 3-7 ka, 14-18 ka and >18 ka, respectively.

Soil-chronoassociation member QGSD5 occupies the top of the local catena on the Madhupur Tract. QGSD4 and QGSD3 soils stand the middle position of the local catena representing the older floodplain, while QGSD2 and QGSD1 are situated at the lower relief of the local catena, indicating the young floodplain. This hierarchy determines the areas of active sedimentation, pedogenesis, and erosion. The final phase of the terrace formation on the Madhupur Tract with QGSD5 soil-chronoassociation member was accomplished during >18 ka (LGM) under subhumid-semiarid climate when sea level regression entrenched the rivers of Bengal low land. During a period between 14 to <18 ka, onset of humid monsoon climate leads the deposition of older Flood plain soils parent material (QGSD4); later during 3-7 ka sea level transgression/oscillation deposits the QGSD3 soils parent materials. Around 0.5-3 ka leads recent phase of soil formation of QGSD2 member. In QGSD1, active sedimentation is going on and at the very initial phase of pedogenic processes.

Fluvial morphology particularly stream initiation, confluence, stream straightness, stream offsetting/bending help identify nine lineaments/faults, namely Kaliganga, Dhaleshwari,

Bongshai, Jhinai, Madhupur east, Madhupur west, Bhaluka, Jaina and Tongi-Narsindi. These lineaments separated the different soil-geomorphic units in the area and have played a significant role in shaping the relief (local catena) and soils of the study area. Therefore, the study has a broader implication to understand the landform evolution and active tectonics of the central part of the Bengal Basin.

Keyword

Madhupur Tract, soil geomorphic unit, soil-chronoassociation, fluvial morphology, active tectonics

Active fault mapping, structural framework, kinematics, and segmentation – An appraisal of the Chittagong Coastal Fault along the outer Indo-Burman Ranges

Md. Sakawat Hossain[1]*, Jahangirnagar University (sakawat@juniv.edu)
Dilruba Yesmin Shetu[2], Jahangirnagar University
Md. Sharif Hossain Khan[3], Jahangirnagar University

Abstract

Large-scale active faults along or close to the convergent plate boundary are complex systems whose growth, structural framework, kinematic, and segmentation are still not well understood. However, it is important to understand these complex fault systems as all the devastating earthquakes and associated geohazards that occur on Earth's surface are generated by these seismogenic faults. These kinds of faults also act as the major conduits for different types of geofluids (e.g., hydrocarbon, magma, etc). Therefore, proper mapping of these complex fault systems and determining the attributes, kinematic model, structural framework, and segmentation not only help to appropriate seismic hazard assessment but also unveil their significance as subsurface conduits. The goal of this research is to map the Chittagong Coastal Fault (CCF), which traverses along the western edge of the outer Indo-Burman Ranges (IBR) and close proximity to the Indo-Burmese plate boundary and to quantify tectonic geomorphology using evidence derived from both at the surface (e.g., surface geology, and geomorphology), as well as in the subsurface (e.g., wireline log, gravity, and seismic). Integration of data sets from the surface, subsurface, and remote sensing have provided the necessary information to understand all processes leading to the growth, extent, geometry, kinematics, and segmentation of the CCF.

The CCF fault system has been studied along the western flank of four prominent anticlinal structures (from north to south: Sitakund, Maheshkhali, Inani, and Dakhin Nhila) situated at the western edge of the Chittagong-Tripura Fold Belt (CTFB). Surface geology, fault attributes, and geomorphology were observed in the field. Field evidence of abrupt change in topography and bedding attitude, dragging, bending, shortening, and visible displacements of beds, domino structures, small-scale recumbent fold, and shear joints suggest high tectonic stress and the presence of a major thrust fault system with dextral strike-slip component. The recorded fault traces along the western flank of the four anticlines are extrapolated and merged together, which form a single fault of approximately 350 km long. The fault map clearly shows that CCF runs parallel to the east coast of Bangladesh, continues inland northward along the Bangladesh-India (Tripura) border, and finally terminates into the Sylhet Fault. The net displacement of the fault has been quantified based on the field outcrop observation and 2D seismic sections, which is about 1150 m. With roughly 1.1 km of net displacement and 350 km length, the CCF, in general, complies with the existing fault length-displacement models. Evidence derived from the surface geology, tectonic geomorphology, historical seismic record, and recent geodetic measurements

suggest that the CCF is an active fault, and possibly segmented into four parts. All observations imply that a seismogenic gap exists in the northern two segments of the CCF. Finally, the interdisciplinary approaches of this study which integrate different data sets from field observations, and structural, geomorphological, geophysical, and remote sensing studies have enabled to elucidate the structural framework, kinematics, segmentation, and length-displacement model of the CCF, which presently accommodating approximately E-W convergence in the eastern Bangladesh, and poses a potential threat of a major earthquake.

Keyword

Plate convergence, Chittagong-Tripura Fold Belt, fault attributes, morphotectonics, seismic hazards

Slab tear and its corresponding crustal deformation of subducted Indian lithosphere in the Eastern Himalayan Syntaxis region

Bo ZHANG[1]*, Peking University (geozhangbo@pku.edu.cn)
Ziqing Li[2], Peking University

Abstract

The southeastern Tibetan Plateau is currently experiencing active southeastward extrusion and rotation around the Eastern Himalayan Syntaxis (EHS) due to the ongoing collision between the Indo-Eurasian continents. This tectonic activity is evident through a series of N-S-striking, NW-SE-striking, and NE-SW-striking ductile strike-slip shear zones/faults in Tibet and the Indochina Block. These geological features play a crucial role in investigating the relationship between Cenozoic crustal deformation and the lithospheric evolution of the Tibetan Plateau. However, the kinematics, linkages, and developmental patterns of these shear zones along their strike remain inadequately understood. This lack of information has led to the formulation of poorly evaluated formation mechanisms, particularly in terms of along-strike geometry variation and linkages, such as the concepts of continuum rotation deformation and discrete extrusion tectonics. Two potential outcomes are predicted: a clockwise rotation around the EHS along the curved strike-slip shear system or southeastward extrusion of related blocks along two conjugated strike-slip shear zones/faults. Therefore, it is crucial to explore the along-strike geometry and linkage of individual strike-slip shear zones/faults to gain essential insights into understanding and evaluating these two proposed mechanisms/models. In this contribution, our investigation focuses on the structures, geometries, kinematics, and thermochronological data to constrain the formation and evolution of the regional-scale dextral strike-slip ductile shear zone system. Our new findings indicate that these dextral shearing zones, delineates a curved regional-scale dextral strike-slip zone system around the EHS region. This observation aligns with the current tracks of GPS and FPD (fast polarization direction) and contradicts the features of a conjugated strike-slip shear system dominating extension tectonics, which initiated nearly simultaneously along a straight strike. These characteristics suggest that the initiation, movement, and linkage of the curved dextral strike-slip shearing are significantly influenced by continuum rotation deformation, driven by slab tear of subducted Indian Plate beneath the EHS region, rather than discrete extrusion tectonics.

Keyword

Strike-slip shearing, Crustal deformation, lithosphere flow, slab tear, Eastern Himalayan Syntaxis

Investigating the relative roles of structural and mechanical (lithology, bed thickness) controls in fracturing in frontal thrust sheets: Insights from fracture characterization and attribute study, Eastern Himalaya, Sikkim

Ammu J.K.[1], Indian Institution of Science Education and Research (IISER) Kolkata
Kathakali BHATTACHARYYA[2]*, Indian Institute of Science Education Research (IISER) Kolkata (kathakali@iiserkol.ac.in)

Abstract

We investigate the partitioning of fracture modes, their temporal evolution, and the competing effects of structural distance from the fault and mechanical anisotropies (lithology and bed thickness) on their intensity, density, orientation, mode, length, and spacing within ~3.4 km of the frontal-most exposure of the Ramgarh thrust (RT) sheet from the Sikkim-Himalayan fold thrust belt (FTB). Shear (~88%) fracture with slickenlines are better exposed than joints with plumose structures due to their favorable relative orientations with the outcrop bearing and bedding. Detailed structural analysis reveals coexisting shear fractures (~59%) and joints (~41%), emphasizing the necessity of such studies in mountainous terranes with limited outcrops to avoid under-representation of a particular mode. Fracturing initiated with low-angle, shear fractures that progressed to high-angle, shear (~44%), and extension (~56%) fractures. This study, for the first time, reveals that lithology has the most dominant control on fracture density, followed by bed thickness and structural distance in the frontal thrust sheet of the Himalayan FTB. However, lithology does not partition fracture mode and angularity. Also, structural distance effects the temporal evolution, intensity, and angularity of fractures, but not their mode. Although mechanical discontinuities constrain fracture lengths irrespective of their mode and angularity, structural distance dominantly controls fracture network evolution close to the fault.

Keyword

Shear and extension fractures, Sikkim-Himalayan fold thrust belt, Fracture network, Joint

Petrotectonic framework of the Siwalik Group in northern part of the Chitwan Dun Valley, Central Nepal

Niraj Singh Thakuri[1]*, Tribhuvan University (niraj.thakuri444@gmail.com)

Abstract

The present field, detailed petrography and modal analysis of representative 38 sandstone thin section have been carried out to determine petrotectonic setting of rocks of the Siwalik Group in Narayangadh-Lothar area, northeast Chitwan Dun Valley. Lithostratigraphically, the study area consists of the Lower Siwalik, the Middle Siwalik and the Upper Siwalik in ascending order. From bottom to top, it is lithologically characterized by light to dark grey mudstone, variegated mudstone, and fine-grained sandstone. Light to dark grey siltstone, salt, and pepper appearance sandstone, pebbly sandstone, and clast to matrix-supported conglomerate. The QtFL (Qt, total quart; F, Feldspar; L, lithic grains) petrofacies indicates most of the sandstones of the Siwalik Group were derived from recycled orogen provenance. Petrographically, the sandstone of the Siwalik Group delineates different microfacies including mainly sub-litherenites to sub-arkose with minor quartz-arenite, litharenite, feldspathic-litharenite, and lithic-arkose. The increasing proportion of biotite and feldspar and decreasing textural maturity of mineralogy in sandstone from the Lower Siwalik to sandstone of the Middle Siwalik indicates the tectonic unstability, shifting of block provenance from low grade to high grade and earlier sedimentation of detrital grains in the Lower Siwalik sandstones from the distant block provenance respectively. The abundance of monocrystalline quartz grains are common in sandstone of both the Siwalik Group units shows the igneous intrusion in related block provenance. The provenance of the sandstones of the Lower Siwalik and the Middle Siwalik was from mixed type sources, most probable from the Lesser Himalaya and the Higher Himalaya.

Keyword

Chitwan Dun Valley, Petrography, Provenance, Petrofacies

Miocene paleo-elevation constraints in the Tibetan Plateau: constraints of deuterium isotope from the Greater Himalayan Complex

Wentao GUO[1]*, School of Earth and Space Sciences, Peking University (2421872153@qq.com)
Bo Zhang[2], School of Earth and Space Sciences, Peking University

Abstract

The study of the Tibet Plateau is an important focus in the field of earth science, and the uplifting history and mechanism of the plateau are important and fundamental issues. By studying the paleo-elevation, the surface uplift can be reflected, the uplift mechanism can be tested, and the uplift history of the plateau can be reconstructed. However, the Tibetan Plateau has a large number of blocks with different uplifting properties, and different paleo-elevation records can only explain the uplifting history of a single block. Consequently, we require a great amount of paleo-elevation data in different regions to reflect the complete uplifting history of the Tibetan Plateau.

A paleo-elevation estimate by means of stable isotope for the Tibetan Plateau is presented based on mica in mylonitic gneiss from the Greater Himalayan Complex in the footwall of the STDS in the northern Yadong area. Using microstructures, hydrogen isotope geochemistry, zircon U-Pb ages, and 40Ar/39Ar chronology of mica, we find that atmospheric fluids in this area infiltrated into STDS footwall and interacted with water-bearing silicate minerals during the deformation (~ 16-11 Ma). For paleo-elevation recovery, we refer to the stable isotope composition of paleo-atmospheric fluids from mica in mylonitic gneiss and the $\delta^{18}O$ values of near-sea level atmospheric precipitation in similar ages calculated from the autogenic carbonates in the Siwalik foreland basin at low altitudes. The difference of $\delta^{18}O$ is $-13.95\pm0.60‰$, and the paleo-elevation is 4982±214m calculated by the global isotope decline rate ($\delta^{18}O$: -2.8 ‰/km) in middle and low latitudes areas. This paleo-elevation estimate indicates that the high topography of the Himalayan orogenic belt during the Miocene has prevented the migration of moist air mass from the south to the north, resulting in a northward rain shadow, which led to the aridity of the northern Tibetan Plateau.

Keyword

Paleo-elevation recovery, Stable isotope, Atmospheric precipitation, STDS, Yadong area

Mantle flow in the southeastern Tibet Plateau since the Eocene: From a geochemical perspective

Ziqing LI[1]*, Peking University (2201110667@stu.pku.edu.cn)
Bo Zhang[2], Peking University

Abstract

In Cenozoic, after the closure of the Neo-Tethys Ocean, the lithosphere of the Indian continent continued to subduct below Asia, resulting in the widespread development of alkaline, potassium, and adakitic rocks and metal deposits in the southeastern Tibet Plateau since the Eocene, which is explained as a result of the removal of the lithospheric mantle. This study compiled geochronological and geochemical data of magmatic rocks in Cenozoic collision orogeny in the southeastern Tibet Plateau, and analyzed their relationship with spatial and temporal evolution. The results of geochronology show that the age in the north shows an east-west zoning but with shorter activity period, while in the south, the age becomes younger near the shear zone and the overall period is longer. Major and trace elements indicate that the southern part of southeastern Tibet Plateau has a wider range of alkaline and potassium rock types compared to the northern part. According to Sr-Nd and zircon Hf isotopes, the contribution of mantle derived materials to the source region of granitic magma in the north is significantly greater than that in the south, while the basaltic magma source region in the north shows sustained depletion and corresponding enrichment in the south. Overall, this phenomenon may suggest the addition of depleted components in the north and strong crust mantle interactions in the south. Geophysical observations indicate that as the thickness of the crust decreases from north to south, the range of the asthenosphere mantle increases, indicating differential lithospheric removal between north and south in the southeastern Tibet Plateau. This may provide space for the southward movement of hot mantle flow and ultimately affect surface processes in the region such as the activity, connection of shear zones and block rotation.

Keyword

Southeastern Tibet Plateau, Geochronology, Orogeny, Mantle flow

New lithostructural map of the Doropo region, northeast Côte d'Ivoire: insight from structural and aeromagnetic data

ZIANDJEDE HERVE SIAGNE[1]*, INSTITUT NATIONAL POLYTECHNIQUE FELIX HOUPHOUET-BOIGNY (siagneh@gmail.com)
Tahar AÏFA[2], Université de Rennes 1
Alain Nicaise KOUAMELAN[3], Université Félix Houphouët-Boigny
Wilfried DIGBEU[4], Université de Man

Abstract

This study, performed in the Doropo region (northeastern Côte d'Ivoire) in the Paleoproterozoic domain (southern part of the WAC), aims to produce a detailed lithostructural map of this area. The geology of this region is less known due to the thick lateritic overburden and the scarcity of outcrops. Recent airborne geophysical data (aeromagnetic) integrated with field structural and lithological observations allowed to distinguish several lithologies including biotite granite, gneissic and migmatitic granite, granodiorite, tonalite, gabbro, amphibolite, rhyolite and dolerite. Filtering techniques of derivatives, upward continuation, tilt, analytical signal, spectral analysis and 3D Euler deconvolution showed the presence of faults, shear zones and intrusions. The structural analysis revealed four deformation events (D1-D4): (i) D1 is a N–S compression marked by E-W foliation (S1), conjugate NE-SW and NW-SE sinistral and dextral shears, respectively, as well as F1 folds with E-W axial planes; (ii) D2 is a major transpressive phase characterized by an intense NE-SW foliation (S2), E-W dextral shear zones, a weakly dipping stretching L2 lineation plunging N-E, and NE-SW faults; (iii) D3 is a NE-SW compressional phase generated NW-SE foliation (S3) with ~E-W shears, and NW-SE axial plane F3 folds; (iv) D4 is a late, rather brittle phase characterized by brittle structures (faults, fractures, etc.) and the emplacement of NE-SW and NW-SE dolerite dykes. This tectonic evolution demonstrates that the Doropo region was subject to ductile and then brittle deformations. Furthermore, we suggest that the geodynamic model which could have prevailed in the Doropo region occurred in an oceanic arc collisional tectonic context.

Keyword

Structural analysis, Aeromagnetic, Dolerite dyke, Shear-zone, Granitoids

Quantitative prediction of tectonic fracture in Puguang gas field based on stress genesis

Hui LI[1]*, Sinopec petroleum exploration and production research institute (lihui2022.syky@sinopec.com)
Yuchun You[2], Sinopec petroleum exploration and production research institute
Daqian Zeng[3], Sinopec petroleum exploration and production research institute
Zhiliang Shi[4], Sinopec petroleum exploration and production research institute

Abstract

The formation of tectonic fracture is a product of regional tectonic stress on stratum. How to carry out quantitative prediction of fractures from the perspective of origin has always been a difficult problem and challenge in the industry. On the basis of structural interpretation of seismic data, this study utilized finite element numerical simulation methods, by simulating the distribution of stress fields during different fracturing periods, a mathematical relationship between fracture density and stress field parameters is constructed based on Hooke's law, elasticity theory, rock strain energy theory, and fracture surface energy theory. Transform the stress field simulation results into fracture density prediction results, ultimately achieving the goal of quantitatively predicting the spatial distribution of fractures. Taking the deep carbonate reservoir of Feixianguan Formation in Puguang Gas Field as an example, the fracture prediction results show that the developed fractures in the target interval are the superimposed products of the Late Hercynian and Late Himalayan periods. Among them, the Late Hercynian period mainly developed northeast oriented fractures, while the Late Himalayan period mainly developed northwest oriented fractures. In areas close to faults and folds, the maximum density of fracture development can reach 4.5 fractures/m, and there is a significant negative correlation between fracture density and distance from the fault. This method can supplement and constrain small-scale fractures, which cannot be predicted by geophysical methods. Meanwhile, it is of great significance to connect the geological modeling, characterization of fault damage zone, and numerical simulation of gas reservoirs.

Keyword

tectonic fracture, Puguang gas field, tectonic stress field, quantitative prediction, Feixianguan formation

Internal characteristics and main influencing factors of buried hill faults in the south Fault zone of Zhu III sub-basin, Pearl River Mouth Basin, China

zedong LIU[1]*, China University of Petroleum (zedongliu2023@outlook.com)
kongyou Wu[2], China University of Petroleum

Abstract

Background: The buried hill with oil and gas shows in the work area is controlled by faults, and no large karst caves have been developed. The reservoir is mainly of fracture type, so whether the fracture zones around the faults are developed or not and their distribution ranges are great influenced on the favorable reservoirs.

Methods: (1) Using Landmark software to make structural interpretation and MOVE software to recover the history of structural evolution. (2) Through the observation of cores combined with the preference of logging curves (sonic differential time, resistivity, natural gamma, density, etc.) to establish a model of the faults (fault core + fracture zones). Then use the likelihoods and curvature attributes to portray the fault structure. (3) In addition to the qualitative description of the influence of lithology and burial depth on the internal structure by means of coring and logging, we focus on exploring the influence of fault activity (fault distance, fault activity intensity, etc.) on the development of the internal structure.

Results: (1) We obtained the planar and spatial distribution characteristics of strata and faults in the work area, and drew the structural evolution diagrams. (2) The "binary structure" of the basement location faults is generally developed with both fault cores and fracture zones, and the fault cores have structural Breccia developed, and the fracture zones have network fractures developed. The density, acoustic time difference and natural gamma values of the fault core are slightly larger than those of the fracture zone, and the RTC curve of the fault core is flat, and the curve of the fracture zone part of the curve varies drastically. (3) The maximum likelihood attribute and curvature attribute show that the fracture zones in the deep part of the fault are wider than those in the shallow part, and the fracture zones are more developed in the stress-concentrated parts of the fault such as turning, convergence, and bifurcation. (4) The paleo fall and fault activity rate of the Cenozoic are calculated isometrically on the strike, and show that the thicknesses of the fault cores and the fracture zones are positively correlated with the strength of the fault activity.

Keyword

structural evolution, fault structure, seismic attribute

Analogue Modeling of Rift Evolution in the Central Africa Bongor Basin: A Dynamical Analysis from Dual Rifting to Reversal Processes

Yanjie GAO[1]*, Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Wuhan 430074, China (gaoyanjie@cug.edu.cn)
Shisheng XU[2], School of Earth Resources, China University of Geosciences, Wuhan 430074, China
Xiang GE[3], School of Earth Resources, China University of Geosciences, Wuhan 430074, China
Wengang HE[4], Department of Engineering and Technology, Zunyi Normal University, Zunyi, China
Mengyang ZOU[5], School of Earth Resources, China University of Geosciences, Wuhan 430074, China
Chuanbo SHEN[6], School of Earth Resources, China University of Geosciences, Wuhan 430074, China

Abstract

Multiple superimposed tectonic activities often occur in nature. Many studies have shown that there is mutual influence between multiple superimposed tectonic activities, and the importance of each tectonic activity during basin formation and evolution varies. In this study, physical simulation experiments were conducted to explore the mechanism of Central Africa Bongor Basin's superimposed evolution through two rifting events and one reversal event models. In the experimental design, steel plates were used to simulate rigid basement in the crust; silicone gel was used to represent the overlying soft layer; and quartz sand was used to simulate sedimentary strata. This model aims to reveal the dynamic process of rift basin formation and evolution. It is found that the initial morphology of the basin is mainly controlled by the first rifting event, laying a framework for the basic morphology of the basin. The subsequent second rifting event carried out further topographic transformation on this basis, but its influence on the basin's morphology was relatively weak. In contrast, later reversal events did not have a significant impact on the overall structure of the basin, highlighting the decisive role of early rifting events in basin evolution. The physical simulation results of this study provide intuitive experimental support for understanding the formation and evolution process of Bongor basin in Central Africa, also similar rift basins. The results also highlight the dominant role played by early rifting in the development history of the rift basin.

Keyword

Central Africa, Analogue Modeling, Multiple superimposed tectonic activities, Bongor Basin

The exhumation history of Qiangtang Basin since the Cretaceous and its control of hydrocarbon accumulation

Qingqing LEI[1]*, Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China (leiQQ@cug.edu.cn)
Xiaofan WAN[2], Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China
Xiaowei ZENG[3], Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China
Chuanbo SHEN[4], Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China
Xiang GE[5], Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China

Abstract

As a significant part of Himalaya-Tethys tectonic domain and the largest Mesozoic marine oil-bearing basin in China, the Qiangtang basin has experienced complex tectonic evolution. Despite significant efforts and extensive thermochronological research, including apatite and zircon fission track as well as (U-Th)/He analyses, controversies persist regarding the Qiangtang Basin's uplift and exhumation processes since Cretaceous. Here we summarize all available thermochronological data from the Qiangtang basin. The data reveal a pattern where older ages are concentrated in the central Qiangtang terrane, gradually becoming younger southward and northward. Regional thermal history reconstruction reveal three periods of rapid cooling stages: Early Cretaceous (140-100Ma), Paleocene-Eocene (65-45Ma) and late Oligocene (25Ma), and exhumation's initiation time progressively decreases from the center towards the south and the north. The exhumation history coincides with hydrocarbon accumulation. The first exhumation event is in response to the Lhasa-Qiangtang terrane collision. The main faults and folds are basically formed during 180-140Ma, which provides good conditions both for trap and migration of the late Jurassic hydrocarbon accumulation. The second and third exhumation events may be contributed to the collision between Indian and Asian plates and the Indian plate's subsequent continuous northward subduction, which corresponds to the destruction or secondary accumulation of oil and gas since the Cenozoic, forming the present complex tectonic pattern and affecting the distribution of ancient reservoirs.

Keyword

Qiangtang Basin, Exhumation history, Thermochronological data, Hydrocarbon accumulation

Zircon U-Pb geochronology of the weathering crust from Permian Maokou Formation, Western Hubei Province and its indication for Emeishan volcanic activity

Yaxian GAO[1]*, Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China (Gyx@cug.edu.cn)
Xiang GE[2], Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China
Chuanbo SHEN[3], Key Laboratory of Tectonics and Petroleum Resources, China University of Geosciences, Ministry of Education, Wuhan 430074, China

Abstract

The Dongwu movement during the Permian is one important tectonic event in South China Block. Because of different regional tectonic settings, various stratigraphic contact relationship, such as disconformity, conformity and unconformity, exits in different geological areas. The nature, timing and dimension of the Dongwu movement is still under controversy. The weathering crust section at the top of the Permian Maokou Formation in Lianziya, northern margin of the Yangtze plate, is an ideal object for determining the nature of the Dongwu movement. In order to find out the provenance of the weathering crust and provide new evidence of chronology for the Dongwu movement, the zircon U-Pb chronology, whole-rock major elements, trace elements and rare-earth elements analysis were conducted.

The results of geochemical analysis show that the claystones characterized by medium SiO2 content (average 42.54%) and enriched in light rare earth elements with weak negative Eu anomaly, presenting uniformity with the previous results of Emeishan Large Igneous Provinces. Combined with the published data of Emeishan basalts, the enrichment trend of major and trace elements and rare earth elements in samples displaying similar geochemical characteristics of Emeishan high Ti basalts. The LA-ICP-MS zircon U-Pb isotopic dating reveals that the weathering crust was formed during ~263Ma-259 Ma, which is consistent with the formation age of the Large Igneous Province(~263-257 Ma). The results show that the Emeishan basalts provide the source for the formation of weathering crust, and the continuous formation time of the Lianziya weathering crust indicates and constrains the time of the Dongwu movement. It is also a response to the Emeishan Large Igneous Province.

Keyword

Dongwu Movement, Weathering crust, Zircon U-Pb age, Unconformity, Emeishan Large Igneous Province (ELIP)

Development Characteristics and Formation Evolution of Cambrian Strike-Slip Faults in the Gaoshiti-Moxi Area, Sichuan Basin, SW China

Ruifeng Wang[1]*, China University of Petroleum(East China) (rfengwang@163.com)
Yangwen Pei[2], China University of Petroleum(East China)
Qingqi Zhao[3], China University of Petroleum(East China)
Zhengshuo Miao[4], China University of Petroleum(East China)

Abstract

Gaoshiti-Moxi area is located in Sichuan Basin, and its Cambrian strata contains rich oil and gas. However, the development of strike-slip faults is complex and diverse due to multi-stage structural superposition, which limits the progress of oil and gas exploration and development. Therefore, based on high-precision three-dimensional seismic data and drilling data, the development characteristics and formation and evolution process of Cambrian strike-slip faults are determined by using seismic attribute calculation, detailed structural interpretation, and analysis of the episodes of faulting. Through ant tracking technology and detailed interpretation of strike-slip faults, the geometric characteristics of strike-slip faults are defined. The faults in the Gaoshiti-Moxi area exhibit two common styles: highly steep vertical structures and flower-like formations, and they show significant variations in fault displacement across different horizons, with most terminating in the Cambrian system. On the plane, three groups of faults trend predominantly in the EW, NE, and NW directions, and there are three typical combination styles of horsetail structures, conjugate shear structures and en echelon structures. By analyzing the activity, nature and geometric characteristics of strike-slip faults in the Gaoshiti-Moxi area, the formation and evolution of strike-slip faults in the Gaoshiti-Moxi area can be divided into Caledonian, Hercynian and Indosinian-Yanshanian periods. Research indicates that during the Sinian period, the Gaoshiti-Moxi area experienced basement faults trending predominantly in the EW and NE directions, which control the tectonic evolution of the overlying layers. During the Caledonian period, the Gaoshiti-Moxi area was under the dynamic setting characterized by NE-trending oblique tension due to the influence of ground fissure activity and cratonic rifting. Under this background, the basement fault generated a tensional torsional strike-slip fault in the Cambrian strata, distributed along the near EW, NW and NE directions, with significant fault displacement and strong activity, and terminated in the Cambrian. During the Hercynian period, affected by Emei mantle plume and Emei volcanic activity, the Gaoshiti-Moxi area was in the dynamic background of NNE extension. Some of the strike-slip faults formed during the Caledonian period were reactivated to form Hercynian faults, which extended from the Cambrian to the Permian, mainly in the near EW and NE directions, with less activity. During the Indosinian-Yanshanian period, the Gaoshiti-Moxi area underwent NW compression. The deformation generated in the Cambrian overlying strata is transmitted to the Cambrian through the plastic layer, forming a large number of secondary faults, which are widely distributed in proximity to the Caledonian and Hercynian strike-slip faults.

Keyword

Sichuan Basin, Gaoshiti-Moxi area, Cambrian, strike-slip fault, structural characteristics

Structural characteristics and development model of fluid diapirs within the structural transition zone, northern South China Sea

Yang QIN[1]*, State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University (yangqin202021427@163.com)
Chiyang LIU[2], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University
Guangrong PENG[3], Shenzhen Branch, China National Offshore Oil Corporation, Shenzhen, 518054, China
Lei HUANG[4], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University
Chaoliang LIANG[5], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University
Hongbo LI[6], Shenzhen Branch, China National Offshore Oil Corporation, Shenzhen, 518054, China
Lihua YANG[7], State Key Laboratory of Continental Dynamics, Department of Geology, Northwest University

Abstract

Fluid diapirs are widespread in the northern South China Sea (SCS), are significant indicators of the existence and distribution of hydrocarbons and natural gas hydrates and are of great petroleum geological significance. Based on high-precision 3D seismic and drilling data, this paper analyses the tectonic features and genetic mechanism of a fluid diapir zone in the northern SCS, and a development model of fluid diapirs is proposed herein. Studies have revealed that the northern SCS large-scale fluid diapir zone is located within a concealed structural transition zone, which is consistent with the spatial distribution location and direction of a concealed structural transition zone and that the formation of a fluid diapir zone is strongly influenced by the structural transition zone. Fluid diapirs are large continuously spreading bright reflection zones in shallow surface layers and are downwards converging high-variance ribbons in middle and shallow layers, all of which are spreading in a NW-NNW orientation on the plane. The profile shows a conical or mushroom-shaped shape that converges from shallow to deep, with a height of approximately 7 km, and is characterized by a compound gas chimney fuzzy zone. The main body of the concealed structural transition zone is a slope structure and is flanked by large-scale NW-NNW-oriented fault systems. Minor en echelon spreading NW-NNW-oriented faults and fractures are developed within the structural transition zone and are soft linkages that match well with the distribution direction and location of the fluid diapirs. On the profile, the overall display is a composite flower-like structure dispersed from deep to shallow, which belongs to a large strike-slip fault zone with a tectonic transformation effect. A comprehensive analysis suggests that the formation and development of the structural transition zone are mainly controlled by preexisting structures in the basement and that minor faults, fractures, and slope zones within the structural transition zone serve as dominant pathways for the migration of deep overpressure fluids and gas hydrates. Consequently, the concealed structural transition zone provides favorable conditions for fluid

diapirs to develop. Moreover, the stratigraphic overpressure systems mainly caused by gas generation provided the main driving force for the formation of fluid diapirs. Obviously, the development location, distribution direction, formation, and evolution of the northern SCS fluid diapirs are jointly controlled by internal minor faults and fractures of the Eocene-Miocene structural transition zone and the overpressure of the rifting period after the Pliocene. The main development period of the northern SCS large-scale fluid diapirs was the second phase of the Dongsha Movement. During the exploration of gas hydrates and hydrocarbons in the PRMB, it is essential to consider the mutually restricting relationships between fluid diapir structures and gas hydrates and hydrocarbons.

Keyword

development model, gas chimney, structural transition zone, fluid diapirs, northern SCS

The impact of fracture development patterns under tectonic influence on hydrocarbon productivity in the Bozi-Dabei region

GUANNAN ZHONG[1]*, zhongguannan0612@163.com (zhongguannan0612@163.com)
[2], zhongguannan0612@163.com

Abstract

The Bozi-Dabei region is located in the western part of the Kelasu tectonic belt in the Kuqa depression. Under the joint control of the Tianshan orogeny and the rotation of the Tarim plate, the tectonic system undergoes passive strike-slip and thrust imbricate fan tectonic system that cut through the basement on the basis of thrust, resulting in complex fracture development under structural control. Based on the latest seismic, outcrop surveys, core and imaging logging data, the development characteristics of fractures at different structural positions were studied. The strain situation of faults and their surrounding areas under the influence of different horizontal forces, rock types, fault dip angles, and distance from the fault plane were simulated using Comsol finite element software. The development patterns of structural fractures under different control factors were analyzed. Based on the above research, the distribution pattern of fractures was systematically summarized and analyzed from a geological perspective. At the same time, from a geometric perspective, parameters such as fracture density, fracture opening, fracture length, fracture morphology, maximum geostress direction, and the angle between fracture strike were considered as the research objects. Through the CRITIC weight method, a set of fracture development evaluation standards was studied and formed. Finally, a mechanism model was established to study the impact of reservoirs on production capacity under different fracture development evaluation standards, in order to guide the subsequent development of oil and gas reservoirs in the Bozi-Dabei area.

Keyword

Crack distribution pattern, COMSOL, geometry, CRITIC, crack evaluation criteria

Characteristics of the Meso-Cenozoic fracture system in the Xihu Sag and its control of the basin

Jinhang Zheng[1]*, China University of Petroleum,Qingdao,China (770593515@qq.com)
Zhiping Wu[2], China University of Petroleum,Qingdao,China

Abstract

The Xihu Depression is in the eastern depression of the East China Sea shelf basin, controlled by the tectonic domain of the Pacific Ocean, the Tethys-Himalayan tectonic domain and the deep crust-mantle action, and has experienced the tectonic evolution process with multiple phases, multiple dynamics, and multiple natures. The basement of the Cenozoic basin in the Xihu Depression is not a flat plate, and the pre-existing basement fractures affect the tectonic structure of the Cenozoic basin. The evolution of the Cenozoic basin has gone through the stage of cleavage and tensioning and extrusion reversal, and there are three sets of basement pre-existing fractures, cleavage and tensioning fractures, as well as the reversal of extrusion and fracture systems. The basement pre-existing fracture system mainly consists of NW-directed fractures, which cut deeply into the basement downward, and most of them do not cut through T30 upward; the rift-tension fracture system consists of NE-directed and NS-directed fractures, which cut downward to the basement, and most of them terminate at T21 upward; the reversed extrusion fracture system consists of longitudinal tensile, transverse tensile, and inverse fractures generated by extrusion, and the transverse tensile fracture develops in the period between T10 and T30, which is suspended above the rift-tension fracture system, and the transverse tensile fracture develops in the period between T10 and T30. Transverse tension fractures are developed between T10 and T30, hanging over the fracture system, longitudinal tension fractures can cut up to T12, and reverse fractures are mostly developed in the wings of the backslope, cutting up to T12.

The NW-directed basement fractures were resurrected to a certain extent in the Cenozoic, which played a transforming and regulating role in the Cenozoic basin, leading to the north-south zoning and segmentation of the slope zone and inversion zone; the NE-directed fracture activity rate was large during the depositional period of the former Pinghu Formation and the vertical activity was stronger than that of the NS-directed faults, and the near-NS-directed fracture activity rate during the depositional period of the Pinghu Formation was large, reflecting the tendency of the shift from NE to near-NS, and the spreading of depositional centers was controlled by fracture activities, which also experienced the shift from NE to near-NS. The spreading of the sedimentary center was controlled by the fracture activity, which also experienced the change from NE to NS direction. The change of the subduction direction of the Pacific plate from NNW to NWW is the main reason for the change of the extension stress direction of the Xihu depression. The extrusion of the Miocene Longjing movement led to the development of the central backslope belt, and the number of longitudinal and transverse tension fractures associated with the formation process correlates well with the fold amplitude of the central backslope belt.

Keyword

Fracture System, Tectonic Features, Xihu Sag, Evolutionary Process, Genesis Mechanism

Characteristics of Unconformity and its Control on Buried Hill Hydrocarbon Reservoirs: A Case Study from the Qiongdongnan Basin, South China Sea

Yanying LI[1]*, China University of Petroleum (East China) (b18010016@s.upc.edu.cn)
Kongyou WU[2], China University of Petroleum (East China)
Yannan DU[3], China University of Petroleum (East China)

Abstract

The T60 unconformity in the Qiongdongdong Basin, as the boundary between the Paleocene and Neocene, witnessed the transition of a faulted basin into a depression basin, and the T100 unconformity, as the basement unconformity, is clearly manifested in the whole basin, and the basin began to develop gradually above it. After years of hydrocarbon exploration, the work in non-structural traps has achieved significant results in Qiongdongnan Basin, and the buried hill hydrocarbon reservoirs have gradually become the focus of offshore oil and gas exploration, but the insufficient study of the structural characteristics and distribution range of the unconformity restricts the development of the exploration. This study combined the seismic data interpretation and logging identification technology to conduct a comprehensive study on the unconformities of T60 and 100, in order to explore the role of the unconformity structure in hydrocarbon formation. This work is crucial for guiding the evaluation of the unconformity reservoirs and the deployment of exploration. The research has three outcomes. (1) The T60 unconformity structure is intact, the thickness of weathered clay layer is 3-6m, the T100 unconformity weathered clay layer can reach a thickness of 8m, and the thickness of weathered clay is negatively correlated with the thickness of the leached layer. (2) The unconformity structure plays a controlling role in hydrocarbon formation in the area. The upper and lower layers of the structure can be the storage spaces or migration channels for oil and gas, and the weathered clay layer with a thickness of over 3m can seal natural gas. (3) The reservoir formation model in the Yacheng area can be summarized as "dual source hydrocarbon supply, composite stepped transport, and structural + stratigraphic trap hydrocarbon accumulation".

Keyword

Qiongdongnan Basin, Unconformity structures, Buried hill hydrocarbon reservoirs

The in situ stress field and microscale controlling factors in the Bozhong depression, Bohai Bay Basin

Guanjie ZHANG[1]*, School of Earth Resources, China University of Geosciences, Wuhan 430074, China (zgj199688@163.com)
Jingshou LIU[2], School of Earth Resources, China University of Geosciences, Wuhan 430074, China
Chuanbo SHEN[3], School of Earth Resources, China University of Geosciences, Wuhan 430074, China

Abstract

To ensure the effectiveness of fracturing treatment and improve the production metamorphic basement reservoirs of individual wells, it is important to accurately predict the in situ stress distribution to prevent the collapse of horizontal wells. under similar structural environments, microscopic factors, such as reservoir and petrophysical characteristics, are often the key factors that affect reservoir fracturing differences and drilling design in same well areas. Therefore, we need to clarified the in situ stress characteristics of metamorphic basement reservoirs and microscale controlling factors. Here, we have determined the three-dimensional distribution of in situ stress in the Bozhong depression, Bohai Bay Basin through the finite element numerical simulation method and revealed the influencing Factors. By establishing a maetamorphic basement reservoir heterogeneity model and a geomechanical heterogeneity model and with the finite element method, the 3D distribution of maetamorphic basement reservoir in situ stress can be predicted, and the effects of the maetamorphic basement reservoir rock density, clay content, rock acoustic velocity and mechanical properties on the in situ stress can be clarified. The results show that: The in situ stress of Bozhong depression, Bohai Bay Basin is generally normal fault type. The horizontal maximum principal stress is between 105-130 MPa, and the horizontal maximum principal stress is between 80-105 MPa, the horizontal stress difference (Δσ) is between 15-25 MPa, and horizontal principal stress difference coefficient (Kh) is between 0.31-0.44 MPa. The clay content is found to be negatively correlated with the Δσ and Kh. The relationships between rock density and Δσ and Kh feature a two-stage pattern. Acoustic velocity has a great influence on Δσ and Kh, but the effects of P-waves and S-waves on Δσ and Kh are different. Rock mechanics parameters has a great influence on Kh, and a little influence on Δσ.

Keyword

In situ stress, Influencing factors, Numerical simulation, Bozhong depression, Bohai Bay Basin

GEOLOGICAL ANALYSIS OF THE DEVONIAN COMPLEX IN THE SOUTHERN PART OF THE CASPIAN BASIN (KAZAKHSTAN)

Aliya ABILGAZIYEVA[1]*, Yessenov University (aliya-abilgaz@mail.ru)
Araibek Zhiyengaliyev[2], Atyrau Oil and Gas University named after S.Utebayev
Sofia Nursultanova[3], Atyrau Oil and Gas University named after S.Utebayev
Yerassyl Anepiya[4], Atyrau Oil and Gas University named after S.Utebayev

Abstract

In recent years, a new stage of research has emerged, focusing on the study and assessment of the oil and gas potential of Paleozoic deposits in the Caspian Basin at significant depths. This stage is characterized by increased interest in deep-lying Paleozoic sediments. In addition to the more accessible lateral parts, structural-tectonic and spatial models of the deeper inner parts of the Caspian Basin have been investigated. This new stage has been made possible by improved technical means and new methods of processing and interpreting geological and geophysical data.

The study of deep-seated sediments in the Caspian Basin, including the Devonian complex, has attracted attention due to their regional distribution, diverse lithologic-facies composition of sections, high differentiation, and unique variety of accumulation conditions, leading to the development of models of Paleozoic sedimentation. This paper reviews various geological and geophysical methods for studying the areas adjacent to the southern and southeastern parts of the Caspian Basin rim.

The results of a comparative analysis of drilling data, seismic surveys, and complexing of potential field data for the Paleozoic complex of the southern part of the Caspian Basin allow us to make positive forecasts for the discovery of significant hydrocarbon accumulations at great depths.

Integrating data obtained from different methods contributes to the formation of more accurate ideas about the geological structure and oil and gas potential of the Caspian Basin. Further studies and integrated data analysis will allow us to deepen our understanding of sedimentation processes, structural features, and conditions of formation of hydrocarbon deposits in this region. The importance of such studies lies not only in their practical significance for the exploration industry but also in expanding theoretical knowledge of the geological history and development of the Caspian Basin in the Paleozoic.

Keyword

South Caspian basin, Devonian system, facies analysis, oil and gas bearing capacity

Characterization of the Deformation and Formation Evolution of Mud Diapir Structure in the Rel Del Rey Basin, Niger Delta

Jixin ZHANG[1]*, China University of Petroleum (2019017@sdipct.edu.cn)
Yangwen Pei[2], China University of Petroleum(East China)
Yixin Yu[3], China University of Petroleum, Beijing

Abstract

The Rel Del Rey Basin in the northeastern Niger Delta underwent by multiple phases of tectonic superposition evolution, resulting in the large-scale development of mud diapir structure in the Akata Formation mudstones. This process had a significant impact on the formation of traps, reservoir development, and the migration of oil and gas, which are elements crucial to petroleum accumulation. However, there is still controversy over the mechanisms and stages of mud diapir formation and evolution in this area. To address this issue, this study collected seismic and well logging data and conducted balanced cross-section restoration alongside physical simulation experiments. The experimental results precisely identified the deformation characteristics of mud diapir structures and variations in surrounding strata thickness, thus uncovering the evolutionary processes of mud diapirs along with their controlling factors. The results show that: (1) The mud diapir structure mainly experienced three evolutionary stages: the initial depositional-weak activity period before the middle Oligocene, the strong uplift activity period in the Late Oligocene-Middle Eocene, and the weak activity-overall burial period from the Pliocene to the present, and the basin is characterized by the multi-phase activation of the orthogonal faults. (2) The development of the mud diapir structure was influenced by gravity sliding and differential loading of the overlying strata, in addition to the Atlantic Transform Fault in the southeastern part of the basin and the sub-mud basement rupture. (3) Influenced by the mud diapir structure and the development of faults at the top, the main reservoir in Agbada Formation often develops backslope, broken backslope and fracture block closure at the top of the mud diapir structure, and also develops the lithological shield closure at the periphery of the mud diapir structure, which provides a good place for the gathering of hydrocarbons. In addition, the flanks of the mud diapir structure and the related faults can be used as good oil and gas transportation channels, which are favorable for the oil and gas generated from the hydrocarbon source rocks of the Akata Formation to be transported to the reservoirs of the Agbada Formation.

Keyword

Rel Del Rey Basin, Mud diapir structure, Tectonic period, Physical simulation experiment

The development characteristics and genetic mechanisms of inversion tectonics in the northern part of the Yinggehai Basin

qingbo WU[1]*, China University of Petroleum (East China) (W17864205620@163.com)
zhiping wu[2], China University of Petroleum (East China)

Abstract

The Yinggehai Basin is a Cenozoic sedimentary basin developed in the western region of the northern continental shelf of the South China Sea. It is located at the intersection of the Eurasian Plate, Pacific Plate, and Indo Australian Plate. Affected by the activity of the Red River fault zone, it is generally distributed in a NW diamond shape, and has undergone multiple important tectonic movements in the Cenozoic Era, resulting in the development of inversion tectonics in the region. Its northern region covers the Hanoi area and the Lingao area. The latest three-dimensional seismic data and drilling data indicate that the northern region of the Yinggehai Basin experienced a significant tectonic inversion process in the Neogene. The Hanoi area in the northern part of the research area has developed three types of positive inversion structural styles: propagation type, back thrust fault type and fold type, with the inversion time of the Late Miocene. According to the recovery of the balanced profile, its positive inversion lateral compression rate is 14.15 percent. The Lingao area in the southern part of the research area only develops fold type positive inversion structural styles, with the inversion time of the Middle Miocene and a lateral compression rate of 2.57 percent. Compared with the Hanoi area, it has the characteristics of earlier inversion time and lower inversion intensity. The northern part of the Yinggehai Basin is located in the NW-SE to nearly NS trending transition section of the Red River fault zone, with a tectonic inversion time of the Middle to Late Miocene, corresponding to the left-right transition stage of the Red River fault zone. It is inferred that the pressure increasing effect of the fault bending section is the main factor leading to the inversion process.

Keyword

Inversion tectonics, Developmental characteristics, Genetic mechanisms, Northern Yinggehai Basin

Analysis of effects of activities of Zahedan and Nosratabad faults on deformation and displacement dikes into zahedan poloton.(southeast of iran))

Zahra IRANI[1]*, Golestan.gu.ac.ir (zahrairani136464@gmail.com)
Aliasghar Moridi[2], Geology Department of sistan and Balochistan
Habib Biyabangard [3], Geology Department of sistan and Balochistan

Abstract

Dikes are keys for realize geological problems, using of this structure help us to understand the regional tectonics. Zahedan granitoid (part of the granitoed Zahedan - Saravan)is located between two faults, Nosratabad and Zahedan in the southeast of Iran that interrupted by anumerous dikes that petrogherphcaly are within the granodiorite to diorite ,these faults belong to fault system East with approximate N-S along a strike-slip action. Activities of these fault make a shear zone in this area . granitoid and dikes are informed by the activities of them. These dikes injected into pre-existing crack that are created by fualts (Zahedan and Nosratabad) activities. Evidences of activities of fault are seen in two scale macroscopic and microscopic.These structures parallel extensions and cross layers in some area. lakhshak poloton is a part of this set located in tip of the zahedan fault . Dikes that injected into Lakhshak poloton
are mainly diorite and granodiorite in composition and consist of plagioclase, biotite, hornblende and quartz.
The deformation evidences are quartz microboudines, mica fish (especially in biotite), and fractures in minerals, inflation in quartz, asymmetric porphyroclasts, preferred orientation and rotation of minerals. These
evidences show that the dikes suffered from brittle to ductile deformation.the microscopic evidencese are seen in Satellite Images and fild.

Keyword

Zahedan poloton, Zahhedan and Nosratabad faults, Deformation, Intraction in fault, Fracture

A Preliminary Study on the Sediment Source of the Maérzheng Formation in the Southern Margin of the East Kunlun Region, China

Lei PEI[1]*, 18810552917 (peilei.1989@163.com)

Abstract

The Buqingshan tectonic mélange played an important role in the tectonic mélange of the southern margin of the East Kunlun. It was formed during the long-term subduction of the Tethys oceanic lithosphere plate from south to north during the Early Paleozoic to Late Paleozoic. Seven different types of rock blocks of the tectonic mélange have been identified within the Buqingshan tectonic mélange zone. The rock blocks mainly include Haerguole ophiolite, Delisitan ophiolite, Delisitan granodiorite, Gerizhuotuo dacite and tuff, combination of limestone and basalt and lower Permian Maérzheng Formation. In order to study the sedimentary source and sedimentary tectonic setting of the lower Permian Maérzheng Formation in the southern margin of East Kunlun, we conducted a detailed study on the sedimentary stratigraphic division, sedimentary environmentand detrital zircon U-Pb geochronology were taken for the Lower Permian Maérzheng Formation in Gerizhuotuo area in the southern margin of East Kunlun. The results indicate that the Maérzheng Formation is a turbidite series formed in a semi deep-sea to deep-sea environment on a continental slope. Detrital zircon U-Pb age spectrum can be clearly divided into two main age spectrum: Early Paleozoic and Neoproterozoicand two secondary age spectrum: Paleoproterozoic and Mesoproterozoic. The main age spectra are 396-573 Ma and 727-947 Ma, respectively, with peak ages of 421 Ma and 862 Ma. The secondary age spectra are 1117-1993 Ma and 2319-3063 Ma, respectively, with no significant peak age. This study suggests that the sedimentary source of the Maérzheng Formation in the southern margin of the East Kunlun are relatively complex, indicating the characteristics of joint supply of sedimentary sources from multiple times including the Early Paleozoic, Neoproterozoic, Mesoproterozoic and Proterozoic. The Early Paleozoic and Neoproterozoic magmatic rocks in the East Kunlun orogenic belt provide about 60-65% of its sediment sources, while the ancient metamorphic basement provides only about 30-35% of its sedimentary debris for Maérzheng formation. Combined with previous data, we suggest that Maérzheng Formation formed in extensional system related to the passive continental margin tectonic setting.

Keyword

East Kunlun, Buqingshan tectonic melange zone, Maérzheng Formation, Detrital zircon

Tectonic significance of the Early Paleozoic ophiolite in the Central East Kunlun orogenic beltChina

Wei DU[1], chang'an university
Lei Pei[2]*, chang'an university (Peile.1989@163.com)

Abstract

The ophiotes are fragments of oceanic ithospheres that provide abundant evidence for studying the evolution history of ancient oceanic and continental margin basins. The latest research results on ophiolites in orogenic belts indicate that they are mostly formed in the tectonic environment of oceanic subduction zones (SSZ type) and oceanic spreading ridge (MORB type).

The East Kunlun orogenic belt is located in the northern part of the Qinghai Tibet Plateau and is a composite continental orogenic belt that has undergone multiple tectonic movements. Previous studies on the chronology and geochemistry of the Central East Kunlun orogenic belt ophiolite have been conducted. There are still controversies regarding the tectonic environment and magmatic source. Along Central Eastern Kunlun zone, the ophiolites in Xiarihamu and Dagele areas are composed of serpentinized dunite, gabbro, and eclogites. Based on the previous studies of petrological and geochemical characteristics, it is inferred that the original rock of eclogite is basalt.

The MgO, SiO2, and TiO2 contents of eclogite are 5.58% to 8.63%, 46.79% to 51.10%, and 1.06% to 1.30%, respectively, which are equivalent to island arc calcium alkaline basalt. The SiO2 and MgO contents of gabbro are 45.54% to 49.49% and 6.51% to 13.59%, respectively. The Al2O3 content is relatively high, ranging from 12.44% to 19.37%. The SiO2 content of serpentinite dunite ranges from 39.87% to 41.82%, while the MgO content ranges from 28.53% to 35.95%. The content of TiO2, CaO, and Al2O3 is relatively low, ranging from 0.11% to 0.56%, 1.32% to 4.15%, and 1.48% to 4.30%, respectively. The geochemistry of trace elements shows rocks are relatively enriched in large ion lithophilic elements such as Rb, Sr, U, while depleted in Zr, Hf, Ta, Nb, Ti, suggesting that they were formed in an island arc environment. In addition, the Th/Yb, Th/Nb, and Hf/Th ratios of eclogite and gabbro are 0.12 to10.11, 0.11 to 2.58, and 0.22 to 3.89, respectively, indicating the characteristics of island arc basalt. In the discrimination diagram of Zr/Y-Zr, Ti/100-Zr-3Y, MnO-TiO2-P2O5 structures, the sample points all fall into the area of the island arc. The above results indicate that the ophiolites in the Xiarihamu and Dagele areas are SSZ type.

Combining this achievement with previous data, the early Silurian island arc type granite belt within the Central Eastern Kunlun zone proves the subduction of oceanic crust and island arc magmatic activity during this period. The Late Ordovician Early Silurian marine volcanic rocks were formed in a back arc basin environment. The basic rock veins exposed in the Central Eastern Kunlun tectonic zone represent the latest magmatic record of oceanic crust subduction. The ages of the ringed granite and monzonite formed in the continental collision, the metamorphic ages of the amphibolite facies, and the metamorphic ages of the eclogite are all between 411.1 to 437.6

Ma, reflecting the final closure of the East Kunlun Ocean Basin in the early Middle Silurian.

Keyword

Ophiolite, East Kunlun orogenic belt, Tectonic Significance

Boundary effects in the evolution of the deformation and stress field of southern Andean plateau, southern central Andes (26°30´–27°30´S)

Rodrigo QUIROGA[1]*, IANIGLA-Conicet-Argentina (rquirogo@gmail.com)
Laura Giambiagi[2], IANIGLA-Conicet-Argentina
Andres Echaurren[3], IANIGLA-Conicet-Argentina
Jose Mescua[4], IANIGLA-Conicet-Argentina
Heiko Pingel[5], Institut für Geowissenschaften, Universität Potsdam
Constantino Mpodozis[6], Departamento de Geología, Universidad de Chile
Manfred Strecker[7], Institut für Geowissenschaften, Universität Potsdam

Abstract

We present a study in the southern Puna region in the southern central Andes (26°30´–27°30´S), aiming to explore the late Cenozoic evolution of the deformation and tectonic stress field during the uplift of the southern border of this plateau. The results correspond to structural field-observations, U-Pb ages, reduced paleostress tensors obtained from fault-slip data, and balanced geologic cross-section. We compare the compression directions from the paleostress analysis with field observations that can help identifying the age of the different deformational events, considering the absolute and relative ages of deformed and non-deformed stratigraphic units and cross-cutting relations between the analyzed faults.

Integrating the data here presented with previously published geologic information, we propose a structural conceptual model that document the spatio-temporal evolution of the deformation and predominant stress field model over the past 24 million years, separated in four stages.

Stage 1, in the late Oligocene to middle Miocene, the region experienced east-west compression and thrust-faulting with an E-W orientation; Stage 2 from middle to late Miocene, a transition to thrust-faulting/strike-slip deformation is observed, while Stage 3, from late Miocene to early Pliocene, showed a further shift in the stress field, resulting in a combination of strike-slip and thrust-faulting; finally, stage 4, from late Pliocene to Quaternary, featured a dominance of strike-slip regime.

Our results show that the type of stress field in each stage is associated with the orogen's internal structural anisotropies, like the nature of the structural systems on each morphoteconic units defined in the southern central andes, and its evolution in the space and time. Vertical stress magnitudes increased due to cortical thickening and topographic uplift of the plateau, and varies in magnitude across the borders, creating topographic gradients. Horizontal stress variations occurred by rotations caused mainly by an edge effect resulting from the growth of the plateau and transference of gravitational potential energy, while it reaches a critical crustal thickness and elevation. This leads to a transfer of compression from high-lying areas to lower regions. The southernmost Puna region shows no significant evidence of normal faulting, suggesting it isn't undergoing orogenic collapse within a regional tensional stress regime, differing from observations in the Altiplano to the north, as well as in the Tibetan plateau.

Keyword

Southern central Andes, Andean Plateau, Stress field evolution

Fractal Dimension Analysis in Breccias of the Colombian Emerald Belts

Camilo Andrés BETANCUR[1]*, Center of Technological Development of the Colombian Emerald (cabetancura@unal.edu.co)
Andreas Kammer[2], Universidad Nacional de Colombia
Javier Toloza[3], Center of Technological Development of the Colombian Emerald

Abstract

This study analyzes the fractal dimension in the breccias of Colombia's emerald belts through the analysis of 2506 rock fragments (880 from the eastern belt and 1626 from the western belt). Fractal dimension analysis was applied to investigate the size distribution of the clasts (Ds), revealing the geometric complexity of the breccias, which is related to the mechanical energy to which the rocks were subjected. Additionally, the fractal dimension of the roughness of the breccias (Dr) was calculated, indicating the interaction of the fragments with the surrounding hydrothermal fluids. The results show that the western emerald belt (WEB) exhibits higher fractal dimension values in the size distribution of the clasts (Ds), suggesting generally higher mechanical energy than the eastern emerald belt. Furthermore, in this belt, the interaction of fluids with the host rock fragments is low, resulting in a lower fractal dimension of roughness. This is consistent with a compressive structural style, where hydrothermal fluids are restricted to shear zones and fold axes. On the other hand, the eastern emerald belt (EEB) shows a higher fractal dimension of roughness (Dr), indicating a more significant interaction of the fragments with hydrothermal fluids, attributable to an extensive structural style, where hydrothermal fluids flow pervasively over the entire rock, altering the edges of the fragments, generating more complex geometries than in the WEB.

Keyword

Fractal dimension, structural geology, emeralds

The ‘fault-controlled-fluid’ diapir in Yinggehai Basin : a new understanding based on OBN data

Chenxi Chen Ma[1]*, China University of Petroleum(East China) (1701050219@s.upc.edu.cn)
Wu Zhi Ping[2], China University of Petroleum (East China)

Abstract

Diapir is an important hydrocarbon bearing structure in Yinggehai Basin. In the past, due to the limitation of seismic and drilling data, people 's understanding of its internal structure, formation process and genetic type is not clear, which largely restricts the in-depth development of hydrocarbon exploration in diapir structure in Yinggehai Basin. Based on the analysis of 3D seismic data collected by OBN (Ocean Bottom Node) in DF1-1 diapir zone, it is shown that the diapir is obviously different from mud diapir, salt diapir and magmatic diapir, which are mainly manifested in the following aspects : (1) OBN seismic data show that the diapir core is not a blank or messy reflection of mud, salt diapir or magmatic diapir core, but has a good layered structure, continuous seismic reflection axis and corresponding extension relationship with surrounding strata. (2) Different from other diapirs, there is no obvious boundary interval between the core of Dongfang 1-1 diapir and the surrounding rock, and the existence of diapirs does not cause severe deformation of the surrounding rock. (3) The mud diapir, salt diapir or magmatic diapir zone is characterized by fuzzy anomalies such as salt bodies, mud mounds and magmas, while the Dongfang 1-1 diapir zone is characterized by multi-stage, overlapping and communicating. There are three sets of fault systems in the NS, NE and NW (NWW) directions, with a large number of faults and high density. (4) There is no deep parent rock or root zone similar to gypsum rock salt pillow, mud source layer or deep magma chamber in Dongfang 1-1 diapir. (5) The distribution of diapirs in the Yinggehai Basin reflects the ' orderliness ' under the control of faults. The diapirs are distributed along the nearly NS-trending tension-shear faults formed during the dextral strike-slip period, and are mostly developed at the intersection of active faults in each stageIn addition, it is worth noting that the abnormally high homogenization temperature of fluid inclusions, the rapid increase in the evolution of clay minerals, the development of hydrothermal minerals such as ankerite and siderite cements, and the enrichment of mantle-derived CO2 and other non-hydrocarbon gases also record the activity of upward invasion of deep thermal fluids from the diapir zone. Therefore, a new understanding that the diapir in the Yinggehai Basin is a ' fault-controlled fluid diapir ' is proposed. It is a deformation structure of the dome (or later collapse) formed by the upward flow of the pressure relief zone formed by the deep high-temperature and high-pressure gas and liquid fluids along the fault fracture zone. The new understanding of " fault-controlled-fluid " diapirs has broken through the restricted area where diapirs can only accumulate at the top and wings. The good stratification characteristics make it also have reservoir-forming conditions inside, which can form multi-layer floor gas reservoirs. This has important guiding significance for deepening and expanding oil and gas exploration in the diapir area of Yinggehai Basin.

Keyword

Diapir, Yinggehai Basin, Fault zones, Fluid, fault-controlled-fluid

New understanding of the evolution and structural deformation of the northern Neuquén Andes (37-38°S)

Lucía JAGOE[1]*, IDEAN (CONICET - Universidad de Buenos Aires) (lu.jagoe@gmail.com)
Martín Miguel Turienzo[2], Instituto Geológico del Sur (INGEOSUR, UNS-CONICET), Departamento de Geología, Universidad Nacional del Sur, Bahía Blanca, Argentina.
Lucía Sagripanti[3], IDEAN (CONICET - Universidad de Buenos Aires)
Natalia Paola Sánchez[4], Instituto Geológico del Sur (INGEOSUR, UNS-CONICET), Departamento de Geología, Universidad Nacional del Sur, Bahía Blanca, Argentina.

Abstract

The Guañacos Fold and Thrust Belt (FTB), located in the northern Neuquén Andes (37°-38°S; 70°30′-71°10′ W), exposes Oligo-Miocene volcaniclastic sequences corresponding to the Cura Mallín Formation. This unit outcrops on both the Chilean and Argentinean flanks of the Andean Cordillera, extending between 37° and 38° S. It encompasses a lower volcanic member and an upper sedimentary member, defined in Chile and correlated in Argentina, reaching a total thickness of up to 3000 meters. The tectonic setting during the deposition of the Cura Mallín Formation is a matter of debate. Two main hypotheses exist in the recent literature regarding this: a) syn-extensional deposition of the Cura Mallín Formation, starting at ~28 Ma, associated with a regional extension phase responsible for creating a series of intra-arc rift basins along the continental margin between 33° and 45° S. This hypothesis is based on the interpretation of a seismic line with limited resolution, where the investigators identified a basin-bounding normal fault that subsequently underwent inversion in a late-Miocene compressional stage. Hypothesis b) states a strata deposition in a compressional regime with horizontal shortening and vertical thickening, grounded in interpreted growth strata near folds and reverse faults.

This work contributes to the interpretation of the evolution of the Cura Mallín Formation with a new structural model carried out on the Guañacos FTB, where we conducted a comprehensive field mapping, identifying and documenting the spatial distribution of geological structures and the orientation of the bedding planes. Analysis of the collected data resulted in a detailed geological map and two balanced cross-sections that included the upper parts of the sedimentary member. We interpreted the deformation style of the Cura Mallín Formation in this portion of the orogen as thin-skin, with no evidence supporting either syn-extensional or syn-compressional deposition of the layers. We also calculated the shortening associated with the uplift and deformation of these sequences, obtaining results between 8,5 and 9,5 km, which we consider reasonable given the regional values provided in previous works. Furthermore, our new U/Pb ages for the Cura Mallín Formation of 15,42 ± 0,15 Ma are consistent with recent work that suggests a younger age for the formation and hence, its deformation. Hereby, our results are consistent with the post-depositional deformation occurring in the late Miocene already postulated in previous works. These findings contribute to the growing body of evidence suggesting younger deformation for these sequences, revising the previously proposed evolutionary context for the Oligocene-Miocene period in the Andes at these latitudes.

Keyword

Cura Mallín, Oligo-Miocene, Andean evolution, Balanced cross-sections

Thermokinematic 2D restoration of the Marañón Fold and Thrust Belt in the Andes along the Puchca Valley, Perú.

CRISTIAN MIGUEL MACHACA SARDON[1]*, Universidade de São Paulo (cristian.machaca@usp.br)
GINALDO ADEMAR DA CRUZ CAMPANHA[2], Universidade de São Paulo

Abstract

The Marañón Fold and Thrust Belt (MFTB) spans from northern to central Peru, the research area is located in the Puchca Valley, Huari province. The basement is composed of schists and gneiss of the Marañón complex, the Mesozoic sedimentary rocks (sandstones, mudstones, and limestones) are the most common, however, our focus lies on the Tithonian and the Berriasian because they are important to generate structures in the research area. Structurally the Tithonian and the Berriasian rocks play an important role as a detachment level, that is because are composed of black shales and carbon layers which are perfect for developing faults overlying upper Cretaceous sedimentary rocks.

Previous research on the evolution of the MFTB used structural models based on outdated geological data. Currently, the Peruvian Geological Survey (INGEMMET) is updating these maps, it has new maps at a scale of 1:50 000, in areas of more structural complexity, high-resolution maps at a scale of 1:10 000 were constructed, and this new data is useful to research the evolution of the Peruvian Andes across the MFTB.

The present research is supported by a geometric analysis to construct a geological balanced cross-section, low-temperature thermochronology, and a sedimentary analysis showing the stratigraphic variations. Currently, the study is focused on developing a thermokinematic model for the geological balanced cross sections of the MFTB, whose geometry of the structures suggests mainly a thin skin style. At the same time, towards the east, the reactivation of previous normal faults is clearer than in the west area, which suggests a thick skin tectonic, the shortening estimated is around 30 to 35% at least.

Keyword

Thermokinematic model, 2D restoration, Thermochronology, Puchca Valley, Detachment

New Understanding of Late Mesozoic Structural Deformation in the South Yellow Sea Basin and Its Significance for Oil and Gas Exploration

Huang ZHEN[1]*, Tianjin Branch of CNOOC (China) Co., Ltd (huangzhen2@cnooc.com.cn)
Lv dingyou[2], Tianjin Branch of CNOOC (China) Co., Ltd
Yang haifeng[3], Tianjin Branch of CNOOC (China) Co., Ltd
Yang bo[4], Tianjin Branch of CNOOC (China) Co., Ltd
Wu qingxun[5], Tianjin Branch of CNOOC (China) Co., Ltd

Abstract

The South Yellow Sea Basin has undergone multiple cycles of tectonic evolution, with strong stratigraphic deformation and extremely complex structures. The overall quality of seismic data is poor, and there is relatively little research on the late Mesozoic tectonic deformation, resulting in unclear understanding of the tectonic deformation mechanism. Traditionally, it is believed that due to the strong compression and transformation during the Indosinian period, it is difficult to form large-scale oil and gas preservation, which has constrained the pace of oil and gas exploration in this area.

Based on gravity data, magnetic data, seismic data, drilling data, and outcrop data, we conducted regional tectonic stress, tectonic evolution history, numerical simulation, physical simulation, and structural deformation analysis, forming the following innovative understanding:

Firstly, it is proposed for the first time that the South Yellow Sea Basin underwent east-west compression deformation in the Late Mesozoic era. A large number of north-south trending wide and gentle anticlines and thrust fault systems can be identified on seismic profiles, and a series of north-south trending faults can be clearly identified on seismic variance slices. Analysis of apatite fission data suggests that this type of fault was formed during the Late Mesozoic era.

Secondly, innovate the establishment of a tectonic deformation mechanism under two periods of conjugate compression forces, pointing out the existence of two periods of compression in the South Yellow Sea Basin, namely the Indosinian north-south and early Yanshanian east-west directions.Based on Ha isotope analysis of intrusive granite, it was first discovered that there is a rigid crystalline basement of the Archean in the South Yellow Sea, which has inherent stability advantages. The rigid crystalline basement of the Archean provides a stress barrier for the development of stable zones.The Silurian mudstone with a thickness of about 1500 meters and the Cambrian gypsum provide a plastic medium for the detachment system. The detachment layer exhibits a structural decoupling phenomenon, providing a dual guarantee for the structural stability below the detachment layer.The compression deformation pattern during the Mesozoic era in the South Yellow Sea is characterized by "strong in the west and weak in the east, strong in the north and weak in the south, and strong in the upper and weak in the lower". It is clear that the central uplift and the thrust zone are structurally stable, which is conducive to the preservation of natural gas in the Cambrian and Sinian systems.

The above understanding has changed the traditional understanding that the preservation conditions of the Lower Yangtze Plate are poor, clarified the advantageous preservation zone of

oil and gas in the South Yellow Sea Basin, guided the implementation of a number of large-scale structural traps in the central uplift, improved the structural development history of the South Yellow Sea Basin, and pointed out the next exploration direction in the area.

Keyword

Late Mesozoic, Structural Deformation, rigid crystalline basement, Oil and Gas Exploration

Effect of tectonic extrusion on the physical properties of clastic reservoirs: Based on physical simulation experiments

Yumeng Song[1]*, China University of Petroleum (East China) (1945476894@qq.com)
Liqiang Zhang[2], 15194507095
Yiming Yan[3], 15194507095

Abstract

Tectonic action plays an important role in the formation and evolution of extrusion basins, and tectonic processes affect the quality of reservoirs by affecting the settlement rate, burial rate, fracture development and other factors of the basin. Although the deep high-quality clastic reservoir has a large burial depth, its reservoir physical properties are still good, which is closely related to the relationship between tectonic movements. Therefore, in order to quantitatively study the influence of lateral compression caused by tectonic movement on the pore evolution of reservoirs, diagenetic physical simulation experiments were carried out. By controlling a single variable in a way that: The quartz sandstone with the same grain size, sorting and rounding was used to adjust the lateral extrusion stress of different sizes under the same temperature conditions, and the vertical compaction was pressurized to the same depth, so as to explore the evolution law of reservoir pores and reveal the influence process of tectonic stress on the physical properties of the reservoir. The results show that there is a certain functional relationship between the change of reservoir porosity and the vertical compaction stress: With the increase of lateral compression stress, the relationship between reservoir porosity and vertical compaction stress gradually changes from exponential to linear, and the slope of linear relationship decreases gradually. That is, with the increase of tectonic stress, the decline rate of reservoir pores gradually slows down, and the existence of tectonic stress will hinder the continuation of vertical compaction to a certain extent, which has a certain improvement effect on the preservation of reservoir pores. Therefore, this study clarifies the mechanism of extrusion on the formation and evolution of deep reservoirs, and has a positive effect on the evaluation and prediction of deep high-quality reservoirs in extrusion basins.

Keyword

Mechanical compaction, Lateral extrusion, Diagenetic physics simulation, Pore evolution

Early Cretaceous lithospheric thinning of the North China craton: Insights from mantle-derived mafic dyke swarms in Jiaodong peninsula

Lei JI[1]*, China University of Geosciences (Beijing) (lji@email.cugb.edu.cn)
Junlai LIU[2], China University of Geosciences (Beijing)
Jun DENG[3], China University of Geosciences (Beijing)
Jinlong NI[4], Shandong University of Science and Technology
Xiaoyu CHEN[5], China University of Geosciences (Beijing)

Abstract

The coupling/decoupling relationships between shallow, crustal and deep, lithospheric mantle tectono-magmatic activities during lithospheric thinning and destruction of cratons remain hotly debated in the last decade. Multidisciplinary studies were done on non-deformed mantle-derived mafic dyke swarms in southern Jiaodong peninsula, southeastern North China craton (NCC) to explore the crustal and lithospheric mantle responses to regional tectonic extension. LA-ICP-MS zircon U-Pb age dating of the dykes gives consistent ages of 122-121 Ma indicating intensive magmatism at the mantle depth around 122 Ma due to large-scale tectonic extension of regional lithospheric mantle. The dykes show island arc basalt-like trace element patterns and enriched Sr-Nd isotope composition, which is indicative of their enriched lithospheric mantle sources. Anisotropy of magnetic susceptibility (AMS) analysis of dykes with different orientations reveals a systemic variation in dihedral angles between dyke walls and magnetic foliations. Geometrically, the magnetic foliations rotate counterclockwise relatively to the dyke walls for most dykes striking NW–N, while clockwise rotation is dominant for the dykes of NE–E orientations. The WNW-ESE (297 ± 5°) oriented extension resulted in the dextral shearing for the former and sinistral shearing for the later during magma emplacement along crustal fractures. Combined with analysis of regional tectono-magmatic events, we show that the Jiaodong lithosphere experienced two stages of Early Cretaceous tectonic evolution, i.e., an early stage (135-122 Ma) lithospheric thinning characterized by large-scale tectonic extension of the crust and limited magmatic activities of crustal sources, and a late stage (122-108 Ma) lithospheric root collapse dominated by intensive tectonic extension and magmatism in the lithospheric mantle level. The decoupling crust-mantle evolution during lithospheric thinning and destruction of the NCC is accompanied by the changes in direction of Early Cretaceous tectonic extension from E-W direction to ESE-WNW direction, which may relate to coeval subduction direction change of the Paleo-Pacific plate underneath the Eurasian plate.

Keyword

lithospheric thinning, North China craton, Jiaodong peninsula, Early Cretaceous, mafic dykes

Neotectonics, geochemical dispersion processes and mineral exploration: linking basement and surface in regions of cover

Ignacio Gonzalez-Alvarez[1]*, CSIRO (The Commonwealth Scientific and Industrial Research Organisation) (ignacio.gonzalez-alvarez@csiro.au)
Carmen Krapf[2], Geological Survey of South Australia

Abstract

Detection of mineral system footprints in regions under thick cover is challenging. The difficulties are enhanced in regions with low-relief landscapes that are deeply weathered. This is also widely the case in Australia where >80% of the surface and subsurface is characterised by transported cover and/or deeply and intensely weathered profiles.

Geochemical dispersion/concentration processes throughout cover units can be efficient in a variety of geological-cover contexts. These processes can produce near surface geochemical anomalies in the landscape, that may be an expression of a mineral system within basement rock units at depth.
Basement structures in Earth's crust are a well-recognised conduit for fluid flow, which can result in the formation of a large variety of mineral deposits. Therefore, identifying basement structures that may be associated with mineral deposit formation has become an important part of exploration protocols and prospectivity assessments.

The possible link between neotectonics and geochemical dispersion processes should be carefully considered when studying landscape geochemistry in areas with thick overburden. Soil or surface landscape units should be selectively sampled in relation to surface structures that are linked to main basement structures that could have been reactivated through time and therefore maintain a direct geochemical link between the basement and the surface.

This study discusses that in areas of deep cover, neotectonics/reactivation surface landscape features have the highest prospectivity to detect deep basement geochemical signatures at surface. This approach may have a critical impact in mineral exploration under cover in similar landscape contexts around the world, such as regions in Australia, West Africa, India, China and Brazil.

Keyword

Landscape Evolution, Surface processes, Neotectonics, Mineral Exploration, Weathering

Deciphering long-term geomorphological evolution through morphometric analysis of the Côa River drainage network (northeast Portugal)

Luca Antonio DIMUCCIO[1]*, University of Coimbra, Portugal (luca@ci.uc.pt)
Raquel Lacerda[2], University of Aveiro, Department of Geoscience, Aveiro, Portugal
Domenico Capolongo[3], University of Bari, Department of Earth Science and Geoenvironmental, Bari, Italy
Rui Ferreira[4], University of Coimbra, Centre of Studies in Geography and Spatial Planning (CEGOT), Department of Geography and Tourism, Coimbra, Portugal
Fernando Rocha[5], University of Aveiro, Department of Geoscience, Aveiro, Portugal
Lúcio Cunha[6], University of Coimbra, Centre of Studies in Geography and Spatial Planning (CEGOT), Department of Geography and Tourism, Coimbra, Portugal

Abstract

Among the various methodological approaches used to study landforms, the morphometric analysis of the drainage network is a valuable tool for understanding geomorphological responses to lithological, tectonic, and climatic constraints. By processing and interpreting a set of geomorphic parameters that describe the topographic, hydrographic, and geometric characteristics of the drainage basin and its sub-basins, it is possible to infer landscape evolution at a local and regional scale. This study proposes a detailed morphometric analysis of the Côa River drainage network, situated on the left bank of the Douro River (northeast Portugal). Geomorphologically, the drainage area under consideration is located on the northwestern edge of the Iberian Meseta, an extensive and polygenic Cenozoic planation surface with regional significance, cutting a metasedimentary and granitic substrate. After producing a detailed Digital Elevation Model of the study area, several geospatial tools were used to process the following geomorphic parameters for the Côa River drainage basin and its sub-basins: the longitudinal profiles of the main watercourses, the channel slope gradient and the normalised channel slope index, together with the identification/characterisation of the respective knickpoints/knickzones, and the bifurcation ratio; the elongation ratio and the asymmetry factor; the swath profiles; the curve and hypsometric integral, the transversal topographic symmetry factor, and the width-height relationship from the main watercourse valley. The results obtained for the Côa River longitudinal profile indicate the presence of convex segments and some knickpoints in the lower half (towards and close to the confluence with the Douro River), highlighting an imbalance associated with a rapid lowering of the local baseline level (defined by the Douro River), as well as to lithological variations (schists/phyllites vs. quartzites/granites) and the presence of local geological structures (fractures). The less evolved sub-basins from the downstream sectors, even maintaining a global concavity in their longitudinal profile, present more significant asymmetry and disturbances from the initial linear trend, indicating a transient response of the profile and a higher imbalance that they must be analysed in the context of the Douro River regional evolution. Thus, in evolutionary terms, the Côa River drainage network was mainly affected by regional factors related to the capture of the “Upper Douro” (endorheic) by the “Lower Douro” (exoreic Atlantic drainage) and the subsequent

rapid fluvial incision under the influence of Plio-Quaternary climatic and environmental variability, as well as by local factors such as the interference of lithological variability and pre-existing geological fractures. Differentiated tectonic uplifts of the substrate between the downstream, central, and upstream sectors of the Côa River basin, with a magnitude of accumulated vertical linear movements around ~0.29-0.15 mm/year, have accompanied this fluvial incision during the last ~2.4-1.6 Ma. Furthermore, some phases of tectonic quiescence and rate variations in the fluvial incision, conditioned by the rapid Pleistocene climate oscillations, are expressed in the regularisation/stability of the main watercourses' longitudinal profiles. These tectonic constraints agree with previous studies on other geological evidence for the Iberian Meseta in northeast Portugal.

Keyword

Fluvial geomorphology, Iberian Meseta, Douro River, Tectonic uplifts, Landscape evolution

The history of the most typical world's great rivers: the evolution of the Yangtze and Yellow rivers controlled by the Himalayan orogeny

Liankang YANG[1]*, Ministry of Natural Resources (15646568081@163.com)

Abstract

In 1963, the author discovered the earliest sediments of the Yellow River - the lower Wuquan gravel layer in Lanzhou, Gansu (2.5 Ma?), the largest visible thickness of the loess (315m), and the most complete profile of the river's evolution (for 2.5 Ma?). In 1981-84, for the first time in human history, he spent 1,111 days on foot to survey the whole course of the Yellow River and the Yangtze, discovered the highest terrace (1250m above the current river bottom), the largest number of terraces (>32 terraces), the longest mountainous river's section (the Yangtze 4500 km; the Yellow 3500 km), the deepest vertical karst (622 m) of the world, etc. and published "The formation of the Yellow River" and "The formation of the Yangtze River" at the 14th INQUA. Since 1992, the author has examined the world's other great rivers with > 5,000 km long (Nile, Amazon, Mississippi, Ob, Yenisei), other longest or famous rivers on six continents (Volga, Murray-Darling, Danube, Rhine, etc.). "The developmental history of global longest rivers" was presented at GSC, AGS, and IAG, and successfully refuted the arguments in "Pre-Miocene birth of the Yangtze River" (PNAS 2013.4) at 33 IGC and in Li Jijun's papers about the formation of the Yellow River. This article further confirmed that the history of the Yangtze and Yellow River is controlled by the Himalayan orogeny which uplifts the world's highest Mt. Himalayas and Qinghai-Tibet plateau, making it the world's most typical one.

Keyword

evolution, Yangtze, Yellow, Himalayan, orogeny

Full-length Hiking Expedition along the Yellow River and Yangtze River, Discovery of Their earliest Sedimentary Layer, and Confirmation of a Complete Developmental Historical Profile

Liankang YANG[1]*, Ministry of Natural Resources (15646568081@163.com)

Abstract

There are seven rivers in the world that exceed 5,000 km in length. From 1981 to 1984, the author embarked on a 1,111-day full-length survey of the Yellow River and the Yangtze River on foot to investigate their earliest sediments and complete historical profiles, marking a significant milestone in human history.

Wuquan Mt. in Lanzhou City, Gansu Province, located 2,200 km from the Yellow River's source, contains a Conglomerate. On December 23, 1963, the author and their group discovered that this conglomerate is divided into two parts: the lower part consists of alluvial material with rounded pebbles of granite and quartzite from the upper reaches of the Yellow River. Furthermore, at Fanjiaping west of Wuquan Mt., the conglomerate layer is distinct from the underlying red strata and contains limestone pebbles with *Verbeekina* from the Western Qinling Mt at its base, providing conclusive evidence of the Yellow River's connection to the Western Qinling Mt, challenging previous beliefs(Yang- Bian, 1936).

During a 750-day survey of the Yangtze River, the author identified the world's highest terrace at 1250m above the current river bottom. This discovery resolved the historical development survey conducted by the Three Gorges Geomorphology Team from 1958 to 1960 and revealed the Wangbuding section of the conglomerate containing Hengduanshanghyrax .gen.nov., representing the most complete section of the Jinsha River in the upper reaches of the Yangtze River, dating back to the Pliocene.

The author has investigated and studied major rivers around the world, and the above methods have played a crucial role.

Keyword

earliest, sediments, complete, historical, profiles

Danxia Landform research in China: Tectonic significance, fracture mechanisms and controlling factors

Fang REN[1]*, Chinese Academy of Geological Sciences (546615019@qq.com)
Zhinxin Pan[2], Hainan University

Abstract

Danxia landform is a kind of erosional landform featuring steep cliff slopes, which mainly developed from continental sandy conglomerate .However, the control factors of of Danxia landform is still controversial. In this study, the surface process and landform morphology of Danxia Landform development are studied through a large amount of data analysis, and it is believed that tectonic factors had extensive influence on the development of Danxia Landform morphology.Through GIS-based remote sensing image interpretation,field geological surveys and regional tectonic settings to study the morphological mechanism of the Danxia Landform. Field data including faults and bedding directions (strike and dip),and kinematic characteristics are analyzed. Field verification for the geomorphological characteristics obtained by remote sensing and DEM data analysis are carried out. The results show that not only the tectonic fractures have great immpact on the formatinon of Danxia steep cliffs, but only tectonic fracture-controlled groundwater erosion has been playing important role in Danxia geomorphology development. The development of Danxia Landform is the unity of time- space, and the result of the joint action of internal and external forces. Tectonic control and water erosion play a crucial role in the formation of Danxia Landform. West Pacific Plate subduction processes and deep earth processes lead to the corresponding surface processes in South China block in the East Asian Continental Margin, which are recorded in the Danxia geomorphology. Geomorphic evolutionary trends and climate change in Danxia red beds basins in the south China block show similarities, thus is the reason that Danxia landform is widely distributed in South China.

Keyword

Danxia landform, surface processes, tectonic control, South China Block, fluvial controll

Controls of tectono-pluviometric forcing on landscape dynamics and seismicity in Java

Manoj Joseph Mathew[1], Department of Geography, Geology and the Environment, Kingston University, London, United Kingdom
Benjamin SAUTTER[2]*, UBS (benjamin.sautter@univ-ubs.fr)
David Menier[3], Geo-Ocean UMR CNRS 6538, Université Bretagne Sud, 56017 Vannes Cedex, France
Franto Novico[4], Research Center for Geological Disaster, National Research and Innovation Agency, Indonesia
Numair Ahmed Siddiqui[5], Department of Geosciences

Abstract

The quasiperiodic frequency of seismicity in rapidly deforming terrains located at plate boundaries is concentrated along faults that are loaded at consistently uniform rates and stochastic signals emanated from such deformation are manifest as non-linear geomorphic phenomena. The island of Java presents a key case-in-point, where, seismicity, deformation and exhumation are driven by steady relative plate motion. However, there remains a paucity of information regarding geomorphic response of the landscape to these tectonic forcing. Here, through a systemic morphotectonic analysis, we show that intrinsic mechanisms govern extrinsic surface processes and pluviometry in Java than have hitherto been perceived or documented. Owing to tectono-climatic forcing, variations in the behaviour of power-law scaling between catchment area and channel slope reveals methodical, large-scale landscape transience, and reorganization of basin geometry and flow line topology. In Java, topographic dissection by disequilibrated streams that demonstrate amplified averaged specific stream power, non-lithologic knickpoints and discrete convexities in channel profiles shows the transmission of transient incisional signals through the river network. Conclusive evidences garnered from our results emphasize the role of progressive tectonic deformation along inherited basement faults in landscape instability and disequilibrium within the island of Java. These NW-SE and NE-SW striking conjugate faults are responsible for differential subsidence and uplift across the island. They function as major conduits/pathways for fluid migration that results in immense isostatic disequilibrium, as is the case with the Lusi mud volcano in east Java. Our results highlight the aggregation of significant geomorphic anomalies along the major Flores Back Arc Thrust Fault and the Cretaceous suture zone. The implication is that present-day crustal motions, which generate topography, influence pluviometry, induce seismicity and instigate geomorphic landscape dynamics are facilitated by long-lasting convergence accommodated by the reactivation of intrinsic basement structures such as faults and suture zones.

Keyword

landscape evolution, seismicity, fault reactivation, transience, basement structures

Relationship between development periods of coastal sand dunes and climate-environmental factors

Min HAN[1]*, Korea Institute of Geoscience and Mineral Resources (hanmin@kigam.re.kr)
Jin Cheul Kim[2], Korea Institute of Geoscience and Mineral Resources
Dong Yoon Yang[3], Korea Institute of Geoscience and Mineral Resources

Abstract

To confirm the relationship between the development of coastal dunes and climate-environmental changes, this study classified the activation periods using optically stimulated luminescence (OSL) dating for major coastal dunes on the west coast of the Korean Peninsula (Taean Chollipo, Seocheon Dasari, and Gochang Sabanri dune). The results from these dunes were compared with those from previous studies to establish a broad understanding of coastal dune development in East Asia. Sedimentation rates were calculated for the three dunes, and their development periods were classified five main periods during mid to late Holocene: <0.1, 0.2~0.5, 1.2~2.0, 2.5~3.2, and 5.5~6.5 ka. These results were compared with temperature anomaly curves and drift ice indices during the Holocene, and it was confirmed that the development of dunes became prominent during the global cooling events and the enhanced East Asian winter monsoon. In addition, it was suggested that increased human activities contributed to the most recent dune development. This study showed how coastal sand dunes can be evaluated as important indicators of global climate change. These results improved our understanding of how paleoclimate changes affected environmental conditions in East Asia and how coastal dune development periods can be used to reconstruct paleo-environmental conditions. As further studies, we plan to compare the development periods of dunes around East Asia and identify other climate factors.

Keyword

Optically stimulated luminescence dating, Coastal dune, Sedimentation rate, East Asian winter monsoon

Decadal and Millennium Scale Gully Expansion Rates, Mthatha, Eastern Cape, South Africa

Debbie Claassen[1]*, Council for Geoscience (debclaassen@gmail.com)
Bastien Linol[2], Nelson Mandela University
Greg Botha[3], University of KwaZulu-Natal

Abstract

Widespread dispersive sequences comprised of colluvium and pedogenic sediments of the Late Quaternary Masotcheni Formation, mantle valley slopes of the rural eastern hinterland of South Africa. These formations are highly susceptible to erosive gullying and extensively scar the landscape. These features exert a substantial impact on environmental health, sustainable socio-economic growth, and infrastructure development in the region. Yet, current studies lack integrated qualitative and quantitative investigations aimed at holistically assessing the influence of both the static and dynamic natural and anthropogenic factors on the temporal erosion rates and evolution of gullies over the decadal and millennium-scale.

The study undertook erosion inventory mapping, detailed pedogenic logging, optical stimulated optical luminescence (OSL) sampling and analysis, multi-temporal study, statistical testing of natural and anthropogenic static erosion drivers, and a near-century temporal investigation of dynamic drivers that included the calculation of gully expansion rates with the aim of investigating how erosion rates fluctuate in response to the temporal variations of drivers.

Gully inventory mapping revealed 1762 erosional features occupying 2.3% or 2579 ha of the study area. Logging across numerous gullies identified 7 laterally consistent paleosols. The normalized gully density and frequency Chi-square test results indicate a statistically significant relationship between the occurrence of gullies and the regolith lithology, slope characteristics, land use, drainage densities, and topographic wetness indexes. The spatial examination of 25 gullies over an 82-year period between 1938-2020 revealed an average gully expansion rate (AGER) of 0.61 m y-1, an AGER of 0.2 m y-1, and an average headcut erosion growth rate of 1.03 m y-1. Erosional features showed an average annual areal increase of 2.8%. The multi-temporal mapping of the Ngwevana Gully across 12 time slices showed systematic fluctuation in the average annual growth percentages, with the largest growth occurring between 1938 and 1948 at 3.98%, and the lowest occurring between 2003-2005 at 0.66%. OSL dating results revealed a chronological sequence for each of the paleosol layers. Minimum burial ages for the oldest and thickest basal paleosol unit ranged from 117±18 ka to 147±12 ka, with the youngest uppermost paleosol dated at 1.3±0.2 ka. Additional accretion pulses occurred at 93±8 ka; 64±18 to 70±3 ka; 43±3 ka and 27±6 and 10±1 ka.

The integrated assessment of drivers revealed that the temporal promotion or suppression of

erosion rates in the last century is the consequence of the complex interaction between dynamic drivers, at specific times in the region. Rapid expansions are directly linked to large-scale flooding events, particularly during drier climate cycles. Periods of increased erosion are exacerbated by invasive dryland agricultural practices, inappropriate land use, and haphazard settlement and infrastructure development compounded by the legacy of Apartheid settlement laws. Findings indicate that although static conditioning factors play a significant role in the location and initiation of gullies, once established, their areal expansion is predominantly driven by dynamic drivers. OSL results show that transgressive and regressive Marine Isotope Stages (MIS) drove long-term depositional and erosional events in relation to alternating warm and cool periods in Earth's paleoclimate from MIS 5e.

Keyword

Erosion, Gullies, Expansion rates, Quaternary, Geochronology

Karst morphologies in the foreland of the West-Congo belt, Republic of Congo: evidence of cone karst in the Madingou region

Nicy Tchiguina BAZEBIZONZA[1]*, Marien Ngouabi University, Faculty of Sciences and Technics (nicybazebizonza@gmail.com)
Prefina SAMBA[2], Marien Ngouabi University, Faculty of Sciences and Technics
Hardy NKODIA[3], Marien Ngouabi University, Faculty of Sciences and Technics
Florent BOUDZOUMOU[4], Marien Ngouabi University, Faculty of Sciences and Technics
Imen ARFAOUI[5], Royal Museum for Central Africa, Tervuren, Belgium / Sedimentary Petrology Laboratory, Liège University, Allée du Six Août, 12, 4000, Liège, Belgium
Pascale LAHOGUE[6], Royal Museum for Central Africa, Tervuren, Belgium

Abstract

The Republic of Congo, located in Central Africa, stands out for its remarkable karstic potential, concentrated in the foreland of the West-Congo belt. This region encompasses a vast expanse of carbonate rocks stretching from Gabon to Angola, through the Republic of Congo (RC) and the Democratic Republic of Congo (DRC). In the Republic of Congo, these formations are found in the southwest, covering approximately 10% of its total area, which extends over 342,000 km^2.

The karst of the carbonate formations in the foreland of the West-Congo belt in the Republic of Congo (RC) is significant due to several distinctive features: the abundance of discovered cavities, the presence of tectonic structures, concretions, as well as the faunal and archaeological richness, and the variety of observed karstic morphologies (Adam et al., 1966; Adam, 1969; Bede and Lanfranchi, 1978).

In the context of geomorphological study to better characterize this karst, the region of Madingou has undergone several explorations involving optical satellite image analysis and processing of a Digital Elevation Model (DEM). These investigations have revealed a profusion of conical hills, either isolated or in clusters, emerging from the limestone plain of the Niari River. This represents a typical example of cone karst, primarily encountered in tropical zones (Salomon, 2006; Gilli, 2011). The evolution and structuring of the Madingou cone karst are closely linked to the progressive lowering and widening over time of the Niari River plain, the main watercourse draining this karst, as well as the discharge of its various tributaries. According to Grund's classification (Grund, 1914), the Madingou cone karst is categorized as mature to old, suggesting a low preservation of numerous underground conduits.

Keyword

Cone karst, Morphology, foreland of the West-Congo belt, Madingou, Republic of Congo

Tackling Mediterranean Hurricanes through artificial intelligence in a near-future climate projection

Giovanni SCARDINO[1]*, University of Bari (giovanni.scardino@uniba.it)
Alok Kushababa[2], IUSS Pavia
Gaetano Sabato[3], University of Bari
Marco Borzì[4], University of Catania
Andrea Cannata[5], University of Catania
Giovanni Scicchitano[6], University of Bari

Abstract

Mediterranean Hurricanes (known as 'medicanes') are extreme weather systems that cause damage along the Mediterranean coasts. These events are intensifying, and future climate projections show increasingly stronger events than now. Medicane effects are reflected in the high storm surge and coastal flooding that enhance coastal erosion and cause infrastructure damages and casualties. These issues are also intensified by ongoing climate changes, which are determining a global sea-level rise. To address these issues, multi-observation platforms could be used integrating modern techniques of deep learning. Deep learning models allow us to automatically analyze a large amount of data related to the effects of medicanes and sea-level rise. The main parameters of medicanes are usually correlated to mean sea-level pressure, sea surface temperature, significant wave height, and wind speed. On the other hand, sea-level rise is determining coastal flooding and shorelinre retreat, which cause damage to the infrastructure and changes in land use. All these parameters can be assessed from numerical climate models and satellite observations. Furthermore, in-situ data from field surveys could be used to calibrate numerical models and satellite data for target coastal areas. In this work, a Convolutional Neural Network was developed by applying sliding convolutional filters to 1-D inputs in Matlab environment, in order to assess the vulnerability connected to medicane impact in a framework of future sea-level rise. Here, datasets of meteo-marine parameters from satellite, Copernicus, ERA5 numerical models, morpho-topographical data from LiDAR surveys have been used for the training and validation of the Convolutional Neural Network. The 1-D inputs are represented by vectors where mean sea-level pressure, sea surface temperature, significant wave height, sea-level rise, and wind speed are reported for the medicanes that occurred in the last decades. Regional technical maps and morpho-topographical data have been considered to extract the landforms and areas occupied by buildings and infrastructures, in order to assess the exposure in the most vulnerable areas. The predictions of Convolutional Neural Network provide an output of the hurricane track and the coastal areas prone to be impacted by storm waves in a given future scenario. For each coastal area, the vulnerability degree is automatically assessed, and the exposure is automatically highlighted through the polygons representing the infrastructures affected by sea-level rise and medicane impact. These findings are particularly useful for multiplatform observation systems to continuously monitor medicane impacts in conjunction with flooding related to future sea-level rise.

Keyword

convolutional neural network, cyclone, storm, coastal vulnerability, monitoring

Climate change versus anthropic induced reactivation of slow-moving landslides in temperate environments

Mihai Niculiță[1]*, Alexandru Ioan Cuza University of Iași (mihai.niculita@uaic.ro)

Abstract

Slow-moving landslides are among the most widespread urban ones that act as natural hazards. In Romania, major cities and rural areas developed since the medieval period on slow-moving landslides. Historically, traditional building materials and technology assured resilience to the communities for landslide reactivations induced by climate. After the Industrial Revolution, new building materials, technologies, and urban sprawl triggered reactivations. In the contemporaneous context in which climate changes can overlay anthropic-induced changes is very important to assess which of the two is the most important or if both overlay. We investigate this situation for the entire Romania using the EGMS dataset and show that sometimes anthropic-induced hydrological changes might be more important for slow-moving landslide reactivations than climate changes. Actually, for the Romanian territory, climate changes in general mean a decrease in overall precipitation although the intensities might increase. We also investigate the future changes in winter precipitation which actually might exacerbate the anthropic changes effects. The EGMS dataset allowed us to identify the slow-moving landslides that show a progressive increase in deformations and we assigned the factors that most probably were involved. Through correlations, we computed future trends and simulated increases in both climate and anthropic changes. The modeling shows that the worst-case scenario regarding the slow-moving landslide reactivations is due to both climate changes and anthropic changes, a situation that requires rethinking structural measures needed to increase resilience.

Keyword

climate changes, anthropic changes, temperate continental, slow moving landslides, Romania

Arctic landscape evolution in the warming climate of Svalbard: Permafrost degradation as a major driver of rock slide activity.

Dirk KUHN[1]*, Federal Institute for Geosciences and Natural Resources (BGR) (d.kuhn@bgr.de)
Reginald L. Hermanns[2], Norges Geologiske Undersokelse (NGU)
Michael Fuchs[3], Federal Institute for Geosciences and Natural Resources (BGR)
Nick Schüßler[4], Federal Institute for Geosciences and Natural Resources (BGR)
Jewgenij Torizin[5], Federal Institute for Geosciences and Natural Resources (BGR)
Juditha Aga[6], University of Oslo (UiO)
Jacob Bendle[7], Norges Geologiske Undersokelse (NGU)
Dirk Balzer[8], Federal Institute for Geosciences and Natural Resources (BGR)
Marie Bredal[9], Norges Geologiske Undersokelse (NGU)

Abstract

The archipelago of Svalbard is one of the fastest warming arctic regions and the temperature increase is more than twice the global average during the last 50 years. Its cryospheric landscapes are adversely affected by increasing temperatures and changing precipitation trends, leading to glacial retreat, permafrost degradation, and associated slope destabilization.

To study the relationship between mass movements and climate warming in a natural environment with negligible human influence, the Forkastningsfjellet coastal ridge was investigated. The west-facing slope was affected by a huge postglacial rock slide and shows a relatively well known litho-structural composition and deformation history.

Field mapping, bathymetrical surveys, GPS- and temperature measurements were performed to reveal the controlling factors, deformation rates and mechanisms that drive the rock slope instability. Four successive UAV surveys acquired between 2019 and 2023 document the spatio-temporal development of the landscape.

The Forkastningsfjellet coastline is characterized by a postglacial rock slide of 100.000.000 m3 that is dissected in 17 slide blocks of different size. After a quiescence of at least 80 years, as indicated by aerial photography covering this period, a 175.000 m^3 rock slide in August 2016 concluded a period of stability at the coastal cliff face. A back-analysis of the rock slide revealed that slope instability initiated along a pre-existing listric block fault that was inherited from the postglacial Forkastnings-fjellet rock slide. Slope failure was attributed to a strength decrease of weak Jurassic shales, permafrost degradation and increasing water pressures. Since this event, we documented rapid surface alterations mainly driven by thermokarst processes.

Thermokarst-driven settlements, sinkhole and subsurface channel formation in combination with redirection of surface water runoff finally lead to a second rock slide event (volume ~700.000 m^3) in November 2022. dGPS data revealed the highest displacements on the block that failed and acceleration was detected on that block in the previous measurements. Again, a reactivation of an older pre-existing sliding plane governed the failure. Drone-based visual observation of the main scarp documents the cryogenic-structural setting and evidences thermo-erosional gullying and permafrost thaw inducing rock mass dilation and slope failure.

The findings show that unfavourable litho-structural settings and climate warming correlated permafrost thaw and increasing water availability are likely first order controls on the stability of the rock slopes. Based on climate projections, an increase in rock slide activity and erosive mass transfer is expected in the future. Moreover, there is the possibility that larger segments of the post-glacial rock slide could be reactivated. Therefore, continued monitoring of Forkastningsfjellet is necessary, as the adjacent blocks to the south are large and could cause dangerous displacement waves in case of rapid failure.

Keyword

Rock slide, Permafrost degradation, Thermokarst, Climate change

Short-Term Climate Change (1981-2021) Impact on Landslide Events in South Sikkim, India

Ria NASKAR[1]*, Department of Geography, School of Human and Environmental Sciences, North-Eastern Hill University, Shillong – 793022, Meghalaya, India (ria.naskar93@gmail.com)
Arindam CHOWDHURY[2], Department of Geography, School of Human and Environmental Sciences, North-Eastern Hill University, Shillong – 793022, Meghalaya, India & Wadia Institute of Himalayan Geology, 33 GMS Road, Dehradun – 248001, Uttarakhand, India (Joined from January 2024)
Milap Chand SHARMA[3], Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi –110067, India
Sunil Kumar DE[4], Department of Geography, School of Human and Environmental Sciences, North-Eastern Hill University, Shillong – 793022, Meghalaya, India

Abstract

The present study examines the complex interplay between short-term climate change impacts from 1981–2021 and the frequency of landslides in the highly susceptible terrain of South Sikkim, India. The analysis of 265 landslides identified through the Google Earth platform and field investigation varied in size and magnitude between 1989 and 2022, revealing a heightened vulnerability in the region. Geological mapping and GIS analysis indicate the significant influence of diverse rock formations, tectonic activities, and river courses on slope instability. The climate of Namchi and Ravong is highly dynamic, as noticeable in the instrumental data of the NASA (LaRC) POWER Project. Mann-Kendall analysis carried out on this data indicates a noteworthy upward trajectory in temperature and precipitation, a clear signal of the impact of climate change. Correlating landslide events with climatic variables underscores the pivotal role of heavy rainfall, especially in lower elevation zones, as a predominant trigger for landslides. Human activities, particularly infrastructure development and road construction, are identified as exacerbating factors for slope instability. Moreover, the Scanning Electron Microscope (SEM) results have been used to ascertain the microscale characteristics of soil and rock types that have the potential to fail. These SEM results reveal intricate material properties influencing landslide susceptibility. According to numerical data of the failures, there was a 44% increase in the occurrence of new landslides, 2% of slides were reactivated, 3% experienced expansion, 10% began shrinking, 21% remained dormant, and 19% stabilized between 2019 and 2021-22, highlighting the growing concern of this issue. A detailed numerical and analytical finding may contribute to evolving a standard database for informed decision-making on local development issues and formulating an effective risk mitigation strategy in similarly intricate environments elsewhere.

Keyword

Landslides, Climate change, Mann-Kendall, Scanning Electron Microscope, South Sikkim

Investigating the response of slow-moving landslides to climate and environmental changes in the Northern Apennines (Italy)

Vittoria VANDELLI[1]*, Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Campi 103, 41125 Modena, Italy (vittoria.vandelli@unimore.it)
Francesca Grassi[2], Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, Via Vivarelli 10, 41125 Modena, Italy
Francesco Mancini[3], Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, Via Vivarelli 10, 41125 Modena, Italy
Carlotta Parenti[4], Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Campi 103, 41125 Modena, Italy
Edda Pattuzzi[5], Regional agency for territorial safety and civil protection of Emilia-Romagna, Viale Silvani 6, 40122 Bologna, Italy
Paolo Rossi[6], Department of Engineering "Enzo Ferrari", University of Modena and Reggio Emilia, Via Vivarelli 10, 41125 Modena, Italy
Mauro Soldati[7], Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Campi 103, 41125 Modena, Italy

Abstract

In mountain environments, landslide activity can be enhanced by extreme events that are becoming more frequent and intense in relation to climate change. A notable example of this occurred in May 2023, when the Emilia-Romagna region in Northern Italy experienced exceptionally heavy rainfall. In numerous mountain basins, rainfall events surpassed historical records, leading to the activation of approximately 60 thousand landslides, resulting in loss of lives and significant economic damages. In this context, comprehending the response of slope dynamics to the evolving rainfall patterns under climate change becomes paramount to provide clues for landslide risk mitigation and adaptation actions. Starting from these premises, this paper shows the outputs of a study aimed at deciphering the response of the slope dynamic to environmental and climate changes in a pilot area of the Modena Apennines (Emilia-Romagna Region) providing insights for landslide risk forecasting and prevention. The analysis involved the study of landslides in selected study sites through an interdisciplinary approach combining proximal and remote sensing techniques with field surveys. The complementarity of different methods and techniques and the synergistic use of the data collected was crucial for the recognition and monitoring of hillslope processes. In this study, data from Interferometric Synthetic Aperture Radar (InSAR) technique, Global Navigation Satellite Systems (GNSS) surveys, traditional topography, Uncrewed Aerial Vehicles (UAVs) photogrammetry, and terrestrial laser scanning were used. Historical aerial photos and high-resolution satellite images were also analysed. All data collected were organized in a multitemporal perspective and implemented in a Geographic Information System (GIS) environment.
The research focused on selected study sites located in the Scoltenna Stream catchment which shows a remarkable number of active and dormant landslides of different types and sizes, serving as exemplary cases of slow-moving landslides of the Northern Apennines. The most frequent are

slow-moving earth slides and earth flows affecting clayey terrains. The latter show a significant propensity to slope instability, related to their poor mechanical resistance and the presence of groundwater, and can be quite easily remobilized, especially in relation to intense precipitation.
The research let to detect the state of activity of the earth flows / earth slides and monitor their evolution through time. The integrated methodological approach enabled to identify centimetric displacements and highlighted that the most significant displacements through time occur at the foot of the landslides, and can be possibly related to extreme rainfall events. Furthermore, this study showed how the integration of different remote and proximal sensing techniques can be beneficial in supporting investigation of slope dynamics in clayey terrains and their response to extreme weather conditions.

Keyword

slope instability, extreme events, remote and proximal sensing, Northern Apennines, Italy

River bank falls of Anavilhanas extreme events in Negro river, Amazon state, Brazil

Cleide RODRIGUES[1]*, Universidade de São Paulo (cleidrig@usp.br)
Neliane de Souza Alves[2], Universidade Estadual do Amazonas

Abstract

River bank falls of Anavilhanas extreme events in Negro river, Amazon state, Brazil
Alves, N. * & Rodrigues,C.**
* UEA Universidade Estadual do Amazonas (nsalves@uea.edu.br)
**USP Universidade de São Paulo (cleidrig@usp.br)
River bank falls are seasonal common processes in most Amazon rivers, particularly in white water rivers with sedimentary beds, such as the Amazon River. This process occurs mainly in two periods throughout the annual hydrological cycle, during the maximum and minimum water levels, promoting social and economic risks in Amazon riverside communities. The Anavilhanas Fluvial Complex, located in the lower Rio Negro region, is considered a particular anabranches river pattern with a predominance of channels of different sizes, sandy bars, and islands limited by functional natural levées with internal lakes. The Anavilhanas Complex has a silt-clay composition and holocenic phytostability in their morphology, despite the river presents high annual rates of stream power, river flow (35 499 m3 s-1) and a high average of annual water level amplitude. In 2023, the Negro River reached its lowest extreme water level registered of 12.70 m and many of its tributaries dried up, affecting the security and mobility of the local communities. During this event, was observed a significant increase in the number of river bank falls and mass movements, including in the islands of the complex, an uncommon phenomenon in this reach of the Negro River. This study evaluated the increase in these mass movements known as “terras caídas” and their relationship with the extreme low precipitation rates recorded in 2023, that was linked to the oceanic-atmospheric phenomenon El Niño. Field work was carried out in the months of October 2023 and January 2024 during the extremes of low levels water in Anavilhanas Complex. Daily data of water level of the Negro River in Manaus have been monitored since 1902, and, for this period, the maximum water level occurred in 2021 (30.02m) and the minimum in 2023 (12.70 m). During the event of lowest water level period of 2023, the Negro River observed a sudden drop of 10.94m only in August. Considering that in their more frequent hydrologic annual regimes, the river takes around four months to reach the lowest water level, this rapid and intense descent appears to have been the main trigger to the increase of frequence of mass movements observed. This appears to be caused mainly related to the following interconnected factors: a greater lag between the speed of descent of the piezometric level compared to water level of the channel; changes of internal resistance forces in the sediments with saturation or drying; increase in hydrostatic pressure of sediments of the islands and river banks; and exfiltration processes in the sediments. This scenario is coherent to the study conducted by Alves (2013) that considers that the occurrence of ‘terras caídas’ because of the rapid descent of

water during the lowest water level periods. In 2023, the frequence of these processes increased, creating new instability and risk zones to riverside communities.

Keyword

Amazon Rivers, Climate changes, Mass Movements

Detailed Survey and Quantitative Risk Assessment of Landslides in Mountainous Village: A Case Study in Jingyang Town, Hubei Province, China

Lei Liu[1]*, Wuhan Center, China Geological Survey (martianstar@163.com)
Laizheng Pei[2], Wuhan Center, China Geological Survey
Yanjun Zhang[3], Wuhan Center, China Geological Survey
Zhipeng Lian[4], Wuhan Center, China Geological Survey
Jianmin Tan[5], Wuhan Center, China Geological Survey

Abstract

Villages and towns in mountainous areas of Hubei province, with complex geological conditions, abundant rainfall, and urbanized development, these areas are often affected by landslides, which pose a great threat to the safety of people's lives and property. Conducting risk analysis and assessment of landslides is an effective means to reduce landslide-caused casualties and economic losses. Therefore, the research on landslide risk assessment at the village scale has become a new challenge and is also urgently required by local governments for risk management.

In this study, we explored a framework for a detailed survey and quantitative risk assessment of landslides at the village scale. We took Jingyang town as the study area, which has the landform Characteristics of a U-shaped Canyon located in the reservoir. Firstly, we surveyed the rock cliffs at the top, the deposit in the middle, and the reservoir-affected slopes at the axis of the canyon, by using unmanned aerial photography, field ground survey, drilling and geophysical exploration and other technical methods. Then, based on physical and mechanical models considered rainfall, loss empirical formulas, and other landslide risk assessment models, we attempted to quantify landslide risk at different locations in Jingyang town. The local government can use them for risk management, and urban planning.

Keyword

Landslides, Quantitative risk assessment, Mountainous village, detailed survey

Impacts of rainfall-triggered landslides in New Zealand: déjà vu all over again

Martin Brook[1]*, University of Auckland (m.brook@auckland.ac.nz)
Matt Cook[2], University of Auckland
Chris Nicoll[3], University of Auckland
Murry Cave[4], Gisborne District Council
Ariane Pola[5], University of Auckland

Abstract

Land surface changes resulting from human activities have emerged as a factor of equal, if not greater importance than climate change in affecting landslide occurrence in New Zealand. Indeed, land use changes mean that the landscape becomes less resilient to the impacts of severe rainstorms, and any climate change. Two examples of this are provided here, from Auckland and Gisborne, cities on New Zealand's North Island. In Auckland, two severe rainstorms in early 2023 (the "Auckland Anniversary Storm" and Cyclone Gabrielle), caused thousands of landslides that damaged houses, infrastructure, and caused fatalities. Many of the damaged houses were constructed in areas exposed to known, existing landslide hazards. Such areas include steep slopes, consisting of weak, Miocene-age weathered rock, residual soils and colluvium. However, irrespective of the known landslide hazard, the prevailing planning legislation allowed development in these areas. In Gisborne, rainfall-triggered landslides have also been a particular issue over the last half-decade, including from Cyclone Gabrielle. An interferometric synthetic aperture radar (InSAR) monitoring programme has been implemented in recent years to identify vulnerable slopes and track slope deformation. Using Sentinel-1 imagery, the pattern of slope deformation across Gisborne's steepland periphery was determined. The InSAR slope deformation time series data shows a coincidence with rainfall and also with seasonal changes, due to shrink-swell of expansive soils. Also, clear evidence exists of the impacts of land use change on slope failure, including tree removal, loading of slopes by construction activity, and installation of unconsented, inadequate retaining walls. Together with existing planning legislation issues, improving landslide resilience in New Zealand cities remains a challenge, despite scientific efforts.

Keyword

landslide, rainfall, landuse, New Zealand, climate

Sea level rise and the ‘hidden’ landslides on the NW coast of Malta

Mauro SOLDATI[1]*, University of Modena and Reggio Emilia (soldati@unimore.it)
Stefano Devoto[2], University of Trieste
Mariacristina Prampolini[3], CNR-ISMAR

Abstract

Bathymetric surveys revealed landslide deposits on the seafloor surrounding the NW coast of the Island of Malta (Central Mediterranean Sea), thus raising questions as to their relations with emerged landslide bodies occurring along the coast and the timing of their development. The aim of this paper provide an overview on Maltese emerged and submerged landslides, and to chronologically constrain their evolution in the frame of post-glacial climate changes. Detailed geomorphological mapping showed a clear continuity between emerged and submerged deposits. Cosmogenic nuclide dating of samples collected from head scarps of two coastal block slides extending below the sea level revealed the oldest detachments as occurring ca. 21 kyr ago, i.e. during the Last Glacial Maximum (LGM). At that time the sea level was about 130 m lower than the current one in the Mediterranean region. This makes it clear that the investigated landslides occurred in a subaerial environment, being possibly accelerated when sea level reached the landslide toes during post-glacial marine transgression. The latter has progressively submerged and hidden at least two third of the landslide deposits. Based on geomorphological observations, this is likely to have applied not only to the dated landslides, but to all those occurring along the investigated coastal stretch.

Keyword

Landslide, Cosmogenic dating, Climate change, Sea level rise, Malta

Late Quaternary slip rate of the strike-slip faults on the eastern margin of the Qaidam Basin and its implication on the northeastern margin of the Tibetan Plateau

Guodong BAO[1]*, Institute of Geology, China Earthquake Administration (baoguodong@ies.ac.cn)
Zhikun Ren[2], Institute of Geology, China Earthquake Administration
Jinrui Liu[3], Institute of Geology, China Earthquake Administration
Guanghao Ha[4], Institute of Geology, China Earthquake Administration
Haomin Ji[5], Institute of Geology, China Earthquake Administration
Lei Wang[6], Institute of Geology, China Earthquake Administration

Abstract

The Qaidam Basin, the largest Cenozoic basin on the northeastern margin of the Tibetan Plateau, is an ideal region for studying regional tectonic deformation. Nevertheless, the mismatch between shortening and the elevation of the eastern basin remains unresolved. The shortening strain in the Qaidam Basin decreases from exceeding 48% in the west to 1% in the east, yet the elevation difference between its eastern edge and the west is minimal. We speculate that the structural deformation on the eastern edge of the basin might not primarily involve compressional shortening. Additionally, the tectonic evolution process of the eastern edge of the Qaidam Basin since the late Quaternary remains unclear.

To address these issues, during field investigations, we identified four active strike-slip faults—two north-west to south-east dextral faults and two east-west sinistral faults. We determined their slip rates using drone-based topography and OSL dating techniques. For the NW-SE Xiariha fault, north to south slip rates are: 1.39 +0.51/-0.34 mm/yr, 1.19 +0.15/-0.14 mm/yr, and 0.9 +0.19/-0.16 mm/yr. The Yingdeerkang fault slips at 1.01 +0.17/-0.13 mm/yr. The E-W Reshui-Taosituohe fault, from west to east, slips at 0.95 +0.22/-0.19 mm/yr and 1.20 +0.11/-0.09 mm/yr. The Taosituohenan fault, west to east, slips at 0.83 +0.36/-0.23 mm/yr and 1.21 +0.43/-0.25 mm/yr. The Taosituohenan fault's exposure revealed a paleoseismic recurrence interval of 3000 years.

Before 16 Ma, Qaidam Basin may have been connected to Gonghe-Qinghai Basin. Around 16 Ma, activation of the Elashan Fault separated Qaidam Basin from Gonghe-Qinghai Basin, closing its drainage system. It intersected with the East Kunlun Fault, leading to compressional uplift and northwestward extension, resulting in the two active strike-slip fault sets. The deformation at the eastern margin is primarily attributed to the initial development of these faults. Ongoing tectonic forces fractured bedrock along southeastern basin perimeters. Examining the strike-slip fault distribution along the northeastern margin of the Tibetan Plateau reveals an eastward "wave-like" trend in slip rates, indicating ongoing structural deformation influenced by distinct geological blocks and detachment layers in the upper crust.

Keyword

Qaidam Basin, Slip rate, Northeast Tibetan Plateau, Late Pleistocene

Spatial Distribution and Regional Tectonic Significance of the Newly Discovered Kalawenguquan Fault in the Interior of the Tian Shan

Zhongtai HE[1]*, Institute of Geology, China Earthquake Administration (hezhongtai@126.com)
Xingao Li[2], National Institute of Natural Hazards, Ministry of Emergency Management of China

Abstract

Quantifying the geometrical and kinematic aspects of faults within the Tian Shan is crucial in investigating tectonic deformation patterns in the region. Through remote sensing image analysis using GF-7 data and field geological surveys, we determined the geometric distribution and fault properties of the Kalawenguquan fault. The newly discovered Kalawenguquan fault spans over 400 kilometers and mainly strikes in the ENE direction, with some localized segments in the NE direction. The fault plane dips southward at angles ranging from 60° to 85°. The Kalawenguquan fault is a recently discovered Holocene active fault in the Tian Shan and is a thrust and left-lateral strike-slip fault. Based on the geological survey findings and sediment dating data from the late Quaternary period, the Kalawenguquan fault has a vertical sliding rate of approximately 0.32 mm/a, as determined through Monte Carlo simulations. The left-lateral strike-slip rate was calculated to be 0.5-1.3 mm/a. We detected that at least two paleoseismic events have occurred in the fault since 4.7 ± 0.7 ka. The active faults in the Tian Shan suggest that the mountain absorbs crustal deformations within the region. Strain is uniformly distributed in the Tian Shan region. The high incision rate of rivers in the Tian Shan supports our results.

Keyword

Tian Shan, Kalawenguquan Fault, GF-7, Remote sensing interpretation, Tectonic significance

Optimization of InSAR based coseismic slip modeling for moderate earthquakes accounting for fore-aftershock sequence

Lejun LU[1]*, School of Earth Sciences and Engineering, Sun Yat-sen University (lulj8@mail2.sysu.edu.cn)
Yu ZHOU[2], School of Earth Sciences and Engineering, Sun Yat-sen University

Abstract

Determination of coseismic slip distribution for moderate (moment magnitude, Mw < 6.5) earthquakes is challenging as the commonly-used interferometric synthetic aperture radar (InSAR) technique is unable to separate mainshock and fore-aftershocks due to its limited temporal resolution. In this study, we propose a new method of optimizing coseismic slip modeling by removing fore-aftershock contributions using earthquake relocation data and empirical earthquake source scaling relationships. The method is tested with a series of synthetic fore-main-aftershock sequences, through which we demonstrate that our method can largely recover the real slip distribution of the mainshock. The synthetic tests show that if the moment release by fore-aftershocks is <= 10% of the mainshock moment release, fore-aftershock corrections are necessary to improve the accuracy of coseismic slip model. We also test the proposed method with the 2021 Mw 6.3 northern Thessaly, Greece earthquake sequence, in which case we have independent InSAR measurements for both the mainshock and aftershocks. We successfully obtain the slip distribution of the mainshock from the main-aftershock-mixed InSAR measurements, and the result is highly consistent with that derived from the mainshock-only InSAR data. We also evaluate the robustness of the method using the northern Thessaly sequence through a series of tests, showing that the proposed method makes significant improvements even if the earthquake relocation error reaches 5 km. In the end, we apply the method to re-investigate the 2021 Mw 6.0 Yangbi earthquake sequence and find that previous studies may have overestimated the coseismic slip by 25% and the total seismic moment by 18%.

Keyword

Fore-aftershock correction, InSAR, Coseismic deformation, 2021 northern Thessaly earthquake, 2021 Yangbi earthquake

Field and UAV surveys of the northern Xainza rift, south-central Tibet: EW extension rates and earthquake hazard assessment

Marie-Luce CHEVALIER[1]*, Chinese Academy of Geological Sciences, Institute of Geology (mlchevalier@hotmail.com)
Ziqi Fang[2], Chinese Academy of Geological Sciences, Institute of Geology
Jiawei Pan[3], Chinese Academy of Geological Sciences, Institute of Geology
Haibing Li[4], Chinese Academy of Geological Sciences, Institute of Geology
Shenqiang Chen[5], Chinese Academy of Geological Sciences, Institute of Geology
Junyi Wang[6], Institute of Tibetan Plateau Research, Beijing, China
Lin Ding[7], Institute of Tibetan Plateau Research, Beijing, China

Abstract

The presence of ~NS-trending rifts within the Tibetan Plateau attests that it is undergoing ~EW extension coevally with the ongoing ~NS shortening due to the India/Asia collision. In southern Tibet, the cumulative extension rate, distributed across seven main rifts over ~1,000 km, has been shown to amount to about half of the shortening rate across the Himalayas. Quantifying late Quaternary extension rates across the south Tibetan rifts is essential to understand Tibetan deformation and to discuss the high plateau evolution during the later stages of continental collision. Extension rates along the prominent Yadong-Gulu rift (YGR) appear to increase northwards from <1 mm/yr south of the Yarlung Zangbo suture, to 1.3 ± 0.3 mm/yr in the central part of the rift, and 3 to 6 mm/yr farther north, likely as a result of dextral slip along the nearby Beng Co fault. Limited data however, makes it uncertain whether such a northward increase also occurs along other rifts. Assuming a ~1.3 mm/yr rate across each of the rifts yields a total late Quaternary extension rate of 9 ± 2 mm/yr across southern Tibet, similar to early inferences and consistent with current geodetic results.

Here, combining detailed UAV surveys from two alluvial surfaces that are vertically offset up to 75 m by the Xainza normal fault, with last interglacial (~120 ka) to late Holocene (~6 ka) ages, we test whether rates along the northern Xainza rift, just west of YGR, also vary along strike. Because the northern Xainza fault merges with the Gyaring Co dextral fault to the north, as does the YGR with the Beng Co fault, we aim to test the inference of a comparable, northward rate increase along the rifts in the Lhasa terrane. We also acquired a high-resolution UAV Digital Elevation Model along the still well preserved 1934 M7 Xainza earthquake surface rupture, reputed to have locally produced ~4-5 m horizontal, and ~1.5 m vertical co-seismic offsets.

Keyword

active tectonics, tibet, xainza rift, UAV DEM, extension rate

Surface Rupture and Slip Distribution along the Chenghai fault mapped from airborne LiDAR data and its tectonic implications

Haomin Ji[1]*, The Institute of Geology, China Earthquake Administration (jhm119325668@163.com)
Zhikun Ren[2], The Institute of Geology, China Earthquake Administration
Xiaoxiao Zhu[3], The Institute of Geology, China Earthquake Administration
Mingkun Bai[4], The Institute of Geology, China Earthquake Administration
Guodong Bao[5], The Institute of Geology, China Earthquake Administration
Jinrui Liu[6], The Institute of Geology, China Earthquake Administration
Guanghao Ha[7], The Institute of Geology, China Earthquake Administration
Zhongtai He[8], The Institute of Geology, China Earthquake Administration

Abstract

The upper crust of the southeastern margin of the Tibetan Plateau is currently rotating clockwise around the eastern Himalayan syntaxis, and its deformation shifted from being concentrated on large strike-slip faults before the early Miocene to the current mainly diffusely distributed on internal secondary faults. The deformation characteristics of the Sichuan-Yunnan block have significantly changed during this transformation, and deformation patterns in its local areas are also different or even opposite from current macro movements due to internal structural complexity. For example, the Red River fault, the southwest boundary of the Sichuan-Yunnan block, had been a recognized significant tectonic boundary fault before the change of its kinematic properties, with left-lateral strike-slip displacements up to 500-1000 km. After transforming into a dextral strike-slip fault, its horizontal slip rate has been gradually decreased to < 2 mm/a. However, different from the right-lateral strike-slip of the middle and southern segments, its northern segment has been a typical normal fault since the late Quaternary with relatively high seismic activity, and its movement was opposite to the direction of macro rotation deformation.

The Chenghai fault is located at the junction of two tectonic boundary faults, the Lijiang-Xiaojinhe fault and the northern segment of the Red River Fault. The clear normal fault landforms, e.g. graben basins, and a series of water systems offset by horizontal slip of faults were well preserved along the Chenghai fault, showing that its kinematic properties have changed significantly influenced by these two faults. As a significant participant in regional tectonic evolution, the structural deformation of the Chenghai fault should record valuable regional evolution information. In addition, the Chenghai fault generated the Chenghai M 73/4 earthquake in 1515 and the Qina Ms 6.0 earthquake in 2001. However, dense vegetation along the fault makes it difficult to obtain its surface deformation characteristics and the distribution of small-scale horizontal offset, resulting in its misty kinematic properties, roughly determined geometric distribution, and the highly controversial rupture parameters of the Yongsheng earthquake in 1515.

In this study, we used LiDAR technology, which can penetrate vegetation to obtain high-resolution surface topography data, to map the Chenghai fault within 120 km. Combined with

Google satellite images and field investigations, we determined that the Chenghai fault is composed of four secondary faults with a simple geometric structure. Discontinuously exposed surface rupture, e.g. fault scarps and valleys, and densely distributed linear landforms, e.g. water systems and ridges, with sinistral offset were preserved along the S2-S4. 102 offsets below 30 m obtained along the S2 and S3 were statistically analyzed, and the calculated results of the cumulative offset probability density (COPD) revealed that both S2 and S3 have a characteristic displacement of ~6 m and they may rupture as a united segment or cascade rupture as different rupture segments in each large earthquake, and thus the magnitude of Yongsheng earthquake is estimated at 7.6. Finally, based on this study, the tectonic evolution and deformation characteristics of the Dali subblock and Sichuan-Yunnan block, where the Chenghai fault is located, are discussed.

Keyword

geometric distribution, surface rupture, slip distribution, seismogenic pattern, Sichuan-Yunnan block

Global basic landform mapping using 30-meter DEM for geologic and geomorphic research

Xingyu Zhou[1]*, School of Geography, Nanjing Normal University (xyzhou@nnu.edu.cn)
Xin Yang[2], School of Geography, Nanjing Normal University
Sijin Li[3], School of Geography, Nanjing Normal University
Yang Chen[4], School of Geography, Nanjing Normal University
Guoan Tang[5], School of Geography, Nanjing Normal University

Abstract

Landforms are complex compositions of endogenic and exogenic forces, recording the traces of tectonic activities, climate changes, material transfer and other incidents. Landform classification and mapping provides basic and critical surface evidence for geomorphological studies. Our team Geomorphology Working Group, which is a group of Deep-Time Digital Earth (DDE) Big Science Program, roots in landform classification and mapping for several years.

The development of earth observation technologies, especially the emergence of 1-arcsecond open Digital Elevation Models (DEMs), has brought opportunities of more detailed and highly accurate landform maps than before. However, the explosive boom of data volume and wide array of landforms on our planet also challenge the evolution of global landform mapping.

Previous studies often utilized local relief and slope as key indicators in basic landform classification. These indicators were commonly calculated by windows, resulting in coarse boundaries, mistaken scatters and serious uncertainty when classifying landforms in large scale. To overcome above problems, we revisit landforms as indivisible elements, and introduced a novel framework, which emphasizes the integrity and continuity of landforms, based on morphology. In this framework, two improved indicators, accumulated slope (AS) and mountain uplift index (MUI), were proposed to replace classical slope and local relief for a more precise result. AS reduces slope variation inside plains but enlarges its increase at transition zones, showing effective delineations of plains. Meanwhile, MUI takes each mountain rather than a window as a computed unit, quantifying mountain relief in a more reasonable way. At last, our team crossed the gap of 30-meter resolution in global landform classification, and published our mapping result, Global Basic Landform Units (GBLU). GBLU presents global basic landforms with unprecedented precision and details, while it indicates a fantastic performance in identifying sand dunes as well.

GBLU is available at DDE Geomorphology platform (https://geomorph.deep-time.org) now and free for personal studies. GBLU serve as a resource, which is able to inspire a deep understanding of morphologic characteristics, spatial distribution and evolutionary process, for scholars, supporting their research in geomorphology, geology and other fields.

Keyword

Landform classification and mapping, Geomorphology, Digital elevation model (DEM), Accumulated slope, Mountain relief

Quantitative Assessment on Relative Tectonic Activity along Western Mae Chan Fault Zone, Northern Thailand

PICHAWUT MANOPKAWEE[1]*, DEPARTMENT OF GEOLOGICAL SCIENCES, FACULTY OF SCIENCE, CHAING MAI UNIVERSITY (pichawut.m@cmu.ac.th)
YANNAWAT NGERNLUMYONG[2], DEPARTMENT OF GEOLOGICAL SCIENCES, FACULTY OF SCIENCE, CHIANG MAI UNIVERSITY
WEERAKORN SATHAPORNPIBOON[3], DEPARTMENT OF GEOLOGICAL SCIENCES, FACULTY OF SCIENCE, CHAING MAI UNIVERSITY

Abstract

Mae Chan Fault Zone (MCFZ) is one of the active fault zones in mainland Southeast Asia that cuts across northern Thailand and continues to Laos PDR. Despite fault activeness, the records of recent earthquakes represent that the frequency and magnitude of earthquakes across MCFZ are significantly lesser than those of the surrounding regions. The use of morphotectonic analysis has been proven to successfully evaluate the relative tectonic activity of drainage systems and geomorphic expressions in numerous tectonically active regions worldwide. In this research, the Western Mae Chan Fault Zone (WMCFZ) is an ideal natural laboratory to explore the spatial adjustment of landscape to differential relative rock uplift and long-term tectonic deformation because lithologic and climatic conditions are relatively uniform. We delineated the fault lines from the remote sensing technique of Sentinel-2 band combinations and the topographic expressions from the 12.5 m resolution digital elevation model (DEM). We also extracted 70 low-order channels developed along WMCFZ in order to analyze the spatial variation of topography and evaluate the tectonic activity using geomorphic indices, including the hypsometric integral (HI) and hypsometric curve (HC), the normalized stream length-gradient index (SL/K), the elongation ratio (Re), the drainage basin asymmetrical factor (AF), the mountain front sinuosity (Smf), and the valley floor width-to-height ratio (VF). The combination of these geomorphic factors and field observations of deflected streams and ridges, active mountain front, and triangular facets helps indicate the relative indices of active tectonics (RIAT). Our findings revealed that the lineament detection from the remote sensing technique on DEM indicates the NW-SE direction of WMCFZ. The analysis of the geomorphic indices showed that the overall tectonic activity in the WMCFZ is relatively moderate. The high tectonic activity was found in large watersheds in the west of the study site: Nam Mae Mao, Huai San, Nam Mae Chai, and Nam Mae Sao, and some elongated watersheds in the east: Klong Hahu, Nam Mae Chan, and Klong Mae Chan Noi. The low tectonic activity is distributed in a few watersheds in the east. Our analysis on RIAT was consistent with the paleo-faulting events along WMCFZ based on C14 AMS, OSL, and TL ages, the spatial patterns of lineament density on granitic rock, and the steepness of longitudinal profiles. Our study provided insight into the fact that the long-term tectonic deformation along this fault zone has sculpted the modern landscape. The use of geomorphic indices can be an effective tool to evaluate spatial variation in tectonic activity on the geomorphic evolution of the WMCFZ.

Keyword

Mae Chan Fault Zone, Geomorphic Indices, Tectonic Activity, Tectonic Deformation

Slip partitioning of the left-step Wulan segment along the right-lateral strike-slip Elashan fault

Jinrui LIU[1]*, Institute of Geology, China Earthquake Administration (liujr@ies.ac.cn)
Zhikun Ren[2], Institute of Geology, China Earthquake Administration
Wei Min[3], Institute of Geology, China Earthquake Administration
Zhimin Li[4], Earthquake Administration of Qinghai Province
Zhiliang Zhang[5], Institute of Geology, China Earthquake Administration

Abstract

Restraining or releasing bends, which distinguish the fault geometry and undergo structural transformation, are widespread along the strike-slip faults. However, it is still unclear how to quantitatively allocate the components of strike-slip and thrust slip, and how to transform and coordinate the strain within the stepover or fault bend area. We target the left-step Wulan segment along the right-lateral strike-slip Elashan fault, which holds both strike-slip and thrust branch faults, and use a suite of high-resolution topography data, including DEMs generated from GF-7 stereo pairs of satellite images, and uncrewed aerial vehicle (UAV)-derived DEMs, to interpret its fine geometry and fault slip characteristics. Furthermore, by dating multi-level measurable offset landforms using optically stimulated luminescence (OSL) and cosmogenic isotope dating methods, we conclude that the geometrically straight main branch fault is characterized by strike-slip and the average slip rates since 16 ka was constrained to be 2.7 ± 0.2 mm/yr. In contrast, The geometrically curved Dongshan branch fault is mainly characterized by reverse, and 6 sets of displace-age data were employed to obtain the incremental slip rates and analyze the fault paleoslip based on the "MCMC-incr_slip_rates. py" program proposed by Zinke et al. (2017). The results indicate that there are no significant temporal variations during the last 60 ka and a constant vertical slip rate can reach 0.35 ± 0.02 mm/yr. This study emphasizes that there are positive flower structures developed in the restraining bend of strike-slip faults and the thrust branch fault bears a significant strain component.

Keyword

Strike-slip fault, Restraining bend, Slip Partitioning, Elashan fault, Slip rate

DATING ABANDONED ALLUVIAL SURFACES USING CALIBRATED MODELS OF GULLY INCISION

Amit MUSHKIN[1]*, University of Washington (mushkin@uw.edu)
Yuval Shmilovitz[2], University of Colorado Boulder
Nimrod Wieler[3], Israel Antiquities Authority
Eitan Shelef[4], University of Pittsburgh
Zhikun Ren[5], China Earthquake Adminstration
Huiping Zhang[6], China Earthquake Adminstration

Abstract

Determining the age of abandoned alluvial surfaces is a key component in quantifying landscape evolution processes, tectonic activity, and paleo-climate conditions. However, the dating of such landforms is often limited by the resources required, field accessibility, availability of dating material and analytical complexities in the dating techniques employed. To help address these limitations, we employ a new and complementary approach for dating abandoned alluvial surfaces that uses landscape evolution models to reconstruct the post-abandonment development of incision gullies. The approach presented uses high-resolution topographic data to: (1) Measure gully profiles and their drainage area; (2) Locally calibrate the parameters of an applicable model describing the incision of multiple gullies incision into a surface with an a-priori known age; (3) Apply the calibrated model to compute the duration of incision required to form observed gully profiles on nearby alluvial surfaces with unknown ages. This approach was tested on a set of previously dated late - mid Pleistocene alluvial terraces in the hyper-arid Negev desert (southern Israel). Model parameters calibrated for gullies incised into a previously dated 70 ka surface were within the typical range reported elsewhere for arid regions. Modeled incision durations for gullies on nearby late Pleistocene (34 and 70 ka) terraces were within 10% of their independently obtained surface-ages. In contrast, modeled incision duration for gullies on an older surface previously dated to 230-539 ka, were grossly underestimated at <120 ka, an underestimation that is associated with documented temporal changes in tectonic/climatic boundary conditions that violate the assumptions that underlie the proposed approach. We also present application of this approach used to constrain temporal variability in lateral slip rates across the eastern termination of the Altyn Tagh fault since 52 ka. Accordingly, we propose morphologic dating of gully incision as a new and effective approach for constraining the age of alluvial surfaces. As with other geologic dating approaches – the validity of the landform ages obtained hinges on the validity of the underlying assumptions employed and scales with the robustness of the geologic framework used for their interpretation.

Keyword

Dating, Abandoned alluvial surfaces, Landscape evolution model, Gully incision

Large-scale Traps Development and Hydrocarbon Accumulation along Transition Surfaces in Lacustrine Basin

Zhanlong Yang[1]*, Northwest Branch, Research Institute of Petroleum Exploration and Development, PetroChina (yang_zl@petrochina.com.cn)

Abstract

For the purpose to systematically analyze the occurrence of “small and multiple” trap groups and then conclude large-scale traps occurrence and hydrocarbon accumulation of lacustrine basins, it is proposed that various transition surfaces controlled by different geological factors such as tectonic activities and climate change are the keys to reflect the evolution of a basin, and the relationship between various transition surfaces in lacustrine basin was established. Structural style, sedimentation, geochemical feature, biogenetic species and abundance of a lake/basin have undergone significant change due to tectonic activity and climate change during lake basin evolution. The changing of these relevant factors are complement with the occurrence of different traps and accumulation of hydrocarbon. In a lacustrine basin, it is mainly developed the structural transition surface dominated by unconformity formed by the changing of tectonic movement, the sedimentary transition surface dominated by lithological differences caused by the cycle of sedimentary system and the bio-transition surface and geochemical transition surface dominated by the change of biota species in different stratification of water bodies. Different types of transition surface control the development of structural, stratigraphic, lithological, diagenesis and physical properties traps respectively. The identification and analysis of various transition surfaces is comprehensive important to understanding the occurrence of large-scale traps and accumulation of hydrocarbon in lacustrine basins.

Keyword

Transition surface, Large-scale traps, Tectonic activities, Climatic change, Lacustrine basin

New evidence of late Quaternary tectonic activity along the eastern margin of the Qaidam Basin

Zhikun REN[1]*, Institute of Geology, China Earthquake Administration (rzk@ies.ac.cn)
Guodong Bao[2], Institute of Geology, China Earthquake Administration
Guanghao Ha[3], Institute of Geology, China Earthquake Administration
Jinrui Liu[4], Institute of Geology, China Earthquake Administration
Zhiliang Zhang[5], Institute of Geology, China Earthquake Administration
Haomin Ji[6], Institute of Geology, China Earthquake Administration

Abstract

The northeastern margin of the Tibetan Plateau has witnessed intense tectonic deformation since the Neogene, leading to the development of numerous large-scale strike-slip faults and secondary fault systems, triggering multiple major earthquakes. This has garnered considerable attention from researchers investigating the seismic hazard associated with these large strike-slip faults. However, the seismic risk posed by complex fault systems, such as those composed of secondary faults, prevalent in areas like the eastern margin of the Qaidam Basin, should not be underestimated. Previous studies have delved into strain distribution along strike-slip faults in this region, yet the precise contribution of the eastern margin of the Qaidam Basin to the overall strain remains unclear. This study is based on the high-precision digital elevation model obtained through drone mapping technology, which identifies three active faults on the eastern margin of the Qaidam Basin: the Xiariha Fault (XRHF) and Yingdeerkang Fault (YKF) are NW-SE strike dextra faults, whereas the Reshui-Taosituohe Fault (RTF) is a nearly east-west strike sinistral fault. This study discusses the seismic hazard and strain distribution in the region based on those strike-slip faults on the eastern margin of the Qaidam Basin.

High-precision displacement measurements of landforms were conducted using Monte Carlo simulations, and optically stimulated luminescence dating was employed to constrain the ages of landforms. We have respectively selected two research points to preliminarily estimate the slip rates of the NW-SE trending dextral strike-slip faults: XRHF ranging from 1.12±0.07 to 1.68±0.12 mm/yr, and YKF ranging from 0.99±0.06 to 2.29±0.13 mm/yr. Additionally, trench excavations constrained paleoseismic events for RTF at 714-1,792 yr BP and at 700 ± 18 yr BP, indicating a recurrence interval of approximately 1000 years for paleoseismic events.

Together these faults possibly form a complex cross-fault system along the southeastern edge of the basin, heightening seismic risk. Compared to recent seismic events triggered by complex fault systems (e.g., the 2019 Mw7.1 Ridgecrest earthquake sequence), we hypothesize that the fault system on the eastern margin of the Qaidam Basin might evolve into a complex cross-fault system following subsequent seismic activities. Deformation in the western part of the northeastern Tibetan Plateau is driven by slip on the Altyn Tagh Fault and Qaidam Basin compression. The central part experiences slip on the East Kunlun Fault, along with secondary faults, shortening, and block rotation. The eastern part primarily experiences slip along the Haiyuan Fault.

Keyword

Qaidam Basin, Tibetan Plateau, Quaternary tectonic activity, fault system, active faults

Coseismic deformation of the 1976 Ms 7.3 Chaldiran earthquake in eastern Turkey measured by satellite imagery, in comparison with field measurements

Yu ZHOU[1]*, School of Earth Sciences and Engineering, Sun Yat-sen University
(zhouyu36@mail.sysu.edu.cn)
Lejun Lu[2], School of Earth Sciences and Engineering, Sun Yat-sen University

Abstract

Large continental earthquakes are infrequent, but they are important for understanding active tectonics. Many pre-1990, magnitude greater than 7 earthquakes have not been well documented due to a lack of data. The declassification of KeyHole (KH) imagery provides opportunities for investigating those historical events. In this study, we present new geodetic observations of surface deformation from the 1976/11/24 Ms 7.3 Chaldiran earthquake in eastern Turkey. We use various historical KH imagery and modern Pleiades stereo imagery to determine the coseismic deformation, providing new constraints on the 1976 rupture. Based on the image measurements, we resolve the coseismic slip at depth. The inverted slip from a simple elastic dislocation model, ~ 4.0 m at shallow depths of the Hidirmentes segment, is larger than the surface displacement, around 3 m from previous field surveys, suggesting that the coseismic deformation is a combination of slip on the primary fault with 30±16% off-fault deformation. We also measure cumulative offsets at two sites with well-preserved features, and find a constant ratio of horizontal to vertical offsets throughout the past few earthquake cycles. Both the observed constant slip ratio in this study and offset clusters from previous field measurements support that the Chaldiran fault exhibits a characteristic slip behaviour in the late Quaternary. By combining all the geodetic and geological observations in the broader region, we also present a brief analysis of the slip rate of the Chaldiran fault.

Keyword

1976 Chaldiran earthquake, KeyHole Imagery, Historical earthquake, Earthquake deformation

Coseismic slip distribution of the 2023 earthquake doublet in Turkey and Syria from joint inversion of Sentinel-1 and Sentinel-2 data: An iterative modeling method for mapping large earthquake deformation

Jianlong Chen[1]*, Sun Yat-sen University (chenjlong25@mail2.sysu.edu.cn)
Yu Zhou[2], Sun Yat-sen University

Abstract

Interferometric synthetic aperture radar (InSAR) decorrelation that creates great challenges to phase unwrapping has been a critical issue for mapping large earthquake deformation. Some studies have proposed a “remove-and-return model” solution to tackle this problem, but it has not been fully validated yet, and therefore has rarely been applied to real earthquake scenarios. In this study, we use the 2023 Mw 7.8 and 7.6 earthquake doublet in Turkey and Syria as a case example to develop an iterative modeling method for InSAR-based coseismic mapping. We first derive surface deformation fields using Sentinel-1 offset tracking and Sentinel-2 optical image correlation, and invert them for an initial coseismic slip model, based on which we simulate InSAR coseismic phase measurements. We then remove the simulated phase from the actual Sentinel-1 phase and conduct unwrapping. The simulated phase is added back to the unwrapped phase to produce the final phase measurements. Comparing to the commonly-used unwrapping method, our proposed approach can significantly improve coherence and reduce phase gradients, enabling accurate InSAR measurements. Combining InSAR, offset tracking and optical image correlation, we implement a joint inversion to obtain an optimal coseismic slip model. Our model shows that slip on the Çardak Fault is concentrated on a ~100 km segment; to both ends, slip suddenly diminished. On the contrary, rupture on the East Anatolian Fault Zone propagated much longer as its geometry is fairly smooth. The iterative coseismic modeling method is proven efficient and can be easily applied to other continental earthquakes.

Keyword

Interferometric synthetic aperture radar, 2023 Turkey-Syria earthquake doublet, Coseismic slip distribution, Iterative modeling, Joint inversion

Long-term influence of seismic activity on hot spring observation

Tian LEI[1]*, China Earthquake Networks Center (tian12lei@126.com)
Zhou Zhihua[2], China Earthquake Networks Center
Zang Yang[3], China Earthquake Networks Center

Abstract

The underground fluid is the most sensitive medium in the crust. The slight change of the water temperature in the underground fluid may reflect the tectonic activity in the process of earthquake preparation. The hot spring, as the most important manifestation of the deep upwelling of the underground fluid, is also one of the most convenient means to characterize the change of the underground structure. In the practice of earthquake monitoring and prediction for many years, a large number of hot springs have been observed, and Litang hot spring is the representative of these springs.

Since the observation of Litang Hot spring in 1975, it has shown serval times of low water temperature anomalies before several earthquakes of magnitude 7 or above occurred around. It showed a decrease for about 0.5-3℃ before the earthquake, and then the low value lasts until the main earthquake. The temperature of Litang showed a step-like decline because of the six main earthquakes.

The reason for this phenomenon is that the channel of the hot flow upwelling in Litang hot spring changes. Litang hot spring is a mixed hot spring by hydrogeochemical result. Before the earthquake occurred, the accumulation of crustal stress caused changes in the surrounding geological structure, resulting in the reduction of the hot flow upwelling channel, which led to the increase of the mixing proportion of cold water. However, before the main earthquake, the stress accumulation time was long, the fault was in a locked state, the channel was relatively stable, and the water temperature was continuously low, so the water temperature of Litang would drop in a stepped shape before these main earthquakes.

Keyword

earthquake, hot spring, temperature, tectonic stress, geothermy

Application of geological and geomorphological data in ground motion simulation

Jiangyi LI[1]*, Institute of Geology, China Earthquake Administration (lijiangyi@ies.ac.cn)
Bengang Zhou[2], Institute of Geology, China Earthquake Administration

Abstract

The Tianshan Mountains are one of the most active seismic regions on the Chinese mainland, as testified by the occurrence of 15 earthquakes of M ≥ 7 leading to surface rupture. The Kalawenguquan fault is known to be the northern edge of the Nalati fault and controls the northwestern edge of the Yultuz Basin (an internal block of the Tianshan Mountains). This left-lateral strike-slip fault has an average strike of N64°E and dips 60–80° to the south. The results of high-resolution remote sensing image interpretation, geological field surveys, geomorphological surveys, drone aerial surveys, trench excavation, and the dating of trench samples with the radiocarbon-14 dating method provides fault parameters for ground-motion simulation. The geological and geomorphological results revealed that the southwestern segment of the F1-3 fault is the most active, and there is a high seismic risk of large earthquakes on this fault in the future. Therefore, we set the largest asperity to be in this location and the smallest asperity to be at the epicenter of the 2007 Tekesi MS 5.9 earthquake.

Based on this source model and a multi-scheme simulation, we used different modeling parameters to design a logic tree. We calculate all the combinations of each scheme using the stochastic finite-fault method to analyze the impact of different site locations on the simulation of near-field large earthquakes, and obtained the minimum, average, maximum, and 50th-, 84th-, and 95th-percentile PGA values and response spectrums. The results showed that the response spectra of the sites located on the hanging wall of the fault were higher than those of sites located on the footwall. Ground motion simulations wherein the site was located near the asperities were greater than when the site was located further away from the asperities. Further, when the site is located on a smaller asperity and has a certain distance from the largest asperity, the simulation results are greater. Our results revealed that the geological and geomorphological data have great effects on the near-field ground motion simulation. Therefore, our study highlights the relevance of determining the source model based on geological and geomorphological data to obtain a reasonable evaluation for near-field strong ground motion simulations at major infrastructures.

Keyword

stochastic finite-fault method, asperity, ground motion simulation, source model

A study on high-resolution 3D seismic velocity structure in southern Sichuan basin, China, using a local temporary network

Yang ZANG[1]*, China Earthquake Networks Center (zangyang@seis.ac.cn)
Lingyuan MENG[2], China Earthquake Networks Center
Yanyan Han[3], China Earthquake Networks Center

Abstract

Induced seismic activity is becoming more and more severe in recent years near the southeast of the Sichuan basin, China, as the rapid development of Shale Gas exploitation around the local area. An MS 5.7 earthquake occurred near Xingwen County on 16 December 2018 within the Sichuan basin which is the largest hydraulic fracturing (HF) earthquake in China to date and caused ground motions intense enough to be felt, triggered landslides, caused 50 million in direct economic losses, injuries, and resulted in the first fatalities. Besides, 8 MS≥5.0 earthquakes have occurred Southeast of the Sichuan basin since 2018 supposedly either caused by HF operation or induced by wastewater disposal, where seismic activity has been low historically. The tomoDD double-difference tomography method has been applied to get the high-resolution three-dimensional structures and accurate locations of small earthquakes in the study area, taking advantage of 21 mobile stations' temporary network. Combined with the inverted structure and events' location data, along with the local geological structural information, we better understood the seismogenic structures of some moderate to strong earthquakes that occurred in the Sichuan basin. This study can help to establish a suitable regulation controlling system for the safe development of shale gas resources in the Southeast of the Sichuan basin as there is no one yet to date.

Keyword

southeast of Sichuan basin, induced seismicity, tomography

Relationship between seabed geomorphology and flexural subsidence in the Sibari and Corigliano basin (Southern Italy)

Nora Markezic[1]*, National Institute of Oceanography and Applied Geophysics (nmarkezic@ogs.it)
Silvia Ceramicola[2], Institute of Oceanography and Applied Geophysics
Emanuele Forte[3], Institute of Oceanography and Applied Geophysics

Abstract

Complex tectonic settings often exhibit particular spatial patterns of seabed morphologies reflecting the deep on-going processes and dynamics. This is the case of the Ionian Calabrian margin, part of the active Calabrian subduction zone, whose accretionary wedge is migrating and thus represents a seismic hazard. The area has undergone a km-uplift scale over the last 1Ma and it is deeply incised by several submarine canyon systems.

The north-eastern sector of the Calabrian margin, i.e. the Sibari and Corigliano Basins, whose formation can be linked to the Neogene-Quaternary evolution of the Gulf, exhibits a peculiar spatial pattern of seabed geomorphologies with different geometries.

We hypothesize that the observed geomorphology and evidence from sub-bottom data, are related to the subsidence that this area is experiencing, which is controlled by the downward flexure of the lithosphere in response to thrust accommodation and loading. Tectonics may have locally enhanced subsidence in the examined near-coastal area.

Seismic data at different resolution integrated with bathymetry data have revealed the presence of multiple stages of submarine landslides as well as aggrading submarine gullies testifying the ongoing activity in this area.

Coupling the seafloor expression to deep tectonic processes where active tectonics is occurring, is crucial for determining the potential geohazards of near-coastal areas. We present new information about on mapped geomorphologies with particular emphasis on their spatial constraints and evolution.

Keyword

Submarine gullies, Subsidence, Calabrian margin, Reflection seismics

Application of Acoustic Classification for Seabed Characteristics of Spratly Islands in the South China Sea

Yin Hsuan Liao[1]*, National Taiwan University (b02208008@gmail.com)
Ho Han Hsu[2], Institute of Oceanography, National Taiwan University, Taipei, Taiwan
Tzu Ting Chen[3], Woods Hole Oceanographic Institution, Falmouth, MA, United States
Char Shine Liu[4], Ocean Center, National Taiwan University, Taipei, Taiwan
Yu Huang Chen[5], Institute of Oceanography, National Taiwan University, Taipei, Taiwan
Liwen Chen[6], National Academy of Marine Research, Ocean Affair Council, Taiwan

Abstract

The Spratly Islands, located in the southern region of the South China Sea, consist of numerous atolls, reefs, shoals, and small islets. The seabed morphology of the islands exhibits marked disparities both within and outside the atolls encompassed by coral reefs, which are consolidated calcium carbonate platforms. Concurrently, being one of the largest marginal seas in the Western Pacific Ocean, the South China Sea receives substantial sediment influx from adjacent continental rivers. In this study, we analyzed different geophysical data collected near Tizard Bank, a partially submerged atoll within the Spratly Islands. These geophysical data, coupled with sediment sampling, facilitated a comprehensive assessment of the topography and classification of the seabed of the Spratly Islands. Based on the results, we developed a method to classify the nature of the seabed that complies with the S-101 encoding standards for the electronic navigational chart (ENC), established by the International Hydrographic Organization (IHO). High-resolution multibeam echo sounding (MBES) bathymetric data, backscatter data, and sub-bottom profiles were acquired to study seabed characteristics. Moreover, through gravity coring and Shipek grab, 33 seabed sediment samples were retrieved and analyzed to validate the geophysical data interpretation. The bathymetric data reveal that the interior of Tizard Bank predominantly features water depths of less than 100 meters, with coral reefs and shallow shoals covering the area. The seabed outside the atoll descends steeply, interconnected by numerous submarine channels, with depths exceeding 2,500 meters between atolls. Analysis of backscatter imagery obtained via MBES reveals the highest backscatter intensity within Tizard Bank, indicating elevated hardness and roughness within the atoll, which also shows high amplitude reflectors on the seafloor in sub-bottom profiles. Conversely, backscatter intensity is heightened within the submarine channels outside the atoll, diminishing as seabed depth increases seaward. Results from seabed sediment analysis demonstrate that the seabed within Tizard Bank primarily comprises coral and coarse-grained foraminiferal sand (<5 phi). In contrast, the exterior seabed sediment exhibits significantly finer particles (6-8 phi), with grain size diminishing towards the atoll. The wide surface data collected by MBES, combined with the sub-bottom profiles on survey lines, finally verified by actual seabed sediment sample analysis, classify the nature of the seabed features in the study area. By application of multiple geophysical acoustic data near Tizard Bank, we develop a method of wide surface seabed characteristics classification for the electronic navigational chart, and provide a deeper understanding of depositional environments and sedimentation processes within

the Spratly Islands and the broader South China Sea.

Keyword

seabed characteristics, acoustic classification, multibeam bathymetry, backscatter, Spratly Islands

Investigation of the genesis and development of the late Pleistocene paleosols for the reconstruction of the geomorphic evolution of the loess deposits near Gorgan, Iran

Sahar MALEKI[1]*, Geological Survey of Iran (sahar.maleki@ut.ac.ir)
Farhad Khormali[2], Gorgan University of Agricultural Sciences and Natural Resources
Faezeh Shahpouri[3], Phd student of Isfahan university

Abstract

During the last glacial-interglacial cycle, wet periods that reduced dust sources resulted in the expansion of loess deposits in northern Iran. These loess sediments formed and developed the Saad Abad loess-soil microtexture sequence, which contains an old soil with moderate evolution. To understand the genesis and development of the landscape in the study area, located on the northern slopes of the Alborz Mountain range in Golestan province, we selected the site based on the exposure of the old soil in the wall after field visits. We sampled every horizon and at 5 cm intervals from the wall. We described the particle size distribution, magnetic susceptibility, morphology, micromorphology, mineralogy and calcium carbonate equivalent (CCE) characteristics in detail. The old soil, associated with the last interglacial period, is an ABk horizon with moderate evolution, which underwent carbonate leaching from surface horizons, decreased soil-forming processes, and reduced humidity. This old soil likely formed during secondary sedimentation intervals. Loess in Saad-Abad is classified as clay loam due to the high clay content, averaging 35%. Many of the collected samples have no particles larger than 200 micrometers, while smaller particles comprise a very large proportion. The loess particles deposited on the slopes of the Alborz mountains are considerably smaller. The presence of various forms of calcium carbonate aggregates, high values of magnetic susceptibility χlf and χfd% in this old soil indicate a period of heavy rainfall during its formation. The values of χfd% for the Bw horizon of the modern soil are about 10.14% and for the old soil between 5.67% and 13.59%. The strong correlation between χlf and χfd% suggests that the super-paramagnetic minerals produced by pedogenic processes are the main cause of the increase in magnetic susceptibility. The highest value of χfd% equal to 13.59% was observed in the old soil, which implies that pedogenic processes in this soil are stronger than in other modern soils. Based on the similarity of the patterns of magnetic susceptibility and particle size distribution and the assumption that the formation of the ABk horizon in Saad Abad coincided with the Bt horizon (1-3) in Toshan and Bk (p1) in Mubarak Abad; the different degrees of soil formation indicate an increase in humidity from east to west and from north to south in the current period and the last interglacial period. Therefore, we infer that the climate gradient of the late Pleistocene was similar to the present one. Consequently, the old loess and soil in Saad Abad, like the stratigraphy of other study areas, show a cyclic pattern.

Keyword

loess, Paleosol, late Pleistocene, past climate, North of Iran

Identification and classification of the Salehyeh wetland sediments and assessment of possible contamination markers (toxic elements)

Nayerehsadat BAYAT GHIASI[1]*, Geological Survey of Iran (na_bayat60@yahoo.com)
Sahar Maleki[2], Geological Survey of Iran
mehdi tahmasebi jam[3], Geological Survey of Iran
Reza Shahbazi[4], Geological Survey of Iran

Abstract

Wetlands are among the most vital and irreplaceable ecosystems on Earth. Salihiya wetland, located near the capital city in Alborz province, is one of the most significant wetlands in Iran. This wetland hosts a variety of migratory birds annually and contributes to the regulation of the local climate. Moreover, it provides habitat for many animals and serves as a natural attraction for visitors. The main objective of this research was to examine the sedimentological, geochemical and environmental features of this wetland and to evaluate the influence of anthropogenic activities on its contamination by heavy elements. Soil texture analyses indicated that the dominant soil texture in the wetland was silty and silty clay. The soil electrical conductivity in the eastern and northeastern parts of the wetland, the sulfate content in the east and the calcium carbonate content in the western and southwestern parts of the wetland were higher than in other areas. The total water hardness was also greater in the eastern and northeastern parts of the lagoon than in other regions. The investigation of heavy metals revealed the predominance of human activities over geogenetic factors in causing wetland pollution. High concentrations of iron, titanium, vanadium, aluminum, beryllium and cobalt were dispersed throughout the lagoon environment, while bismuth was enriched in the western and southwestern parts, chromium and zinc in the center, copper in the east, manganese in the east and nickel in the northwest. These patterns were associated with the activities of factories, industries, agriculture, road transport and mining. The modified degree of contamination index showed the high degree of contamination of the lagoon by chromium, manganese, vanadium, barium, zinc and cobalt. The enrichment factor was also very high for vanadium, Ba, Mn, P, Y. The geoaccumulation index values of these elements exceeded the standard value, indicating the pollution of the wetland environment.

Keyword

geochemistry, Salehieh wetland, heavy metals, nutrition, environmental pollution

Understanding the Long-Term Impacts of Human Activities and Climate Change on the Krishna-Godavari Delta through Remote Sensing

RESHMA KADAKATH NARANTHATTA[1]*, NATIONAL CENTRE FOR COASTAL RESEARCH (reshmarechu16@gmail.com)
MANI MURALI RAJAGOPAL[2], CSIR NATIONAL INSTITUTE OF OCEANOGRAPHY
SANTHOSH KUMAR SAKTHIVEL[3], CSIR NATIONAL INSTITUTE OF OCEANOGRAPHY

Abstract

Deltas, characterized as dynamic ecosystems, play a vital role in global biodiversity and carbon cycling, and function as economic hubs. Despite their significance, global delta systems face imminent threats from a combination of natural and human-induced activities. Upstream damming of rivers disrupts the essential flow of water and sediment crucial for deltaic sustainability. Moreover, the impact intensifies with local exploration of oil, gas, and groundwater, contributing to subsidence, wetland loss, and accelerated erosion. This study focuses on a long-term understanding of the Krishna-Godavari delta, the second-largest delta in India, to assess its response to the impacts of climate change and human-induced activities. By utilizing remote sensing technologies and incorporating both optical and microwave satellite data, parameters such as land use pattern, ground deformation, and shoreline of the twin delta were assessed. The methodologies employed in this study encompassed the utilization of the maximum likelihood supervised classification approach to analyze land use changes. For assessing shoreline changes, the study employed the Net Shoreline Movement statistical analysis. Additionally, the Rate of deformation was determined through Short Baseline Interferometric analysis. The analysis reveals a substantial and abrupt increase in urbanization from 96.90 km2 to 325.63 km2 in Godavari and 13 km2 to 114 km2 in Krishna over the past 48 years. Increasing urbanization exerts pressure on the delta ecosystem through land conversion, and groundwater exploration, leading to urban-induced subsidence (upto-10mm/yr.) at various locations of the delta. High Erosion (-320m to -781m) near the river mouths of the delta was estimated from 1973 to 2014. The pronounced erosion identified poses a significant threat, rendering the delta more susceptible to the impacts of climate change. In parallel, mangrove restoration initiatives within the coastal zones of this delta have led to an increase in mangrove cover, contributing to enhanced stability along the coastal area. Despite the positive influence of mangrove restoration on coastal stability, the cumulative impacts of high erosion, subsidence, and urbanization underscore the vulnerability of the Krishna-Godavari delta in the face of climate change scenarios. This study emphasizes the critical need for integrated and sustainable coastal management practices to mitigate the adverse effects of urbanization, subsidence, and erosion, thereby safeguarding the ecological integrity and resilience of the Krishna-Godavari delta against evolving
environmental challenges.

Keyword

Krishna, Godavari, Climate Change, Delta, Remote Sensing

Tectonic Segmentation along the Himalayan Arc from Geomorphic Analysis and its implication on the Strength of the underthrusting Indian Lithosphere

Raj Sunil KANDREGULA[1]*, CSIR-National Geophysical Research Institute
(krsunil17@gmail.com)
Pavankumar Gayatri[2], CSIR-National Geophysical Research Institute
Ajay Manglik[3], CSIR-National Geophysical Research Institute

Abstract

The Himalayan collision belt presents a complex geological scenario where the underthrusting Indian plate exhibits segmentation along its arc. This segmentation, marked by variations in the angle of underthrusting of the Indian mantle lithosphere (IML) and its northern limit beneath Tibet, is intricately linked to pre-existing transverse tectonic fabric in the Ganga foreland basin. These structural variations hint at changes in the mechanical properties of adjacent blocks, likely reflected in spatial variations in topography and related parameters. To delve into this phenomenon, an extensive analysis was conducted, combining the study of the normalized river channel steepness index (ksn) with key factors such as the width of the Ganga foreland basin vis-à-vis disposition of major thrust faults and Bouguer gravity anomaly. The results support a linkage between the spatial variability in the ksn and the segmentation of the Indian plate. This analysis delineated six distinct sectors within the Himalaya, mirroring sectors identified through independent studies based on the GPS studies, analysis of topography and Bouguer gravity anomaly data. Furthermore, significant deviations in high ksn pockets from the arc-parallel distribution were attributed to the transverse tectonic fabric of the Indian plate in the Ganga-Brahmaputra plains. Importantly, the integrated findings shed light on the mechanical strength of various lithospheric sectors, identifying regions like the Kashmir - Himachal and the eastern part of Arunachal as possessing mechanically strong lithosphere, in contrast to the central-eastern Nepal sector which exhibits lithospheric weakness. This comprehensive analysis highlights the linkage between the tectonic segmentation, topographic variations, and lithospheric mechanical properties in the Himalayan region, offering valuable insights for understanding its seismic hazard potential.

Keyword

Himalayan arc, Segmentation, Normalized Steepness Index, Transverse Ridges, Foreland Basin

The climate-tectonic interplay in Ladakh, NW Himalaya (India)-Records during the Quaternary Period

Binita PHARTIYAL [1]*, Birbal Sahni Institute of Palaeosciences, Lucknow
(binita_phartiyal@bsip.res.in)
Debarati Nag[2], Department of Geology Savitribai Phule Pune University, Pune, India
Priyanka Joshi[3], Agharkar Research Institute, Pune, India

Abstract

In the complexity of the Himalayan system lies Ladakh-a cold arid high-altitude desert. It is the part of the NW Trans Himalaya exhibiting a cold desert environment being the rain shadow area of the India Summer Monsoon. The region is sensitive to environmental changes where a little perturbation may lead to massive sediment production, erosion, and sedimentation resulting in dynamic evolution of the landform development and evolution of the area. This sector offers a rich platform for Quaternary palaeoclimatic studies. It is also tectonically very active due to its vicinity to the Karakorum fault and the Indus suture zone. It is well established that the monsoonal precipitation over the Indian subcontinent is largely controlled by the thermal gradient between the Tibetan Plateau and the Indian subcontinent and is highly variable with contrasting precipitation patterns seen from east to west and north to south, especially over Himalaya. This has contributed significantly to the varied geomorphology of different sectors of the Himalaya. The bulk of the precipitation over Ladakh and Karakoram regions is received as snow between November-April which is crucial to replenish and maintain the water budget of the ten major rivers originating from the Himalaya and Tibetan Plateau area and catering to almost 20% of the world's population. However recent uprising trends in flash floods induced by abrupt and intense precipitation events in the high-altitude Himalaya are becoming worrisome. A spatial variation exists in the studied records and to understand this concurrent variability it is very important to have good knowledge of past variability. Thus, strategically as well as critically placed Ladakh region provides an opportunity to unravel the signatures of palaeoclimate and neo-tectonics preserved in these Quaternary deposits and their relation with the regional and global climate and morpho-sedimentary.

This paper discusses the sediment archive record of the cold arid altitude desert of India i.e., Ladakh- to understand the overall geomorphological evolution in view of both exogenic as well as endogenic forcings. The entire region displays a wonderful play of tectonics in its multiple levels of terraces and the recurrence of soft sediment deformation structures in its sediments. Studies suggest that the Indus Valley has undergone tectonic disturbances, which are seen in the deformed lacustrine sediments moreover the palaeolakes have been formed due to the damming of the rivers by different landslides (either due to seismic disturbances or abrupt monsoon years) at different periods in the past. Several lake sediments (paleo and proglacial) from the Ladakh range and the Indus Valley were studied with a multi-proxy approach for recording the climate. A composite picture of the Late Quaternary from Ladakh is sought and a higher resolution picture since LGM

shows several prominent arid phases intervened by comparatively warmer conditions.
This mid-latitude, high-altitude cold desertic region aptly known as the roof of the world has a very good archive of sediments that are preserved along the river valleys which would answer questions of climatic perturbations, geomorphological evolution, and tectonics and thus hold key to the understanding of several climate uncertainties.

Keyword

Trans-Himalaya, Exogenic, Endogenic, Indian Summer Monsoon, Seismites

Tectonic landforms and Morphometric analysis of the frontal part of the Belt of Schuppen: Focus on Naga Thrust

SENTISENLA JAMIR[1]*, NAGALAND UNIVERSITY (sentisenla123@gmail.com)
KHAYINGSHING LUIREI[2], WADIA INSTITUDE OF HIMALAYAN GEOLOGY
GLENN T THONG[3], NAGALAND UNIVERSITY

Abstract

The Belt of Schuppen (BoS) which trends NE-SW in the western part of the Indo-Myanmar ranges, represents a tectonically active zone. Development of landforms suggests recent tectonic activity in the BoS, particularly along the Naga Thrust (NT). The mountain front is defined by the NT. The current study is an attempt to establish neotectonic activity in the study area using structural and morphotectonic features, through field observations and analysis of morphometric parameters with the help of Digital Elevation Models and Google Earth Imagery. Multiple levels of strath terraces, incised bedrocks, nature of the mountain front are important morphotectonic features. Structural features include the development of duplex structures in the BoS and swing in strike of the bedrock that resulted in curved mountain front. The study area, situated in the western part of the BoS, is divided into 15 sub-basins. Morphometric analysis of 15 third order and above sub-basins were carried out. Asymmetric factor (AF) values indicate tilting of all the sub-basins. Mountain front sinuosity (Smf) values of the study area ranges from 1.06 to 1.26, which indicates a tectonically active front. Steepness index (Ksn) and valley floor width to height ratio (Vf) for Dzüdza River were also determined. Several knickpoints were noted which are located in the proximity of major thrusts, viz., Disang Thrust, Piphema Thrust, Sanis Chongliyimsen Thrust and Naga Thrust. Numerous normal faults and folds are developed in the bedrock. The Naga Thrust appears as an emergent thrust in the field, with abrupt contact between the bedrock and Quaternary deposits. Multiple fluvial terrace levels (T1 at 221 m asl, T2 at 224 m asl, T3 at 227 m asl and T4 at 255 m asl) are developed along the Dzüdza River. The presence of paleochannels depicts shifting of streams, tilted fluvial deposits, and deformed sediments, which suggest later phases of tectonic activity.

Keyword

Naga Thrust, Belt of Schuppen, Neotectonics, Morphotectonics, Geomorphology

Multi-phase drainage rearrangement in response to geodynamic mechanism transition in southeastern Tibet

YONG ZHENG[1]*, Institute of Geology, Chinese Academy of Geological Sciences (zygeology@163.com)

Abstract

Fluvial systems react rapidly to tectonic events and therefore paleo-drainage changes are often used to shed light on the tectonogeomorphic evolution of an area. There are several large-scale rivers of southeastern Tibet characterized by particular geometries, which indicates changes in river patterns due to river capture and drainage direction reversal. Among them, the Dadu River abruptly shifts from south- to east-flowing forming a ~90° bend, and the upper Yangtze River abruptly shifts from southeast- to northeast-flowing forming a ~110° bend. Here we report our identification, based on detrital zircon U-Pb age distribution, of a range of fluvial sands left by the paleo-Dadu River. Cosmogenic 10Be and 26Al burial dating provides burial ages for these fluvial sands and indicates that reorganization of the Dadu drainage completed within the last 0.6 Ma. Additionally, using the low-temperature thermochronology, we have dated the rerouting and formation of the Great Bend of the upper Yangtze River in the Miocene. We hypothesize that the Miocene river capture was caused by geodynamic mechanism transition. During this period, the regional fault systems started to shift from pure strike-slip faulting activities to transpressional faulting. Because enhanced river incision since Quaternary in the southeastern margin of the Tibetan Plateau occurred mainly within a narrow region between the Sichuan Basin and the Eastern Himalayan Syntaxis, we attributed the river rerouting during this period to an episode of widespread extensional deformation superimposed above middle- to upper-crustal flexure.

Keyword

paleo-drainage changes, southeastern Tibet, river capture, burial dating, low-temperature thermochronology

Geomorphological evidence of neotectonic activity in the Ganga-Brahmaputra plains: A review

CHINMAY DASH[1]*, Department of Geography Education, Korea University, Seoul-02841, Republic of Korea (chinmayism2012@gmail.com)
PITAMBAR PATI[2], Department of Earth Sciences, Indian Institute of Technology, Roorkee, Uttarakhand 247 667, India

Abstract

The dynamic interplay of spatio-temporal stress variations within the Ganga-Brahmaputra plains has instigated the formation of numerous neotectonically induced geomorphic features along the Himalayan foothills. Notably, the investigation into the terminal fans and soft sediment deformation structures in the Indo-Gangetic plains and the paleopedological records in the Brahmaputra basin offers significant insights into recent tectonic movements. The distribution of terminal fans in the Ganga plain reveals three distinct episodes of basin segmentation during the past 10 ka. The earliest segmentation occurred roughly between 9,000 and 7,000 years ago, succeeded by faulting episodes from 6 ka to 2 ka and 1 ka to 0.7 ka. The peak of faulting activity transpired during the second stage, constituting approximately 70% of the total faulting events. The formation of shallow sub-surface faulting facilitated sediment accumulation, while sediment supply for fan development was spurred by fluvial sediment discharge during various climatic epochs. Notably, larger fans tended to develop during wet climatic periods. The presence of shallow sub-surface deformation structures along basement faults suggests ongoing neotectonic activity and the propagation of secondary faults. Holocene sediment records from the Brahmaputra plain mirror the intense tectonic activity observed in the Ganga plain during the Holocene, indicating significant sediment redistribution. Soil classification in the Brahmaputra Plain reveals four sub-categories based on age, with the oldest soils occurring along the Brahmaputra Arc. These older soils developed during the early to mid-Holocene along the Brahmaputra Arc within a compressional regime between the Naga Thrust and the Himalayan Frontal Thrust (HFT). This is supported by the closeness of the Naga Hills and the Himalayan Frontal Thrust at the center of the valley than at the periphery. Similarly, the distribution of alluvial fans and Naga Hill piedmonts also suggest that the older deposits occur along the central region. These findings from the sediment distributions in the Brahmaputra valley indicate that the intense compression between the Naga Thrust and the HFT uplifted the Brahmaputra Arc. The younger sediments in the valley were derived from the erosion of the older soils along the arc. In summary, the Ganga and Brahmaputra plains showcase consistent patterns of neotectonic activity, highlighting their regional importance in unraveling the broader geological dynamics of the Himalayan foothills.

Keyword

Ganga-Brahmaputra plains, Himalaya, Neotectonics, Holocene, Terminal fan

Mangroves ecosystem metamorphosis impacted by climate change in Indus Delta

Ping YIN[1]*, Qingdao Institute of Marine Geology,China Geological Survey
(yinping@mail.cgs.gov.cn)
Jingpeng Liu[2], Qingdao Institute of Marine Geology,China Geological Survey
Yuqing Tian[3], Qingdao Institute of Marine Geology,China Geological Survey

Abstract

Mangroves are salt-tolerant woody plants growing in the intertidal zones of tropical and subtropical regions, playing a significant role in cementing coastal berms, controlling wind and waves, purifying water quality and regulating climate. They also play an irreplaceable role in protecting biodiversity and maintaining the ecological balance of coastal zones. The Indus Delta is home to 95% of Pakistan's mangroves, making it the largest dry-climate mangroves, as well as the seventh largest mangrove forest in the world. Integrated Earth Observation on the Indus River delta revealed the spatial and temporal changes of mangroves, corresponding to climate changes and anthropogenic impacts, geo-information based risk assessment and management strategy study provide scientific supports for coastal ecosystem restoration and wetland protection in the future. Over the past 30 years, mangroves in the Indus Delta have changed significantly in spatial composition and distribution with an overall trend of increasing then decreasing. Mangroves in the west of the present Indus estuary showed an overall growth trend while to the east of estuary generally show a trend of increasing then decreasing during the same time frame. Landscape pattern index shows that mangrove fragmentation was decreasing and mangrove was growing more concentrated, ecosystem connectivity and aggregation index is increasing in most areas west of the present Indus River estuary.

Coastal erosion due to climate change, rising sea levels and reduced sediment input from the Indus River is the major factor contributing to the widespread loss of mangrove habitats. Sea level near Karachi increased at a rate of 1.1 mm/yr, increasing eastward to 1.9 mm/yr, the rise of sea level is positively correlated with the rate of coastal erosion, over the past half century, Indus Delta has lost approximately 3,750 km^2 land under the continuous influence of sea level rise and coastal erosion. In addition to coastal erosion squeezing living space, sea level rise can also lead to stronger wave action, higher tides and more intense storm surges, all of which further increase coastal vulnerability and exacerbate mangrove decline.

The abandoned tributary channels and tidal branches undergo long-term dynamic adjustment, the reconstruction of the geomorphic balance of the delta is accompanied by the adjustment of the mangrove ecosystem. The Indus River main tributary channels located near Karachi was abandoned in the middle of 19th century, afterwards large river channels and tidal channels are filled and tend to be consistent with the elevation of the tidal flat, and secondary tidal channels with shallow depth and small width are developed, which is conducive to the stable expansion of the mangrove body system. On the southeast side of the delta near India, the overall elevation is

low, and the lack of sediment supplementation, strong tidal currents and waves brought by the southwest monsoon have widened and deepened the tidal channels, which is not conducive to the growth of mangroves and leads to the erosion of mangroves at the edge of the tidal channel.

Keyword

Indus Delta, Mangrove, Climate change, Coastal erosion, Abandoned tributary

Quaternary Tectonism and Channel Migration in the Banas River, Western India M.R. Resmi and Manisha Gupta

Resmi M.R[1]*, Banasthali Vidyapith (resmiarun.mr@gmail.com)
Manisha Gupta[2], Banasthali Vidyapith

Abstract

The Banas drainage basin in central Rajasthan displays asymmetry in nature, particularly in relation to the 6th order Banas River channel (highest order). In the southeastern segment of the Banas River catchment, near to the Mej River sub-basin in the Chambal catchment, the channel's minimum distance from the watershed is merely 7 km. This characteristic is ascribed to the migration of the Banas watershed, estimated at 25-30 km, from its original position along the Vindhyan hills to its present location. From our present study, it is evident the southward shifting of Banas River has occurred in the past. This shift is a consequence of the superposition of the Mej river system and its headward erosion within the Banas system, influenced by neotectonism. Consequently, a portion of the Banas catchment has been annexed by the Chambal River system. Given the dynamic nature of the Mej river system, there exists a potential for future piracy and beheading of a significant segment of the Banas River. In addition, the tectonic activity in and around Banas River can be attribute to reactivation of Great Boundary Fault (GBF). Ultimately, we can correlate the reactivation of GBF is due to Himalayan Tectonics and Indian plate motion.

Keyword

River migration, GBF, Banas River, Mej river, river capture

Sediment characteristics and carbon stock in mangroves of Mahanadi delta in western Bay of Bengal

KAKOLI BANERJEE[1]*, Central University of Odisha (banerjee.kakoli@yahoo.com)
Pramod Kumar Bindhani[2], Central university of Odisha
G Jayanti Reddy[3], Central University of Odisha

Abstract

Mangrove forests, one of the most important ecosystems, provide a range of ecosystem services in carbon cycle, coastal protection, fisheries habitat and water filtration. The physical, chemical, and biological properties of mangrove sediment vary widely depending on the forest site, which is a result of the intricate interactions between biotic and abiotic factors. We present a case study conducted at four different mangrove sites investigating the diversity changes in mangrove species (*Avicennia marina*, *A. officinalis*, *Excoecaria agallocha*, and *Rhizophora mucronata*) in relation to sediment properties. The present research work is an attempt to understand the carbon storage capacity of mangrove forest of Odisha coast at Bhitarkanika Wildlife Sanctuary in Mahanadi delta in western Bay of Bengal during 2017-2022 in these 4 different dominant mangroves. We found that sediment parameters such as temperature, pH, electrical conductivity (EC), bulk density (BD), soil organic carbon (SOC), available nitrogen, phosphorus, potassium, and soil texture were significantly correlated with the Importance Value Index (IVI) of the selected mangrove species. The diversity of mangrove species was found significantly higher at sites with higher levels of SOC and BD. A significant variation was observed between station vs depth and season vs depth ($p<0.05$) which proves that carbon deposition in mangrove sediment is highly dependent on soil quality as well as variation in temperature and rainfall w.r.t season and station respectively. The present study has proved the inefficiency of high saline sediment to store carbon which actually leads to stunted mangrove vegetation. Year–wise trend of AGB shows the dominancy of *Excoecaria agallocha* > *A. officinalis* > *Avicennia marina* > *Rhizophora mucronata*. Analysis of variance computed between species, between stations and between seasons as well as species vs station showed remarkable variation ($p<0.05$) proving the reason for varied distribution of the selected species in the study area. AGC is almost a replica of AGB which proves that highest biomass and carbon was observed at areas with low salinity and high pH due to freshwater discharge. Regression equations plotted for AGB and AGC values for the selected species showed significant relation (R2= 1) proving the fact that with increase in AGB, AGC increases. This suggests that mangrove conservation efforts should focus on maintaining or increasing the levels of these sediment properties. Overall, findings of this study have important implications for the conservation of mangrove forests in the existing deltaic ecosystem. By understanding the relationship between mangrove diversity, carbon stock and sediment properties, we can develop more effective management strategies for these valuable deltaic ecosystems prone to cyclonic depressions, which are the carbon sinks in the changing era of climate.

Keyword

Biodiversity, carbon stock, Importance Value Index, mangrove conservation, sediment properties

Sustainable Habitability of the Mountain Valley Systems under Emergent climatic transition: A case of the Himalaya

Satish Jagdeo SANGODE[1]*, Savitribai Phule Pune University (sangode@rediffmail.com)

Abstract

A range of mountain valley architectures broadly classified into Outer, Lesser and Higher Himalayas show variable denudational and depositional fronts that are rapidly converging due to climate change and thus interfere with the habitability at higher rates in this densely populated South Asian region. The complex combination of natural as well as anthropogenic effects have laid to new phase of landform evolution demanding recognition of new stable/metastable surfaces under the altered weather conditions for safer habitability. The frequent changes in sediment mass to slope gradient ratios are triggered by; i) altered weather conditions due to climate change, ii) the effect of tectonics, iii) changes in basin fill conditions and iii) altered pathways of sediment mass transfer; demands cautious human intervention. Accounting for the scope of extreme events such as cloud burst, snow/rock avalanches, glacial serge and GLOFs, a synergy of defining the stable/metastable surfaces amongst these valleys is essential and the uncertainties can be reduced using systematic studies in individual valley basins. Adopting case study from NW Himalaya (viz., Dun valleys in Outer Himalaya, Chandra valley in Higher Himalaya; Leh and Pangong-Tangtse valleys in Trans Himalaya) a first order approach has been produced here to evaluate the dominating processes, their magnitudes and scaling.

Based on the parameters suggested by Sangode et al (2021) ‘the convergence and divergence of the denudational front (Dw) with depositional front (S), advancements of lateral valley denudation front (Lw) and the changes in base levels (bn) under constant valley-accommodation-space; efforts are made to develop the approach of finding stable and metastable surfaces. A guideline for database with parametric inputs is suggested for the long- term predictions with variable rates of denudation, basin fill and sediment transfer under tectonically active and stable valley conditions over this hugely characteristic region of the earth.

Keyword

Himalaya, India, sustainability

The Ganga Plain rupture cyclicity deduced from the terminal fans; and its coherency with the Himalayan earthquake cycles

PITAMBAR PATI[1]*, IIT ROORKEE (pitambar.pati@es.iitr.ac.in)

Abstract

The Himalaya has been seismo-tectonically active since its inception. As the Ganga plain is coupled and segmented with the Himalayas, its tectonics are mainly controlled by the Himalayan tectonics. Minor surface rupture and displacement allow the fluvial system to form terminal fans on the down-thrown block of the fault. Hence, terminal fans are promising tectono-geomorphic markers in the Ganga plain, extensively used for mapping active faults. Forty-five Holocene terminal fans mapped from the Ganga plain are spatially well distributed throughout and temporally clustered. The temporal clustering of these geomorphic features suggests episodic rupture of the Ganga plain, which is propelled by the Himalayan tectonics. A total of six tectonic episodes have been identified in the Ganga plain based on the temporal clustering of the terminal fans. The average recurrence interval of these rupturing events has been calculated to be 681±66 years. This recurrence interval closely matches the recurrence interval of large earthquakes in the Himalayan Arch proposed by Gupta and Gahalaut (2014), which is about 750 years. Other studies on the recurrence interval of large earthquakes from different parts of the Himalayan region do not match the Ganga plain rupture cyclicity. The Ganga Plain rupture during the 2015 Nepal earthquake supports a necessary topographic requirement for forming terminal fans.

Keyword

Ganga Plain, Holocene, faulting, Cyclicity, Himalaya

The enigmatic Sarasvati River: Unravelling the mystery through space and time-A multidisciplinary approach

HARSH TEWARI[1]*, GEOLOGICAL SURVEY OF INDIA (harsh.tewari@gsi.gov.in)
Manoj Kumar Shukla[2], GEOLOGICAL SURVEY OF INDIA
Deepali Kapoor[3], GEOLOGICAL SURVEY OF INDIA
Sanjiv Kumar[4], GEOLOGICAL SURVEY OF INDIA
Maloy Kumar Bhowmic[5], GEOLOGICAL SURVEY OF INDIA
Chandrabadan Tiwari[6], GEOLOGICAL SURVEY OF INDIA
Rajesh Chaturvedi[7], GEOLOGICAL SURVEY OF INDIA

Abstract

Sarasvati, a legendary river mentioned in ancient Indian texts, believed to be flowing in parts of NW India has captivated the interest of academicians from various disciplines for centuries due to its linkage with the term "lost river" and its generous portrayal in the ancient Indian scriptures like Rigveda. The exact course and geographical extent of the Sarasvati River remains a subject of debate. Extensive evidence from diverse fields supports the existence of a high-energy palaeo fluvial system in Northwestern India during Late Pleistocene - Holocene period. A comprehensive study employing multi-disciplinary approach viz. remote sensing, geochronology, sedimentology (grain size, heavy mineral and SEM analysis), geochemical (XRF and XRD) studies as well as geophysical investigations, has been undertaken to shed light on the spatial and temporal evolution of the palaeo Sarasvati River system.

Using temporal multi-sensor satellite data, such as Landsat TM, MSS, Resourcesat AWIFS and ESA Sentinel, a comprehensive palaeochannel map of the Sarasvati River system comprising three major palaeochannels viz. Satluj palaeochannel, Yamunanagar Kurukshetra Shutrana palaeochannel (YKSP) and Drishadwati palaeochannel, having combined length of approximately 2000 km was delineated from Himalayan foothills to Arabian sea. For the first time, this palaeochannel system was ground validated and sampled to unravel its temporal evolution and provenance. Geophysical survey (Vertical Electrical Sounding) and topographic profiles made across the palaeochannels on DEM data also confirms the existence of palaeochannels. The upstream extension of YKSP and its connectivity with Yamuna River was also established using geophysical survey.

Based on OSL dates (64 samples), collected from critical locations, the authors conclude that the Sarasvati fluvial system was active from at least 45,000 years BP to 10,000 years BP. Striking similarity in the sediments collected from palaeochannels and present-day perennial rivers viz. Satluj and Yamuna was also observed. Analysis viz. XRD (50 samples), XRF (93 samples), heavy mineral speciation (57 samples), SEM analysis of quartz grains (20 samples) confirmed that Satluj and Yamuna River supplied higher Himalayan sediments and glacial melt water to Sarasvati River system. Ephemeral rivers originating from the piedmont zone and Outer Himalayas, in the Yamuna-Satluj interfluve, also contributed to its discharge and now flow as misfit rivers inside wide palaeo-valleys. Based on the above inferences, spatio-temporal evolutionary model of the

Sarasvati paleo-fluvial system has been generated.
The beginning of the Holocene period played a critical role in the ultimate disappearance of the Sarasvati fluvial system due to the shifting of both the perennial sources of this fluvial system i.e the eastward shift of the Yamuna River, probably after 13,000 years BP, and the westward shift of the Satluj River after 10,000 years BP. This phenomenon of drainage reorganisation of mighty Sarasvati River system during the Late Quaternary may be related primarily to upliftment of tectonic mountain belts of Outer Himalayas and climate change. The present study involving multi-disciplinary approach has contributed significantly to our understanding of the evolution and demise of the ancient Sarasvati River system which is also applicable to folded mountain belts in other parts of the world.

Keyword

Sarasvati palaeochannel, remote sensing, provenance, geochronology, Holocene

Comparative analysis of sea level changes along the South Sea coast in South Korea during the Holocene Thermal Maximum

Jeogyun KIM[1], Pukyong National University
Baekyeong SO[2], Samgang Cultural Heritage Researcher
Hankyo SEO[3], Korea Social Science Institute
Ayoung KIM[4], PUKYONG NATIONAL UNIVERSITY
JUNGHYUNG RYU[5]*, PUKYONG NATIONAL UNIVERSITY (jryu@pknu.ac.kr)

Abstract

The Holocene Thermal Maximum (HTM), a period of peak temperatures during the mid-Holocene between 9,000 and 5,000 years ago, brought warmer conditions to South Korea. This warming event led to notable changes in the coastal landscape and human activities. However, the lack of well-defined transgressive shoreline and comprehensive geological evidence limits our understanding of historical sea level variations and their impacts on coastal environments. This study aims to estimate past shoreline movements through a multiproxy approach, including geological, geomorphological, microfossil, and archaeological analyses. Multiple long cores were extracted from the southwest to the southeast along the coast of the South Sea, encompassing various estuarine environments such as the Nakdong, Nam, and Hwang Rivers. Geological and geomorphological data indicate a significant oceanic transgression occurred around 7,000 BP, resulting in a strong saline water incursion, identified approximately 41 km inland from the South Sea. This finding corresponds to the presence of acorn pits and shell mounds, which serve as important archaeological evidence for past sea levels due to their implications regarding past human behavior, environmental conditions, and the proximity of ancient communities to water sources. During the HTM period, the coastline likely retreated significantly inland, forming wide ranges of brackish and saline environments along the coast until around 5,000 BP. This study reveals that the inland movement of coastlines during the HTM had a significant impact on the habitats, diets, and behaviors of ancient peoples.

Keyword

Sea level, The Holocene Thermal Maximum, Warming, Coast, History

Kuanchuanpu biota – An early Cambrian Orsten-type Lagerstätte yielding the earliest ecdysozoan body fossils

Huaqiao ZHANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China (hqzhang@nigpas.ac.cn)
Yunhuan LIU[2], School of Earth Science and Resources, Chang'an University, Xi'an, China

Abstract

Ecdysozoans refer to a group of protostomes that regularly moult their cuticles during growth, and their modern representatives include Scalidophora (Kinorhyncha, Loricifera, and Priapulida), Nematoida (Nematoda and Nematomorpha), and Panarthropoda (Tardigrada, Onychophora, and Arthropoda). Molecular clock estimates indicate that ecdysozoans may have diverged in the Ediacaran Period or Cryogenian Period, but it was not until the earliest Cambrian Period (ca. 538.8 million years ago) when ecdysozoans first appeared in the fossil record, as represented by *Treptichnus pedum*, a putative priapulid trace fossil. Unambiguous ecdysozoan body fossils, however, first appeared in the early Fortunian (ca. 536.4–531.8 million years ago) Kuanchuanpu biota in northern Sichuan and southern Shaanxi Provinces, South China. The key bed yielding abundant soft-bodied fossils falls within the small shelly fossil *Anabarites trisulcatus-Protohertzina anabarica* Assemblage Zone, and has an estimated age of about 535 million years old. In the past decade, we processed rock samples of more than 10 tons from the key bed through acetic acid maceration, and recovered relatively abundant and diverse ecdysozoan body fossils, including several crown-group cycloneuralian species (e.g., *Eopriapulites* and *Eokinorhynchus*), a total-group ecdysozoan taxon *Saccorhytus*, a total-group ecdysozoan fossil embryo *Saccus*, and introvert musculature of scalidophoran animals. All these fossils are three-dimensionally phosphatized and microscopic in size, and they are preserved in a manner similar to the Orsten-type fossils from the Furongian of southern Sweden. Most are preserved as cuticular remains, some have a digestive tract, and only very rarely can the muscles be preserved. Our analysis shows that *Saccorhytus* is a bag-shaped ecdysozoan and not the earliest deuterostome. The bag-shaped body of *Saccorhytus* indicates that the last common ancestor of the Ecdysozoa may be bag-shaped rather than vermiform. The introvert musculature of scalidophoran animals indicates that priapulid-like introvert musculature may have diverged by the early Fortunian. The Kuanchuanpu biota represents an early Cambrian Orsten-type Lagerstätte. It yields the earliest ecdysozoan body fossils, and provides key insights into the origin and early diversification of the Ecdysozoa, the most speciose and ecologically successful animal lineage on Earth.

Keyword

Saccorhytus, Cycloneuralia, Ecdysozoa, Orsten, Kuanchuanpu

Adaptive specialization of hexactinellid sponges from the early Cambrian black shales of southern China

Hao YUN[1]*, Northwest University (steven6886@126.com)
Cui LUO[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Dorte JANUSSEN[3], Senckenberg Research Institute and Nature Museum
Xingliang ZHANG[4], Northwest University
Joachim REITNER[5], Göttingen Academy of Sciences and Humanities in Lower Saxony

Abstract

Black shales are mostly deposited in dysoxic to anoxic marine environments that inhospitable to most benthic animals. However, flourishing sponge communities dominated by diverse hexactinellids were discovered from the early Cambrian black shales (Niutitang, Shuijingtuo, Hetang, and Huangboling formations; Stages 2 to 4) in the South China block, reflecting an intriguing pattern of adaptive evolution. The adaptive specialization of these sponges is well revealed by two articulated fossil species: Sanshapentella tentoriformis Yun et al., 2022 and Hyalosinica archaica Mehl and Reitner, 1993. The S. tentoriformis has a unique dendriform body that composed of a columnar trunk and multiple conical high projections; each projection is framed by a quadripod-shaped dermal pentactine spicules. This body shape likely reflects a consequence of adaptation that help enlarging the surface area-volume ratio and then maintaining an effective using of oxygen and a low energy cost in the hypoxic condition. The H. archaica possesses an ovoid main body and an impressive long, rope-like stalk, representing the oldest extinct taxon that took advantage of a long root tuft/stalk to elevate the main body above the sediment surface. The long root tuft links Hyalosinica to a series of fossil and recent sponge taxa and indicates a parallel evolution within the Hexactinellida in response to two types of special environmental pressures: 1) frequent currents from different directions and 2) dysoxia. Furthermore, different morphological groups of sponge bodies are discerned from 15 Cambrian hexactinellid genera. The common bodies, including ovoid and cylindrical shapes, are characterized with a relatively smooth wall and mostly a conspicuous osculum at the top (represented by Diagoniella, Protospongia, and Triticispongia). Some cylindrical bodies have an uneven body wall that characterized by numerous small, circular parietal gaps (represented by Hintzespongia) and/or a serrated oscular margin (represented by Lantianospongia). The above-mentioned dendriform (and tent-like) S. tentoriformis and long stalk-bearing H. archaica represent the most uncommon body shapes within the Cambrian sponge communities. Generally, the ovoid and cylindrical bodies were adapted to a large spectrum of environments and thus are ‘one size fits all’ in the adaptive evolution. However, the uncommon bodies, such as Lantianospongia, Hyalosinica, and Sanshapentella, are restricted to black shales, indicating that they are adaptive morphological specializations in response to the inhospitable, oxygen-deficient environments.

Keyword

Porifera, Hexactinellida, adaptive strategy, black shale, Cambrian

Phosphatised calcified cyanobacteria at the terminal Ediacaran and the earliest Cambrian transition stage: Response to the paleoenvironment

Xiao MIN[1]*, Chengdu Center, China Geological Survey (Geosciences Innovation Center of Southwest China) (360446872@qq.com)

Abstract

Calcified cyanobacteria were only sporadically discovered in the Neoproterozoic and did not appear widely until the early Paleozoic. It is proved that the abundance of calcified cyanobacteria is related to the change of atmospheric CO2 level and the calcium carbonate saturation of seawater. Description and systematic research of phosphatized calcified cyanobacteria in the Cambrian is rare, even though some phosphatized materials were reported. A variety of phosphatised calcified cyanobacteria recovered from the terminal Ediacaran Gaojiashan and early Cambrian Terreneuvian Kuanchuanpu biota fill a major gap in the fossil record of calcified cyanobacteria during this transitional period. Calcified cyanobacteria share some similarities in composition and phosphatised preservation style. Thus, research on phosphatised calcified cyanobacteria of the Kuanchuanpu and Gaojiashan biota around the Precambrian–Cambrian boundary sheds new light on the mechanisms of calcification and phosphatisation in cyanobacteria. Based on the morphological variations of Girvanella in these two biotas, three preservation modes, which may not be discernible in thin sections, were recognized. These different preservation modes should result from different degrees of calcification and phosphatisation, instead of evolution. The continuity in the evolution of calcified cyanobacteria and changes in marine chemical conditions indicate that atmospheric CO2 levels may have risen to approximately 10 times present atmospheric level (PAL) after 551 Ma, during the critical period of the Precambrian–Cambrian transition.

Keyword

Phosphatized calcified cyanobacteria, Gaojiashan biota, Kuanchuanpu biota, Terminal Ediacaran, Early Cambrian

Cambrian small skeletal fossil bioprovinces and their application to test paleogeographic models

Michael STEINER[1]*, Shandong University of Science and Technology (Michael.Steiner@FU-Berlin.de)

Abstract

The transition from the Neoproterozoic to the Cambrian period marked a significant era of restructuring and innovation across the Earth's geosphere, hydrosphere, and biosphere. The Cambrian "explosion" witnessed a bioradiation of metazoans, leading to the abrupt appearance of various metazoan bauplans within a brief 20-million-year span of time in the fossil record. This biotic revolution was characterized by a remarkable increase in disparity, with a somewhat moderate rise in metazoan diversity. Despite numerous hypotheses attempting to explain the Cambrian Bioradiation, a consensus has not yet been achieved.

Understanding the causes behind this event necessitates a deeper exploration of sedimentological, geochemical, paleontological, environmental, and tectonic aspects during the Precambrian-Cambrian transition. Astronomical, geophysical, and geotectonic factors are believed to have played a pivotal role in the Cambrian Bioradiation, yet detailed information on these aspects lags behind other geoscience subjects related to this event. Factors such as the geotectonic regime, specific paleogeographic configurations with larger supercontinents or deep ocean barriers, are likely to have exerted influential effects on the biotic development during the Ediacaran-Cambrian period.

Geographic speciation emerges as a crucial mechanism in metazoan evolution, alongside competitive speciation and polyploidy. The division of the gene pool by a geographic barrier, like deep oceanic basins, which has the most impact on benthic fauna, is a prerequisite for speciation and diversification. Therefore, reconstructing the paleogeography and biogeography of the Ediacaran and early Cambrian becomes paramount for a comprehensive understanding of the Cambrian Bioradiation.

Regrettably, the paleogeography of the Ediacaran to early Cambrian remains insufficiently constrained. Recent reconstructions highlight considerable uncertainties in the positions of smaller continental blocks and terrains, with only larger continents showing robust data consistency (e.g. Gondwana). Small terrains impacted by later orogenies (such as the Central Asian Orogeny Belt-CAOB) and more generally by remagnetization events add complexity due to vague hypotheses about the paleogeographic positions of the microcontinents.

To address these uncertainties, Small Skeletal Fossil (SSF) occurrence data for different Cambrian intervals were compiled, and hierarchical cluster analysis was conducted to determine fauna

similarities in different tectonic or geographic sub-regions. Categorizing the SSF fauna into 11 larger provinces facilitated discussions on paleobiogeographic relationships, allowing for a comparison with existing paleogeographic models based on paleomagnetic data.

The results provided a more precise paleogeographic reconstruction for smaller tectonic blocks, especially those undergoing collisional events. The paleobiogeographic reconstruction based on SSFs contributed to the development of a hypothesis for the early Cambrian Ocean circulation pattern, aligned with constraints from modern ocean circulation patterns. This method serves as an independent toolkit to test the validity of existing paleogeographic models in deep time, less susceptible to tectonic and thermal overprinting.

Keyword

Small Skeletal Fossils, Cambrian, Biogeography, Palaeogeography, Cambrian Bioradiation

Chronology of the Ediacaran-Cambrian BoundaryDiscussion with new data from Aksu area of Xinjiang Province, China

Ben YANG[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(yangben8@foxmail.com)

Abstract

GSSP of the Ediacaran-Cambrian Boundary is currently set at the Fortune Head section in Newfoundland of Canada, indexed by the first appearance datum (FAD) of the trace fossil Treptichnus pedum. The Ediacaran- lower Cambrian deposits in this section are composed with siliciclastic sediments preserving no δC13 isotope value and missing the earliest record of body fossils (small shelly fossils or acritarchs etc.). In addition, the FAD of Treptichnus pedum in global sections varied in the lower Cambrian strata. These problems have been challenging the section as a GSSP. Studies are discussing on reassessing the current section or selecting other potential sections for the boundary though most of them has similar problems. Here we make a preliminary discussion on the global correlation of Ediacaran- Cambrian Boundary with new data from the Aksu region of Xinjiang Province in China. The Aksu areas, lying in the northwestern part of the Tarim Block, preserves a set of sections with the earliest small shelly fossils (Protohertzina anabarica, Protohertzina unguliformis, Anabarites trisulcatus, etc.), acritarchs, trace fossils in the basal Cambrian Yuertusi Formation, also δC13 isotope data around the Ediacaran-Cambrian boundary (possibly correlated to the boundary of Yuertusi and underlying Qigebulaq formations). Our data demonstrates a consistence among different types of the data. Comparing with other known sections, here, the data diversity and resolution show potential to overcome the problems discussed above. It is possible to fix a point at sections of the Aksu area for the chronological correlation of the Ediacaran-Cambrian Boundary.

Keyword

Ediacaran-Cambrian boundary, Aksu area of Xinjiang, carbon isotope, small shelly fossils, GSSP

3D morphologies of the early Cambrian Chengjiang arthropods

Yu LIU[1]*, Yunnan Key Laboratory for Palaeobiology, Yunnan University (zac.liu@126.com)
Xianguang Hou[2], Yunnan Key Laboratory for Palaeobiology, Yunnan University
Dayou Zhai[3], Yunnan Key Laboratory for Palaeobiology, Yunnan University
Huijuan Mai[4], Yunnan Key Laboratory for Palaeobiology, Yunnan University

Abstract

The “Cambrian Explosion”, or “Cambrian Radiation”, represents one of the most important events in the evolution of metazoans. Evidence of this event has been found in various Lagerstätten from all over the world, among which the Chengjiang Biota located in Yuxi, Yunnan Province, China provides unparallel fossils of over 300 species from the early Cambrian. More than 80 Chengjiang species belong to the most abundant animal group throughout the entire geological time —the Arthropoda. Knowing the exact morphologies of the early Cambrian arthropods is fundamental for understanding their evolutionary history and ecological traits, which then reflect the co-evolution of these widespread animals and the environment they used to live in. For a long time, due to limitations of methods, researchers have been able to extract only little information, mostly from the surface of the fossils. Little has been known about the important soft-body structures on the ventral side of the Chengjiang arthropods. In recent years, our team has conducted in-depth research on various Chengjiang arthropods from multiple perspectives such as 3D morphology, ontogeny, and phylogeny by using micro-CT scanning, computer-based 3D rendering, and virtual anatomical dissection techniques. New information that had been ignored in previous studies has now been discovered, and certain progress has been made. As a representative of our team, I will talk about these new developments, and provide prospects for the next step of this kind of research.

Keyword

Cambrian Explosion, Arthropoda, Chengjiang Biota, micro-CT, 3D rendering

Ventral Morphology and Their Ecological Implications of Two Xandarellids from Chengjiang Biota, China

Maoyin ZHANG[1]*, Yunnan University (maoyin_zhang@163.com)
Xianguang Hou[2], Yunnan Key Laboratory for Palaeobiology, Yunnan University
Huijuan Mai[3], Yunnan Key Laboratory for Palaeobiology, Yunnan University
Michel Schmidt[4], Yunnan Key Laboratory for Palaeobiology, Yunnan University
Javier Ortega-Hernández[5], Harvard University
Yu Liu[6], Yunnan Key Laboratory for Palaeobiology, Yunnan University

Abstract

Xandarellida, a group of Artiopoda from Cambrian Lagerstätten, is characterized with a broad shape of the exoskeleton dorsally, and a pair of compound eyes followed by a pair of antennae and a series of similar post-antennal appendages ventrally. More morphological details remain ambiguous. The ecological inferences that Xandarellids with large compound eyes are likely to be predators or scavengers do not seem insufficient and still remain controversial. Phylogenetically, the relationships between artiopods and other euarthropods, such as Total-group Mandibulata and Total-group Chelicerata, are still under debate. Phylogenetic relationships among species within this taxon are also uncertain. An explanation for these is that, most artiopods are known with very limited morphological details pertaining to key structures such as the head organization and the biramous appendages. In the present study, we employed X-ray computed tomography to reveal the ventral morphology of two xandarellid species, *Xandarella spectaculum* and *Cindarella eucalla* from the Chengjiang Biota. Key structures including the head organization, trunk limbs and mismatch between tergites and ventral trunk limbs are demonstrated in detail here. We further carried out phylogenetic analyses using both parsimony and MrBayes inferences. Our results suggest that, 1) xandarellids are closely related to naraoiids; 2) xandarellids may not be predators or scavengers, but rather particle feeders that used to live near the sea floor in shallow waters.

Keyword

Artiopoda, exceptional preservation, Ventral organization, micro-CT, Ecology

Spatially and temporally dynamic marine redox state through late Ediacaran-early Cambrian: evidence from carbonate I/Ca proxy

Ruliang HE[1]*, Northwest University (rulianghe@nwu.edu.cn)
Chao Chang[2], Northwest University
Hao Yun[3], Northwest University
Wei Liu[4], Northwest University
Xingliang Zhang[5], Northwest University

Abstract

Ediacaran-Cambrian witnessed the bio-diversification from the appearance of earliest metazoans to Cambrian Explosion. The increased oxygenation state of marine-atmosphere system has commonly been considered as a primary environmental trigger. However, growing evidence of geochemical proxies and numeric models has questioned the unidirectional shift of marine redox state during this interval, highlighting a spatiotemporally dynamic redox condition during Ediacaran to Cambrian. To address this issue, we report new I/Ca data, a local redox proxy, from Ediacaran-Cambrian carbonate successions of different depositional environments in Tarim Basin and South China. In Tarim Basin, comparing to the relatively low I/Ca background of Ediacaran, high I/Ca ratios up to 2-4μmol/mol, comparable to I/Ca in the modern well-oxygenated waters, are observed at the Yuertusi Formation of early Cambrian, coincident with the occurrence of small shelly fossils (SSFs). For South China cores, the overall I/Ca values of early Cambrian are comparable to the background of Ediacaran (< 1μmol/mol) with transient I/Ca pulses observed, suggesting a generally oxygen-depleted condition in the upper ocean. Some high I/Ca values are observed in Yanjiahe Formation South China, but they are suspectable to the contamination from apatite, suggested by a positive correlation between I/Ca and P content. Our results suggest the overall marine O2 content may still be relatively low in Ediacaran-early Cambrian; oxygenation pulses could have occurred both in Tarim Basin and South China, but such oxygenation events are temporally inconsistent and spatially heterogenous, probably associated with their own local oceanographic settings. The spatiotemporally dynamic redox condition could be a major feature of the Ediacaran-early Cambrian ocean that nurtured the Cambrian Explosion.

Keyword

Cambrian Explosion, redox, I/Ca proxy

The anterior sclerite in early arthropods

Mengxiao YU[1]*, Yunnan University (ymx720@126.com)
Yu Liu[2], Yunnan Key Laboratory for Palaeobiology, Yunnan University
Xianguang Hou[3], Yunnan Key Laboratory for Palaeobiology, Yunnan University
Huijuan Mai[4], Yunnan Key Laboratory for Palaeobiology, Yunnan University

Abstract

The so-called “arthropod head problem” is a highly debated topic in the studies of arthropod evolution. This “problem” mainly deals with the alignment of head segments across various groups. The anteriormost head segment of euarthropods is often called “anterior sclerite” which, in our view, only refers to the tergite of that segment. The anterior sclerite has been considered as a derivative of the dorsal plate in the anterior region of radiodonts. Despite suggestions of its homology and neurological origin across these groups, the precise morphology and evolutionary significance of this structure remains ambiguous. This is mainly because of the flattened preservation of the fossils, which didn’t allow in-depth investigations along the direction of fossil compression. Due to the recent advances in technology, such as microtomography and computer-based 3D rendering techniques, our team has been able to observe and reconstruct the ventral organization of the head in various early arthropods from the early Cambrian Chengjiang biota. By comparing the new data from several arthropod species from Chengjiang, we propose that the anterior sclerite has a more intimate relationship with the visual system than previously thought. After inherited from radiodonts, the anterior sclerite remains as a separate structure in several euarthropod groups, but becomes part of the head via a fusion mechanism in various euarthropod lineages.

Keyword

Arthropoda, anterior sclerite, evolution, micro-CT

TriBE: An international working group dedicated to understanding the early Palaeozoic dispersal and radiation of trilobites, and first results on trilobite palaeobiogeographical patterns

Harriet Bethany B. DRAGE[1]*, University of Lausanne (harriet.drage@unil.ch)
Luis Collantes[2], University of Coimbra
Elizabeth M. Dowding[3], Friedrich-Alexander-University
Jorge Esteve[4], Complutense University Madrid
James D. Holmes[5], University of New England
Katherine J. Jordan[6], University of Nebraska-Lincoln
Lukáš Laibl[7], Czech Academy of Sciences
Adriane R. Lam[8], Binghamton University
Kelsey N. Lucas[9], University of Calgary
Mark C. Nikolic[10], American Museum of Natural History
Stephen Pates[11], University of Exeter
Alexis Rojas[12], University of Helsinki
Fernanda Serra[13], CICTERRA (CONICET - UNC)
María Gabriela Suárez[14], University of Zürich

Abstract

Earth's Palaeozoic marine environments were undoubtedly dramatically impacted by the evolution and global radiation of trilobites, an extremely diverse extinct euarthropod group that occupied almost all marine ecological niches. However, the processes by which trilobites dispersed and diversified around the globe in the early Palaeozoic remain unclear, amplified by aspects such as incomplete understanding of the biogeographical occurrences of different trilobite groups and underlying uncertainty around geographical reconstructions (e.g., biologically-informative regions, plate reconstruction models). We introduce an international working group ('TriBE: Trilobite Biogeography and Ecology') of primarily early-career researchers established to drive forward research on trilobite biogeography and dispersal, and their links to ecological mode. We present reconstructed trilobite biogeographical patterns accompanying their initial global radiation from the early to late Cambrian. We used biogeographical data collected by the working group members and data retrieved from the Paleobiology and Geobiodiversity Databases to analyse trilobite biogeography. We used the published Cambrian phylogenetic tree of 107 species with tip-dating (representing most of the Cambrian trilobite families) by Paterson et al. (2019) and conducted biogeographic analyses using the R package BioGeoBEARS to reconstruct ancestral area relationship. The results of the BioGeoBEARS analysis inform on Cambrian trilobite ancestral geographical ranges, infer the number and type of allopatric evolutionary events, and reveal the connectivities of different regions during this crucial stage of euarthropod evolution. These data will then be applied, in addition to occurrence, ecological (e.g., life habit, diet), and environmental information, to broad-scale analyses exploring dispersal mechanisms and patterns in the Cambrian and later Palaeozoic using sophisticated network analyses. The TriBE working group is thereby elucidating the enigmatic and foundational dispersion of trilobites in the

Palaeozoic, the underlying causes of their biogeographical ranges, and their varied and extensive impact on early global ecosystems.

Keyword

Trilobita, Palaeobiogeography, Vicariance, Dispersal, Cambrian

Crown group sponges from the Nama Group of Namibia, and the evolution of spiculogenesis across the Ediacaran-Cambrian transition

Alex George LIU[1]*, University of Cambridge (agscl2@cam.ac.uk)
Xiaopeng WANG[2], Nanjing Institute of Geology and Palaeontology, Nanjing, China
Brennan O'CONNELL[3], University of Cambridge, U.K.
Philip VIXSEBOXSE[4], University of Cambridge, U.K.
William J. MCMAHON[5], University of Cambridge, U.K.
Helke MOCKE[6], Geological Survey of Namibia Museum, Windhoek, Namibia

Abstract

Macrofossils of late Ediacaran age are increasingly recognised to include representatives of stem and crown group metazoan phyla, but robust fossil evidence for Ediacaran Porifera has proven elusive. Here we describe a new Ediacaran macrofossil genus, comprising two distinct species, from the late Ediacaran Aar Member (~548 Ma) of the Nama Group of southern Namibia. The two new taxa, which are globular and bowl-shaped respectively, can reach at least 40 cm in size, are often preserved three-dimensionally, and exhibit surface impressions of a grid of sub-divided quadrate boxes that covers the entire body. Preservation of some specimens in the assemblage with regions showing entirely smooth surfaces (lacking the grid, which often occurs on sub-millimetric surface veneers), and wrinkling, suggests that these taxa possessed a smooth and flexible internal membrane. Such specimens find comparison with a number of similar smooth, three-dimensional, bag-like structures preserved in sandstones in other global localities. The grid impressions are interpreted to indicate the presence of a non-mineralized organic exoskeleton comprised of cruciform skeletal elements, similar to that seen in several biomineralized Cambrian hexactinellids. Reappraisal of late Ediacaran candidate sponges and earliest Cambrian sponge spicules supports the suggestion that spiculogenesis evolved prior to the evolution of biomineralization, and is consistent with the independent acquisition of biomineralization amongst the major poriferan clades. The Namibian specimens provide a new search image for fossil sponges prior to the evolution of mineralized spicules, and suggest that the fossil record of late Ediacaran sponges may be far more diverse than previously recognised.

Keyword

Ediacaran, Spicule, Biomineralization, Porifera, Silica

Systematics of the Redlichiidae (Redlichiida, Trilobita) and related groups

Zhixin SUN[1]*, Nanjing Institute of Geology and Palaeontology, CAS (zxsun@nigpas.ac.cn)
Fangchen ZHAO[2], Nanjing Institute of Geology and Palaeontology, CAS

Abstract

As an exemplification of primitive trilobites, redlichioids and related groups from the early Cambrian is important for understanding the origin and early evolution of trilobites. Here, we suggest a revised systematics of Redlichiidae Poulsen 1927 and related taxa based on types and new materials from South China. The new systematics through phylogenetic analysis indicates that Redlichiidae s. l. is indeed nonmonophyletic, and many groups previously placed under this superfamily (such as Saukiandidae Hupé 1953, Menneraspidae Pokrovskaya 1959, Metadoxididae Whitehouse 1939, Kueichowiodae Liu 1965 and Mayiellidae Chang 1966) are reassigned to other clades. The Yinitidae Hupé 1953 s. l. do not constitute a monophyletic group in our analyses, and most genera previously belonged to this family are reassigned to Longduiidae Zhang & Qian 1980, Drepanopygidae Lu 1961 and Yiliangellinae Zhang & Lin 1980 (?Gigantopygidae). Longduiidae and Drepanopygidae was nested within the ‘corynexochids’ clade, and Yinitidae s. s. are possible annectant forms between Redlichioidea s. s. and stem ‘corynexochids’ such as the Edelsteinaspididae Hupé 1953 and Jakutidae Suvorova 1959. In addition, our new systematics suggest that ‘ellipsocephaloids’ should not be included in the Redlichiidae s. s., and favor a relationship between this group and Paradoxidoidea. Although the considerable uncertainty across phylogenetic analysis, these results imply that early trilobites require a new high-level classification scheme.

Keyword

Trilobite, phylogenetic analysis, early Cambrian, Redlichiidae

Ediacaran chronostratigraphy: falling into place or falling into pieces?

Dmitrii GRAZHDANKIN[1]*, Northwest University, Xi'an, China (f6oeoua@mac.com)

Abstract

The prospect of subdivision of the Ediacaran System into chronostratigraphic units that would represent globally recognisable intervals of geological time and serve as references in narratives about biosphere evolution is tremendously appealing, but hardly any pattern is discernible in the distribution of fossil taxa. Ediacaran chronostratigraphy is currently in a state of ferment, stirred by the addition of new geochemical and geochronological data as well as controversial interpretations of fossils. It appears that biotic evolution proceeded in mostly anoxic environments, and was punctuated by episodic oxygenation, global-scale euxinia, and alkalinity events. It is generally accepted that the Ediacaran macro-organisms were “normal” aerobic metazoans; however, recent evidence from Siberia suggests that not only were these organisms tolerant of anoxic conditions, but they also had the capacity to function anaerobically. The implications are sobering: the late Ediacaran increase in ecological and morphological complexity does not represent an expansion of aerobic metabolism. Recent discoveries continue to challenge the existing orthodoxies. Previous studies have separated late Ediacaran palaeocommunities into three taxonomically distinct assemblages. Known as the Avalon-, White Sea- and Nama-type biotas, these benthic communities were arguably adapted to different specific yet-unknown environmental conditions and were the subject to different taphonomic processes. Hydrodynamics, water depth, sedimentation rates, and/or substrate heterogeneities have been suggested as potential factors that could determine taxonomic composition and structure of the Ediacaran communities; however, it has been difficult to explain the absence of Ediacaran fossils in lithofacies that are otherwise fossiliferous. What is usually overlooked is the relative position of chemocline. Although persistent widespread anoxic conditions are generally assumed to be lethal to benthic Ediacaran communities, studies in the Khatyspyt lagerstätte of Arctic Siberia have demonstrated that anoxia might have driven ecological differentiation of organisms, and that heterogeneous and dynamic redox landscapes were far more significant in early animal evolution than hitherto appreciated. More important is that the preservation of Ediacaran soft tissues via authigenic precipitation of micrite cements in the Khatyspyt lagerstätte appears to be controlled by the relative position of redox chemocline, whereas the disappearance of the fossils in the Khatyspyt Formation correlates with the stepwise oxygenation of the water column. So taphonomy and palaeoecology both matter for the Ediacaran chronostratigraphy – but to a surprising extent in a positive and constructive way. Eventually, there may be no simple correlation between the Ediacaran biotic evolution and the geological record of environmental perturbations; but it seems increasingly possible that the Ediacaran macro-organisms disappeared from the geological record as a consequence of progressive oxygenation, providing strong evidential basis in support of the “Cheshire cat” model. The observed patterns of Ediacaran fossil distribution most likely mirror the the episodes of basin-scale authigenic cementation of the sediment during alkalinity events

triggered by redox fluctuations in Ediacaran habitats. Perhaps those glued to their computer screens laboriously correlating peaks and plateaus on carbon isotope variation curves should emerge blinking into sunlight where the emerging Ediacaran palaeobiology awaits our exploration. This research was supported by the Russian Science Foundation (project 23-17-00202).

Keyword

Ediacaran, chronostratigraphy, palaeontology

Preservation of arthropods and microbes in Cambrian Orsten Lagerstätten

Jonathan POPLE[1], University of Lausanne
Pierre GUERIAU[2], University of Lausanne
Allison DALEY[3]*, University of Lausanne (allison.daley@unil.ch)

Abstract

The Upper Cambrian Orsten locality in Sweden has yielded abundant microscopic arthropods phosphatically preserved in exquisite 3-dimensional detail, revealing much about their anatomy, systematics, and ontogeny, and providing a window into Cambrian meiobenthic faunas which are usually absent from the more common Burgess Shale-Type Lagerstätten. However, despite this exquisite quality of preservation, the Orsten is highly selective in the range of sizes, tissues, and taxa preserved and almost only yields hollow carcasses of cuticle-bearing metazoans smaller than 1-2 mm. The reasons for this selectivity and the processes that led to the exceptional preservation of these organisms have yet to be elucidated. Combining synchrotron radiation X-ray microtomography (SR-µCT) with scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDX), we undertook a taphonomic examination of over 60 bivalved phosphatocopine arthropods that we collected from an Upper Cambrian Alum Shale outcrop in the Kinnekülle region of Västergötland, Sweden. Shield valves are extremely well preserved in all specimens, and soft tissues within the valves are preserved in a third of specimens but restricted to small individuals (length < 350 µm). These soft tissues include the external cuticle of the body and the appendages, and a grade of taphonomic states was observed ranging from highly detailed and complete external cuticle, through various stages of disarticulation and loss of cuticular detail, to indistinct masses of globules reproducing only broad anatomical features.

SR-µCT and SEM results show that no internal anatomical structures can be distinguished within the internal space of the body and appendages of the Orsten phosphatocopines. Instead, spherical phosphatic globules partially fill the cuticle, sometimes creating near-complete pseudomorphs of external anatomical structures and appendages. These globules are hollow or less dense at their core, and in any given specimen they have a narrow diameter size range averaging between 2 and 5 µm depending on the specimen. The size, morphology, and spatial distribution of these globules lead us to propose that they represent autolithified and minerally overgrown bacteria preserved inside the cuticle, and that these bacteria were intricately associated with the phosphatisation process. We also observed highly localized filamentous structures interpreted as bacterial biofilms, which also indicate that bacterial activity was taking place in the immediate proximity of decaying arthropod carcasses. These observations provide direct evidence for the involvement of internal and external microbial activity in Orsten-type preservation and allow for a step-by-step reconstruction of phosphatization processes.

Keyword

Cambrian, Arthropoda, Orsten, Phosphatization

Taxonomic revision of Dickinsonia Sprigg

Nikita SOZONOV[1]*, The Trofimuk Institute of petroleum Geology and Geophysics SB RAS (n.sozonov@g.nsu.ru)
Natalia Bykova[2], The Trofimuk Institute of petroleum Geology and Geophysics SB RAS
Nikolay Bobkov[3], The Trofimuk Institute of petroleum Geology and Geophysics SB RAS
Dmitriy Grazhdankin[4], The Trofimuk Institute of petroleum Geology and Geophysics SB RAS

Abstract

This study presents a comprehensive analysis of the genus Dickinsonia, a prominent member of the Ediacaran biota, aimed at refining its taxonomy and deepening our understanding of its ecology and evolution. A total of nine species of Dickinsonia have been described, of which six remained valid until recently: D. costata, D. tenuis, D. lissa, D. brachina, D. menneri and D. rex. Initially described based on a few specimens, these species gradually become increasingly difficult to distinguish from each other as material accumulates. Thus, determining the species identity of many individuals might be difficult due to the lack of clear diagnostic characters, especially for small-sized individuals. A similar fate befell the Dickinsonia population, discovered in the Konovalovka Member of the Cherny Kamen Formation cropping out along the Sylvitsa river in the Central Urals. The Central Ural population possesses a narrow unpaired deltoidal module, which brings them closer to D. tenuis, but the density of modules is not high enough for being attributed to this species.

A recent attempt on the revision of the genus Dickinsonia, shows that the taxonomy of the genus is redundant. Based on the results of the study, they propose to reduce the number of species to two, the most clearly distinguishable. But this study mainly analyzed samples from Australia, and only 2 samples from the White Sea were used, which cannot reflect the entire range of intraspecific variability in D. menneri and D. tenuis.

Our study is the first large-scale attempt to revise the taxonomy of genus Dickinsonia using specimens from all three known localities. To evaluate intraspecific variability and aid in species delineation, we performed morphometric analyses on 259 specimens, utilizing extensive collections from the Melbourne Museum and the South Australian Museum (161 specimens), the White Sea coast (20 specimens), and the Ural Mountains (78 specimens).

Our findings reveal significant morphological diversity within Dickinsonia populations, challenging previous taxonomic classifications. Through principal component analysis (PCA) and clustering techniques, we identified distinct clusters corresponding to different geographic regions, with notable variations in size and module density. Importantly, our results support the division of the Australian collection into two clusters proposed by previous studies but also reveal two additional clusters encompassing Ural and White Sea samples.

This revised taxonomy provides a framework for more informed comparisons between Dickinsonia specimens from different localities, offering new insights into their ecology and evolutionary trajectories during the Ediacaran period. Furthermore, our study underscores the importance of considering intraspecific variation and geographic distribution in elucidating the

adaptations and developmental processes of Ediacaran organisms.

The study was supported by the Russian Science Foundation № 23-27-00413, https://rscf.ru/project/23-27-00413/

Keyword

Dickinsonia, Ediacaran, clusterization, taxonomy

A tiny Cambrian euarthropod illuminates the early evolution of mandibulates

Han Zeng[1], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Yao Liu[2]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
(yaoliu@nigpas.ac.cn)

Abstract

The mandibulates are the most abundant and diverse euarthropods on the earth. Although the diverse stem- and crown-group mandibulate euarthropod fossils have been discovered from the Cambrian, the evolutionary gaps in the origin of mandibulates remain to be filled, and the phylogenetic position of the related groups of mandibulates need to be clarified. Cambrian Burgess Shale-type fossil Lagerstätten have contributed significant evidence for exploring these questions. Recently, we study a common few millimeters-large euarthropod that is a potential mandibulate taxon from the early Cambrian Chengjiang fauna, China, which lacks high-resolution morphology and has questionable evolutionary affinities. By using computed microtomography, scanning electron microscope and other imaging techniques, we have uncovered additional and crucial high-resolution morphology, encompassing the intricate structures and the precise position of the appendages, novel structural elements and the details of the soft tissue. Furthermore, we have conducted a comparative analysis of the key morphological characters with those of closely related groups within the mandibulates and chelicerates, while also providing an in-depth discussion on its Palaeoecology. Through the integration of morphological linkages and phylogenetic analysis, we have documented its precise phylogenetic placement and provided comprehensive insights into the intricate aspects concerning the origin and early evolution of mandibulates.

Keyword

Mandibulata, computed tomography, phylogeny

Complete radiodonts from the early Cambrian Chengjiang fauna: implications on radiodont evolution

Han ZENG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (hzeng@nigpas.ac.cn)

Abstract

The Palaeozoic radiodonts are important for understanding the evolution and ecology of early euarthropods. Nonetheless, complete radiodont specimens are extremely rare and are only discovered from soft-bodied fossil deposits. Among these fossil records, the oldest Chengjiang Lagerstätte has yielded three radiodont species with complete specimens. Here we provide detailed redescription of a classical specimen from the Chengjiang fauna and assign it to a new taxon Innovatiocaris maotianshanensis gen. et sp. nov.. The head of I. maotianshanensis has a pair of stalked eyes, an ovate dorsal sclerite, a pair of frontal appendages composed of 11 distal articulated podomeres bearing spiky endites with only anterior auxiliary spines, and a putative triradial oral cone. The body possesses six anterior pairs of small differentiated neck flaps and ten posterior pairs of trunk flaps, with soft tissues including alimentary canal and musculature preserved. The tail includes a tail fan comprising three pairs of lateral blades and a pair of very long furcae. Another two possible species of Innovatiocaris, Innovatiocaris? sp. and I.? multispiniformis sp. nov., are also established based on the distinct features of frontal appendages uncovered from the Chengjiang fauna. The evolutionary implications of Innovatiocaris are discussed in the context of radiodont phylogeny. Phylogenetic analysis retrieves Innovatiocaris as either a basal member of Hurdiidae or early-branching species of the non-hurdiid clade. Innovatiocaris provides new insights into the radiodont phylogeny and illuminates the early diversification of Radiodonta.

Keyword

Radiodonta, Arthropod evolution, Chengjiang fauna, Cambrian explosion, Anomalocaris

Did ctenophores construct colonies in the Ediacaran?

Vladislav DESIATKIN[1]*, Trofimuk Institute of Petroleum Geology and Geophysics of Siberian Branch Russian Academy of Sciences (IPGG SB RAS) (desyatkinvd@ipgg.sbras.ru)
Dmitry Grazhdankin[2], Trofimuk Institute of Petroleum Geology and Geophysics of Siberian Branch Russian Academy of Sciences (IPGG SB RAS)

Abstract

Among all Ediacaran macroscopic organisms feather-like specimen stimulate minimal interest from the researchers. However, these organisms may provide us a lot of new information and make us reconsider our understanding of certain Metazoan groups.

Our study is based on exceptionally preserved fossils from Ediacaran Yorga Formation, Southeast White Sea area. In contrast to the feather-like fossils found in South Australia and Avalonia, which are preserved as high-relief casts on the surfaces of sandstone beds, the White Sea specimens are preserved as pyritized three-dimensional composite casts within sandstone beds. We have managed to observe not only well described morphostructures such as holdfast, axial structure, lateral antimers and rows of metamers but also some internal structures. Through observing certain specimens and CT-scanning we have discovered a set of membranes that apparently are continuation of lateral antimers in the axial structure. Internal membranes separate axial structure into high-integrated and distinct segments. We assume that an axial structure wasn't an organ that carried lateral antimers like an axial zooid of sea-pens. The metamers occur as rows that have alternated localization at the each segment. These data indicate a biradial symmetry and possible colonial organisation of feather-like fossils.

Recently, the possible colonial organisation of feather-like fossils has generally been regarded in the context of Cnidaria association hypothesis. However, the presented herein evidence contradicts this hypothesis. Despite the similarity between certain structures of Pennatulacea and the feather-like fossils we observe two different body plans. In this case, could we associate feather-like fossils with another group of Metazoa? Among all Metazoa types only Bilateria, Cnidaria and Ctenophora are able to construct complex multi-tissue bodies. This result in considering the less popular Ctenophora phylogenetic association hypothesis. Previously, the hypothesis couldn't operate with the informations about ctenophores that we have now, and therefore it wasn't able to provide answers to some critical questions. Since then, several morphological and molecular-genetic studies have yielded interesting results which allows us to consider the hypothesis. By studying the modern ctenophore genome and comparing it to the genomes of other Metazoa groups, we have identified several features that we consider as significant evidence for the hypothesis: an earlier separation of ctenophores from others; independent development of the neural and muscular system; phenotypic plasticity with common body-plan. If we assume that feather-like fossils are a stem or an extinct crown-group ctenophores, then the question arises regarding the colonial organization that we observe in feather-like fossils but not in modern ctenophores.

The basal position of ctenophores in the phylogenetic tree of animals, their high regenerative ability and phenotypic plasticity allows us to suppose the presence of the ability for colonial organisation and a sedentary lifestyle in stem ctenophores, which is typical in other Metazoa and lost in ctenophores during their evolution. The construction of feather-like fossils corresponds to the proposed construction of colonial sedentary ctenophore. The paleontological, morphological and molecular-genetic evidence presented above allow us to consider feather-like fossils as colonial ctenophores.

This research was supported by the Russian Science Foundation (project 23-17-00202).

Keyword

Ediacaran, Feather-like fossils, Ctenophores, Coloniality

Putative soft-bodied structures in early Cambrian Orsten-type fossil lagerstätten of the Yangtze Platform

Yuqian CHEN[1]*, Shandong University of Science and Technology (rubbycyq@163.com)
Michael Steiner[2], Shandong University of Science and Technology
Ben Yang[3], Chinese Academy of Geological Sciences

Abstract

The Ediacaran–Cambrian transition is a fundamentally important period in the history of life on Earth, the global rearrangement of palaeo-plate tectonics, the palaeo-climate, the marine palaeo-environments and their diverse habitates and palaeo-biocenoses all underwent significant changes during this period. Therefore, the Ediacaran–Cambrian holds an important role in the origin and evolution of metazoan clades and marine palaeo-environmental changes.

Orsten-type preservation is an exceptional preservation that refers to an early, three-dimensionally stabilizing preservation of soft integument and soft-part structures by calcium phosphate (apatite). This type of preservation shows features that are usually not recognizable in fossils, and their detailed morphological characteristics provide convincing evidence of the general body plan, organ preservation, systematics, and ontogeny. In South China, Precambrian and Cambrian sediments have yielded multiple evidence of invertebrate embryos and larvae in Orsten-type preservation (including Doushantuo-type preservation sensu Butterfield). Some key Orsten-type lagerstätten with embryos have been reported from the early Cambrian of Shaanxi, Sichuan, Hubei, Yunnan, the upper to middle Cambrian of Hunan, and the Ediacaran of Guizhou. Here we discuss a new occurrence from the early Cambrian of the south-western margin of the Yangtze Platform. The assemblage contains eggs, embryos and hatchlings as well as small skeletal fossils (SSFs).

The Ediacaran-Cambrian strata of the Yangtze Platform of South China preserve rich sedimentary facies, continuous deposition and extensive exposure which makes them an important repository for unravelling the early co-evolution of life and environments. We provide an overview of the regional and stratigraphic distribution of the key Orsten-type taxa, extraordinarily preserved embryos, hatchlings, phosphatized organisms with putative soft-bodied structures, and some associated SSFs. In addition, we discuss a new interpretation of putative soft-bodied structure based on our newly found samples.

SSFs have been widely discovered in early Cambrian successions across the globe, and owing to their broad distribution and rapid evolution, SSFs have been applied for global correlation of early Cambrian strata. They are abundant in Early Cambrian carbonates of the Yangtze Platform and are found especially in shallow water environments. Based on the comparison of the SSF assemblages and other evidence of different regions in China, the similarities in the palaeoenvironmental

conditions for the Orsten-type preservation are considered. The new findings may have some relevance for the future recovery of potential Orsten-type fossil deposits on other palaeo-continents.

Keyword

Embryo, Ontogeny, Taphonomy, Small skeletal fossil, Orsten-type

The structural diversity of mollusk shells in early Cambrian

Luoyang LI[1]*, Ocean University of China (liluoyang@ouc.edu.cn)

Abstract

The evolutionary success of mollusks can be related to the effective protection of their highly mineralized shells that were acquired during the period of the Cambrian explosion (~560–520 Ma) when most modern animal phyla first emerged alongside the acquisition of the ability of biomineralization. Mollusks can construct extremely intricate shells with crystals of calcium carbonate (CaCO3, mainly aragonite and calcite), >95wt%, embedded within a three-dimensional organic matrix that generally accounts for less than 5% of shell weight, and their multiscale hierarchical architectures endow their outstanding mechanical properties that are far superior to non-biogenic counterparts. Over the past decades, extensive studies and great interest in modern shells have allowed the biological, chemical, and material science fields to elucidate many principles of molluskan biomineralization. From a palaeontological viewpoint, mollusks originated and diversified very early in the Cambrian, flourished around the globe, and constituted major elements of Cambrian marine communities. Much attention has previously been paid to the taxonomy, phylogeny, biostratigraphic, and palaeogeographic implications of Cambrian mollusks, particularly based on millimeter-size ‘micromollusks’ that were retrieved from so-called Small Shelly Fossil (SSF) assemblage worldwide. Microstructurally, global phosphogenesis events across the Precambrian-Cambrian transition enabled the preservation of mollusk shells in fine detail, even at micrometer and sub-micrometer levels, however, biomineralization studies are still very challenging due to the long history and complex processes of diagenesis. Since the pioneering work of Bruce Runnegar, few authors have investigated the shell microstructures of Cambrian mollusks that were preserved on the surface of phosphatic steinkerns. So far, available but scattered fossil data has suggested that, possibly from an ancestral organic scaffold, different mollusk groups first constructed various laminar fibrous microstructures under weak control, followed by the evolution of more complex, more derived architectural organizations through time. A range of microstructures that are commonly found in modern shells was demonstrated to have also occurred in early Cambrian fossil shells, such as foliated aragonite, fibrous, prismatic, and crossed-lamellar forms, suggesting the rapid architectural diversity and increasing control over biomineralization of early Cambrian mollusks.

Keyword

Biomineralization, Shell microstructure, Mineralogy, Cambrian Explosion

Cambrian Burgess Shale-type fossil Lagerstätten of North China

Pingli WANG[1]*, Shandong University of Science and Technology (wangpingli@sdust.edu.cn)
Michael STEINER[2], Shandong University of Science and Technology
Yuze WANG[3], Shandong University of Science and Technology

Abstract

The North China Plate is as a classical region for studying sedimentary strata and associated fauna of the Cambrian Period with a research history spanning over a hundred years. However, Burgess Shale-type fossil lagerstätten have only lately been discovered there and did not attract much attention until now. In recent years, some Burgess Shale-type fossils reported from North China have provided new data on the temporal and spatial distribution of important Cambrian taxa. Furthermore, their preservation as organic films offered valuable material for unique taphonomic studies. The previously documented Burgess Shale-type fossils include palaeoscolecids from the Early Cambrian of Anhui Province. Besides this, the majority of Burgess Shale-type fossils reported from North China comes from the Mantou Formation and the Panchegou Member of the Zhangxia Formation. Some of them are assigned into the so-called Weifang Biota and Linyi Lagerstätte. These preservations include bivalved arthropodsSeries 2, Shandong Province, eocrinoids (Series 2, Liaoning Province), the frontal appendage of anomalocaridsSeries 2, Hebei Province, the arthropod Sidneyia cf. inexpectans (Miaolingian, Shandong Province), articulated hexactinellids sponges (Miaolingian, Henan Province, hurdiadids (Miaolingian, Shandong Province) and trilobites with putative gut preservationMiaolingian, Shandong Province. The most recently reported Burgess Shale-type fossil Lagerstätte from North China is the Linyi Lagerstätte (Miaolingian, Shandong Province)which includes excellent preservation of arthropod limbs, eyes and gut-induced structures contributing to the general understanding of the preservational mechanisms of fossil lagerstätten. Moreover, the Linyi Lagerstätten indicate a close similarity in the taxic composition to Laurentian Lagerstätten. We extend the record of Burgess Shale-type fossils from North ChinaMiaolingian, Shandong Provinceby palaeoscolecids, slightly three-dimensionally preserved hexactinellids, new types of tubular remains, as well as trace-preserving hurdiids and arthropods Tuzoia. Especially the fossils preserved in organic-rich shales are helpful in identifying the remaining organic components and deducing on the fossil burial mechanisms, which shed light on exploring for more Cambrian exceptional preservation in North China.

Keyword

North China, Burgess Shale-type fossil, Cambrian

Evolution in Polar Ecosystems: The Early Ordovician of Morocco and France

Gaëtan JM POTIN[1]*, University of Lausanne (gaetan.jm.potin@outlook.fr)
Farid Saleh[2], University of Lausanne
Lorenzo Lustri[3], University of Lausanne
Pierre Gueriau[4], University of Lausanne
Jonathan Pople[5], University of Lausanne
Allison C Daley[6], University of Lausanne

Abstract

Exceptional fossil preservation enhances our understanding of ancient ecosystems by providing a record of soft-bodied organisms lacking characterized structures. Sites containing such fossils offer valuable insights into past animal ecosystems, particularly during the Cambrian and the Ordovician, (~500 million years ago), when most modern animal phyla appeared and diversified. However, a significant challenge arises as most of these preservation sites are associated with paleotropical and temperate ecosystems, leaving a notable gap in our knowledge regarding past polar regions.

Addressing this knowledge gap is crucial for comprehending the evolution of animal life on Earth, especially since the Early Ordovician was characterized by elevated temperatures, warmer than those experienced today, with little to no ice at the poles. Earth's history has witnessed fluctuating environmental periods between Greenhouse and Icehouse conditions, characterized by the absence or presence of ice on the poles, respectively. This study explores two Early Ordovician fossil sites with soft-tissue preservation located in Morocco and France, both previously situated on the margin of the Gondwana continent within the polar circle.

The Fezouata Shale, the Tremadocian/Floian formation from Morocco, reveals an exceptionally diverse assemblage of marine animals including abundant arthropods, echinoderms, brachiopods, and graptolites. This biota provides, for example, unique insights into giant suspension-feeding radiodonts and the ontogeny of the oldest horseshoe crabs. The Cabrières Biota, from the Floian of France, has been recently discovered, and it exhibits a diverse assemblage dominated by arthropods and sponges. Being the closest biota to the paleo south pole, the Cabrières Biota likely served as an animal refuge amidst the high-water temperatures at lower latitudes. Due to their paleogeographical position and high biodiversity, the Fezouata and Cabrières biotas offer unique opportunities to explore animal adaptations under Greenhouse conditions in deep time.

Keyword

Polar ecosystems, Early Ordovician, Evolution, Fezouata Biota, Cabrières Biota

Morphological comparison with Cambrian relatives reveals the evolution of tardigrades

Ji-Hoon Kihm[1]*, Korea Polar Research Institute (jhkihm@kopri.re.kr)
Xingliang Zhang[2], Shaanxi Key Laboratory of Early Life & Environment, Department of Geology, Northwest University, China
Jianni Liu[3], Shaanxi Key Laboratory of Early Life & Environment, Department of Geology, Northwest University, China
Tae-Yoon S Park[4], Division of Earth Sciences, Korea Polar Research Institute

Abstract

The phylum Tardigrada, commonly known as water bears, is renowned for their ability to enter cryptobiosis, the state of metabolic suppression. These microscopic invertebrates possess four paired limbs and are classified into two classes: Eutardigrada and Heterotardigrada. Tardigrades are believed to have evolved from lobopodians, ancient soft-bodied vermiform animals with lobopodous limbs that have been discovered mainly in Konservat-Lagerstatten. Unlike their closest relatives, onychophorans and euarthropods, the specific origin of tardigrade morphological features remains uncertain, and thorough comparison with lobopodians has been lacking.

We have conducted a detailed morphological comparison between tardigrades and Cambrian lobopodians. Our analysis includes a phylogenetic assessment encompassing a wide range of lobopodians and three panarthropod phyla. The result of the analysis suggests that ancestral tardigrades likely exhibited a morphology similar to Cambrian lobopodians and shared a most recent ancestry with the luolishaniids, a lobopodian group with two types of lobopodous limbs. Internally, ancestral tardigrades likely possessed a worm-like body shape devoid of segmental plates, but with cuticular structures surrounding the mouth opening. Additionally, their lobopodous legs terminated with claws, but lacked digits. These findings contradict the long-standing hypothesis of a stygarctid-like ancestor.

The highly compact and miniaturized body plan observed in tardigrades emerged after their lineage diverged from an ancient shared ancestor with the luolishaniids. This also warrants a future research topic for further comparison of tardigrade mouth structure with other ecdysozoans, such as palaeoscolecids.

Keyword

Ecdysozoan, Tardigrade, Lobopodian, Cambrian, Morphological comparison

Preliminary study on Cambrian shell fossils from the Xiweikou Section in Yuncheng, ShanxiChina

Zhao Wang[1]*, Northwest University (1306788040@qq.com)
Zhifei Zhang[2], Northwest University

Abstract

As a typical area of the traditional triadic Cambrian study, the North China Platform has carried out systematic trilobite stratigraphy since the last century. With the in-depth exploration of the Cambrian explosion, ecosystem evolution, and the scientific demand for intercontinental stratigraphic correlation with other plates in recent years, the Cambrian strata and shell fossils on the southern edge of the North China Platform have received renewed attention. Early research on Cambrian fossils from the North China Platform was mostly limited to the Xinji Formation, with abundant numbers and types of small shell fossils providing key materials for stratigraphic division and correlation, as well as paleogeographic reconstruction. The Cambrian stratigraphy of Yuncheng area is exposed completely, but its Cambrian lowest stratigraphic age is not clear. This paper preliminarily reports small shell fossils from the Cambrian Mantou Formation and the Zhangxia Formation in the Xiweikou section in Yuncheng, North China. The 7687 miniature skeletal fossils obtained through acid etching treatment include Brachiopoda, including 1 genus and 2 species of the Priestly family, and 3 genera and 4 species of the Lactiformes family; Mollusca, including 1 genus and 1 species of Heliocentera and 1 unidentified genus and species; 4 genera and 5 species of open cavity orthopedics; Uncertain species of the genus Pleuroglossa; In addition, it also includes fragments of echinoderms and trilobites, with the largest number of mollusk fossils, but mostly consisting of a core, making it difficult to identify them in detail. Based on the fossil biological assemblage of Cambrian the Mantou Formation, it is inferred that the Mantou Formation in the Xiweikou section belongs to the early Wuliuan Stage of Cambrian Miaolingian, this study provides an important reference for the stratigraphic division and correlation of the early and middle Cambrian in Ordos Basin.

Keyword

North China Platform, Cambrian, Small Skeletal Fossils

Characterisation of Carbon isotope of the Cambrain Jialao Formation, Jianhe County, Guizhou Province, China

Zhen LI[1]*, Guizhou University (gs.zli21@gzu.edu.cn)
Xinglian Yang[2], Guizhou University

Abstract

The stratigraphy of Guizhou Province is relatively complete, in which the Cambrian strata are widely exposed, basically distributed throughout the whole province and more complete development. The Jialao Formation was deposited in the transitional region of Southeast Guizhou with sandy dolomite as the main lithology, where it overlies Kaili Formation and overlain by Loushanguan Formation. We selected the Balang section and Wuhe section as the study sections, which are deposited in the same county with the section of Miaolingian Series and Wuliuan Global Stratotype Section and Point (GSSP). A total of 98 samples were collected from the upper part of Kaili Formation, Jialao Formation and the lower part of Loushanguan Formation to determine carbon and oxygen isotopes. The results indicate that the δ13C profile of the two sections have the similar evolutionary trend, and comparing the study sections with other contemporaneous strata worldwide, it is found that although the absolute value of δ13C and the variation amplitude of δ13C are different, the evolution pattern of δ13C is comparable in a certain time scale background. And beyond that, DICE (the Drumian Carbon Isotope Excursion) was identified from the Jiaolao Formation in the Balang and the Wuhe sections, respectively. The identification of DICE in this study is considered reliable by combining DICE reported worldwide and biostratigraphic work done by predecessors in the contemporaneous formations. In conclusion, the correlation of δ13C profiles and identification of DICE not only indicate that the Jialao Formation has an important value and potential for stratigraphic correlation, but also provide a reference basis for the correlation of other strata with few fossils at the same time.

Keyword

Carbon isotope, Cambrian, DICE, Stratigraphic correlation, South China

[Keynote] Isoxys volucris from the lower Cambrian Sirius Passet lagerstätte: a spiny solution to avoid predators

Arne Thorshøj NIELSEN[1]*, University of Copenhagen (Arnet@ign.ku.dk)

Abstract

Isoxys volucris from the lower Cambrian Sirius Passet lagerstätte: a spiny solution to avoid predators
Morten Lunde Nielsen*, Mirinae Lee#, Philip R. Wilby¤, Tae-Yoon Park#, Arne T. Nielsenx [speaker], Jakob Vinther*

* University of Bristol, Beacon House, Queens Road, Bristol, BS8 1QU, K. Email: mortenlunde@gmail.com & Jakob.Vinther@bristol.ac.uk
# Division of Glacial and Earth Sciences, Korea Polar Research Institutes, 21990 Incheon, Republic of Korea. Email: mirinae.lee@kopri.re.kr & typark@kopri.re.kr
¤ British Geological Survey, Nicker Hill, Keyworth, Nottinghamshire NG12 5GG, UK. Email: prwi@bgs.ac.uk
x Department of Geosciences and Natural resource Management, University of Copenhagen, Øster Voldgade 10, DK-1350 Kbh K, Denmark. Email: Arnet@ign.ku.dk

The lower Cambrian Sirius Passet lagerstätte in Peary Land, northernmost Greenland, is famed for its relatively well-preserved fauna, dominated by arthropods associated with common lobopods, trilobites as well as other organisms. The fossil density is high and especially the bivalved arthropod Isoxys volucris is extremely common. Nearly all sampled beds from the fossiliferous interval contain this fossil and blooms of juveniles are seen occasionally. The Greenlandic representative of Isoxys is equipped with cardinal spines that are longer than in most other species of this genus. Measurements of body and spine length in 84 specimens show that the ratio of cardinal spine length vs. carapace length decreases during ontogeny. This indicates that the spines most likely had a primary defensive function against predators rather than aiding swimming or bouncy, as have been suggested for Isoxys in the literature (Pates et al. 2021). However, the negative allometric growth appears inconsistent with a hydrodynamic function, as larger carapaces must be assumed to require equally longer spines, which is not observed. Instead, the negative allometry points to a defensive function where the long spines conceivably increased the overall size of smaller specimens to escape gape-limited predators. This interpretation as a defensive feature is further supported by the fact that Isoxys volucris is the most commonly occurring prey content within guts of several Sirius Passet taxa, e.g. Pambdelurion, documenting a high predation pressure on the species. The results thus corroborate the conclusions of another recent study on the coeval species I. minor from the Chinese Qingjiang Lagerstätte (Ma et al. 2023).

Cited literature:

Ma J, Pates S, Wu Y, Lin W, Liu C, Wu Y, Zhang M, & Fu D. 2023: Ontogeny and brooding strategy of the early Cambrian arthropod Isoxys minor from the Qingjiang biota. Frontiers in Ecology and Evolution 11. (doi:10.3389/fevo.2023.1174564)

Pates, S., Daley, A.C., Legg, D.A. & Rahman, I.A., 2021: Vertically migrating Isoxys and the early Cambrian biological pump. Proceedings of the Royal Society B. Biological Sciences. (https://doi.org/10.1098/rspb.2021.0464)

Keyword

Lower Cambrian, Sirius Passet, Arthropod, Palaeoecology

Comparison of mineralized skeleton and microstructure of early Cambrian tubular animals

Jingliang ZHAO[1]*, NorthWest University (zhaojingliang@stumail.nwu.edu.cn)
Zhifei Zhang[2], NorthWest University

Abstract

In the early Cambrian, the famous Cambrian explosion event occurred. During this period, a large number of metazoan animals with skeletons suddenly appeared. After death, the mineralized bones of these animals could be preserved as fossils, which became an important basis for the study of evolution in the early Cambrian . Tubular fossils are the most common of these mineralized skeletal fossil in this periods and tubular fossils are not standard taxa, but are distinguished by fossil morphology.Those kind of fossils are generally simple in shape, easy to identify but difficult to determine the relationship. The Yangtze area is a typical area for the study of Cambrian marine sedimentary rocks in China, which has the advantages of wide development of Cambrian strata, relatively complete stratigraphic sequence, obvious petrological characteristics and easy identification. The Nanzheng region of southern Shaanxi Province is located in the Yangzi Craton, and the fossils in this area are relatively comprehensive and complete. In addition, the Xiannüdong Formation in this area is rich in small shelly fossils, with abundant brachiopods, palaeocalpids, tommotiids and tubular fossils with abundant variety, which is the focus of this study.This paper describes the fossil assemblages of the Xiannüdong Formation in Dayingcun section, Fucheng Town, Nanzheng Area, Shaanxi Province. The fossil assemblage comprise brachiopods, palaeocalpids, tommotiids, order bradoriidas, sponge spicule and tubular fossils. We mainly focused on the morphology, microstructure and biomineralization of the tubular fossils. We identifie *Sphenothallus* Hall, 1847, *Torellella* Holm, 1893, *Hyolithellus* Billings, In 1871, *Mongolitubulus* Missarzhevsky, 1977, a sample of tubular fossils from four genera. Among these tubular fossils, we focus on the in-depth study of the shell morphology and microstructure of *Sphenothallus*. The morphological characteristics of 130 samples were measured and statistically analyzed. On this basis, morphological comparison with *Sphenothallus songlinensis*, *S. taijiangensis* was made. The longest length of the shell of this sample is 3.4mm, while the length of the shell of the above samples is more than 4mm, and the longest is up to 20.7mm. In addition, the maximum width of the base and aperture of this sample are 0.48mm and 0.94mm, respectively, while the base width and aperture width of the above other types are significantly larger than that of this sample, and the maximum width of the base is up to 1.32mm. Mouth width up to 5.0mm; Based on SEM images, it is considered that the sample has a lamellar fiber structure and a lamellar fiber structure, but the long axis direction of each layer of minerals is intersected at an acute angle. In addition, it is found that the shell has a layered superimposed transverse pattern, and the shell secretion pattern on the surface may be layer by layer. Lenticular thickening layers can be secreted on the narrow edges of both sides, and sometimes only one thickening layer is secreted. The thickening layer shows a tendency of middle

dense and loose edges, indicating that the secretion of thickening layer is carried out from the center of the lens to the periphery.

Keyword

early Cambrian, the Xiannüdong Formation, Tubular Fossils, Biomineralization, Microstructure

Shallow water fauna from deep-water deposits, in the Zhaolaoyu Formation, late Ordovician at Fuping area, southern Ordos Basin

Caibin ZHANG[1]*, Northwest University (961068755@qq.com)
Zhifei Zhang[2], Northwest University

Abstract

Deep water deposits have been the hotspot for oil and gas exploration, especially in gravitational systems. It is believed that the Zhaolaoyu Formation in Fuping area, Shaanxi Province, is dominated by deep-water carbonate deposits, deep-water gravity-flow deposition, radiolarian chert, and volcanic tuffs. The lack finding of fossils from the Zhaolaoyu Formation not only limits the deep exploration in relative deposits, but also makes it hard to reconstruct its depositional environment.

By systematic sampling on the carbonate and treating with acid-etching method, abundant skeletal fossils, including brachiopods, gastropods, tetrapod corals, echinoderms, bryozoan and some tubular fossils of undetermined classification, were obtained. The brachiopods are mainly consisted of acrotretids and orthids; the gastropods mainly include tower-shaped, lenticular-shaped and conical-shaped shells; and the echinoderms are mainly dominated by discrete ossicles with rounded and pentagonal outlines splitted away from the stem or carpus of crinoids that can be assigned to five genera and eight species, including Pentagonocyclicus sp.Yeltysheva & Schewtschenko,1960Pentagonocyclicus sp. GYeltysheva & Schewtschenko1960Pentagonocyclicus sp. CYeltysheva & Schewtschenko1960Lanxocolumnus sp.Donovan1989Pentagonocyclopa sp. AMoore1939Cyclocyclicus sp. AYeltysheva1955Cyclocyclicus sp. CYeltysheva1955Comptocrinus aff. comptusYeltysheva1955

It is obviously that the fossil assemblages retracted from the Zhaolaoyu Formation could be assigned to shallow water fossil assemblages, which doesn't couple with previous analysis of the depositional environment in the area. However, considering the lacking of carbonate microfacies analyses, it is hard to rule out the possibility that the fossils in the Zhaolaoyu Formation are originated by deep-water gravity flow transport deposits. Based on this preliminary reports, it can be concluded that the Zhaolaoyu Formation are with well preserved, high diversed and abundant skeletal fossils. Thus, with the contribution fauna assemblage, combined with carbonate microfacies analyses, the stratigraphic and depositional analyses for the Zhaolaoyu Formation will be determined, supporting oil and gas exploration in the Ordos Basin.

Keyword

Ordos Basin, Ordovician, Zhaolaoyu Formation, Echinoderms

Evolutionary significance and biological affinities of Ediacaran to Cambrian tubular fossils

Yuze WANG[1]*, Shandong University of Science and Technology (wangyze_river@163.com)
Michael Steiner[2], Shandong University of Science and Technology
Pingli Wang[3], Shandong University of Science and Technology

Abstract

The Cambrian Bioradiation is mostly manifested in the worldwide appearance of so-called Small Skeletal Fossils (SSFs) and the dramatic increase in number, styles and complexity of trace fossils during the Fortunian Stage and continued during Cambrian stages 2 to 4 with the appearance of many new types of SSFs and the rapid diversification and dispersal of the Archaeocyatha and other Porifera. During the late stage of Cambrian bioradiation many crown group metazoans appeared in so-called ***Burgess Shale-type*** fossil lagerstätten of which the Weifang and Linyi biota are partly reviewed herein. There exists a general consensus on the idea that the earliest Cambrian diverse metazoan clades had Neoproterozoic ancestors. However, globally only few bodyfossils are known from the Ediacaran that are uncontroversially regarded as metazoan remains, such as the tubular cloudinids.

Many of the putative metazoan ancestors exhibit a tubular exoskeleton or housing structure, which led to the interpretation of an Ediacaran “wormworld” that also experienced a major extinction event prior to the explosive bioradiation of the early Cambrian SSF taxa. However, recent studies revealed that the tubiculous Ediacaran fauna (including cloudinids) persisted into the Cambrian. Our study documents the continuous occurrence of various tubiculous organisms into the Drumian Stage. The various morphologies and ornamentations, biomineral/ diagenetic preservation and ultrastructural characteristics of multiple tubiculous taxa are reviewed. We also discuss the potential affinities of the tubiculous organisms, assignable to the eukaryotic algae, cnidarians, annelids, and hemichordates.

Cloudinids are here considered to represent polychaete tubes due to ultrastructural characteristics, despite many recent studies assigned them with cnidarians. The nature of other putative ancestral metazoan remains of the Neoproterozoic with tubular construction, such as ***sinosabelliditids***, ***sabelliditids***, ***Sinocyclocyclicus*** etc. remains speculative and has been discussed controversially. Partially these fossils may represent eukaryotic algae.

By discussing the morphological characteristics, growth pattern and the chemical composition of tubular fossils it is intended to conclude on the environmental complexity. The degree of biomineralization, the type of sedimentary processes and the diagenetic alteration is thought to have had a major impact on the preservation of tubular fossils. Thus, it is concluded that the understanding of the taphonomy of tube-forming organisms is crucial for the biological interpretation of them.

Keyword

lagerstätten, cloudinids, worm, taphonomy

Continental weathering during the Great late Ediacaran Glaciation revealed by Mg isotope

TIANZHENG HUANG[1]*, Peking University (tzhuang@pku.edu.cn)
Bing Shen[2], Peking University

Abstract

Conversion between icehouse climate and greenhouse climate in geological history is critical for understanding the evolution of surface Earth system and modern climate changes. Cryogenian - Ediacaran is the most ‘frozen’ period in geological history, containing Sturtian glaciation (717–660 million years ago
[Ma]), Marinoan glaciation(650-641 Ma) and late Ediacaran glaciation(560-580 Ma). The former two Cryogenian glaciations are ‘Snowball Earth’ events, in which global distributed glacial deposition occurred in paleo- equator. However, observations of the late Ediacaran are composed by multiple glaciation strata with poor chronological correlation . The late Ediacaran glaciation was thought to have multiple episodes, while a new hypothesis integrated glacial deposits to a global glaciation called the Great Ediacaran Glaciation (GEG) that approached to 30° latitude with paleomagnetism records. Limited by poor chronological and paleomagnetism records in Ediacaran, it is hard to further test the GEG hypothesis. Yet a global glaciation will cause decrease of weathering intensity due to low temperature and low atmospheric CO2, even if in non-glacial deposits. We tested the GEG hypothesis with Mg content-Mg isotope weathering proxy. Samples from Doushantuo Formation in South China block showed significant decrease of weathering intensity and extreme erosion signal during shuram excursion (SE) of carbon (C) isotope in 570-562 Ma. The decrease of weathering intensity and extreme erosion was caused by global cooling and low atmospheric CO2 in GEG, rather than South China block moving toward high latitude. Our study confirms the GEG hypothesis and reveals that the peak of GEG was highly correlated with strong negative C isotope excursion (SE), which is a new mechanism for onsets of Cryogenian - Ediacaran glaciations which are different from all Phanerozoic glaciations.

Keyword

glaciation, continential weathering, Ediacaran, Mg isotope

Morphogenesis simulations unravelling novel recognition biases in Paleozoic trilobite injuries

Xiaoyong YAO[1]*, Chang'an University (yaoxy@chd.edu.cn)
Xikun Song[2], Institute of Deep-Sea Science and Engineering, Chinese Academy of Sciences
Jian Han[3], Northwest University

Abstract

Trilobites exhibiting injuries are ideal paleontological achieves for Paleozoic predator-prey interactions. However, the recognition of trilobite scars mainly relies on various individual traits exhibiting ambiguity and lacks morphogenesis evidences. Here we establish a new discriminative system integrating exceptionally preserved trilobites displaying injuries from the Chengjiang Lagerstätte, and long-term comparative laboratory morphogenesis simulations utilizing both 'trilobite larvae' and late-stage juveniles of the extant horseshoe crab proxies. The experimental paleontological approach elucidates the crucial criteria for injuries on trilobite fossils: the old wounded exoskeleton remains unchanged before subsequent molting; after molting, the new repaired outside exoskeleton exhibits abnormalities with variable individual characteristics, with thickened margin or smoothed outline, or a small tip regenerated in a distoproximal order. This recognition system is fully applicable to 409 fossils of 141 trilobite species documenting abnormalities. It indicates that 95% of injured trilobites with clearly identifiable scars have experienced subsequent ecdysis and suggests that most recognizable unambiguous trilobite scars are limited to healed sublethal injuries fulfilled at least one subsequent ecdysis. This uncovers novel recognition biases leading to the underestimation of trilobite injury frequency, in addition to other biases already acknowledged in relation to fossil taphonomy and field collection. These biases address the significant incongruity between the intense Paleozoic predator-prey 'arms race' and the infrequent observation of injured trilobites throughout geohistory.

Keyword

Cambrian explosion, Chengjiang Lagerstätte, trilobite, predation, experimental paleontology

Isolated radiodont mouths: case study of two unique oral cones from the Fezouata Shale Formation (Early Ordovician, Morocco).

Gaëtan JM POTIN[1]*, University of Lausanne (gaetan.jm.potin@outlook.fr)
Pierre Gueriau[2], University of Lausanne
Farid Saleh[3], University of Lausanne
Allison C Daley[4], University of Lausanne

Abstract

Radiodonts are an emblematic group of the Cambrian Explosion, including apex predatory species such as the iconic Anomalocaris canadensis. During the Early Ordovician, abundant radiodont remains are found in the Fezouata Shale (Morocco). So far, three species have been described, to which we can add at least three other unpublished morphotypes. Those descriptions are based only on frontal appendages, the most commonly preserved bodypart of the animal. However, on rare occasions, other anatomical features can be preserved, such as the mouthpart. The radiodont mouthpart, also known as the oral cone, has a peculiar morphology characterized by a circular shape with overlapping plates of different sizes around a central opening. The rarity of oral cones in the fossil record and the fact that they are often found in isolation has made it difficult to associate oral cones with frontal appendages and bodies, complicating our understanding of radiodont taxonomy and feeding strategy.

In this work, we describe two almost complete but isolated radiodont oral cones from the Fezouata Biota. The first specimen consists of 28 plates in tetraradial arrangement and is one of the smallest oral cones ever found in the fossil record (3.1mm in diameter). The larger oral cone specimen has a unique morphology consisting of 24 plates, in tetraradial arrangement, and bearing prominent nodes on just two of the larger plates. The observed combinations of features are unique and neither oral cones can be confidently attributed to known radiodont taxa.

Based on morphological characters, multivariate statistics have been used to predict the most probable radiodont family and feeding strategy for these oral cones. These analyses show that two oral cone morphospaces can be distinguished for feeding strategies: the raptorial predators and the sediment sifters. However, there are no clear distinctions of oral cone morphospaces associated with different radiodont families. This is confirmed when the two oral cone morphospaces are mapped onto a radiodont phylogenetic tree, showing no clear distribution of oral cone morphotypes within the major radiodont clades.

This method shows that the feeding strategy of the newly discovered oral cones can be predicted, while their assignment to a specific family is unclear. This is likely the result of the lack of data concerning suspension-feeding radiodonts that are rare in the rock record but are abundant in the Fezouata Shale.

Keyword

Arthropoda, Radiodonta, Oral cones, Fezouata Shale, Feeding strategy

Modularity and fluctuating asymmetry in the early Cambrian trilobite Protoryctocephalus arcticus from the 'Tsinghsutung' Formation, South of China

Esteve JORGE[1]*, Universidad Complutense de Madrid (UCM), Spain (jorgeves@ucm.es)
Yang Xinglian[2], Guizhou University, Guiyang, China

Abstract

We conducted a study on the cranidium of the Cambrian trilobite Protoryctocephalus arcticus using geometric morphometrics techniques to delve into the intricacies of its modular structure and its implications for diversity within trilobites. Our primary objective was to unravel the underlying mechanisms driving the integration of various morphological features, particularly exploring the roles of developmental pathways and functional interactions in shaping the evolutionary trajectory of these ancient organisms.

Central to our investigation was the hypothesis that distinct modules of the cranidium, namely the anterior and posterior regions of the glabella (the central portion of the head shield) and corresponding sections of the fixigena compartments (the lateral portions), represent independent developmental units exhibiting differential variation. Through rigorous measurements, we assessed both inter-individual variation and random disparities within individual cranidia, specifically examining fluctuating asymmetry (FA).

Our analyses, which focused on elucidating the covariance patterns between the anterior and posterior segments of the glabella compartments via partial least squares methodology, revealed a notable degree of integration between these compartments. This integration was evident not only in terms of individual variation but also in the context of FA. Consequently, while it might appear that the anterior and posterior components of the glabella act autonomously, their covariance suggests a shared developmental trajectory largely responsible for the observed variation in this region.

In summary, our findings suggest that both inter-individual variation and developmental perturbations contribute to the shaping of cranidial morphology, with these influences being integrated across multiple compartments. Interestingly, while some variation can be attributed to localized processes within specific compartments, the overarching modular structure of the cranidium suggests a more complex interplay between development and function than previously assumed. This challenges the notion that functional associations exclusively dictate the modular organization of trilobite cranidia, highlighting the need for a nuanced understanding of the underlying processes shaping morphological diversity in these ancient arthropods.

In this manner, representatives of oryctocephalid trilobites, as well as others such as ptychopariids or redlichiids, particularly those from the Cambrian Series 2, Stage 4 of southern China, present a unique opportunity to investigate the modality in these Cambrian arthropods and assess how rapid the diversification of these groups was during the Cambrian Explosion.

Keyword

Geometric morphometrics, evolution, oryctocephalid trilobites, Cambrian

Taxonomy and Morphology of Choia from the Qingjiang Biota

Laiyuan Wu[1]*, Northwest University(China) (202121907@stumail.nwu.edu.cn)
Hao YUN[2], Northwest University(China)
Xingliang ZHANG[3], Northwest University(China)
Qingshan WANG[4], Northwest University(China)

Abstract

Early diversity of sponges in Animal Tree determines their importance in interpreting the origin and early evolution of muticellular animals.The Choia is one of the representative demosponges that occurred during the Cambrian Explosion. Although fossils of Choia were discovered in a wide spectrum of Cambrian biotas, the body shape and growth pattern of this sponge group have not been scrutinized. Three species of Choia, including Choia qingjiangensis sp. nov., C. striatus sp. nov., and C. carteri Walcott, 1920 from the Cambrian Stage 3 Qingjiang Biota are described herein. Based on previous data, new taxonomic models for the preservation of Choia is provided to restore the body shape and original orientation of this animal. The results indicate that the Choia is flat obconic in shape and has a thin wall with two layers of spicules. There are three levels of height to width ratios: the first one refers to small, near-flat, and dwarf conical shapes that usually retain their outlines after burial; the second is a relatively high conical shape, which is usually prone to being flattened laterally during burial and left fan-shaped specimens; the third one is intermediate in shape between the former two, which is usually preserved as an oval outline with a broken central disc and rare coronal spicules.

Keyword

Qingjiang Biota, Choia, systematic classification, morphological restoration, spatiotemporal distribution

New artiopodan euarthropods from the Chengjiang fauna (Cambrian, Stage 3) at Malong, Yunnan, China

Yuyan ZHU[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (yyzhu@nigpas.ac.cn)
Han ZENG[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Yao LIU[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Fangchen ZHAO[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The artiopodans, consisting of trilobites and their relatives, were a group of euarthropods that were abundant during the Cambrian and then became extinct in the Permian. Since the first discovery of Naraoia from the lower Cambrian Chengjiang fauna (Cambrian Series 2, Stage 3) in 1984, new artiopodans are constantly being discovered. Here we describe three new artiopodan species from the Chengjiang fauna at Malong, Yunnan, China. Zhugeia acuticaudata gen. et sp. nov. is a new xandarellid with an elongated needle-like median tail spine. Tonglaiia bispinosa gen. et sp. nov. is a new type of trilobitomorph with a pair of parallel posteriormost tail spines. Sidneyia malongensis sp. nov. is the oldest species of Sidneyia with eight imbricated tergites and two abdominal segments. The evolutionary affinities of these new taxa are reconstructed and discussed in a phylogenetic context. Phylogenetic analyses resolve Z. acuticaudata among the xandarellids and T. bispinosa gen. et sp. nov. as a trilobitomorph with an uncertain placement. This is the first discovery of non-trilobite artiopodans other than Naraoia from the Chengjiang fauna at Malong area. These three new species provide new insights into the differential spatial distribution of the Chengjiang fauna across eastern Yunnan and enriches the diversity of non-trilobite artiopodans from the Cambrian.

Keyword

Trilobitomorpha, Vicissicaudata, Lagerstätten, Yu’anshan Formation, Chengjiang

Ecological and environmental implications of predatory groups in the Cambrian Guanshan Biota

Deguang JIAO[1]*, Yuxi Normal University (103256437@qq.com)

Abstract

The Guanshan Biota (Southern China, Cambrian Stage 4) is often considered a crucial link between the Chengjiang Biota of the Cambrian Stage 3 and the Kaili Biota of the Cambrian Stage 5, specifically burying multiple groups of soft fossilized organisms. The fossil treasure trove itself contains many unique and distinct fossil organisms. The diversity of the predatory group of its stem group of arthropods is rich, including *Anomalocaris canadensis*, the currently known endemic genus Paramalocaris, and Tamisiocaridae in southern China, which includes *Anomalocaris kunmingensis* and other new materials that need to be studied, as well as true arthropods with ecological indicative significance such as *Astutuscaris bispinifer* gen. et sp. nov and *Lihuacaris ferox* gen. et sp. nov. This predatory group combination differs from the Chengjiang Biota, Kaili Biota, and other reported fourth order Cambrian biota that have preserved shrimp fossils. And the above-mentioned fossil organisms were found in the same section and layerwhich type specimen are collected at Yuxi Normal University . The collective appearance of multiple top-level predatory groups in the same water environment reflects the diversity and subdivision of predatory niches, representing highly complex ecological community types. This conclusion indicates the importance of continuously discovering as many different profiles as possible in order to gain a more comprehensive understanding of the ecology and environment of early animals.

Keyword

Cambrian, Guanshan Konservat-Lagerstätte, Ecological Environment

Mineralogical characteristics of pedogenic carbonates in Devonian paleosols and their environmental implications

jingru LUO[1]*, Chengdu University of Technology (luojingru@stu.cdut.edu.cn)
Meng Ning[2], Chengdu University of Technology
Tianzheng Huang[3], Peking University
Bing Shen[4], Peking University

Abstract

The mid-Paleozoic colonization of land by plants catalyzed a metamorphosis of the Earth's surface environments, accelerating the transformation of the atmosphere, promoting chemical weathering and the formation of soil, which represents the largest carbon pool in terrestrial ecosystems. Pedogenic carbonates serve as a significant component of the soil inorganic carbon (SIC) and play a crucial role in the terrestrial carbon cycle.

Pedogenic carbonates preserve essential climatic and environmental information throughout their formation process. Previous research studies of pedogenic carbonates were focused on the reconstruction of paleoenvironmental conditions by using their geochemical indicators. However, the basic mineralogical characteristics of pedogenic carbonates and their potential to reveal the pedogenic processes and environmental conditions have been ignored. Here, we investigate the mineralogical characteristics of pedogenic carbonates formed during the mid-Paleozoic colonization of land by plants to reveal their environmental implications.

Pedogenic carbonates from the Lower Devonian Guijiatun Formation (Lochkovian) and Xujiachong Formation (Pragian-early Emsian) in Qujing district, Yunnan province, China were recognized in paleosols with root traces and alternating soil horizons. Morphological, petrographic, and mineralogical analyses including SEM and XRD demonstrated that authigenic dolomites constitute an important part of the mineral composition of the Devonian pedogenic carbonates. These dolomites were precipitated as primary minerals during pedogenesis, indicating an arid-evaporative pedogenic environment. Considering the positive correlation between the contents of dolomite and illite, we propose that clay mineral may play a role in inducing the formation of pedogenic dolomite. Furthermore, the more positive δ18O values of pedogenic dolomite from the Guijiatun Formation (average= -7.98 ‰) coupled with the higher dolomite content indicating a transition from a strong arid-evaporative pedogenic environment during the Lochkovian stage to a semi-arid-evaporative pedogenic environment during the Pragian-early Emsian stage.

Keyword

pedogenic carbonates, Devonian paleosols, mineralogical characteristics, pedogenic dolomite, paleoenvironment

Devonian coevolution of forests and tetrapods

Gregory John RETALLACK[1]*, University of Oregon (gregr@uoregon.edu)

Abstract

Central New South Wales has a rich fossil record of Late Devonian (Famennian) fossil fish (8 species, mostly Bothriolepis and Remigolepis) and a single tetrapod (Metaxygnathus). Trace fossils, fossil plants, and paleosols of the Hervey Group provide new evidence for evolution of Devonian trees and tetrapods. Late Devonian paleosols of the Hervey Group in New South Wales formed in a semiarid climate with low shrubby desert vegetation, but at two levels including one with a tetrapod, there is evidence of subhumid woodland. That double spike to subhumid climate matches paleoclimatic spikes in Pennsylvania cued to global atmospheric spikes in carbon dioxide correlated with the Annulata event of marine black shales dated at 365 Ma. This evidence supports the woodland hypothesis of tetrapod origins rather than the idea that they evolved from fish escaping shrinking desert ponds, or evolved in tidal flats. The Canowindra fish bed of mass mortality in a desiccated billabong (oxbow lake) at a stratigraphic level of arid paleosols is a stunning example of what happened in drying desert ponds. New South Wales has no clear evidence of intertidal vertebrates, and trackways which inspired this hypothesis are now controversial. In otherwise aquatic Late Devonian tetrapods, limbs may have been adaptations to negotiating or hiding from predators in streams choked with woody debris, and their necks allowed feeding on land, or in water shallower than their bodies.

Keyword

Devonian, tetrapod, paleosols

A preliminary study of three vascular plants from the Middle Devonian Haikou Formation of Qujing, Yunnan Province, China

Gaofeng ZHENG[1]*, Peking University (2201210120@pku.edu.cn)
Jinzhuang Xue[2], Peking University

Abstract

In recent years, plenty of studies of the early land plants in Devonian have been mainly focusing on the evolution of vascular plants in the Early Devonian and the early forests and early seed plants in the Late Devonian. However, the Middle Devonian was also an important epoch in the evolution of the early land plants, when many important plant species originated and evolved. Thus, more collecting from the Middle Devonian is needed to further reconstruct the evolutionary history of the early vascular plants throughout the Devonian period.

Based on our recent exploration of the Middle Devonian Haikou Formation in the Qujing region of Yunnan, China, we have unearthed and conducted preliminary examinations on three distinct plants. A lycopsid plant assignable to Tomiodendron sp. is characterized by its distinctive ligule pit that bifurcate at the apex, which displays a curvature reminiscent of the letter M, and simple dichotomous branching and inconspicuous ligule cushion. Its leaves are arranged in pseudo-whorls on slender branches, 8-10 per whorl. Additionally, it also preserves intact reproductive structures, sporangia are aggregated to form a strobilus about 18 cm long, sporangia are situated in leaf axils, and the sporophylls are different with the sterile leaves. The sporophylls often curve inward in the shape of a sickle, while the sterile leaves remain slender and straight.

A second plant is a euphyllophyte, which displays evident tertiary branching. The first-order branches protrude from the main axis oppositely, presenting a triforked structure, the second-order branches extend exclusively from the upper surface of the first-order branches at obtuse angles, and the third-order branches bifurcate from the second-order branches, forming an approximate "antler-like" structure. Within its reproductive structure, subelliptical sporangia are borne on the terminal twigs, with 2-3 sporangia forming a truss. Terminal twigs commonly bifurcate.

A third plant is also a euphyllophyte, which is characterized as a slender herbaceous plant with stem less than 1 mm in width. Preserved specimens appear fragmented, exhibiting a simple branching structure. The reproductive structure is well preserved, 3-5 elongated sporangia are borne on thin branches extending from the side of the main stem, forming a sporangial cluster reminiscent of a "finger-like" structure, and such structures often occur in pairs.

This study enriches the composition of the flora from the Haikou Formation, and expands the stratigraphic and paleogeographic distribution of Tomiodendron-type lycopsids.

Keyword

Middle Devonian, Haikou Formation, Tomiodendron, lycopsid, euphyllophyte

Coupling relationship between radiation of early vascular plants and the long-term water cycle

Jinzhuang XUE[1]*, Peking University (pkuxue@pku.edu.cn)
Bingxin Li[2], Peking University
Jiashu Wang[3], Peking University

Abstract

The origin and diversification of early vascular plants (EVP) contributed to the Silurian-Devonian terrestrial revolution and induced profound changes in continental weathering, erosion and sediment transport systems, and biogeochemical cycles of carbon, nitrogen, phosphorus, and other elements. As a consequence of the diversification of EVP, there emerged distinctive soil-plant-atmosphere continuum (SPAC) systems in different plant groups, including among others the zosterophyllopsids, drepanophycaleans, pseudosporochnaleans, and archaeopteridaleans. Each of these groups has been extensively studied and can be described by different SPAC models. Key innovations that are closely associated with water transport processes, and that involve roots, vascular tissues, stomata, leaves, and body size and architecture, evolved in different groups, leading to more complex and presumably more efficient water cycling in the SPACs. The earliest vascular plants of the Silurian and Early Devonian periods typically show small aboveground stature with shallow roots, although some groups such as zosterophyllopsids and drepanophycaleans are characterized by extensive rhizomatous clonal growth, producing complex and shallow underground rhizome systems. Nevertheless, deeper underground water did not become available to plants until deep roots evolved during the Middle to Late Devonian. Within the evolving SPAC systems, soils from the Early Devonian onward showed increasing thickness and complexity of horizonation, increased maturity in composition, and diversification of soil classes. Forest canopies that first appeared in the Middle Devonian would have had a profound impact on water runoff, evaporation and transpiration. Therefore, the evolution of plants in both their underground and aboveground tissues, as well as their enhanced effects on water cycles and weathering domains, led to a dramatic expansion of the Earth's Critical Zone.

The radiation of EVP enhanced feedbacks among vegetation, geomorphology and water cycles. From the late Silurian onward, the tracheophyte-type land-ocean hydrologic continuum (LOHC) was established as an essential landscape on the Earth's surface, as exemplified by the Old Red Sandstone facies of the Laurussian paleocontinent and the non-marine siliciclastic sequence of Qujing, Yunnan of the South China Block. Such LOHCs are characterized by geomorphological stability of inland drainage basins and coastal areas, leading to establishment of vegetated, stable lowlands that provided accommodation space for increasing volumes of fine-grained particles derived from plant-induced intensified weathering. Such lowlands provided abundant opportunities for preservation of plant fossils and organic matter, contributing to an apparent increase in plant diversity from the late Silurian through Late Devonian; that is, the diversification

of EVP enhanced landscape stability, thus providing more opportunities for plants themselves to be preserved in the fossil record. The evolution of EVP was closely coupled with changes to carbon and water cycles by SPAC and LOHC systems and the underlying processes. Development of geomorphologically stable wetlands favored an increase in burial of terrestrial organic carbon as coals and other organic-rich sediments, as well as long-term pedogenesis on dryland floodplains, processes leading to an increase in organic and inorganic carbon sequestration, respectively.

Keyword

Early vascular plants, Devonian, paleosols, soil-plant-atmosphere continuum, land-ocean hydrologic continuum

The cycle of S element in pyrite from Carboniferous bauxite in South china

Yulei CHEN[1]*, Chengdu University of Technology (434846733@qq.com)
Chaochao Xing[2], State Key Laboratory of Geohazard Prevention and Geoenvironment Protection, Chengdu University of Technology
Bing SHEN[3], Key Laboratory of Orogenic Belts and Crustal Evolution of the Ministry of Education, and School of Earth and Space Science, Peking University
Xianguo LANG[4], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, and Institute of Sedimentary Geology, Chengdu University of Technology

Abstract

The bauxite of Jiujialu formation of the Carboniferous was widely distributed in Guizhou, South China, and has obvious characteristics of high sulfur content. Based on sampling analysis of pyrite from different paleogeographic locations (coastal, karst depression, karst valley/funnel), we suggest these pyrites be initially classified into three categories according to the classification of bauxite. These profiles have different vertical characteristics of sulfur isotopes, lithology, and mineral composition. In the coastal sections, pyrites develop along the beddings and are preserved in carbonaceous shales in the form of nodules or laminae, the surfaces of which are partly dissolved, and the δ34S tends to be stable (-10~-25‰). In sections of karst depression area, pyrites are preserved in the form of nodules in the ferruginous claystones or distributed in the form of scattered bauxite cement, and the surfaces were also partially dissolved, with δ34S varing widely from -25 to 38‰. In the karst canyon/funnel sections, pyrites were scattered in claystones in silty crystal form or preserved funnel areas as huge nodules, and the δ34S varies widely too (-28~18‰). In addition, micro-region characteristics of these pyrites are also different. Due to intense weathering, leaching, frequent volcanism and transgression in the bauxite formation area, the sources of sulfur element of the pyrites might be very complicated. Therefore, to track the sulfur cycle of pyrites in Carboniferous bauxite in Guizhou, South China, it is necessary to conducting both macroscopic and microscopic analysis of pyrites.

Keyword

Bauxite, pyrite, sulfur isotope, mineral characteristics, in situ analysis

[Keynote] In situ preservation enhances systematic study: a case in research of the Wuda Tuff Flora, Inner Mongolia

Jun WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (jun.wang@nigpas.ac.cn)
Mingli Wan[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Weiming Zhou[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Dandan Li[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

A peat-forming forest was preserved in situ by a 298.34 ± 0.09 Ma volcanic ash bed in the Wuda Coalfield, Inner Mongolia, being called Wuda Tuff Flora. With respect to the geologic and taphonomic similarities to the world-famous Italian UNESCO World Heritage Site of the Roman city of Pompeii, this flora has been also called Chinese “vegetational Pompeii”, well known as a plant fossil lagerstätte, snapshooting a glimpse to the late Palaeozoic peat-forming forest.

Such a T0 deposit provides an unrivalled chance to reconstruct not only the taxonomic diversity but also the vegetation structure and density, small- to medium-scale distribution patterns, and synecological associations. Along with the progress of the open-cast mining of the Wuda Coalfield in the past two decades, numerous outcrops have been accessible from time to time, offering opportunities for fossil collecting and in total certain area over 10, 000 square meters quantitative investigation of forest ecology, which have yielded a larger collection of the material.

The completeness and the exquisiteness of plant remains certainly facilitate a thorough systematic study of many taxa of this peat-forming forest. In many cases, the size of the specimens even enables us to assess the natural variability and the reconstruction of whole-plant taxa, which is impossible in most other localities due to the often small number and the limited size of specimens. Nearly all the taxa of this peat-forming forest show both gross morphology and anatomy, and both vegetative and fertile parts, and thus likely to facilitate restoration as whole plants and natural species. Here we present the latest research progress on the systematic study of this flora. Ten species are described in a sense of whole plant species (organs including gross form, fertile, vegetative, stem anatomy, in situ spore), such as the lycopods Sigillaria cf. S. ichthyolepis (Presl) Corda; sphenophytes Sphenophyllum angustifolium (Germar) Geoppert, Sphenophyllum parvifolium Libertín et al.; the calamitacean sphenopsid Palaeostachya guanglongii Liu et al.; the eusporangiate fern Scolecopteris libera Li et al.; the noeggerathialean progymnosperms Tingia unita Wang, Tingia pentalobata Shen, Paratingia wuhaia Wang et al., and Paratingia wudensis Wang et al. Several taxa reaching a status of natural species (both fertile and vegetative organs known) include the zygopterid fern Nemejcopteris haiwangii Pšenička et al.; the sphenophytes Sphenophyllum cf. oblongifolium (Germar et Kaulfuss) Unger, Sphenophyllum cf. angustifolium (Germar) Geoppert; the eusporangiate ferns Scolecopteris minuta Wan et al., Scolecopteris zhoui Zhang et al., Eoangiopteris congestus Sun et al.; the leptosporangiate ferns Oligosporangiopteris zhongxiangii Frojdová et al., Chansitheca wudaensis Deng, Sun et Li emended He et al., Botryopteridium sinensis Zhou et al., Hansopteris uncinatus Zhou et al.

Besides those, some taxa only with abundantly vegetative information have been identified through their anatomic features, including the eusporangiate fern Pecopteris lativenosa Halle emend. Li et al.; the leptosporangiate fern Diodonopteris virgulata Zhou et al.; the pteridosperms Wudaeophyton wangii Pšenička et al., Yangopteris ascendens Zhou et al.

Keyword

whole plant reconstruction, natural species, Wuda Tuff Flora, Permian

The Middle-Late Triassic Boundary Extinction: Palynological evidence

Yuewu SUN[1]*, Research Center of Palaeontology and Stratigraphy, Jilin University (sunyuewu@jlu.edu.cn)
Ying ZHANG[2], International Center for Geoscience Research and Education in Northeast Asia, Jilin University, China
Xiang LI[3], Huzhou Zhili City Construction Investment Operation Group Co., Ltd., China
Shuqin ZHANG[4], Research Center of Palaeontology and Stratigraphy, Jilin University, China

Abstract

The Middle-Late Triassic Boundary Extinction, i. e. Ladinian-Carnian Boundary Extinction is less attractive than the End-Permian Mass-extinction, Carnian Pluvial Event and End-Tiassic Mass-extinction, but it is genuine as the Ladinian crisis. However, due to lack of detailed investigation on Ladinian-Carnian transition, the vegetation extinction and renovation are thought to be resisted Ladinian crisis (Ruban, 2017). Recent palynological investigation engaged in the Middle Triassic and Upper Triassic transitional zone in the Ordos Basin, China (Li et al., 2023) reveal the End-Ladinian vegetation crisis. The palynoflora during the latest Ladinian was composed of 121 species of 47 genera, including 54 species of 17 genera from fern spores and 67 species of 30 genera from gymnosperm pollen; while the earliest Carnian palynoflora was only 35 species of 29 genera which include fern spores (9 species of 6 genera) and gymnosperm pollen (26 species of 23 genera). Ladinian-Carnian Boundary crisis is characterized by 70% fern species and over 30% gymnosperm species lost. The crisis covered every types of eco-plants from aquatic plants, under-story herbs, tree ferns, bushes, evergreen and deciduous arbor forests. Meanwhile, vegetation renovation and innovation ongoing quietly in mesophytic and xerophytic gymnosperms. As the emergence of Discisporites (Cheirolepidiaceae) and Perinopollenites (Cupressaceae), the earliest Carnian climate should be much drier than the latest Ladinian. Thus, we are preferable to attribute the End-Ladinian vegetation crisis to the arid climate. However, there are still some aquatic lycopods, river bank or lake shore sphenophytes, and some evergreen trees in the earliest Carnian vegetation. Meanwhile, the depositional environment indicate that the earliest Carnian deposits are deep lacustrine with anoxic eutrophic characters, and the sediments are organic rich shales and oil-shales. Therefore, the earliest Carnian climate was thought to be strong seasonal arid on one hand and high seasonal precipitation on the other hand, which is the typical monsoon climate. It is the enhanced arid season that caused a great loss of plant biodiversity in the end-Ladinian vegetation although there are some pluvial interruption exist.
This work is supported by the National Nature Science Foundation of China (41972012)

Keyword

End-Ladinian Mass-extinction, Palynofloral crisis, Carnian monsoonal arid climate, Triassic, Ordos Basin

New material of Radula heinrichsii (Radulaceae, Porellales) from mid-Cretaceous Myanmar amber

Xiangbo SONG[1]*, State Key Laboratory of Palaeobiology and Petroleum Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China (xbsong@nigpas.ac.cn)
Zixi Wang[2], State Key Laboratory of Palaeobiology and Petroleum Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Diying Huang[3], State Key Laboratory of Palaeobiology and Petroleum Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

Abstract

Radula Dumortier, with ~260 living species, is one of the largest genera of the Porellales and the phylogenetically isolated genus of the leafy liverwort family Radulaceae. Radula heinrichsii Feldberg et al. is the second species of Radula reported from the mid-Cretaceous Kachin amber. Here, we review and illustrate Radula heinrichsii based on the new fossil specimen from Myanmar amber. Our new finding represents the first fossil species of Subgenus Amentuloradula Devos et al. present knew and adds new information on morphological diversity of this genus. The fossil specimen shares many diagnosis of Radula: gametophyte densely pinnately branched, with a few irregularly Radula-type branches, mostly entire-margined and complicatedly bilobed leaves with a large dorsal lobe and a smaller ventral Lejeunea-type lobule, rhizoids produced on leaf lobules, and absence of underleaves. In contrast to the previous fossil material, the new specimen exhibits one-three amentulose shoots by irregularly pinnatedly branching at the base of the leaves. Therefore, the fossil is assigned to subg. Amentuloradula. Extant subg. Amentuloradula usually occurs in tropical forest, where they grow as epiphytes on the bark of trees and shrubs, indicating that there was likely an extensive epiphyte flora in the mid-Cretaceous of Myanmar. The new fossil specimen enhances our comprehension on the morphological evolution and diversity of Cretaceous leafy liverworts.

Keyword

Porellales, leafy liverwort, Mesozoic, Myanmar amber

Tracking Darwin's climbing plants in a 298 Ma swampy forest

ZHOU WEIMING[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (wmzhou@nigpas.ac.cn)
WANG JUN[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The late Paleozoic era emerged as a pivotal period in the genesis and advancement of terrestrial forest ecosystems. From the emergence of the first forests in the Mid-Devonian period, these ecosystems exhibited a trajectory of gradual complexity through the evolution of plants and their interactions with the environment. During the Permo-Carboniferous period, the forests were characterized by a diverse array of climbers with adaptations akin to those seen in modern angiosperms. However, the documentation of these climbers across various ages and locations has posed challenges to our understanding of their ecological role in late Paleozoic forests. In this study, we undertook a comprehensive investigation of the climbers within the earliest Permian fossil Lagerstätte "Wuda Tuff Flora" (also known as the Chinese "vegetational Pompeii"). Our investigation revealed that the five climbing strategies outlined by Darwin—twining, tendril-climbing, hook-climbing, leaf-climbing, and clinging—are all represented within this forest community. The examined climbers exhibited modified appendages that showed convergence with those observed in contemporaneous pteridosperms and extant angiosperms. Remarkably, some vines or lianas employed multiple strategies to secure support or ascend. Moreover, the estimated species proportion of climbers stands at approximately 22.4% (11 out of 49), a figure comparable to that observed in modern tropical forests. Furthermore, individuals from various climbing species frequently shared a common tree support, with instances of one climber ascending upon another, indicating nuanced space allocation likely stemming from pervasive space competition. These groundbreaking discoveries provide valuable insights into the intricate forest dynamics of Permo-Carboniferous swampy forests.

Keyword

climbing strategy, convergent evolution, terrestrial forest ecosystem, Darwin, Wuda Tuff Flora

Eusporangiate Fern from the Early Permian Peat-forming Forest in Wuda, Inner Mongolia, China

Dandan LI[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (ddli@nigpas.ac.cn)
Jun WANG[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

Eusporangiate fern is one of the most ancient of the living fern groups, appeared first in the Late Carboniferous and diversified through late Paleozoic until the present day. During the Permo-Carboniferous, most eusporangiate elements with erect stem belong to the Psaroniaceae, Marattiales, and are the main component of peat-forming forest canopy. Due to the incompleteness of plant fossils, most taxa of Paleozoic eusporangiates have been found only with single part of parent plant that makes a big trouble in reconstructing whole-plant and exploring evolution of eusporangiates.

An autochthonous peat-forming flora was found from early Permian in Wuda Coalfield, Inner Mongolia, which is buried by volcanic ash and named as “vegetational Pompeii”. There are seven groups in the vegetational Pompeii, namely lycopsids, sphenopsids, pteridophytes, progymnosperms, pteridosperms, Cycadales, and Cordaitales. Among all classes, eusporangiates (pteridophytes) has the highest diversity in the species number. According to the features of reproductive organs, there are at least six genera, nine species of eusporangiates in this flora, including four species of Scolecopteris, one species of Eoangiopteris, one species of Acitheca, one species of Asterotheca, and two new genera with two new species. Those species are supposed to have similar entire morphology, like several pinnate fronds locate in the top of an erectly unbranched stem. However, there is only one genus of permineralized or impressed stem of eusporangiates has been found in the vegetational Pompeii, Psaronius with 4 species (permineralized stem) and Caulopteris with 8 species (impressed stem); only two types of permineralized axis have been found. Evidences from the organically connected specimens from vegetational Pompeii show that one type of eusporangiate stems could bear two different types of fronds. Not only in the vegetational Pompeii, but the generic numbers of different organs of eusporangiates in the literature are not comparable. Of Paleozoic eusporangiates, there are about 30 genera of reproductive organ, three genera of compressed stems, three genera of permineralized stems, four genera of permineralized axis, and four different types of vegetative pinnae. The distinction in the number of different organs demonstrates that the evolutionary diversification of reproductive organs was much higher than shown in stem and leaf axes in eusporangiate plants. Evolutionary conservatism of stems and leaf axes compared to fertile organs indicates that the fossils had modular evolution with different modules (roots, stems, axes, vegetative and fertile pinnules, sporangia, etc.) evolving at different rates.

Keyword

Eusporangiate, vegetational Pompeii, organ, modular evolution, Paleozoic

Biomarkers in fossil resins (ambers) – diversification and application

Jan PAŃCZAK[1], AGH University of Krakow
Paweł Kosakowski[2]*, AGH University of Krakow (kosak@agh.edu.pl)
Adam Zakrzewski[3], AGH University of Krakow

Abstract

Fossil resins ("ambers") are one of the tree exudate products, produced by gymnosperm and angiosperm taxa. Through conventional geochemical methods (e.g. chromatography), an insight into ambers' extracts, composed of hydrocarbons mostly from a terpene group, is possible. Various terpenes in ambers serve as biomarkers, the compounds that provide the genetic information on the amber origin. The terpenes in ambers are more volatile (mono- and sesquiterpenes), and less volatile (di- and triterpenes). Except for the terpenes, ambers can contain carboxylic acids in significant quantities, such as succinic acid which occurs in high concentrations in succinite, the Eocene-aged amber from Central Europe (e.g., "Baltic amber").

Volatile terpenes occur in minor amounts in comparison with a primary resin composition, due to their loss in the initial stages of resin transportation and deposition in sediments. In particular, monoterpenes in ambers play numerous roles in modern plants defense system; for instance, borneol, camphor, and fenchone indicate deterring and antimicrobial behavior in modern plants. These compounds occur in Baltic amber; although, in relatively low concentrations. Mono- and sesquiterpenes are observed in the extracts of ambers younger than the Cretaceous because in older ambers these compounds predominantly undergo advanced maturation and cross-linking processes. Their presence was observed in many fossilized dammar resins from South-East Asia, such as in Miocene-aged amber from Sumatra.

Di- or triterpenes occur as the most abundant compounds in all amber extracts; these compounds are mainly the biomarkers of several tree families among the gymnosperm and angiosperm clades. Thus, their occurrence has a chemotaxonomic significance. Usually, the occurrence of diterpenes indicates the gymnosperm origin of the analyzed material; although, ambers from the angiosperm Fabaceae family contain enantio-diterpenes (e.g., Dominican amber) which possess the chiral configuration of the occurring diterpenes. Except for the Fabaceae, the ambers of angiosperm origin are rich in triterpenes. The more advanced attribution of an amber sample to its botanical origin requires more detailed studies on comparison of modern and past plant products; however, some ambers contain biomarkers which pinpoint their origin to only one family. For example, glessite, a type of Bitterfeld amber, contains betulines, which might indicate the Betulaceae as the source family.

Ambers can contain compounds that may indicate their more advanced stages of maturity. Amberene (15,19,20-trisnorlabda-5,7,9(10)-triene), a diterpene from the labdane class, occurs in numerous Cretaceous-aged ambers, such as in Spanish amber from Álava. The compound might indicate more advanced stages of resin acids diagenesis processes. We have found this compound in other Cretaceous ambers - valchovite from the Czech Republic and in amber from Trepcza in

the Polish Carpathians. This, together with the general resemblances of the chemical composition, might suggest a similar botanical origin of the ambers.
Therefore, various biomarkers in ambers can be applied as a chemical tool in paleobotany to track the plants evolution and their state of maturation.
The project was financed by the program: „Excellence initiative – research university for the AGH University of Krakow ” (grant no. 501.696.7996/L34) and by AGH University of Krakow (grant no. 16.16.140.315).

Keyword

Biomarker, Amber, Terpene, Chemotaxonomy

Palaeodepositional environment, implications of Glossopteris flora, and organic matter characteristics from Early Permian Period, Karo OCM, East Bokaro Coalfield, Damodar Basin, India

Suraj Kumar Kumar SAHU[1]*, Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow-226007, UP, India; Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India (surajk14@yahoo.com)
Sankar Suresh Kumar Pillai[2], Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow-226007, UP, India; Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India
Runcie Paul Mathews[3], Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow-226007, UP, India; Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India
Rose Ann Sebastian[4], Department of Geology, School of Earth Science Systems, Central University of Kerala, Kasaragod-671316, Kerala, India
Mrutyunjaya Sahoo[5], Department of Geology, Ravenshaw University, Cuttack-753003, Odisha, India
Srikanta Murthy[6], Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow-226007, UP, India
Anju Saxena[7], Birbal Sahni Institute of Palaeosciences, 53 University Road, Lucknow-226007, UP, India
Gulshan Kumar Dhingra[8], Department of Botany, Sridev Suman Uttarakhand University, Uttarakhand-249145, India

Abstract

The present study deals with the Early Permian floral diversity, palaeoenvironment, palaeoclimate and depositional setting using a multiproxy approach that include morphotaxonomy, palynology, and organic geochemistry of Karo OCM (Open Cast Mine), East Bokaro Coalfield, Damodar Gondwana Basin, India. The Gondwana sediments are widely regarded as fluvio-lacustrine deposits. The macroplant fossil assemblage exhibits the presence of Glossopteridales, comprising *Glossopteris*, *Gangamopteris*, and *Vertebraria*, as well as Coniferales, which includes *Noeggerathiopsis*. The palynological assemblage encompasses the dominance of the striate bisaccate pollen *Faunipollenites* sp. and the sub-dominance of the non-striate bisaccate pollen *Scheuringipollenites* sp. with Glossopterid affinities. The megafloral and palynofloral assemblage confirms the biostratigraphical age to be Upper Barakar palynoflora of Kungurian affinity. The studied morphological characteristics led us to envisage the presence of dense forest that prevailed during their deposition. Moreover, it also confirmed that a warm and humid climate prevailed during the deposition of Upper Barakar sediments. The organic geochemical characterization based on functional group and biomarker analyses reveals the diagenetic effects on organic matter. Aliphatic symmetric (2865–2855 cm-1) and asymmetric stretching (2930–2910 cm-1) peaks are identifiable in coal samples, whereas they are absent in carbonaceous shale. The A-factor vs. C-factor plot suggests that the kerogen type is Type III, which can generate mainly gaseous kerogen. The vitrinite reflectance studies (Rr av. 1.1%) show increased maturity of the

samples, which is support-ed by the *n*-alkane distribution pattern and the absence of hopane terpenoids. The Indian floral assemblages in contemporary of southern Gondwana continents reveal a stronger inclination/affinity with the flora of Africa than that of South America, thereby supporting the age to be of Artinskian-Kungurian.

Keyword

Glossopteris, Palynomorph, Gondwana, Permian, Palaeoclimate

Organo-floral characteristics of the Jagannath coal mine (Talcher Coalfield) from Mahanadi Basin: Implications to Paleoecology, Paleovegetation and depositional settings

DEVESHWAR PRAKASH MISHRA[1]*, BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES (dpmishra@bsip.res.in)
Srikanta Murthy[2], BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES
Vikram Pratap Singh[3], BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES
Anju Saxena[4], BIRBAL SAHNI INSTITUTE OF PALAEOSCIENCES
Dieter Uhl[5], Senckenberg Forschungsinstitut und Naturmuseum Frankfurt, Senckenberganlage 25, 60325 Frankfurt am Main, Germany
Bindhyachal Pandey[6], Banaras Hindu University Varanasi

Abstract

The combined analysis includes miofloral, megafloral, palynofacies, petrographical and fossil charcoal for the sediments of the Jagannath coalmine section in Talcher Coalfield from the Mahanadi Basin. Attempts are made to establish the age, reconstruction of palaeo-environment and evidence for the occurrence of palaeo-wildfires. Palynological investigation reveals one palynoassemblage namely *Scheuringipollenites barakarensis* palynoassemblage zone and assessed Early Permian (Artinskian) age for studied section. The palynoassemblage shows dominance genera of Glossopteridales and sub dominance of genera of trilete spores followed by Cordaitales and Coniferales. Megaflora comprise a low diversity assemblage dominated by Equisetales (*Schizoneura* and *Paracalamites*), with less common Glossopteridales (*Glossopteris*, *Gangamopteris*) and Filicales (*Dichotomopteris*) indicative of dense arborescent vegetation. Petrographic indices suggest that peat-forming vegetation accumulated mainly in telmatic settings under ombrotrophic-mesotrophic (intermittent fluctuating) hydrological conditions. Palynofacies suggest that the deposition of organic matter (by high energy fluvio-deltaic agents) took place in an oxic to occasionally dysoxic setting. The macroscopic charcoal fragments exhibit presence of homogenized cell walls and anatomical characters such as uniseriate simple, multiseriate alternate pitting on the tracheid walls and rays of varying heights suggested that the studied charcoal has gymnospermous wood affinity. The parautochthonous origin for these charcoal due to it's excellent preservation, their large size and unabraded edges in most of the specimens. Our multiproxy study is significant for understanding Permian peat-forming ecosystems and environments and provides a robust age assessment based on inter and intra-basinal correlations of coeval sequences across the Gondwana.

Keyword

Palynology, Glossopteridales, Palynofacies, Fossil charcoal, Macerals

Vegetation and climate oscilations during MCO/MCT in Central and Eastern Paratethys

Marianna Kováčová[1]*, Comenius University Bratislava (marianna.kovacova@uniba.sk)
Nela Doláková[2], Masaryk University Brno

Abstract

Originally, we analyzed the Late Burdigalian to Serravalian pollen spectra from the Czech and Slovak regions of the Central Paratethys, as well as the Mura-Zala basin and Transylvanian basin. These were compared with spectra from Eastern Paratethys in Turkey. The climax of the Miocene Climatic Optimum (MCO) revealed oscillations in climatic factors, such as increasing seasonality in temperatures and precipitation. Subsequent cooling and observable precipitation fluctuations were documented as evidence for the Miocene Climate Transition (MCT) (Doláková, Kováčová, Utescher, 2021). The vegetation character in Central Paratethys underwent significant changes due to the Alpine uplift of the western Alps and Carpathians, initiating altitudinal zonality. Differences mainly in quantitative representation of zonal elements between northern localities (Czechia and Slovakia) and southern parts of this are (Slovenia, Romania) indicates increasing of latidudinal zonality. In Eastern Paratethys, palynospectra indicated an earlier trend of gradual cooling and a notable shift towards more arid and continental climate conditions. This trend may be linked to the presence of the vast moderate Eurasian continent (Vernyhorova et al., 2023).

Doláková, N, Kováčová, M, Utescher, T. (2021): Vegetation and climate changes during the Miocene climatic optimum and Miocene climatic transition in the northwestern part of Central Paratethys. - Geological Journal.56, (2), 729–743.
Vernyhorova, Y.V., Holcová, K., Doláková, N., Reichenbacher, B., Scheiner, F., Ackerman, L., Rejšek, J., De Bortoli, L., Trubač, J., Utescher,T. (2023): The Miocene Climatic Optimum at the interface of epicontinental sea and large continent: A case study from the Middle Miocene of the Eastern Paratethys. - Marine Micropaleontology 181, 102231

Keyword

Vegetation, Climate, Miocene, MCO/MCT, Paratethys

Palynofloral Succession on the Cretaceous-Paleogene Transition in Northeast China

Jiahui YU[1], College of Earth Sciences, Jilin University, China
Yuewu SUN[2]*, Research Center of Palaeontology and Stratigraphy, Jilin University (sunyuewu@jlu.edu.cn)
Shuqin ZHANG[3], Research Center of Palaeontology and Stratigraphy, JilinUniversity, China
Eugenia BUGDAEVA[4], Federal Scientific Center of the East Asia Terrestrial Biodiversity, FEB, RAS, Russia

Abstract

The mass extinction at the Cretaceous-Paleogene (K-Pg) boundary significantly changed the earth's ecosystem, and profoundly influenced the global animal and plant evolution. It is attributed to climate change resulting from the Chicxulub impact in the Yucatan Peninsula in the Gulf of Mexico and the massive Deccan volcanic eruption. However, the K-Pg boundary clay has not been reported in China and northeastern Asia either. The terrestrial sediments in the Jiayin area of Heilongjiang Province, NE China, had been identified as the 95th locality of the K-Pg boundary, mainly based on the palynological data (Sun et al., 2011). In order to better understand the vegetation succession and climate change, detailed palynological investigation was engaged again on the K-Pg boundary transition from the XHY2008 borehole in Jiayin of Heilongjiang Province, China. A total of 153 species assigned to 72 genera were identified from 157 palynological samples in a 14.50 meters long borehole striding the K-Pg boundary. The Cretaceous-Paleogene vegetation as a whole was pteridophyte-angiosperm rich flora. Two palynological assemblages and one assemblage were recognized for the latest Cretaceous and earliest Paleogene, respectively. The latest Maastrichtian palynological assemblages were named as in ascending order: 1) Gabonisporis vigourouxii - Pinuspollenites microinsignis - Aquilapollenites stelckii Ass., and 2) Laevigatosporites spp. - Monocolpopollenites spp. - Ulmoideipites krempii Ass.; and the earliest Danian assemblage was named as Osmundacidites spp. - Pseudointegricorpus clarireticulatus - Wodehouseia spinata Ass. The two latest Maastrichtian assemblages were productive in palynomorphs and with high pollen concentration, while the earliest Danian samples were much lower in pollen concentration. The index pollen for the latest Maastrichtian and earliest Danian age determination were the occurrences of Wodehousia spinata and Triatriopollenites confuses, respectively. The vegetation succession on the K-Pg boundary was characterized by the rise of Osmundacidites fern spores and the diverse of gymnosperm pollen, while the angiosperm pollen were decreased obviously and most species of the Aquilapollenites were disappeared. On the contrast, the latest Maastrichtian vegetation succession was characterized by great rising of angiosperm pollen such as Monocolpopollenites, Alnipollenites and Ulmoideipites, and decreasing of fern spores such as Gabonisporis and Triporoletes. From the general view on vegetation succession, there were not any great event happened on the K-Pg boundary. It showed us another scenario which is totally different from the asteroid impacts in North America. This work was funded by National Science Foundation of China (41972012, 31270277).

Keyword

XHY2008 borehole, K-Pg boundary, Palynofloral succession, pteridophyte-angiosperm rich flora, Heilongjiang River

Middle-Late Permian Palynofloras in lacustrine-pluvial fan depositional system in Junggar Basin, northern Xinjiang, China

Yuewu SUN[1]*, Research Center of Palaeontology and Stratigraphy, Jilin University (sunyuewu@jlu.edu.cn)
Xueqin WANG[2], Research Center of Palaeontology and Stratigraphy, Jilin University, China
Shuqin ZHANG[3], Research Center of Palaeontology and Stratigraphy, Jilin University, China

Abstract

The Permo-triassic terrestrial deposits in Junggar Basin of northern Xinjiang are well developed, and have been studied in detail, especially the P-Tr boundary transition since 1980's. However, little palynological investigation was done after 1990. In order to see the vegetation and climate changes during the Guadalupian and early Lopingian, 170 palynological samples were collected systematically from the uppermost of Lucaogou-, Hongyanchi-, Quanzijie- and the bottom of Wutonggou- formations in the south limb of West Dalongkou anticline, Jimsar, norther Xinjiang, China. Among them, 39 samples are productive, and 69 species of 40 genera were identified. Based on the vertical distribution of palynomorphs in the Dalongkou profile, two distinct palynofloras were recognized in ascending order: 1) Corditina subrotata – Striatoabietes lipidus – Protowelwitschiapolis exolescus palynoflora (SLE), is occurred in uppermost of Lucaogou-, and Hongyanchi- formations. The palynomorphs in this horizon are characterized by abundant gymnosperms pollen, such as Cordaitina, Protowelwitschiapolis, Striatoabiites, Vittatina, Protohaploxypinus and Cycadopites. Spores are rare, only Raistrickia and Laevigatosporites. 2) Kraeuselisporites spinulosus – Tuberculatosporites homotubercularis – Potonieisporites turpanensis palynoflora (SHT), is located in Upper Quanzijie-, and Lower Wutonggou-formaitons. It is characterized by abundant both fern spores and gymnosperms pollen. Fern spores are mainly Kraeuselisporites, Tuberculatosporites, Raistrickia, Apiculatisporis and Cyclogranisporites. Neoraistrickia, Schopferites and Polypodidites are also seen. Gymnosperms pollen are mainly Cordaitina, Potonieisporites, Klausipolenites, Falcisporites and Platysaccus. According to the geological age span of known pollen and spores taxa in the two palynofloras, the SLE and SHT are assigned to the early Guadalupian and early Lopingian, respectively. As the palynomorphs in the lower Quanzijie Formation are closely related to those in SLE, we consider that the G-L boundary might be between the Lower and Upper Quanzijie Formation in West Dalongkou profile, although there would exist hiatus between the Hongyanchi and Quanzijie formations. Meanwhile, the paleoclimate of the SHT would be more humid than the SLE, and the paleoclimate of the lower Quanzijie Formation might be even much drier than the Lucaogou and Hongyanchi formations. This drived two types of fan deposits: the alluvial and pluvial fans. This work is supported by the National Natural Science Foundation of China (31670215).

Keyword

Guadalupian, Lopingian, palynoflora, paleoclimate, Junggar basin

The Leaf Fossils of Tuff Units in Metro Manila and Rizal, Philippines

Andrea Pamintuan[1]*, National Institute of Geological Sciences (andreapamints@gmail.com)
Alyssa Peleo-Alampay[2], Nannoworks Laboratory, National Institute of Geological Sciences, University of the Philippines, Diliman
Pastor Malabrigo[3], Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines, Los Banos, Laguna, Philippines
Arthur Glenn Umali[4], Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines, Los Banos, Laguna, Philippines

Abstract

Plant fossils found in sedimentary rocks have been utilized extensively for geological, evolutionary, and paleoecological studies. Plant macrofossils are particularly useful in correlational and evolutionary studies, as they keep records of morphological features of plants. Despite the rich flora of the Philippines, studies on fossil leaves from the Philippines are rarely reported, making this study particularly significant in deepening our understanding of the past environments that once thrived in this area. Consequently, paleoflora studies provide valuable insights into the geological and ecological history of the Philippines.

In this study, fossil leaves collected from Pleistocene volcaniclastic units in Metro Manila and Rizal Province are examined and identified. Insights into the paleoenvironment of the area was interpreted based on fossil leaf species identified and previous literature. Fossil flora families identified from Laguna Formation samples indicate a tropical climate and moist environment that could possibly be a mixed dipterocarp or sub-montane forest. Similarly, samples from the Diliman Tuff indicated a tropical to subtropical climate and a moist environment. General lithology, data from previous work and the nature of the fossil leaves narrows the paleoenvironment of the Diliman Tuff to a riparian setting. This is the first detailed work on fossil leaves in the Philippines, shedding light on the region's past ecological and geological landscapes.

Keyword

fossil leaves, paleobotany, paleoenvironment

Ostracod Faunas from the Early Cretaceous Liupanshan Group (Pingliang, NW China): Implications for Biostratigraphy and Palaeoenvironment

Yaqiong WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (yqwang@nigpas.ac.cn)
Byung-Do CHOI[2], Daegu National Science Museum
Deyan WU[3], Yunnan University

Abstract

The Liupanshan Basin is one of the small-scale Mesozoic-Cenozoic rift basins, which situated in the northern part of the North-South tectonic belt and bounded by the Ordos Block, the Alxa Block, the Hexi Corridor belt, and the Qinling-Qilian orogenic belt. Within this basin, the Lower Cretaceous Liupanshan Group comprises five formations: Sanqiao, Heshangpu, Liwaxia, Madongshan, and Naijiahe formations, arranged in ascending stratigraphic order. This study investigates a non-marine ostracod fauna recovered from the Liwaxia and Madongshan formations, encompassing eight species belonging to seven genera: *Bisulcocypridea gaodianensis*, *Cypridea cavernosa astuta*, *C. elegantula*, *Mongolocypris* sp. A, *Liupanshania typica*, *Lycopterocypris debilis*, *Ziziphocypris costata*, and *Limnocythere* sp. A. Among these ostracods, the genus *Bisulcocypridea* is found in Aptian to lower Paleocene deposits in the USA, Mongolia, and China, while the genus *Mongolocypris* is recorded in Aptian to Paleocene strata in China, Mongolia, and Korea. *Lycopterocypris debilis* is widely distributed in Hauterivian to Albian non-marine strata in East Asia, and *Ziziphocypris costata* occurs in Aptian to the lowermost Danian non-marine strata in East Asia. Based on this ostracod biostratigraphy, the age of the Liwaxia and Madongshan formations in the Pingliang area is probably Aptian to Albian.

In this ostracod fauna, the endemic-dominated extinct genus *Liupanshania* is perhaps most closely related to the living genus *Cyprois* of the family Notodromadidae. All living species from the family Notodromadidae possess swimming ability, and most feed on the neuston. Additionally, notodromadidae are known to inhabit mostly lentic habitats. Furthermore, based on our previous findings, the other ostracod genera from this fauna may indicate a fresh to slightly saline lacustrine to fluvial environment. Therefore, we interpret the Liwaxia and Madongshan formations in the Pingliang area of the Liupanshan Basin as having been deposited in a fresh to slightly saline lacustrine environment.

Acknowledgments. This study is supported by the National Natural Science Foundation of China (42372022).

Keyword

Liwaxia Formation, Madongshan Formation, Aptian to Albian, Family Notodromadidae

Exceptional preservation of reproductive organs and giant sperm in the Cretaceous ostracods

He WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (wanghe0701@163.com)

Abstract

The bivalved crustacean ostracods have the richest fossil record of any arthropod group and display complex reproductive strategies contributing to their evolutionary success. Sexual reproduction involving giant sperm, shared by three superfamilies of living ostracod crustaceans, is among the most fascinating behaviours. However, the origin and evolution of this reproductive mechanism has remained largely unexplored because fossil preservation of such features is extremely rare. Here, we report exceptionally preserved ostracods with soft parts (appendages and reproductive organs) in a single piece of mid-Cretaceous Kachin amber (approximately 100 Myr old). The ostracod assemblage is composed of 39 individuals. Thirty-one individuals belong to a new species and genus, Myanmarcypris hui gen. et sp. nov., exhibiting an ontogenetic sequence from juveniles to adults (male and female). Seven individuals are assigned to a new species and genus Electrocypria burmitei gen. et sp. nov. and one to Sanyuania sp. Our micro-CT reconstruction provides direct evidence of the male clasper, sperm pumps (Zenker organs), hemipenes, eggs and female seminal receptacles with giant sperm. Our results reveal that the reproduction behavioural repertoire, which is associated with considerable morphological adaptations, has remained unchanged over at least 100 million years—a paramount example of evolutionary stasis. These results also double the age of the oldest unequivocal fossil animal sperm. This discovery highlights the capacity of amber to document invertebrate soft parts that are rarely recorded by other depositional environments. We further describe taphonomic traits indicating that the studied ostracods were quickly surrounded by resin and instantly immobilized. The palaeoenvironment is considered to be a vegetated brackish (mesohaline-oligohaline) lagoon.

Keyword

Kachin amber, ostracods, giant sperm, palaeoenvironment, taphonomy

[Keynote] Phenotype Puzzle: Challenges in Paleontological Studies

Yanhong PAN[1]*, Nanjing University (panyanhong@nju.edu.cn)

Abstract

Evolutionary processes, driven by the interplay of natural selection and genetic variation, shape the characteristics of biological populations over time. In the field of paleontological research, the primary focus frequently shifts towards phenotypes, which poses a challenge in distinguishing individuals and species due to inherent deficiencies in fossil records. The phenotypic characteristics recorded in fossil specimens can be broadly classified into two types: those indicating a binary presence or absence, which may effectively represent species even at an individual level. Others exhibit continuous variation necessitating the definition of species based on population characteristics. The latter arises from the blurred distinction between phenotypic characteristics, especially when specimens are limited and gathered from multiple locations. Nonetheless, this practice raises inquiries, such as the determination of whether specimens from distinct locations belong to the same species. It is also important to decide whether incomplete specimens can be discarded without compromising the integrity of the study. Moreover, the inquiry of what constitutes a sufficient sample size becomes a crucial consideration. To address these obstacles, we try to employ mathematical statistics and computational models to compensate for the limited sample sizes, aiming to enhance comprehension of fossil populations and their evolutionary dynamics. In conclusion, the phenotype puzzle in paleontological research requires solutions to navigate the challenges posed by incomplete and limited fossil records.

Keyword

Phenotype, Fossil Population, Statistical Analysis

A review of non-marine ostracod faunas from the Cretaceous Gyeongsang Basin, South Korea

Byung-Do CHOI[1]*, Daegu National Science Museum (dinobd87@gmail.com)
Yaqiong WANG[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Min HUH[3], Department of Geological and Environmental Sciences & Korea Dinosaur Research Center, Chonnam National University

Abstract

Non-marine ostracod records from the Cretaceous Gyeongsang Basin, South Korea are reviewed here. Although many faunas show a relatively low diversity and poor state of preservation, a total of 36 species belonging to 10 genera of superfamily Cypridoidea are recognized. Basis on major generic compositions, three ostracod assemblages are established in ascending order: 1) Barremian–early Albian *Cypridea-Mongolocypris-Scabriculocypris* assemblage (Nakdong, Hasandong, and Jinju formations); 2) late Albian–Cenomanian *Cypridea-Ziziphocypris-Lycopteorcypris* assemblage (Iljik, Banyawoel, and Chunsan formations); 3) Turonian–Santonian *Lycopteorcypris-Candona* assemblage (Geoncheonri Formation); 4) Campanian *Mongolocypris* assemblage (Anpo Tuff) in ascending order. The most diverse group of these assemblages is genus *Cypridea* (including 12 species) as many strata in East Asia. Except several species, the Barremian–early Albian faunas show a high endemicity, which may indicate that many ostracod taxa evolved in the isolated environments; e.g., *Mongolocypris kohi* from the Albian Jinju Formation is considered an ‘early form’ of the genus. After faunal turnover, the post-early Albian faunas show affinities to those of the Late Cretaceous in China and Mongolia, providing evidence of active faunal exchanges. In addition, a restricted stratigraphic distribution of genus *Ziziphocypris* (late Albian–Cenomanian) is useful for biostratigraphic correlation. A comprehensive interpretation about ostracod faunal significances herein provides new information on the evolution, biostratigraphy, and paleobiogeography of the Gyeongsang Basin, as well as the Cretaceous of East Asia.

Keyword

Taxonomy, Cypridoidea, Biostratigraphy, Paleoecology, Paleobiogeography

Late Devonian benthic ostracods from South China and their response to the Frasnian–Famennian event

Junjun SONG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (jjsong@nigpas.ac.cn)

Abstract

The Late Devonian Frasnian–Famennian mass extinction (i.e., F–F event) is traditionally known as one of the Phanerozoic "Big Five" faunal crises, and had a severe impact on marine realm, especially the shallow-water ecosystems. In this study, Late Devonian ostracods are described for the first time from the Frasnian–Famennian (F–F) transition of the Zengpiyan section, Guangxi, South China. Forty-five ostracod species belonging to 25 genera are identified and figured and one is new: Jenningsina guilinensis sp. nov. The Frasnian–Famennian boundary (F–FB) in the Zengpiyan section is coincident with the lithological boundary between the Guilin Formation and the Dongcun Formation, and could be marked by the disappearance of Rectobairdia proximischimensis (Lethiers & Casier, 1998) and Jenningsina guilinensis sp. nov. The ostracods belong to the Eifelian Mega-Assemblage, which implies a shallow-water palaeoenvironment. The ostracod fauna and sedimentary features of the Guilin and Dongcun formations at the Zengpiyan section suggest a transition from subtidal to low energy tidal flat on the Guilin Platform during the Frasnian-Famennian event. The extinction rate of benthic ostracod species is about 61% during the F–F event in the Zengpiyan section. Two stages of faunal changes have been recognized in the event and the second stage is more severe than the first one.

Keyword

Benthic ostracods, Frasnian–Famennian boundary, Biofacies, Mass extinction, South China

[Keynote] Time Machine Biology: ostracod examples

Moriaki YASUHARA[1]*, The University of Hong Kong (moriakiyasuhara@gmail.com)

Abstract

Direct observations of marine ecosystems are inherently limited in their temporal scope. Yet, ongoing global anthropogenic change urgently requires improved understanding of long-term baselines, greater insight into the relationship between climate and biodiversity, and knowledge of the long-term consequences of our actions. Sediment cores and small fossils included there, so called microfossils (including various taxonomic groups of photosynthetic plankton such as coccolithophores and diatoms, various mixo- to heterotrophic protists such as planktonic and benthic foraminiferaand planktonic radiolarians, and small metazoans such as benthic ostracods as well as parts of larger organisms, such as the scales and teeth of fish and shark denticles), can provide this understanding by linking data on the responses of marine biota to reconstructions of past environmental and climatic change. Given continuous sedimentation and robust age control, studies of sediment cores have the potential to constrain the state and dynamics of past climates and biodiversity on timescales of centuries to millions of years. Here, we will overview the development and recent advances in "ocean drilling paleobiology" or "Time Machine Biology"—a synthetic science with potential to illuminate the interplay and relative importance of ecological and evolutionary factors during times of global change. Climate appears to control marine ecosystems on various timescales. I will showcase several examples from recent studies from our group, especially focusing on microfossil ostracods, and give an outlook on ongoing and future anthropogenic changes.

Keyword

paleobiology, paleoecology, biodiversity, climate change

Late Ordovician ostracods of Valcour Island, New York State, USA

Yichi ZHANG[1]*, School of Biological Sciences, The University of Hong Kong, Hong Kong SAR, PRC (yichi@connect.hku.hk)
Moriaki YASUHARA[2], School of Biological Sciences, The University of Hong Kong, Hong Kong SAR, PRC
Skye Yunshu TIAN[3], Institute of Geosciences, University of Bonn, Bonn, Germany
Melanie HOPKINS[4], Division of Paleontology (Invertebrates), American Museum of Natural History, New York, USA

Abstract

Ordovician ostracods of the New York State had been recorded preliminarily with systematic paleontology under an unrevised classification scheme. New materials are collected from the Late Ordovician Crown Point Formation of Valcour Island, northeastern New York State, for thorough studies on systematic revision, diversity analysis, paleoecological and paleogeographical implications. Fifty-one species of 39 genera are identified with 6 species being reexamined and revised accordingly. Within the fauna, Krausella variata, Cryptophyllus oboloides, Eohollina depressa and Eurychilina placida are the most common species. Both beyrichiocopids and podocopids are dominant in the Valcour fauna. Faunal comparison shows close relationships between Laurentia and Baltica, Avalonia and Ibero-Armorica during this time interval. Hill number is used for diversity analysis on each sample, and a general increase in diversity is recognized. Furthermore, new exceptionally well-preserved materials of palaeocopid Eurychilina placida are collected, with development of moult retention. The phenomenon of moult retention has been found in several genera of Paleozoic ostracod, which are assigned to the Suborder Eridostracina empirically. New materials with moult retention not only reveals a new survival strategy for ostracods during the period of unstable environment, but also shows that moult retention possibly could not be the characteristic feature to define a suborder, and the classification scheme should be revised accordingly.

Keyword

Ostracods, Late Ordovician, New York State, Moult Retention

Distribution and community structure of ostracods across the Isthmus of Panama

Kk Aye[1]*, University of Hong Kong (u3007074@connect.hku.hk)
Moriaki Yasuhara [2], University of Hong Kong
Aaron O'Dea[3], Smithsonian Tropical Research Institute

Abstract

The complete emergence of the Isthmus of Panama between 4.0 – 2.5 Ma has completely shaped the present–day environmental conditions of the Caribbean Sea and the Tropical Eastern Pacific Ocean (TEP). The Caribbean Sea is biologically unproductive and exhibits higher surface salinity and sea surface temperatures with freshwater input from local precipitation. It is in stark contrast to the TEP which encompasses low salinity and well-stratified waters with some of the most nutrient-compressed waters originating from major coastal upwelling areas of Panama. Such heterogeneous conditions will produce unique habitats that prompt considerable differences in marine ecosystems on either side of the Isthmus of Panama. This project will make use of Ostracoda as a model system to provide insight into the relationship between the community dynamics (assemblage composition, depth distribution, abundance, diversity analysis, etc.) of ostracods in various regions of the Caribbean Sea and the TEP, as well as gain further knowledge of indicator species within the tropical shallow marine ecosystems. Ostracods are the ideal taxonomic group to explore this question in detail due to their high sensitivity to environmental changes and exceptional preservation quality. We will use 110 surface dredge and grab samples from the Panama Palaeontology Project (PPP) covering 4 major regions of the southern Caribbean Sea and 2 major regions of the northern TEP. Methods involve washing, sieving, drying, and picking of the surface samples and individual ostracods will be identified to the species level where possible. Based on several investigations into the Platycopid signal and response of ostracods to oceanic oligotrophic conditions during the Oceanic Anoxic Event 2 excursion, I hypothesise that ostracod assemblages will differ distinctly in the Caribbean Sea and the TEP by way of a higher abundance and diversity of oligotrophy-bearing Platycopid species on the Caribbean side of the Isthmus of Panama. Results on trends in ostracod community dynamics will be presented at the conference.

Keyword

Ostracoda, Panama, Community Structure

Ecological Impact of the Suez Canal: Distribution and Diversity of Invasive Ostracods in the Mediterranean Sea

Lalita WEERACHAI[1]*, School of Biological Sciences, The University of Hong Kong (lalita347@gmail.com)
Moriaki Yasuhara[2], School of Biological Sciences,The University of Hong Kong

Abstract

The Lessepsian invasion is a consequence of the construction of the Suez Canal in 1869. This human activity led to the migration of marine species from the Red Sea in the Indo-Pacific region to the eastern Mediterranean Sea. Both biologists and paleontologists have been studying the non-indigenous species to understand the history of marine biodiversity in the region. The results showed that the eastern Mediterranean has experienced a significant collapse in native biodiversity over the past few millennia, which has been aggravated by recent human activities such as shipping and ballast water, and climate change. To achieve more comprehensive understanding of the ecological impact of this invasion, it is important to consider the spatial distribution of small organisms as well as the diversity and faunal compositions. This study aims to investigate the distribution and abundance of ostracod species from core and surface samples. Ostracods are small and well-calcified bivalved crustaceans that inhabit a wide range of aquatic environments. They have been widely used as a bioindicator, and they can also be used to reconstruct historical changes, as ostracod shells have excellent preservation potential in sedimentary archives. Additionally, ostracods are often abundant and diverse, making them useful for biodiversity assessments and monitoring. The study of ostracod invasive species will provide us with the spatial distribution of ostracods following the opening of the Suez Canal.

Keyword

Lessepsian migration, alien species, ostracoda, paleoecology, anthropogenic impacts

OSTRACOD ASSEMBLAGES OF THE MIDDLE MIOCENE TRANSGRESSIVE SEDIMENTS IN THE CARPATHIAN FOREDEEP (JAWORZNO, SW POLAND; THE CENTRAL PARATETHYS)

Zbigniew Jan ZIAREK[1]*, AGH University of Krakow; Faculty of Geology, Geophysics, and Environmental Protection; A. Mickiewicza 3 Av., 30-059 Krakow, Poland (zbysiuziarek@student.agh.edu.pl)
Monika PILARZ[2], AGH University of Krakow; Faculty of Geology, Geophysics, and Environmental Protection; A. Mickiewicza 3 Av., 30-059 Krakow, Poland

Abstract

During the Middle Miocene the Fore-Carpathian Basin in Poland represented the northernmost part of the Central Paratethys. The Langhian in the Central Paratethys was characterized by a major marine transgression into the Pannonian and Carpathian Foredeep basins. Investigated area encompasses the Middle Miocene sediments of the western part of the Carpathian Foredeep in Poland, where the northern boundary is erosional in nature and the southern boundary is tectonic and correspond to the Carpathian overthrust. Profiles containing a sequence of the transgressive sediments in the north of this part of basin are very rare.

We present new results on samples taken from Jaworzno 5902 borehole located in southern Poland. Investigated area covers the northernmost isolated patch of transgressive Langhian sediments and are represented by marls, light ash-grey/green clay marls (the Klodnica Fm.) and grey clays (the Skawina Fm.).

Obtained material mainly consists of foraminifera, ostracods and detritus of bivalve shells.

In the ostracod microfauna two assemblages can be distinguished. The first (the Klodnica Fm.) is the *Aurila-Cytheridea* assemblage and is dominated by species: *Aurila punctata*, *A. angulata*, *A. haueri*, *Cytheridea acuminata*, *Olimfalunia pliculata*, *Loxoconcha* sp., and *Cytherura* sp.. This assemblage indicates the depth zone of 0-25m according to Keen (1989). Sissingh (1976) associates the dominance of *Cytheridea* and the co-occurrence of *Aurila* and *Loxoconcha* with an environment related to the infralittoral zone, constituting the shallower part of the sublittoral zone, not exceeding 50m. Mentioned species indicate a brackish environment. The second assemblage (the Skawina Fm.) is dominated by *Henrychowella asperrima*, *Parakrithe rotundata*, and *Pterygocythereis jonesii* – typical ostracods related to deeper marine environments. The coexistence with the shallow-water *Costa* sp. suggests that the basin depth did not exceed 100m.

Ostracods from Jaworzno show dwarfism, which suggests difficult environmental conditions. The abundance of ostracods in the samples varies widely, and their carapaces in the lower part of the profile are thin, sometimes transparent, whereas in the upper part, they are slightly thicker, which suggests changes in the environment. These data indicate transition from a brackish shallow-water environment (Klodnica Fm.) to a fully-marine one (Skawina Fm.).

The ostracods of the Klodnica Fm. in Jaworzno borehole resembles the assemblages from the

profiles located west (Nowy Dwor) and south (Polomia) of Jaworzno. Similarly, all these ostracods represent deposits of the shallow-marine brackish zone at 0-25m. The difference is observed in case of the Beczyn profile located in the Carpathian thrust zone. In this case assmeblage is rich and diverse in well-preserved thick carapace ostracods. This part of basin depth could not have exceeded 100m (Schiller, 1977). The studied ostracod assemblages show full analogies in species composition to the same-age assemblages described from the Vienna Basin in Austria.

The results of the study of the presented ostracod assemblages are consistent with the conclusions drawn from the analyse of foraminifera. On the basis of foraminifera, it was possible to determine the age of studied deposits as Langhian which corresponds to the Badenian in the Central Paratethys, *Orbulina suturalis* – *Praeorbulina glomerosa* Zone (Cicha et al. 1975).

Keyword

Miocene, Ostracoda, transgression, the Central Paratethys, the Carpathian Foredeep

Testing the deep-sea glacial disturbance hypothesis as a cause of low, present-day Norwegian Sea diversity

Anna JÖST-KIM[1]*, Tropical and Subtropical Research Center, Jeju, Korea Institute of Ocean Science and Technology (underwater.myhome@gmail.com)
Huai-Hsuan Huang[2], Princeton University
Yuanyuan Hong[3], The University of Hong Kong
Chih-Lin Wei[4], National Taiwan University
Henning Bauch[5], Alfred-Wegener-Institut Helmholtz Center for Polar and Ocean Research, c/o GEOMAR Helmholtz Centre for Ocean Research Kiel
Benoit Thibodeau[6], The Chinese University of Hong Kong
Thomas Cronin[7], Florence Bascom Geoscience Center, U.S. Geological Survey
Hisayo Okahashi[8], The University of Hong Kong
Moriaki Yasuhara[9], The University of Hong Kong

Abstract

Within the intensively-studied, well-documented latitudinal diversity gradient, the deep-sea biodiversity of the present-day Norwegian Sea stands out with its notably low diversity, constituting a steep latitudinal diversity gradient in the North Atlantic. The reason behind this has long been a topic of debate and speculation. Most prominently, it is explained by the deep-sea glacial disturbance hypothesis, which states that harsh environmental glacial conditions negatively impacted Norwegian Sea diversities, which have not yet fully recovered. Our aim is to empirically test this hypothesis, using ostracod (Ostracoda: Crustacea) fossil assemblages (Middle Pleistocene-Late Holocene, i.e., 620.7–1.4 ka) from three sediment cores (MD992277, PS1243(-1), M23352(-3)) from the deep Norwegian Sea (1819 m–2800 m). Specific research questions are: 1. Has deep-sea biodiversity been lower during glacials than during interglacials? 2. Was there any faunal shift at the Mid-Brunhes Event (MBE) when the mode of glacial-interglacial climatic change was altered?

We empirically test the deep-sea glacial disturbance hypothesis by investigating temporal patterns of species diversity and comparing them to global climate proxies. Additionally, we apply comparative analyses to determine a potential faunal shift at the Mid-Brunhes Event (MBE), a Pleistocene event describing a fundamental shift in orbital climate cyclicity. Our results indicate that the deep Norwegian Sea diversity was not lower during glacial periods compared to interglacial periods; that Holocene diversity was much lower than that of the last glacial period; and that Faunal composition changed substantially between pre- and post-MBE. Therefore, these results reject the glacial disturbance hypothesis, since the low glacial diversity is the important precondition here. The present-day-style deep Norwegian Sea ecosystem was established by the MBE, more specifically by MBE-induced changes in climate cyclicity, which has led to more dynamic post-MBE. In a broader context, this implies that the MBE has played an important role in the establishment of modern polar deep-sea ecosystem and biodiversity in general.

Keyword

Deep-sea diversity, Faunal turnover, Macroecological patterns, Mid-Brunhes Event, North Atlantic

Cretaceou stratigraphy and ostracod funa in the Songliao Basin, NE China

Dangpeng XI[1]*, China University of Geosciences (Beijing) (xdp1121@163.com)
Benjamin Sames[2], University of Vienna
Zhongye Shi[3], China University of Geosciences (Beijing)
Qin Zuohuan[4], China University of Geosciences (Beijing)
Xiaoqiao Wan[5], China University of Geosciences (Beijing)

Abstract

The Songliao Basin is one of the largest non-marine oil and gas bearing basins that developed during the Cretaceous period, recording an almost complete Cretaceous non-marine stratigraphy and biota, providing an important reference succession for understanding the non-marine Cretaceous. The Lower Cretaceous strata (Hautervian–Albian) in the Songliao Basin are dominated by volcanic-sedimentary deposits, while the lower-middle Upper Cretaceous (Cenomanian mid-Campanian) strata are dominated by lacustrine deposits, and the upper Upper Cretaceous strata (late Campanian–Maastrichtian) are dominated by fluvial-lacustrine deposits. Based on the lithostratigraphy, biostratigraphy, geochronology, magnetostratigraphy, and cyclostratigraphy, a comprehensive stratigraphic framework of the Songliao Basin has been established in this study.

Fossils are very abundant in the Songliao Basin, especially ostracod; and three biotas, the Jehol Biota, the Songhuajiang Biota and the Mingshui Biota are recognized in the Songliao Basin. Widespread non-marine deposits in the basin contain abundant ostracod. These well-preserved fossil ostracods provide valuable information about Cretaceous climate changes and biotic responses in a greenhouse environment. The Cretaceous International Continental Scientific Drilling Project core SK1 and SK3 from the Songliao Basin offers a rare opportunity to study Late Cretaceous non-marine ostracods over a long, continuously documented, time interval. The SK1 contains the upper Quantou, Qingshankou, Yaojia, Nenjiang, Sifangtai, and Mingshui formations in ascending order. The SK3 contains the Denglouku and lower to middle Quantou formations in ascending order. A high-resolution non-marine ostracod biostratigraphy based on SK1 and SK3 has been established. Twenty ostracod assemblages have been recognized from the upper Quantou to Mingshui formations. This series of zones can be correlated regionally and supraregionally. The preliminary biostratigraphic correlation indicates that assemblages 1 to 19 span the Cenomanian to Maastrichtian, while Assemblage Zone 20 might span the latest Maastrichtian to earliest Danian.

Keyword

Cretaceous, Songliao Basin, stratigraphy, ostracod, bipta

No-marine Ostracod fauna from the Early Cretaceous Jinchuan Formation of the Ordos Basin: Taxonomy and Biostratigraphy

Huazheng ZHU[1], 1. Nanjing University; 2. Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Yaqiong WANG[2]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (yqwang@nigpas.ac.cn)
Yanhong PAN[3], Nanjing University

Abstract

The Ordos Basin, also known as the Shaan-Gan-Ning Basin, stands as a significant reservoir of energy resources (coal, gas, and oil) in China, covering an expansive area of approximately 250,000 km^2. This basin is surrounded by the Yinshan Mountains in the north, the Qingling Mountains in the south, the Helan and Liupan Mountains in the west, and the Lvliang Mountains in the east. Within the basin, the Lower Cretaceous Zhidan Group comprises of the Luohe, Huanhe-Huachi, Luohandong, Jingchuan, and Fengshan formations in ascending order. Notably, the Jingchuan Formation is characterized by greyish-green breccias, conglomerates, yellowish-green calcareous sandstones, and variegated mudstones interlaced with oolitic limestone and marls. This formation hosts abundant fossil invertebrates (ostracods, clam shrimp, bivalves), vertebrate (dinosaurs), and plants, which have long been of interest to paleontologists. Recently, a non-marine “Purbeck-Wealden type” ostracod fauna is recovered from the Jinchuan Formation in Pingliang area; this ostracod fauna consists of five species belonging to three genera: *Cypridea* sp., *C. koskulensis*, *Lycopterocypris*? *multifera*, *L. debilis*, *Alicenula* sp. Of these ostracods, the species *Cypridea koskulensis* is widely distributed in Barremian to Aptian strata in China and Russia. *Lycopterocypris*? *multifera* was discovered in the Hauterivian to Albian Zuunbayan Formation of Mongolia, and *Lycopterocypris debilis* is widely distributed in Hauterivian to Albian non-marine strata in East Asia. Based on the available ostracod biostratigraphy information above, the age of the Jingchuan Formation is Barremian to Aptian.
Acknowledgments. This study is supported by the National Natural Science Foundation of China (42372022).

Keyword

Cypridea koskulensis, Zhidan Group, Barremian to Aptian, Pingliang area

Geochronology and biostratigraphy study on the Early Cretaceous basins in the Jilin region, northeastern China

Yu-Ting ZHONG[1]*, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences (zyt9797@gig.ac.cn)
Yaqiong Wang[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, 39 East Beijing Road, Nanjing 210008, China
Byung-Do Choi[3], Daegu National Science Museum, Dalseong Yuga-eup, Daegu 43023, Republic of Korea
Jianfang Hu[4], State Key Laboratory of Organic Geochemistry, Guangzhou Institute of Geochemistry, Chinese Academy of Sciences, Guangzhou 510640, China
Yanhong Pan[5], Nanjing University, Nanjing 210023, China

Abstract

The Cretaceous system is well developed in Jilin Province, consists of two types: the Songliao Plain type and the eastern/western mountainous region type. Recently, we have undertaken biostratigraphic, geochemical and geochronological studies on the sedimentary basins of eastern/western mountainous of Jilin. These investigations have yielded significant primary data that will contribute to further exploration of the evolution of terrestrial biota and its connection to the destruction of the North China Craton (NCC).

The Baishan Basin is located on the northern margin of the NCC. The early Cretaceous is divided into the Yingzuilazi, Linzitou, Shiren, and Xiaonangou formations. The Yingzuilazi Formation comprises of the conglomerate, sandstone, siltstone, mudstone with coal seams yielding abundant fossils. The ostracod fauna from this formation includes Cypridea tuberculatis, C. horni, C. bulumensis, C. aff. multispinosa, C. cf. unicostata, C. beipiaoensis, Rhinocypris jurassica, R. sp., Djungarica sp., Ziziphocypris linchengensis, Lycopterocypris infantilis, L. debilis, Timiriasevia principalis, Alicenula? dadianziensis, A.? Leguminella, indicating a Hauterivian to Barremian age. Meanwhile, zircon U-Pb dating from the upper part of the Yingzuilazi Formation yielded an age of 128.5±1.0 Ma. The overlying Linzitou Formation mainly consists of acidic volcanic rocks, dated at 127.4 ±1.1 Ma at the bottom. Consequently, ostracods show the similarities with the second stage of Jehol Biota in the Yixian Formation of western Liaoning, although its absolute ages aligns with the first stage of the Jehol Biota.

In the Yanji Basin, the late Early Cretaceous to early Late Cretaceous comprise the Tongfosi, Dalazi, and Longjing formations. The Tongfosi Formation includes of thick conglomerates at the base, with sandstone, siltstone, and sandy mudstone layers, and oil shale in the top. Ostracod fauna from this formation include Vlakomia jilinensis, V. ustinovskii, Scabriculocypris tonfosiensis, S. yanbianensis, Mongolianella kyranbeki, Lycopterocypris infantilis, Candona spp., indicating an Albian age. And the Dalazi Formation has lower conglomerates and upper layers of muddy sandstone, sandy mudstone, shale, oil shale, and tuff, yielding fossil ostracods: Cypridea concinaformis, Mongolocypris yanjiensis, Cyprois sp., Lycopterocypris sp., Yumenella toorojensis, which indicates an Albian-Cenomanian age. The topmost of Dalazi Formation is dated

at 105.14±0.37 Ma. The Longjing Formation mainly comprises conglomerates, and sandstones, containing abundant vertebrate fossils. Ostracod fossils from this formation include Mongolocypris cf. rostrata, M. yanjiensis, Candoniella cf. candida, Candona sp., indicating an Albian-Cenomanian age. Combine with the precise U-Pb age of 101.039±0.061 Ma from the bottom of the Longjing Formation, it suggested that the Longjing Formation of the Yanji Basin may include the terrestrial Lower-Upper Cretaceous boundary. Additionally, ostracod Vlakomia and our geochemistry data may indicate that a correlation between the Tongfosi Formation's oil shale and marine transgression event.

The Luozigou Basin, zircon U-Pb dating on the lower and middle parts of the Dalazi Formation yielded ages of 104.6±1.2 Ma and 103.3±1.0 Ma, respectively. This precise radiometric age for the Dalazi Biota from Luozigou Basin provides an important temporal constraint on the evolution of major plant and vertebrate groups.

Acknowledgments. This research was funded by the National Natural Science Foundation of China (Grant Nos. 42372022 and 41873018).

Keyword

Ostracods, Zircon U-Pb dating, North China Craton, Transgression, Upper-Lower Cretaceous boundary

Holocene hydroclimate changes in the source area of the Yellow River inferred from ostracod assemblages and their isotopes in Lake Gyaring

Xiangzhong LI[1]*, Yunnan University (xzhli04@163.com)
Deyan Wu[2], Yunnan University

Abstract

The Yellow River, as the mother river of China, is vital for the wellbeing of millions. The source area of the Yellow River (SAYR) contributes over one-third to basin discharge and is crucial for water conservation in China. However, understanding hydroclimate changes in the SAYR remains challenging due to limited hydroclimatic records. Here, we analysed ostracod assemblages, and their oxygen isotope (δ18O) values in 14C-dated sediments from Lake Gyaring, one of largest lakes in the SAYR, to reconstruct regional hydroclimate changes during the Holocene.

Based on the dominance of ostracod species Eucypris mareotica and their high δ18O values, we infer that Lake Gyaring experienced a prolonged period of high salinity and a closed lake state, suggesting persistently dry conditions in the SAYR during the early to middle Holocene. After 5.3 ka, however, the presence of Leucocythere sp., Fabaeformiscandona rawsoni, and Ilyocypris bradyi with decreased δ18O values, along with the absence of Eucypris mareotica and Limnocythere inopinata, indicates a transition of Lake Gyaring to an open-freshwater lake, suggesting a wetter climate in the region.

These findings provide valuable insights into the hydroclimate variability of the SAYR during the Holocene, contributing to a better understanding of regional climate dynamics. Such knowledge is crucial for informed decision-making in water resource management policies for this important river basin.

Keyword

Ostracod assemblages, Oxygen isotope, Yellow River, Qinghai-Tibetan Plateau, Lake evolution

PALEOZOOGEOGRAPY OF THE LOWER CREATACEOUS QUIRICÓ FORMATION, SÃO FRANCISCO BASIN, MINAS GERAIS STATE, BRAZIL: A STUDY BASED ON LIMNIC OSTRACODS

Amanda MOREIRA LEITE[1]*, University of Brasília, Brazil (amanda_mleite@hotmail.com)
Dermeval APARECIDO DO CARMO[2], University of Brasília, Brazil
Lívio Reily DE OLIVEIRA GONÇALVES[3], University of Brasília, Brazil
Dangpeng XI[4], China University of Geosciences, Beijing, China

Abstract

This paleozoogeographic study is based on 20 species of ostracods recovered in sections from the Quiricó Formation, São Francisco Basin, Minas Gerais State, Brazil. Five of the 20 species (*Penthesilenula pintoi* Leite et al., 2018; *Alicenula longiformis* Leite et al., 2018; *Timiriasevia sanfranciscanensis* Leite et al., 2018; *Cypridea* sp. 1; *Cypridea* sp. 2) were recovered only in the Quiricó Formation and are restricted, to date, to this basin. The 15 species recovered in other basins from Brazil, Argentina (South America), and Gabon, Congo and Angola (Africa) are: *Brasacypris ovum* Krömmelbein, 1965, Berriasian (Tucano Basin, Brazil); *Cypridea infima* Krömmelbein and Weber, 1971, Berriasian-Valanginian (Recôncavo Basin, Brazil); *Cypridea hystrix* Krömmelbein, 1962, Valanginian-Hauterivian (Recôncavo Basin, Brazil); *Cypridea jequiensis* Krömmelbein and Weber, 1971, Barremian (Sergipe-Alagoas Basin, Brazil), Barremian-Aptian (Campos Basin, Brazil); *Damonella ultima* (Krömmelbein and Weber, 1971), upper Barremian-lower Aptian (Recôncavo Basin, Brazil), upper Aptian (Jatobá and Araripe basins, Brazil), Barremian-Aptian (Golfo San Jorge Basin, Argentina); *Wolburgiopsis plastica* (Musacchio 1970) and *Wolburgiopsis chinamuertensis* (Musacchio 1970), Barremian (La Amarga Formation, Neuquén Province, Argentina); *Harbinia angulata* (Krömmelbein and Weber, 1971), upper Aptian (Sergipe-Alagoas, Araripe, Cedro and Jatobá basins, Brazil); *Harbinia symmetrica* (Krömmelbein and Weber, 1971), Aptian (Araripe and Grajaú basins, Brazil; Gabon, Congo and Cabinda basins, Africa); *Harbinia alta* Antonietto et al., 2012, upper Aptian-lower Albian (Araripe Basin, Brazil), upper Aptian (Grajaú and Jatobá basins, Brazil), middle-upper Aptian (Potiguar Basin, Brazil); *Harbinia salitrensis* (Krömmelbein and Weber, 1971), Aptian (Araripe and Grajaú basins, Brazil); *Harbinia crepata* Do Carmo et al., 2013, middle-upper Aptian (Potiguar Basin, Brazil), Aptian (Araripe Basin, Brazil); *Penthesilenula martinsi* (Silva 1978), Aptian (Araripe Basin, Brazil), middle-upper Aptian (Potiguar Basin, Brazil); *Neuquenocypris* (*Protoneuquenocypris*) *antiqua* Musacchio and Simeoni, 1991, Aptian (Golfo San Jorge Basin, Argentina), Albian (Austral Basin, Argentina); *Brasacypris fulfaroi* Dias-Brito et al., 2001, Turonian-Santonian (Paraná Basin, Brazil). From the stratigraphic distribution of ostracods in the studied sections, together with the lithology, two different paleoecological contexts were recognized: one basal, with greater fluvial influence; and an upper one, with drier conditions and high salinity. From Berriasian to Barremian?, the São Francisco Basin was located in an area of

high precipitation and large volume of water. This condition is corroborated by the basal paleoecological context, with indicators of fluvial contribution, probably the product of a large drainage related to the paleo São Francisco River. Ostracod species from the Quiricó Formation that occur in other basins during this interval suggest a link between the São Francisco Basin and other basins from Brazil and Argentina. During the lower Aptian, the São Francisco Basin was under desert regime, corroborated by the upper paleoecological context of the Quiricó Formation. However, during the Aptian there is the greatest diversity of ostracods, which also occur in several other basins. This scenario of diversity, combined with arid conditions, suggests that the São Francisco paleodrainage was well established, connecting several basins. This study allows a great expansion of the paleozoogeographic correlation between the São Francisco Basin and other basins from the marginal rift system in central Gondwana, during the Early Cretaceous.

Keyword

Ostracoda, Cretaceous, São Francisco Basin, Quiricó Formation, Correlation

Holocene ostracod assemblages and paleo-water depth from a raised beach sediment near Lake Suribachi-Ike, East Antarctica

Satoshi SASAKI[1]*, Gunma University (satoshi-ssk@gunma-u.ac.jp)
Toshiaki IRIZUKI[2], Shimane University
Koji SETO[3], Shimane University
Yusuke SUGANUMA[4], National Institute of Polar Research

Abstract

Accelerated melting of the Antarctic ice sheet (AIS) is one of the major contributors to global sea-level rise. To better constrain future climate and environmental consequences, it is important to understand the history and mechanism of AIS changes. Regional sea-level reconstructions are critical components of these efforts to resolve past changes in ice sheets (IPCC, 2019). In particular, regional sea-level reconstructions have previously been attempted across the Skarvsnes area of Lützow-Holm Bay, East Antarctica (e.g., Takano et al., 2012; Verleyen et al., 2017). However, the results were not consistent, making it difficult to provide firm constraints on the past AIS in this region. Therefore, this study examined for paleo-environment and paleo-water depth near Lake Suribachi-Ike, Skarvsnes, based on grain size, CNS (carbon, nitrogen, and sulfur) elemental, and microfossil (ostracod) analyses of an outcrop of the Holocene-raised beach which was excavated approximately 4 cm from the surface by the 46th Japanese Antarctic Research Expedition (JARE 46).

As a result, the 14C dating of an annelid tube collected from the same outcrop was also conducted using accelerator mass spectrometry, which was estimated at approximately 5,800 cal. year BP. A total of 16 ostracod species belonging to 10 genera were identified for the first time from all study samples near Lake Suribachi-Ike, Lützow–Holm Bay, East Antarctica. The phytal species was discovered to be the most dominant, implying a rich seagrass and/or seaweeds environment at approximately 5,800 cal. yr BP. The paleoenvironment was estimated using the autecological method and the modern analog technique (MAT) on ostracod assemblages. The result from the MAT suggested that the paleo-water depth of approximately 30 m at that time is the most probable estimation, implying the glacial-isostatic uplift of approximately 30–40 m (5.1–6.8 mm/year) until sample date. It is concordant with the previous studies on the 14C ages of the marine shells collected from raised beach sediments near the present study site.

The results include a paper (Sasaki et al., 2022) and we will discuss the repeatability of using these methods on other sites.

Keyword

Ostracod, East Antarctica, Holocene, paleo-water depth

Reconstructing Global Diversification Pattern of Non-marine Cypridoidea from Fossil Occurrence Data

Wonseop LIM[1]*, Seoul National University (david9456@snu.ac.kr)
Byeon-Gak CHOI[2], Seoul National University

Abstract

Studying the fossil records of an organism can provide a direct window to the past to study their long–term macroevolutionary dynamics. Non–marine cypridoidean ostracods, one of the most successful colonizers of freshwater environments, have exceptionally well–preserved fossil records starting from the Mesozoic. Thus, they have significantly contributed to our understanding of past ecological and environmental dynamics of non–marine environments. However, despite their importance in paleoecology and paleoenvironmental studies, the macroevolutionary dynamics of non–marine Cypridoidea have rarely been studied. Here, we compiled fossil records of non–marine Cypridoidea from existing literature and analyzed their diversification dynamics using the open–source software PyRate within a Bayesian framework. PyRate models the temporal dynamics of speciation and extinction processes using birth–death model, and can model the fossil preservation process with modified versions of the Poisson process. Given the fossil occurrence data, PyRate searches through the model space and infers posterior probability distributions of parameters for the diversification dynamics of the clade of interest. The results of PyRate analysis show that non–marine Cypridoidea underwent explosive radiation during the Jurassic period after their origination, although with high uncertainty in the estimation of speciation and extinction rates, possibly due to sparse fossil occurrences during the Jurassic. After the Jurassic–Cretaceous transition, the speciation rate of non–marine Cypridoidea declined, until it began to rise slowly around 100 Ma to the present. The extinction rate of non–marine Cypridoidea was inferred to be almost constant throughout time. However, there was an abrupt rise of the extinction rate around the Cretaceous–Paleogene boundary, presumably linked to the K–Pg mass extinction event. We also investigated the correlations between the diversification dynamics of the non–marine Cypridoidea and its potential biotic and abiotic drivers, such as intra–clade competition, and various climatic and geological variables. Our study attempted to reconstruct the past diversification patterns of non–marine Cypridoidea on a global scale in a quantitative framework, revealing patterns that necessitate further research to fully understand their macroevolutionary dynamics.

Keyword

Fossil Records, Evolution, Diversification Dynamics, Non-marine Ostracods, PyRate

A new record of Notodromadidae (Ostracoda) from southern Thailand: preliminary result

Anisong Chitnarin[1]*, Suranaree University of Technology, THAILAND (anisong@sut.ac.th)

Abstract

Non-marine ostracods of Family Notodromadidae Kaufmann, 1900 are rarely known in Thailand and Southeast Asia. The only living species that has been found from rice fields in northern and northeastern regions of Thailand is Notodromas sinensis Neale & Zhao, 1991 (Savatenalinton and Suttajit, 2016). Recently, new materials from stream outcrops in Krabi Province, southern Thailand are found, and they are preliminarily classified to the Notodromadidae. The investigating site is located on Quaternary colluvial sediments bounded by the Permian limestone (Ratburi Limestone) and the Jurassic marginal marine rocks (Lam Tab Formation) according to a geological map of Krabi Province (Department of Mineral Resources, 2013). The outcrops consist of intercalations of thin-bedded fine-grained sandstones, shales, and mudstones showing gentle dipping. The lithology of the outcrops resembles the sequences of the Lam Tab Formation, although the age of the rocks is still controversial. Surprisingly, delicate ostracod valves are found embedded in the greenish grey mudstone. Carapace morphology and ornamentation suggest characters of the Notodromadidae, possibly belonging to genera Notodromas Lilljeborg, 1853 or Cyprois Zenker, 1854. However, the identification at specific level is still ambiguous because the soft parts are not preserved. This finding is the first record of subfossil Notodromadid materials in Thailand, and it provides a clue that the sediments might have been deposited in fluvial environments during the Pleistocene or Holocene.

References

Department of Mineral Resources. 2013. Geological map of Krabi Province, scale 1:250,000. Bangkok.

Savatenalinton, S. & Maitree S. 2016. A checklist of Recent non-marine ostracods (Crustacea: Ostracoda) from Thailand, including descriptions of two new species. Zootaxa 4067(1): 001-034.

Keyword

Non-marine ostracod, Cypridoidea, Notodromas, Cyprois, fluvial deposit

Spatiotemporal changes of Ostracoda and paleoenvironment in brackish Lake Nakaumi (SW Japan) in relation to climatic and anthropogenic influences since the Little Ice Age

Toshiaki IRIZUKI[1]*, Shimane University (irizuki@riko.shimane-u.ac.jp)
Ryohei KAWAKAMI[2], Shimane Prefectural Government
Hiroaki SHAKUTSUI[3], Yachiyo Engineering Co., Ltd.
Minori NARITA[4], Shimane University
Katsura YAMADA[5], Shinshu University
Kotaro HIROSE[6], University of Hyogo
Koji SETO[7], Shimane University
Shigenori KAWANO[8], Tochigi Prefectural Museum
Ritsuo NOMURA[9], Shimane University

Abstract

Lake Nakaumi is the fifth largest lake in Japan. It is a polyhaline lake at the mouth of the Hii River bounded by a sand barrier and connected to the Sea of Japan through a narrow strait. Benthic ostracods in the lake have been sensitive to minor changes in climate, abrupt climatic or geologic events, and anthropogenic impacts since the 20th century.

Thus, this study aims to reconstruct decadal to centennial spatiotemporal changes in ostracod assemblages and paleoenvironments in relation to climatic and anthropogenic impacts since the Little Ice Age.

Five short sedimentary cores were collected from the central part of the lake using a piston or gravity core from a ship. The cores were cut into samples of 0.5- or 1-cm thickness to analyze ostracod assemblages as well as total organic carbon, total nitrogen, and total sulfur contents (i.e., CNS elemental analysis). Furthermore, 14C, 210Pb, and 137Cs dating were conducted in some of the cores.

Approximately 50 ostracod species were obtained from the five cores. The most dominant species is *Bicornucythere bisanensis*. This species is abundantly found in enclosed inner–middle brackish bays in eastern Asia and can survive in oxygen-poor and organic-rich bottoms. Subordinate species comprised enclosed inner bay species, such as *Callistocythere alata* and *Spinileberis quadriaculeata*. *Cytheromorpha acupunctata* was also abundant, mainly in the upper samples, and it is a typical sandy mud dweller in inner bay areas. *Trachyleberis scabrocuneata* lives in relatively oxygenated areas under the influence of tidal and open waters and is present only in specific horizons.

Enclosed inner bay ostracods with moderate species diversity were developed from the 14th to 16th centuries. From the 17th to 18th centuries, ostracod abundance and diversity were low, reflecting weak water circulation and low salinity. Specifically, the lake deteriorated drastically from the late-17th to the mid-18th centuries probably because of high precipitation and low sea levels during the Maunder Minimum. In the 19th century, inflow from the Sea of Japan became strong and peaked in the mid-19th century. Since the 20th century, many anthropogenic impacts

have influenced environments and ostracods. The construction of an artificial dike in 1922–1930 AD greatly influenced the lake environment, and total organic carbon and total nitrogen contents rapidly increased, suggesting the intensification of eutrophication. After the construction of a water-barrier gate and dikes and land reclamation, conducted in 1968–1981 AD, eutrophication accelerated in the central part of the lake. However, improvements in water conditions occurred only near the mouth of the lake owing to the change in the seawater inflow route.

Keyword

Ostracod, Little Ice Age, anthropogenic impact, Lake Nakaumi, SW Japan

PALEOZOIC OSTRACODS FROM MONGOLIA

Yarinpil ARIUNCHIMEG[1]*, Mongolian Stratigraphical Commission (ariunyarinpil@gmail.com)
Yarinpil Ariunchimeg[2], Mongolian Stratigraphical commission

Abstract

One of the crucial problems in the study of stratigraphy is the boundary between systems. During the investigation of the Ordovician/Silurian, Silurian/Devonian and Devonian/Carboniferous boundary sections in Mongolia together with conodonts some ostracoda were found.

Ostracods together with conodonts Icriodella baotaensis, Icriodella cf baotaensis Eoplacognathus jianyeensis, Eoplacognalhus protoramosus, Baltonoidus alobatus, and? Ambalodus triangularis were found at the Undershil area from the sediments mapped as Silurian Onootolgoi Formation. According to the conodonts the age of the formation is early-middle Late Ordovician (Wang et al., 2008). Ostracods from the bed 1 of the section 141 are Microcheilinella aff. rozdestvenskaja Neckaja, Ovornina aff. ancoralis Melnicova, Ovornina sp., Martinssonozona sp. and indicate the upper Ordovician, but from the bed 4 ostracods such as Spinobolbina bispina Abushik, Bolbiprimitia sp., Microcheilinella sp., Lomatobolbina sp., Sarytumia sp., Eurychilina sp. and Collibolbina sp. were identified and they are more common for the Silurian. Based on the study of ostracoda L.Gereltsetseg (2003) suggested to draw the boundary between systems in this section below the bed with Silurian ostracoda. Some part of section with Ordovician fossils suggested assain to the Ordovician Zeeriinhural Formation.

Ostracods were found during the study of Silurian/Devonian boundary from the Tsagaanbulag section in the Shine Jinst area of Southern Mongolia. Conodonts discovered in the upper part of the Tsagaanbulag Formation are Caudicriodus neowoschmidti Wang et al., Caudicriodus sp. A, Kimognathus sp., ‘Ozarkodina’ planilingua, Pandorinellina optima, and Ozarkodina excavata and indicate that the upper part of section is middle Lochkovian rather than Silurian, as previously proposed (Wang et al., 2005). Ostracods in this section are rare and low diversity, represented by Microcheilinella (?) sp., which are common in Silurian in many different localities in the world. Brachiopods and bryozoans from this section also were identified as Silurian.

Late Devonian ostracoda Amphissites irinae Egorov, 1953 were found in Baruunhuurai area (Thomas et al., 2020) of the south-western Mongolia during the field work of IGCP 596. Later in detail the section at Hushoot Shiveetiin gol in the Baruunhuurai area was investigated. A generally well-preserved and diverse ostracods fauna was collected from the Famennian Samnuur-Uul Formation. It is the first rich assemblage of ostracods described from Mongolia. The ostracoda fauna consists of 19 genera and 25 species and is similar to coeval faunas in western China but also contains new, endemic species. Two new taxa Beyrichiopsis hushootensis and Ampuloides beckeri were described. Ostracods findings are characterized by the Eifelian Mega-Assemblage (I-III) representing a nearshore palaeoenvironment (Nazik et al., 2021). Late Devonian ostracods also are known from the Indert Formation in the Shine Jinst section (Thomas et al., 2024).

Keyword

Paleozoic, Mongolia, ostracods

PLIOCENE NON-MARINE OSTRACODS FROM THE SHARGA BASIN

Belgutei Belgutei BOLD[1]*, Institute of paleontology,MAS (belguteibold001@gmail.com)

Abstract

Abstract

The study of ostracods in Mongolia has started in the mid 1950s in the southeast of the country in conjunction with petroleum exploration. Ostracods have been regarded as one of the most important microfossils for biostratigraphic correlation and paleoenvironmental reconstruction of Paleozoic, Mesozoic as well as Cenozoic sediments. Nonmarine Cenozoic sediments are widely distributed on the territory of Mongolia in the Great Lakes Basin. These sediments include the fossils of ostracods, charophits, gastropods, mammals and contains the bird remains.

The sediments in the Sharga basin in the Gobi Altai province consists of silts and clays of lacustrine origin, bluish-green in color with small marl inclusions. Moreover, it appears as a bright layers of gray and dark gray on satellite image. In the study area, the sediments overlay the middle Oligocene red clay with minor unconformity and correspondingly overlined by Miocene pale yellow sand sediments.

The three samples were collected from the section of light gray, greenish-gray clay, clayey argillite, and clayey sandstone (46°06’34.8’’N; 95°05’20.6’’E) in Ikh Berkh Tolgoi area. Two well-preserved ostracods belonging to two genera and two species were identified. This is a first report of non-marine ostracods from the Khyargasnuur Formation. Based on the line drawing of adductor scars Cypridopsis vidua and Ilyocypris brady species were identified and age of this sediments is considered as lower-middle Pliocene (Undariya et al., 2021). The ostracod assemblage indicates a shallow continental freshwater paleoenvironment at that time.

Keyword

Mongolia, Cenozoic, Ostracods

NON MARINE OSTRACODA FROM THE CRETACEOUS OF THE TSOGT-OVOO BASIN IN MONGOLIA

Jalbaa UNDARIYA[1]*, School of Geology and Mining Mongolian University of Science and Technology (j_undar@must.edu.mn)
Belgutei Bold[2], Mongolian University of Science and Technology

Abstract

Abstract: The Mongolian Cretaceous is subdivided into eight formations. The Lower Cretaceous iscomposed of the Tsagaantsav (Berriasian-Valanginian),Shinekhudag (Hauterivian-Barremian) and Khukhteeg (Aptian-Albian) formations. The Upper Cretaceous consists of the Baruunbayan (Albian-Cenomanian) Bayanshiree (Cenomanian-Turonian), Bayanzag (= Djadokhta) (Coniacian-Santonian), Baruungoyot (Campanian) and Nemegt (Maastrichtian) formations.
Non marine Cretaceous sediments are widely distributed and contain variously abundant ostracods in Mongolia.
We investigated a total 16 samples from these 22 sections, 10 of which appeared devoid of any microfossils, the remaining ones yielded either ostracods, charophytes or gastropods.
The genus Cypridea, Rhinocypris, Cyprideidini from the Upper and Lower Cretaceous were found in micropaleontological examinations.
Seven fresh-water ostracode species belonging to tree genera described from Cretaceous continental deposits from Tsogt-Ovoo basin in Mongolia. Seven ostracodes species have been recorded in the from Shinekhudag to Bayanshiree formations, Tsogt-Ovoo basin: Cypridea unicostata Galeeva, 1956, Cypridea trita Lubimova, 1956, Cypridea copulenta Lubimova 1956, Cypridea shuvalovich Stankevich, 1974, Langtonia setila rectidorsata Sylvester-Bradley, 1949, Rhinocypris panosa Lubimova, 1974 and Gobicypris tugrigensis Khand, 1974

In the Tsagaantsav Formation Cypridea trita Lubimova, 1956 appear, followed by Cypridea unicostata Galeeva, 1956, Cypridea trita Lubimova 1956, Cypridea copulenta Lubimova, 1956 in the Shinekhudag Formation. In the Khukhteeg Formation ostracods are abundant, including Langtonia setila rectidorsata Sylvester-Bradley, 1949, in the Baruunbayan Formation of ostracods are recognized, mainly including Cypridea shuvalovich Stankevich, 1974. In the succeeding Bayanshiree and Bayanzag formations, the first appearances of Gobicypris tugrigensis Khand, 1974 and Rhinocypris panosa Lubimova, 1974 are recorded.
In the present paper, biostratigraphy of the Upper and Lower Cretaceous is discussed in terms of ostracod assemblages.

Keyword

Mongolia, Tsogt-Ovoo, basin, Cretaceous, Octracods

The study of AI deep learning Yolov5 algorithm analysis for distinguish Ostracoda in meiofauna microscope pictures

Hyunsu YOO[1]*, Fisheries Science Institute, NRF Reserach center, Chonnam University
(youe1999@hanmail.net)

Abstract

Recently, methods to distinguish objects and living things using artificial intelligence algorithm analysis have continued to be developed worldwide. In particular, object detection algorithms are useful in distinguishing objects or living things, so they are being applied to various fields such as video surveillance, autonomous driving, and augmented reality. Yolo (You Only Look Once), an object detection algorithm, was first announced in 2015 and is widely used due to its high accuracy and speed in detecting objects.

Ostracods are included in meiobenthos and zooplankton and are distributed in a wide range of freshwater and marine water (even deep sea and extreme environments). Usually, this taxon is not a dominant organism in meiofauna communities, but often abundance blooms the environmental condition matches hatching. The main characteristic of ostracods is a carapace to protect their appendages. Usually, special features of the carapace are used to identify the family level. However, non-experts often confuse them with Bivalvia and Branchiopods because carapace shapes are similar. And then the size of less than 400um is misidentified as foraminifera.

Usually, when analyzing living things using artificial intelligence algorithms, large creatures (parrots, mammals, etc.) or insects (flies) that the eye can easily distinguish are used. In this study, we research conducted to determine whether it is possible to distinguish organisms at the level of higher taxa from photos of meiofauna, which are difficult to discern and in particular to find out what the margin of error is when distinguishing between ostracods.

A preliminary study on dividing subfamilies of insect larvae showed an accuracy of about 98%, so it is expected that if the characteristics are clearly distinguished, it will be possible to differentiate between Ostracods and other taxa. If the amount of data increases in the future, it is expected that programs can be created that can be easily identified even by non-experts.

Keyword

Ostracods, Meiofauna, yolov5

Paleocene-Eocene Larger Benthic Foraminifera from Meghalaya and Indo –Myanmar Orogenic belt of Eastern Tethys, India, collision of Indian –Asian plates and global paleobiogeography

VINOD CHANDRA TEWARI[1]*, Professor of Geology (Retd.), Sikkim University, Gangtok – 737102, Sikkim, India (Professorvct54@gmail.com)

Abstract

Abstract :

. The Late Paleocene – Middle Eocene Tethyan foraminiferal – algal carbonate biofacies are well developed after Late Cretaceous – Paleogene mass extinction event in the Meghalaya, east India.The Paleocene- Eocene LBF and algal assemblage are important contributors in depositional environment of the Tethyan limestoes. The limestones have yielded the diverse LBF species of Alveolina sp., , Assilina sp., Miscellanea miscella Discocyclina sp., D.jauhrii ,Ranikothalia sp., Rotalia sp., Lokhartia sp., Quinculoculina sp., Nummulites sp. as dominant assemblage.The orthophragminid foraminifera assemblage of the Lakadong and Umlatodoh Limestone indicate shallow marine carbonate ramp, and tidal flat depositional environment. The predominance of coralline algae, Sporolithon associated with LBF assemblage indicates that the Paleocene – Eocene limestones of Meghalaya have been deposited in shallow, high energy tidal and open shelf environments.A correlation of eastern and western Neotethys has been established on the basis of Standard Benthic Zone(SBZ3-SBZ8)of European,Adriatic and Himalayan-Tibetan LBF zones.During the early Paleogene, Meghalaya witnessed several sea-level changes ranging in age from the late Paleocene to middle Eocene. Paleocene – Eocene Thermal Event (PETM)is also recorded from the Lakadong Limestone, Mawmluh Quarry area confirmably overlying the foraminiferal limestone.Their deposition commenced with the emergence of the carbonate platform in which the LBF - algal carbonates were formed formed. The western Tethyan LBF assemblage from Mediterranean, Adriatic platform(Trieste - Slovenia area)and the Middle East region is comparable with South Asian Himalayan assemblage. Recent stable C and O isotope chemostratigraphy of Meghalayan and Manipur Ophiolite Belt (MOB) limestones is comparable with the Tibetan shallow marine limestone. The north-eastern region represent a complex tectonic set up due to the juxtaposition of Indian-Eurasian and Myanmar plates. The MOB is a part of Tethyan oceanic crust involved in collision of Indian and Myanmar micro plate during Late Cretaceous –Eocene as suggested by LBF. In Ladakh area , Western Himalaya, LBF assemblage have suggested that the regression of the Tethys sea from Indus- Tsangpo –Suture Zone (ITSZ)initiated in Ypresian time ,however in the Indo –Myanmar region, the regression took place from east to west. The Indo Myanmar ranges continue towards Andman-Sumatra subduction zone which also marks the junction between Indian and Eurasian Plates.The Subathu LBF yielding limestone is found in Shimla and Jammu areas in western Lesser Himalaya and Bhainskhati valley in Nepal Central Himalaya.Marine Eocene (Ypresian – Lutetian) LBF is known from Subathu type area near Shimla and in small limestone bands in adjoining parts of Indian Lesser Himalaya.

It represents marine transgression in the Lesser Himalaya of India and Nepal. The LBF distribution and paleobiogeography of the Eastern Tethys (Meghalaya, Subathu Lesser Himalaya, Ladakh) and its correlation with western Tethys is reconstructed in the light of India – Asia collision and emergence of the Himalaya.

Keyword

Paleocene-Eocene, Foramainifera, Tethys sea, Himalaya, Paleobiogeography,

Foraminiferal assemblage and palaeoenvironmental reconstruction of early Eocene Umlatodoh Limestone form south Shillong Shelf: Signature of ETM2?

T. Ngamlengin Haokip[1]*, Assam university, Silchar (tngamlengin.haokip@gmail.com)
Urbashi Sarkar[2], Assam University, Silchar

Abstract

Microfacies analysis of Early Eocene shallow-marine carbonate successions are sampled from the outcrop of Thangskai, Jaintia Hills, Meghalaya, India and the subsequent integration with sedimentology has been used to produce a detailed palaeoenvironmental reconstruction. From the forty-one meters high outcrop, nine microfacies types, viz., quartz abundant wackestone (MFT1), rotaliid grainstone (MFT2), sandy foraminiferal packstone (MFT3), Oolitic grainstone (MFT4), fossiliferous dolomitic grainstone (MFT5), *Ovulites* grainstone (MFT 6), alveolinid miliolid grainstone (MFT7), fossiliferous wackestone (MFT8), and glauconitic mudstone (MFT9), are identified. Larger benthic foraminiferal and coralline algal assemblages are the dominating constituents here and larger benthic foraminifera indicates the age as SBZ 6 to SBZ 9. Four facies belts have been inferred associated with specific facies, for example, the facies U-MFT1, U-MFT3, U-MFT8, and U-MFT9 are located in the sheltered lagoon (SL); U-MFT4 indicate the facies belt shoal setting (SS); U-MFT2, U-MFT6, and U-MFT7 indicate deposition in the high-energy back shoal (BS); and U-MFT5 is designated to be deposited in the fore shoal (FS) belt. Overall, two types of faunal associations are identified: perforate foraminifera (*Nummulites* sp. and *Discocyclina* sp.) and porcelaneous forams and green algae (*Rotaliid-Alveolinid-Miliolid-Ovulites*). The faunas are dominated by both r- and k-strategists in an oligotrophic nutrient regime during this time. Dominant foraminiferal species are *Alveolina* sp., *Glomalveolina* sp., *Quinqueloculina* sp., *Biloculina* sp., *Idalina* sp., *Periloculina* sp., *Lockhartia* sp., *Nummulites* sp., *Orbitoclypeus* sp., *Discocyclina* sp., *Bolivina* sp., and *Textularia* sp. Subordinate constituents of bivalve and ostracods are observed. The algal components include *Ovulites* sp., *Halimeda* sp., and Dasycladalean (*Salpingoporella* sp.) represent green algae, and *Distichoplax* sp. represent the non-geniculate coralline-red algae. Also, sutured type horizontal and parallel stylolite present in the MFT8 indicates the upper part is subjected to dissolution, and underwent tectonic stress during diagenesis. Thus, variable energy above the fair-weather wave base influences the depositional architecture of the Umlatodoh Limestone, which ranges from hypersaline lagoonal to normal marine within the inner shelf of shallow marine carbonate settings. Concurrently, the foraminiferal diversity and subsidiary abundance of rectilinear benthic foraminifera (biserial forams) and the small size of larger benthic foraminifera can be correlated with the transient climatic Eocene Thermal Maximum -2 (ETM -2) (SBZ 8; 54.1 Ma) event.

Keyword

Early Eocene, Eastern Neo-Tethys, Umlatodoh Limestone, ETM2, Larger Benthic Foraminifera

LARGER BENTHIC FORAMINIFERA (LBF) BIOSTRATIGRAPHY OF PALEOCENE – EOCENE SEDIMENTS IN PARTS OF ASSAM SHELF OF ASSAM AND ASSAM ARAKAN BASIN WITH REFERENCE TO DEPOSITIONAL ENVIRONMENT

KALPANA DEKA KALITA[1]*, DEPARTMENT OF APPLIED GEOLOGY, DIBRUGARH UNIVERSITY, ASSAM. INDIA (kdkalita@dibru.ac.in)
KALPANA DEKA KALITA[2], DIBRUGARH UNIVERSITY

Abstract

The Assam and Assam Arakan Basin is a category 1 petroliferous basin situated in the northeastern part of India covering an area of 11,6000 square kilometres producing oil and gas commercially for more than a century. Larger Benthic Foraminifera (LBF) biostratigraphy provides insights into the age and depositional environment as well as play a crucial role in the hydrocarbon exploration endeavours of this basin. Three major tectonic elements of this basin include Assam Shelf, Naga Schuppen belt and Assam-Arakan Fold belt. The Assam Shelf extends from northeast of Shillong Plateau, Garo Hills, Khasi and Jaintia Hills, Mikir Hills and include the Upper Assam Valley. Geologically the Upper Assam valley is regarded as the Upper Assam Shelf. This study provides LBF biostratigraphy of Paleocene -Eocene sediments of Sylhet Limestone Formation in southern parts of Shillong Plateau and parts of the Upper Assam Shelf. The five members namely Lakadong Limestone, Lakadong Sandstone, Umlatodoh Limestone, Nurpuh Sandstone and Prang Limstone of the Sylhet Limestone Formation are exposed in Meghalaya where as in the Upper Assam Shelf, the clastic sequence nonconformably overlying the granitic basement complex and is conformably overlain by limestones of the Sylhet Formation. Identified twenty-five numbers of LBF species dominated by Nummulitidae family from an oil well of Kathaloni area in Dibrugarh District of the Upper Assam Shelf indicates shallow marine to transitional environment where Palaeocene -Eocene subsurface sediments are reported at depth more than 2977metre. Twenty-six species of LBF associated with various species of coralline red algae and green algae reported from Lumshnong area of Jaintia Hill district, Meghalaya suggests inner ramp, mud-free shallow neritic shelf carbonate sedimentation of the Umlatodoh Limestone showing depositions in calm water, low-energy conditions in the lower part changing to moderately high-energy conditions in the middle followed by low-energy restricted environment represented by micrite towards the upper part in lower Eocene. Ten genera of LBF reported from of Nongthymai Mawsmai Area, Cherrapunji, twelve genera of LBF from Ri-Kaleng Limestone Mine, both belonging to Lakadong Limestone and fifteen species of LBF of Prang Limestone from Sohbar Nongjiri road section of east Khasi Hill district, Meghalaya are interpreted to be deposited in shallow marine environment. Evidenced from the larger benthic foraminifers reported from Paleocene-Eocene limestone sediments in parts of Meghalaya suggest shallow marine environment while in the Upper Assam Shelf the subsurface sediments of Paleocene-Eocene age suggesting marine to transitional environment of deposition.

The studied shelf sediments of Paleocene-Eocene age of Cherrapunji and Lumshnong area in southern part of Shillong Plateau is at approximately 1000m and 580m above Mean Sea Level (MSL) respectively. The LBF identified in the Kathaloni area of the Upper Assam Shelf indicate that the of Paleocene- Eocene sediments are reported at depth of more than 2977m. The LBF data of the studied areas suggest that these sediments were part of the same palaeo shelf sea during Palaeocene -Eocene age. Because of tectonic modification of the Assam and Assam Arakan Basin, the sediments are reported at different level.

Keyword

Upper Assam Shelf, LBF, Meghalaya

[Keynote] Larger Benthic Foraminifera: Valuable Proxies in Biostratigraphic Evaluation of Paleogene Carbonate and Siliciclastic Sequences in Indian Petroliferous Basins

VINOD CHANDRA TEWARI[1]*, Professor of Geology (Retd.), Sikkim University, Gangtok – 737102, Sikkim, India (Professorvct54@gmail.com)
SUDHIR SHUKLA[2], EX.ONGC LTD. INDIA

Abstract

Larger benthic foraminifera in the Indian Paleogene are highly diversified and represented by important genera such as Nummulites, Assilina, Miscellanea, Lockhartia, Alveolina, Daviesina, Operculina, Operculinoides, Actinosiphon, Discocyclina, Lepidocyclina, Pellatispira, Heterostegina, Spiroclypeus, Cycloclypeus and Miogypsinoides. Several species amongst these genera have great index value in high impact biostratigraphy in order to serve as excellent age dating tools facilitating inter and intra-regional stratigraphic correlations. Indian Paleogene sequences are prolific with the warm, shallow water carbonates build up of rich and diverse larger benthic foraminifera, additionally compounded with reefal elements such as corals, algae, bryozoa, crustaceans and associated faunal elements. In the areas of turbidity and clastic sedimentary influx, siliciclastic sediments or carbonate muds have also shown a rich assemblage dominated by the imperforate larger benthic foraminifera related to the Coskinolina, Medocia, and Dictyoconoides groups. Local SBZ / LBF zonation were established and successfully correlated with international multimicrofossil (LBF) zonations, thus making them immensely useful in the bio-chronostratigraphic determinations of Indian Paleogene.

During earliest Paleocene, although true larger foraminifera are believed to be absent excepting for probably Laffeiteina which is reported from North-Eastern India from the stage Danian (Meghalayan) referred to planktic stages P1 & P2= SBZ 1. This is followed by the occurrence of Miscellania & lockhartia akbari, Disticoplex & Rotaliid-Miliolids on the Meghalayan shelf. Highest Paleocene and early Eocene in Indian sedimentary basins show relatively lesser diversification in the larger foraminifera, excepting for the appearance of Orbitolites and Sakesaria close to the Paleocene / Eocene boundary. Alveolina is an important constituent in the LBF assemblage here. Early Eocene shallow marine, transgresive sediments comprising mostly carbonates and some finer clastics have abundant, well diversified larger foraminifera where the diversity of Assilina is at maximum, however, it is during the Middle Eocene that the larger foraminifera diversity reaches its acme, further on slightly declining during the younger ages, so that the number of genera touches lowest level near to the Eocene / Oligocene boundary.

The diversification of Nummulites is rapid during middle Eocene where a number of new forms are added. Middle-late Eocene boundary almost coincides with the extinctions of Assilina, Lockhartia, Alveolina, Dictyoconoides, Coskinolina & others. Reticulate Nummulites & Lepidocyclina (Eulepidina) frequent on the western shelf characterizing the “nummulitics” of early Oligocene. Post early-Oligocene nummulitids are dominated by genera Operculina,

Operculinoides, Grzybowskia, Lepidocyclina (Nephrolepidina), Hetrostegina and Spiroclypeus, some of which continue up to Recent times. Another LBF acme along with diversity of genera / species is witnessed during late Oligocene, when new forms (Miogypsinids) are added, however, throughout the Paleogene larger foraminifera are dominated by Nummulites in almost all the Indian sedimentary basins.

Keeping in mind exceptional index value of the larger benthic foraminifera, the E&P companies, in recent years, promoted domain specific research and expertise needed to develop more real time biostratigraphic analysis and provide innovative solutions to the geological problems. An emphasis was also made on combining geosteering / biosteering applications utilizing larger benthic foraminifera with other multi-microfossil proxies to reduce operating costs and enhance production more particularly from inclined

Keyword

Foraminifera, Paleogene, SBZ

Biostratigraphy Bentic Foraminifers of Triassic- Jurassic boundary in Zagros Basin (SW Iran)

Vahid AHMADI[1]*, Corresponding author (v_ahmadi_geo@yahoo.com)
Reza Monsef[2], Department of Geology, Estahban Branch, Islamic-Azad University, Estahban, Iran

Abstract

Vahid Ahmadi, Reza Monsef
1*Department of Geology,Shiraz Branch, Islamic-Azad University, Shiraz, Iran
2Department of Geology, Estahban Branch, Islamic-Azad University, Estahban, Iran
*Corresponding author e-mail address:v_ahmadi_geo@yahoo.com
zaos13000@yahoo.com

Abstract
Triassic- Jurassic deposits are related to Khaneh Kat, Nyris and Surmeh Formations and they are in the Interior Fars from High Zagros belt of Iran. Triassic deposits (Kaneh Kat Formation) with 420/6 m thicknes and the include Sand stone, Dolomitic and limestone also Jurassic deposits (Nyris and Surmeh Formations) with 680m thicknes and the include Dolomitic limstone and Limestone in Kaftar stratigraphic section. In total, after studying 600 microscopic thin sections and identifying benthic foraminifera, 5 biozones for Triassic deposits and 5 biozones for Jurassic deposits were introduced. Some of these benthic foraminifera include: Nodosaria cf. shnnablensis, Aulotortus gacchei ,Arenovidalina chialingchiangensis, Involutina communis , Glomospirella friedli, Glomospira meandrospiroides, Lenticulina sp., 4- Agathammina austroalpina, Pragsoconulus cf. robustus , Pragsoconulus cf. robustus, Pfenderina trocoidea,Meyendorffina sp., Andersenolina elongata , Kurnubia palastinensis, Nautiloculina cf.cricularis, Andersenollina elongeta
Trocholina palastinensis, Pseudomarssonella plicata, Nautiloculina cf. cricularis.These Trassic biozones(Early to Late Triassic) are reported for the first time in the SW Iran. According to evidence of biostratigraphy and lithostratigraphy, the boundary between Kaneh Kat and Neyriz Formations is disconformity.In the base part of the Jurassic deposits can be seen with a layer containing bivalves of the Lithiotis , which contains benthic foraminifera with Bajocian-Callovian age.

Keyword

benthic foraminifera, Biozone, Triassic- Jurassic, Zagros Basin, Iran

Insights into raphiophorid trilobite glabella spine as a sensory organ for collective behaviour

Iván Gómez[1], Universidad de los Andes
Matheo López-Pachón[2], Universitat Rovira i Virgili
Esteve JORGE[3]*, Universidad Complutense de Madrid (UCM), Spain (jorgeves@ucm.es)

Abstract

Raphiophorid trilobites are small blind trilobites with a glabella expanding forwards and inflated anteriorly, usually with anteromedian spine, or with a tubercle in comparable forward position. Two of the common genus of this family are Ampyx and Lochodomas with a wide geographical distribution (Morocco, Czech Republic, France, Sweden or USA) and bearing a long anterior glabellar spine. In the case of Ampyx appear communally in the Lower Ordovician (upper Tremadocian-Floian, ca 480 Ma) Fezouata Shale of Morocco as linear clusters. Here we explore the hydrodynamic behaviour of Ampyx by means of fluid dynamic simulations (CFD) in two different scenarios: i) a single individual or ii) a linear cluster with two or three individuals. In addition, we assess the influence of the long anterior glabellar spine into the drag and lift coefficients and the results shed no influence in any case. Some specimens from the Lower Ordovician of Sweden show pits in the cuticle what is pointed out a sensorial organ rather that a hydrodynamic tool. Therefore, the combination of our CFD results and the fossil evidences support the idea that the long glabellar spine in raphiophorids as well as the long genal spines were mechanical sensors as was suggested by Vannier et al. (2019).

Keyword

Biomechanics, Ordovician, Functional Morphology, hydrodynamic, palaeoecology

Enrolment in trilobites: insights for development and phylogeny

Esteve JORGE[1]*, Universidad Complutense de Madrid (UCM), Spain (jorgeves@ucm.es)
Alejandro Corrales-García[2], University of Saskatchewan
Jesús María[3], Facultad de Ciencias Exactas Físicas y Naturales, Universidad Nacional de Córdoba, Córdoba, Argentina
Francesc Pérez-Peris[4], Iowa University

Abstract

The study of enrolment in trilobites has bring the interests of palaeontologists during last century. This is because enrolment is an adaptive behaviour against predators and environment. Functional morphology shows us that enrolment and interlocking devices enhance throughout the evolution of this group and seems that different lineages tend to develop independently a sphaeroidal enrolment style. Trilobite also shown a great adaptation of morphology to achieve different enrolment styles through the growth. In some cases, the adaptation is as consequence of the morphological variation of some trilobites such as the Cambrian trilobite Solenopleuropsis or the Silurian trilobite Aulacopleura. Esteve & Hughes (2023) have shown how ontogenetic development controls the enrollment style throughout the development of the Silurian trilobite Aulacopleura koninckii, varying from spheroidal to spiral and finally external spiral. However, other trilobites such as the phacopid Ordovician trilobite Pterygometopus sclerops change the enrolment style without putative variation in the number or shape of its thoracic segments but changing the size. Within Phacopida, the genera Cybele, Pterygometopus, Pliomerops and Placoparia show a tendency towards inverted enrolment type where the pygidium is anchored on the dorsal anterior edge of the cephalon. P. sclerops could present a transitional form from spheroidal to inverted, with Placoparia being the taxon that most developed the inverted style. Finally, the fact that P. sclerops presented two types of enrollment styles throughout its development would be the earliest evidence of the importance of ontogenetic control in the development of different types of enrollment.

Keyword

Trilobites, Enrolment, Ordovician, evolution, palaeoecology

[Keynote]Distinct causes underlie double-peaked trilobite cephalon disparity, but this disparity is unrelated to exoskeleton moulting behaviour

Harriet Bethany B. DRAGE[1]*, University of Lausanne (harriet.drage@unil.ch)
Stephen Pates[2], University of Exeter

Abstract

Trilobites had strongly biomineralised exoskeletons with a diversity of morphological adaptations to different niches across the Palaeozoic. The group was extremely influential on the development of Palaeozoic ecosystems, having a global range and being found in vast abundance in varied marine environments. Correspondingly, there is a long history of research on their functional adaptations, diversity, and disparity, which we are increasingly able to develop using expanded datasets and technological advancements. We used a global dataset of c. 1000 trilobite cephalon outline curves (including 387 specimens resampled from Suárez and Esteve, 2021) to create an expansive morphospace exploring the full extent of trilobite cephalon outline morphometric disparity. We then used these data to analyse the differences in morphospace occupation across the Palaeozoic and between taxonomic orders. Elliptical Fourier transformation visualised as a Principal Components Analysis suggests significant differences in morphospace occupation and disparities for order and geological Period groups. Cephalic outline disparity increases from the Cambrian to Ordovician, apparently as a result of radiations to new niches. This is followed by morphospace occupation constriction to the Silurian, a second disparity peak in the Devonian caused by within-niche diversification, and a further constriction following the Devonian. The latter decline was likely the result of a high number of species going extinct, notably forms at the extremes of occupied morphospace. The post-Devonian survivors and trilobites that originated after the end-Devonian mass extinctions are constrained towards the centre of the morphospace. Kmeans clustering analyses support this constriction in natural grouping through the Palaeozoic. However, analyses interrogating the predictiveness of cephalon outline morphometry suggest that order and geological Period assignment cannot be robustly predicted for an unknown trilobite, except for Harpida and the Cambrian and Ordovician Periods. Analyses of morphological disparity can also be used to explore key trilobite behaviours, such as exoskeleton moulting. Like all euarthropods, trilobites moulted their exoskeletons repeatedly throughout their lives to grow and develop, but were uniquely variable in the behaviours involved, partly because of their cephalon morphological disparity. However, analyses using this dataset suggest cephalic shape had little overall impact on moulting behaviour, with the behavioural groups almost entirely nested in morphospace. Further, cephalon morphometry cannot be used to predict moulting behaviour from this dataset. Perhaps trilobites demonstrated high phenotypic plasticity in moulting that cannot be explained by individual variables or evolutionary drivers such as morphometry.

Keyword

Moulting, Trilobita, Palaeozoic, Morphometric analysis

Computational fluid dynamics simulation indicates morphological selection of the Upper Ordovician graptolite dicranograptids by hydrodynamics

Shijia Gao[1], Central South University
Wenhui Wang[2]*, Central South University (whwang@csu.edu.cn)

Abstract

Graptolites is one of the iconic and dominant zooplanktons within the Paleozoic Evolutionary Fauna. It underwent rapid evolution during the Ordovician and Silurian, making it an important biostratigraphic correlation tool. In the evolutionary history of planktonic graptolite, there are at least four obvious rapid increasing phases of morphological complexity. The triggering mechanism of these morphological complexity is suggested in association with sea-level increasing and high-stand. However, the specific mechanism how sea-level changes has exerted influence on graptolite ecology is still unclear. In order to test the role of sea-level increase has played in the morphological complexity of graptolites, we assume that the morphological change is triggers by hydrodynamic properties due to sea-level rising. Then we choose the late Middle to Late Ordovician dicranograptids, as target taxa to test the hypothesis. We reconstructed three-dimensional models based on the type specie of Jiangxigraptus as well as Dicellograpus, representing an earlier and later evolutionary forms of dicranograptids, respectively. Hydrodynamic properties (outer-wall pressure fields and velocity fields) can be obtained by using computational fluid dynamics (CFD). The models of both Dicellograptus and Jiangxigraptus keep rotating in different velocity in the simulation field. During rotational movement, Dicellograptus exhibits greater stability due to its wider construction of the U-shaped proximal end, which results in an expanded water-facing area. Additionally, the delicate branches of Dicellograptus compromise its resistance to hydrodynamic shocks. The thecal apertures of Dicellograptus, however, exhibit a higher volecity in the fluid medium, thereby augmenting its diffusion capability in water. The V-shaped proximal end of Jiangxigraptus rendered its rotational stability in the current more precarious. Furthermore, under equivalent ambient flow conditions, Jiangxigraptus exhibited a lower velocity of thecal apertures, indicating a comparatively weaker diffusion capacity. The results of our study suggest that the evolutionary transition from Jiangxigraptus to Dicellograptus in dicranograptids was characterized by an increase in both stability and rotational speed under hydrodynamic complex conditions when sea-level fluctuated. Our study highlights the importance of hydrodynamic constraints in shaping the evolutionary trajectory of planktonic graptolites.

Keyword

Zooplankton, dicranograptids, Functional morphology, computational fluid dynamics, Ordovician

Biomechanics of the echinoid skeleton and its relevance to ecological reconstructions and preservation potentials in the fossil record

James Henry NEBELSICK[1]*, Department of Geosciences, University of Tübingen (nebelsick@uni-tuebingen.de)
Andrea Mancosu[2], Dipartimento di Scienze Chimiche e Geologiche, Università degli studi di Cagliari, 09127 Cagliari, Italy
Valentina Perricone[3], Department of Research Infrastructures for Marine Biological Resources, Stazione Zoologica Anton Dohrn, 80121 Naples, Italy
Tommaso Gamboni[4], Museo Geo-mineralogico-Naturalistico “G. Cesaraccio”, Stagnali locality, Caprera Island, La Maddalena Archipelago
Anita Roth-Nebelsick[5], State Museum of Natural History Stuttgart, Rosenstein 1, 70191 Stuttgart, Germany
Wilfried Konrad[6], Department of Geosciences, University of Tübingen, Schnarrenbergstrasse 94-96, D-72076 Tübingen, Germany

Abstract

Echinoids possess a hierarchical multiplated skeleton and have shown a number of skeletal adaptions during their evolution. These skeletal modifications not only allowed them to expand into new environments and to exploit different food resources, but also have profound implications for their fossilization potentials. Studies on the biomechanics of the echinoid skeletons have dealt with major changes among different clades, on skeletal modifications during modular growth, as well as detailed mechanical studies on a few taxa. Studies with respect to biomechanics and taphonomic implications have concentrated on irregular echinoids including sand dollars. This study deals with regular echinoid taxa from shallow water environments in both recent environments and corresponding fossil occurrences. The combination of weakly articulated skeletons together with high energy conditions is usually associated with poor preservation potentials. The present study considers biomechanical aspects of skeletal architectures in combination with biotic and abiotic taphonomic processes including predation, disarticulation, fragmentation, encrustation and bioerosion. The morphology of specific echinoid tests is studied in detail using CT scanning techniques together with SEM analysis to explore morphological features including plate boundaries which can show interconnecting skeletal features such as pegs and sockets. Experimental fragmentation shows specific breakage patterns along plate boundaries. Echinoid remains from both recent and fossil environments are also compared with respect to the distribution of skeletal elements and size distributions.

Keyword

Biomechanics, Paleoecology, Taphonomy, Echinoids, Skeletons

[Invited] Exploring patterns of adaptive evolution across the Cambrian trilobite radiation

James Dougal HOLMES[1]*, Uppsala University (jamesholmes83@gmail.com)

Abstract

Evolutionary radiations—rapid diversifications within individual biological groups—have occurred frequently in Earth's history. These are often attributed to 'adaptive radiation', where diversification is driven by ecological speciation into different niches. However, despite being potentially responsible for much of Earth's biodiversity, almost all evidence for adaptive radiation comes from studies of extant animals that have diversified in the recent past (e.g. Caribbean anoles lizards, African Rift Lake cichlid fish). In the fossil record, adaptive radiation is often invoked whenever a group shows rapid initial diversification (the 'early burst' model of adaptive radiation), but purported instances of this process in deep time remain largely untested. Doing so requires demonstrating if diversification patterns are related to ecology, which is problematic for most fossil groups due to a lack of data. Trilobites are a group of biomineralizing marine euarthropods that underwent an explosive radiation beginning in the early Cambrian Period (starting c. 521 Ma), rapidly increasing in taxonomic and morphological diversity ('disparity'), and occupying a range of marine environments across different palaeocontinents. Here, I explore patterns of morphological disparity-through-time and morphospace occupation in Cambrian trilobites, in relation to biogeography, environmental parameters, and a recently published family-level phylogeny, to reveal if adaptive radiation was important in driving the group's rapid early diversification.

Keyword

Cambrian, trilobite, arthropod, Paleozoic, evolution

The Middle Ordovician Bivalves from Dali, Yunnan Province, SW China and their palaeogeographic significance

Yong WANG[1]*, Nanjing Institute of Geology and Palaeontology, CAS (yongwang@nigpas.ac.cn)
Zong-jie FANG[2], Nanjing Institute of Geology and Palaeontology, CAS
David A. T. HARPER[3], Durham University
Yu-chen ZHANG[4], Nanjing Institute of Geology and Palaeontology, CAS
Xin WEI[5], Nanjing Institute of Geology and Palaeontology, CAS
Ren-bin ZHAN[6], Nanjing Institute of Geology and Palaeontology, CAS

Abstract

An abundant and diverse bivalve fauna has been discovered in Dali, western Yunnan Province, SW China. It is from the Lower-Middle Member of the Hsiangyang Formation (Darriwilian, Middle Ordovician), and contains 18 genera and 22 species: Fasciculodonta impressa, F. fengyiensis, F. curvatum, Taselasmodum decussatum, Glyptarca sinensis, G. symmetrica, G. sp., Rhomboconcha tresdentes, Daliella daliensis, Haidongoconcha radialis, Erhaiconcha xiangyangensis, Paracyclas initium, Eopterinea aequiconcha, Biseriodonta simplex, Yunnanoredonia laevis, Redonia deshayesi, Trigonglyptarca magna, Goniophorina contracta, Prealeda sp., Modiolopsis sp., Similodonta sp. and Phestia sp., all of which are from 35 collections at the Haidong section beside the eastern bank of the Erhai Lake. Palaeogeographically numerical analysis on the distribution of 11 Middle Ordovician bivalve faunas shows two distinct faunal groups: the HPL group (including Morocco, Czech Republic, Argentia, Spain, France, UK, Portugal), representing the bivalves that lived in higher palaeolatitudes, and the LPL group (including Australia and South China) of the lower palaeolatitudes. The Dali bivalve fauna shares similarity with both groups, indicating that the Indo-China Palaeoplate was located in middle-high palaeolatitudes between the palaeoplates represented by the HPL and LPL groups. So, it is reasonable to propose that the Indo-China Palaeoplate was probably an isolated radiation center for bivalves during the Middle Ordovician. Community analysis for the Dali bivalve fauna shows that three possible bivalve-dominated communities could be recognized, the Fasciculodonta-Yunnnanoredonia-Redonia (FYR) community, the Taselasmodum (T) community and the Daliella (D) community, and the Daliella community (representing semi-infaunal life habit) was stratigraphically between the others (dominated by free-living burrowers, such as Fasciculodonta, Yunnanoredonia, Taselasmodum and Glyptarca), indicating the regularly fluctuating environment in that particular area during the Middle Ordovician. The triggers of environments changing could be founded with some sedimentology work.

Keyword

Bivalve, Darriwilian, Dali, Indo-China plate, Palaeogeography

[Keynote] Methods for β−level paleobiogeography using dendrogram and cladogram

Dong-Chan LEE[1]*, Chungbuk National University (dclee@chungbuk.ac.kr)
Jikhan Jung[2], Korea Polar Research Institute
Yeongju Oh[3], Korea Polar Research Institute
Tae-Yoon Park[4], Korea Polar Research Institute

Abstract

β-level paleobiogeography describes relationship among areas occupied by a group of taxa during a geologic time interval or change of relationship through time intervals. Dendrogram based on cluster analysis of presence/absence of taxa and cladogram based on parsimony analysis of morphologic characters of taxa are commonly used. A dendrogram shows affinity among areas as hierarchical clustering based on similarity indices calculated from presence/absence of taxa in areas. A method called “area distance expression” using similarity indices of clusters is devised to trace temporal changes of area relationship. The closest and furthest possible distance between two components of a cluster are employed, which represent the similarity index of a cluster calculated from a presence/absence dataset for each time interval and a combined dataset for all the intervals, respectively. The closest possible distance is expressed as an angle along a circle representing the furthest possible distance. The two distances are sequentially added from a cluster with the highest similarity index and the resultant 2D expression of area distribution can be used to trace how the affinity among areas changed through time. A cladogram showing ancestor-descendant relationship of taxa is used to infer relationship among areas inhabited by the taxa by replacing terminal taxa with the area(s), in other words, constructing area cladogram. A method called “area transition count” uses cladogenetic area transtions between an ancestral node and two descendant nodes in area cladogram. Combination of four anagenetic area transitions, range contraction, range expansion, range switch, and no range change, results in 10 theoretically possible cladogenetic area transitions. The area transition types and areas involved in the transitions are counted for each set of three nodes. The compilation of the counts for transition types and areas for each time interval can be used to explain how the distributional area change expressed as the counts affected evolution of a group.

Keyword

Paleobiogeography, dendrogram, area distance expression, cladogram, area transition count

Middle–Late Ordovician cephalopod fauna from southern Xizang (Tibet) and its palaeogeographic implications

Jiaqi SONG[1]*, State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (jqsong@nigpas.ac.cn)
Xiang Fang[2], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Wenjie Li[3], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Shenyang Yu[4], School of Geography and Tourism, Qufu Normal University
Wenhui Wang[5], School of Geosciences and Info-Physics, Central South University
Yuandong Zhang[6], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

In the Mt. Qomolangma region of southern Xizang (Tibet), continuous and well-exposed Ordovician strata yield abundant cephalopod fossils. This study focuses on the classic Ordovician Jiacun section within the region, with an emphasis on the cephalopod palaeontology and palaeogeography. From a collection of cephalopod specimens, a total of 30 species (including two new species: Wutinoceras multiseptum new species and Wennanoceras remotum new species) in 16 genera belonging to 10 families and 6 orders have been identified and systematically described, wherein newly documented specimens have been discussed for their biostratigraphic implications, broadly indicating the age of the lithostratigraphic unit with questionable geological age. We also collect Ordovician cephalopod occurrences of the northeastern peri-Gondwana region: on the one hand for Igraph R package-based network analysis and on the other hand for PAST software-based cephalopod fauna biodiversity research, new understanding and discoveries have been made regarding the cephalopod provinces on the northeastern peri-Gondwana region and the appearance of cephalopod fauna in southern Xizang. Overall, this study provides more Ordovician cephalopod occurrence data and improves the faunal composition of Middle–Late Ordovician cephalopod in the Mt. Qomolangma region of southern Xizang by utilizing new fossil materials and emerging data analysis methods, with biodiverse and palaeobiogeographic implications explained.

Keyword

Middle–Late Ordovician, Mt. Qomolangma region, Network analysis, Palaeontology, Palaeobiogeography

New insights into the Great Ordovician Biodiversification Event: Evidence from the Early Ordovician Liexi Fauna

Xiang Fang[1]*, Nanjing Institute of Geology and Palaeontology, CAS (xfang@nigpas.ac.cn)
Ying-yan MAO[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Zhong-yang CHEN[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Wen-hui WANG[4], Central South University

Abstract

The Ordovician Lagerstätten record substantial amounts of excellent preservation and soft-bodied fossils during the Great Ordovician Biodiversification Event (GOBE). However, few Lagerstätten are known from the Lower Ordovician, most of which are preserved in the restricted environment and high latitude areas. Here a new tropical Lagerstätte, Liexi fauna, has been recently discovered from a carbonate succession within the Lower Ordovician Madaoyu Formation in western Hunan, South China. It contains a variety of soft tissues, exceptional preservations, as well as rich shelly fossils, including paleoscolecidan worms, possible Ottoia fossil, trilobites, echinoderms, sponges, graptolites, polychaetes, bryozoans, conodonts, and other fossils. The Liexi fauna includes up to 11 phyla of marine animals, which suggests they occupied a wide range of niches. A biologically complex and complete marine ecosystem with diverse organisms and varied lifestyles is proposed here, including endobenthic (palaeoscolecidans, possible Ottoia, linguliform brachiopods and machaeridian polychaetes), sessile benthic (dendroid graptolites, echinoderms, sponges, rhynchonelliform brachiopods and bryozoans), mobile benthic (demersal trilobites), nektonic (conodonts) and planktic taxa (agnostids, planktic trilobites and graptoloids). The Liexi fauna is regarded herein to be one of the most well-preserved and most fossiliferous Ordovician Lagerstätte. The fauna includes taxa that not only belong to Cambrian relics, but also Ordovician origins, constituting a complex and complete marine ecosystem. This scenario would imply that the GOBE represents a long, gradual and continuous evolutionary process following the fade-out of the Cambrian explosion. The Liexi fauna represents one of the diverse open-marine communities, located in a specific tropical area in the peri-Gondwanan region, indicating a complex and complete ecosystem at the transition between the Cambrian and the Palaeozoic evolutionary faunas.

Keyword

Great Ordovician Biodiversification Event (GOBE), Lagerstätte, exceptional preservation, open-marine communities, tropical area

A distinctive type in the earliest Phanerozoic reef pattern: calcimicrobial-cement reefs from the Cambrian Series 2 Xiannüdong Formation, China

Daecheol KIM[1]*, Kangwon National University (dckim@kangwon.ac.kr)
Jino Park[2], Kangwon National University
Jongsun Hong[3], Kangwon National University

Abstract

Marked changes in the late Proterozoic ocean-atmosphere system triggered the development of skeletal frameworks and decreased abiogenic precipitates, resulting in the prevalence of lower Paleozoic microbial-skeletal reefs. While the microbial crust-cement reefs during that time stand out for their abundant early marine cement and sparse skeletal metazoans, it remains poorly understood how this distinct structure and composition from contemporaneous reefs have occurred. This study examined the developmental process of the Cambrian Series 2 *Girvanella* crust-cement reefs in the Xiannüdong Formation of Sichuan, China. *Girvanella* crust-cement and thrombolitic reefs together comprise a closely spaced, 2-m-thick microbial-dominated reef complex with the surrounding peloid-*Girvanella* crust packstone to grainstone and fine-grained siliciclastic thin beds. *Girvanella* crust-cement reefs are amalgamated bioconstructions of a centimeter- to decimeter-scale cabbage-like porous structure. This structure consists of vertically to horizontally aligned thin arcuate *Girvanella* crusts, attached to closely spaced to one another, with the pore spaces filled by abundant fibrous and blocky calcite cement and rare internal sediments. Thrombolitic reefs reaching heights up to 1.5 m are composed of largely mesoclot-forming calcimicrobes and microbial lumps and rare irregular archaeocyaths. Their interstitial spaces are equilateral pores a few centimeters in size, nearly completely filled with internal sediment. The surrounding deposits point that the reef complex had formed in moderate- to high-energy shallow subtidal with frequent siliciclastic influxes. The crust-cement reefs were constructed by a coalescence of *Girvanella* crusts with the aid of marine cementation. Much lower content of internal sediment, dense arrangement of the reef-building *Girvanella* crusts and presence of crust-rich surrounding deposits, indicate that the crust-cement reefs were possessed vulnerable, semi-closed frameworks. These architectural characteristics seem to have hindered the incorporation of skeletal components within the reefs, leading to the formation of microskeletal reefs as microbial-abiotic hybrids. Since they are comparable to other lower Paleozoic calcimicrobial crust-cement reefs in composition, texture, and structure, ample occurrences of abiotic carbonate and the absence of skeletons in the coeval reefs elsewhere were also likely caused by the internal controls. Lower Paleozoic calcimicrobial crust-cement reefs broadly resemble Precambrian microbial-abiotic hybrid reefs in terms of key carbonate components. The differences in texture and the associated developmental process, however, suggest that such a distinctive development of lower Paleozoic calcimicrobial crust-cement reefs may have been significantly influenced by the Cambrian Explosion, rather than being an anachronistic variant of the Precambrian.

Keyword

calcimicrobial crust-cement reefs, reef frameworks, hybrid carbonates, Cambrian Explosion

The global distribution of Upper Ordovician acritarchs

Kui YAN[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (kuiyan@nigpas.ac.cn)
Thomas Servais[2], CNRS, Université de Lille, UMR 8198 Evo-Eco-Paleo
Bing Huang[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Jun Li[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The Peri-Gondwana and Baltica acritarch provinces are easily recognized in the Early-Middle Ordovician, illustrating a clear provincialism of the global phytoplankton. However, acritarch assemblages have been reported to become increasingly similar with a general cosmopolitanism towards the Late Ordovician, although acritarch assemblages from Laurentia and Baltica are reported to be rather different from those from peri-Gondwana, based on more recent studies. In the last decades, new acritarch assemblages reported from South America, Baltica, Iran, and Siberia as well as the new material from South China and Tarim provide additional data that helps to understand in more detail the palaeobiogeographical evolution of the phytoplankton during the Late Ordovician.

We reviewed Late Ordovician acritarch assemblages and built datasets with binary presence/absence data. Quantity analysis including Cluster Analysis (CA), Nonmetric Multidimensional Scaling (NMDS) and Network Analysis (NA)were used to understand the implication of acritarch palaeogeography in the Late Ordovician.

A strong palaeobiogeographic differentiation occurred in the Katian and weakened in the Sandbian and Hirnantian. The palaeogeographic distribution of the phytoplankton roughly parallels palaeolatitudes in the Katian, possibly leading to a global temperature zonation.

The high diversity acritarch assemblage normally existed around 30° in the Southern Hemisphere, which is similar to the LDG model in the Late Ordovician published by Zacaï et al. (2021).

The total diversity of acritarchs was highest in the Katian, together with a strong palaeobiogeographic differentiation in the Late Ordovician. This higher acritarch diversity may be linked to stronger palaeobiogeographic variations.

The proportion of the endemic acritarch taxa is very high in different plates (regions) during the Late Ordovician. The proportion of the cosmopolitan acritarch taxa was higher in the Hirnantian than that in the Sandbian and Katian. Acritarch assemblages from different plates (regions) exhibited various diversity trends affected by the Late Ordovician Mass Extinction.

Keyword

acritarchs, Late Ordovician, palaeogeography, biodiversity

Oldest stromatoporoid reefs are found in South China

Juwan JEON[1]*, Department of Earth and Environmental Sciences, Korea University, Seoul, 02841, Republic of Korea; The Institute of Basic Science, Korea University, Seoul, 02841, Republic of Korea (juwanjeon@korea.ac.kr)
Jeong-Hyun Lee[2], Department of Geological Sciences, Chungnam National University, Daejeon 34134, Republic of Korea
Stephen Kershaw[3], Department of Life Sciences, Brunel University, Kingston Lane, Uxbridge, UB8 3PH, United Kingdom/ Earth Sciences Department, Natural History Museum, Cromwell Road, London, SW7 5BD, United Kingdom
Zhong-Yang Chen[4], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, People's Republic of China/ University of Chinese Academy of Sciences (UCAS), Beijing 100049, People's Republic of China
Jun-Ye Ma[5], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, People's Republic of China/ University of Chinese Academy of Sciences (UCAS), Beijing 100049, People's Republic of China
Yuan-Dong Zhang[6], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, People's Republic of China/ University of Chinese Academy of Sciences (UCAS), Beijing 100049, People's Republic of China

Abstract

Stromatoporoid sponges were reef builders for over 100 million years in the Palaeozoic Era. Since the emergence and proliferation of stromatoporoids as reef builders in the late Darriwilian (Middle Ordovician), stromatoporoids played a key role in the development of complex reef ecosystems, especially contributing to the Great Ordovician Biodiversification Event. However, the mechanisms by which stromatoporoids were integrated into reef communities remain poorly known. Our discovery of stromatoporoids from the upper Tremadocian to the lower Floian (Lower Ordovician) in South China represents the oldest known stromatoporoids and sheds light on the initial stage of middle Palaeozoic reef development. These stromatoporoids are essential for building the structure of the reef, similar to those of the late Middle Ordovician and later, by binding other components and together with other reef builders formed a complex reef community. In particular, these Early Ordovician stromatoporoid reefs, in association with Cambrian biotic relics and Ordovician fossils, replaced late Cambrian microbial-dominated reefs in South China significantly earlier than in other continents, where microbial-lithistid sponge reefs persisted over the same time period. These newly-described Early Ordovician stromatoporoid reefs in South China thus are evidence for diachronous onset of metazoan-dominated reef community development among regions, and to a greater extent in South China. Combined with the available data, this early reef transition from microbial to metazoan domination in South China is most likely due to multiple environmental changes, including a global decrease in seawater temperature, an increase in dissolved oxygen levels, and the palaeogeographic position of South China within the tropical to subtropical climate zone. In perspective, South China served as a focal

point for reef evolution during the Early Ordovician. The earliest stromatoporoids, as newly emerging skeletal reef builders, expanded globally during the late Darriwilian, when environmental conditions became more suitable for metazoan reef development.

Keyword

Stromatoporoids, Ordovician, South China, Great Ordovician Biodiversification Event

The Ordovician-Silurian boundary deposits in northwestern Tarim, Xinjiang: the Xikeer bed (new unit) and its implications

Yuchen ZHANG[1]*, Nanjing Institute of Geology and Palaeontology (yuchenzhang@nigpas.ac.cn)
Peng TANG[2], Nanjing Institute of Geology and Palaeontology
Renbin ZHAN[3], Nanjing Institute of Geology and Palaeontology

Abstract

A stratigraphic succession across the Ordovician-Silurian boundary is discovered in the northwestern margin of the Tarim Basin, Xinjiang, NW China, and is named Xikeer Bed, which ranges from uppermost Hirnantian (Upper Ordovician) to lowermost Rhuddanian (Llandovery, Silurian). The holostratotype of the Xikeer Bed is located at the Xikeer Service-area North section, Xikeer Town, Jiashi County, while the parastratotype is located at the Dawangou section, northwest of the Yingan village, Kalpin County. In the holostratotype, the lower part of the Xikeer Bed is composed of gray-green argillaceous siltstone, and the upper part consists of gray calcarenite, which produces brachiopods, corals (tabulate and rugose), bryozoans, stromatoporoids, and some other fossils, with a total thickness of 1.5 m. In the parastratotype, the Xikeer Bed has a sequence of gray-green muddy siltstone and silty mudstone with bryozoans, gastropods, cryptospores, algae and land plant fragments, with a total thickness of 2.5 m. In the Kalpin-Jiashi area, the Xikeer Bed is underlain unconformably by the Terekawat Formation (upper Katian Stage, Upper Ordovician), suggesting the absence of the lower-middle Hirnantian rocks in the study area, and is overlain conformably by the Kalpintag Formation (Rhuddanian, Llandovery). The Xikeer Bed is widely and stably distributed in the Kalpintag Mountains and some other places in the Kalpin area, and will serve as an important lithostratigraphic marker for the division and correlation of the equivalent strata. A brachiopod assemblage collected from the bed is typically represented by Cathaysiorthis yushanensis and Leptaena rugosa, which belong to the Edgewood-Cathay (EC) Fauna, the first brachiopod assemblage inhabited shallow marine after the Late Ordovician Mass Extinction (LOME). Based chiefly on the yielded brachiopods, the Xikeer Bed is well correlated with the Wulipo Bed in Meitan County and the Shiqian Bed in Shiqian County, northern Guizhou Province, along with the Weiba Bed in Zhenxiong, northeastern Yunnan Province, South China. These equivalent beds are assumed to be the products of global rapid transgression and climate warming in the aftermath of the Hirnantian glaciation and mass extinction. Due to the cold climate and sea-level drop in the Hirnantian, the Kalpin area was exposed and denuded until latest Hirnantian when the glacial climate ended and the sea level rose rapidly, and as a result the area began to accumulate deposits again. As shown by a trans-regional correlation, the absence of the lower-middle Hirnantian stratigraphic records also occurred in some areas of the Yangtze Region, such as northern Guizhou Province, northeastern Yunnan Province, the border area of Zhejiang and Jiangxi provinces, etc. This shared absence sheds light on the depositional history and paleobiogeography of northwestern Tarim Basin during the Ordovician-Silurian transition.

Keyword

Ordovician–Silurian transition, Northwest Tarim, Kalpin County, Brachiopod, Edgewood-Cathay (EC) Fauna

Paleozoic oxygenation event - evidence from late Silurian tubular trace fossils in South China

Yuxuan WANG[1]*, China University of Geosciences (Wuhan) (2514548715@qq.com)
Xiaole Zhang[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Peng Tang[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Liao Yang[4], China University of Geosciences(Wuhan)
Zhong-Qiang Chen[5], China University of Geosciences(Wuhan)

Abstract

The Paleozoic Oxygenation Event (POE) is the third major oxygen increase in atmosphere and ocean following the great oxygenation event (GOE) in 2.2-2.5 billion years ago and Neoproterozoic Oxygenation event (NOE) around 800-700 million years ago. Previous studies showed that the POE had a significant impact on biotic radiation and witnessed the emergence of vascular plants and terrestrialization process (including vegetation on land) during the Silurian. Geochemical and modelling studies estimated that the atmospheric oxygen content could be close to or reach modern levels (O2 >15-17%) during approximately 420-400 Ma. Nevertheless, how marine animal reacted the elevated oxygen levels during the Silurian has long remained poorly understood. Here we document abundant tubular trace fossils from the upper Silurian Xiaoxi Formation in the Guizhou, Chongqing and Hunan regions, South China, emphasizing burrowing behavior variations of trace-making animals during the late Silurian oxygenation process. The newly obtained trace fossils combining with the previously reported materials show that significant increases in burrow diameter of tubular trace fossils from the upper Silurian Xiaoxi Formation when compared with those from early-middle Silurian, implying the result of elevated oxygen levels in marine settings. Field observation and measurement also reveal that the burrowing density and diameter of tubular trace fossils negatively correlate each other. Accordingly, an increase in burrow sizes, coupling with decrease in burrowing density of tubular trace fossils is evident from the early Silurian (Xiushan Formation) to late Silurian (Xiaoxi Formation), implying the controls of water depth and oxygen level on trace-making animal activities at that time, reinforcing the occurrence of oxygenation event.

Keyword

Paleozoic oxygenation event, tubular trace fossils, elevated oxygen level, Silurian, South China

Latest Ordovician graptolite fauna of the Wufeng Formation in South China

Qing CHEN[1]*, Nanjing Institute of Geology and Palaeontology, CAS (qchen@nigpas.ac.cn)
Xu Chen[2], Nanjing Institute of Geology and Palaeontology, CAS

Abstract

The Wufeng Formation (Wufeng Shale) was first delineated as a stratigraphic unit established by Sun Yunzhu in 1931 based on the field surveys and graptolite specimens collected by Xie Jiarong and Liu Jichen at Yuyangguan Town, Wufeng County, Hubei Province, South China. The age and stratigraphic division of the Wufeng Formation had long been an unresolved issue in the Chinese geological community until a conclusive paper titled "On the Wufeng Shale" was published by Mu Enzhi in 1954. In this publication, a reliable conclusion was reached that the Wufeng Formation belongs to the Upper Ordovician based on the presence of graptolites within it. Over the past two decades, the Wufeng black shale in the Upper Yangtze Region has emerged as a significant shale gas production horizon. In this scenario, the division and precise correlation of graptolite biozones play a crucial role in identifying and comparing shale gas sweet spots underground. Achieving this requires accurate graptolite classification and identification. Since the 1990s, a large number of graptolites from the Wufeng Formation have been collected for research on the GSSP of the Hirnantian Stage in South China. Recently, better-preserved graptolite specimens, including a few three-dimensional ones, have been obtained from the Guizhou Province. This presents a valuable opportunity for further study of latest Ordovician graptolite fauna. In this study, a total of 25 genera and 80 species of graptolites are described using over 1,000 selected graptolite specimens. The descriptions cover research history, morphological characteristics, distinctions from similar species, and other pertinent discussions. Additionally, the study clarifies the stratigraphic ranges, distribution patterns, and ecological characteristics of the latest Ordovician graptolites across more than 70 sections and collection sites in South China and worldwide. Distinctions are made among various graptolite ecological types, and their evolutionary processes during the end-Ordovician mass extinction are examined. The graptolite fauna can be classified into three types: the background extinction unit, the mass extinction unit, and the origination unit. The end-Ordovician mass extinction impacted both the mass extinction units and the background extinction units. The effect of the mass extinction was consistent across all graptolite species, irrespective of the size of their geographic ranges. Biogeographic dynamics and evolutionary processes of graptolite species further support the transition from diplograptids to neograptids.

Keyword

Wufeng Formation, graptolite, end-Ordovician mass extinction, biogeography, shale gas

[Keynote] Integrative Ordovician stratigraphy of China: a critical constraint on orogenies and palaeogeographical evolution of NE peri-Gondwana

Yuandong ZHANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (ydzhang@nigpas.ac.cn)
Xiang FANG[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Wenjie LI[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

Present-day China comprises several independent tectonic palaeoplates or terranes and parts of other blocks, which have been assembled over geological time. During the Ordovician, these blocks included South China, North China, Tarim, Qaidam, Junggar, Qiangtang-Qamdo, Lhasa, and partially Himalaya, Sibumasu and Indochina, as well as the Altay-Xing'an and Songpan-Garze fold belts, which were likely discrete but adjacent. The Ordovician strata of China reflect a largely consistent and continuous deposition during the period, but with some significant interruptions or major facies changes on some of the constituent blocks due to regional orogenies or global factors. Therefore, an integrative stratigraphical framework of the Ordovician, including lithostratigraphy, chronostratigraphy, biostratigraphy, chemostratigraphy, cyclostratigraphy and magnetostratigraphy, would provide a critical constraint for the timing and extent of these orogenies, as well as major palaeogeographical dispersions or conversions of the constituent blocks in northeastern peri-Gondwana region. In South China, the Ordovician System is characterized by a major facies change from an extensive marine platform-slope-basin pattern into a pattern of restricted foreland basin with some isolated carbonate platforms in the Late Ordovician, which has been widely attributed to the Kwangsian Orogeny initiated in Sandbian and lasted until early Silurian. The Ordovician System of North China is dominated by carbonates including extensive deposits of evaporites in the Darriwilian, and shows distinctive occurrences of two major hiatuses, i.e. the two episodes of the long-lasting Huaiyuan Epeirogeny, one in the Early-Middle Ordovician and the other in the Late Ordovician which lasted until Carboniferous. In Tarim, the Ordovician System displays apparent facies differentiation from the west (marginal shelf-slope facies) to central (shallow-water platform with developed reefs) and to the east (largely siliciclastic flysch facies), and is distinctive in the occurrences of an extensive hiatus in middle-late Katian and another one in the Hirnantian. The Ordovician System of Tibetan terranes represents the oldest non-metamorphosed marine deposits in the region, typified by the occurrence of an extensive hiatus between the Ordovician and the underlying Cambrian basement caused by the Kurgiakh Orogeny, showing a likely close affinity with Sibumasu, and North China. The overall lithostratigraphical sequences and faunal assemblages, especially the benthic and nektonic organisms on constituent blocks of China show a prominent similarity between South China and Tarim, and a close relationship between North China and Tibetan terranes in the Early to Middle Ordovician. A dynamic palaeogeographic analysis of the Chinese constituent terranes through the Ordovician shows a complex dispersion and convergence pattern, which is highlighted by the

rifting of North China from Gondwana and the approaching of South China towards Australia and the equatorial region.

Keyword

Ordovician, Integrative stratigraphy, Orogeny, Palaeogeography, China

New techniques for studying the morphology of chitinozoan plugs

Yan LIANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (liangyan@nigpas.ac.cn)
Olle Hints[2], Tallinn University of Technology
Jaak Nõlvak[3], Tallinn University of Technology
Peng Tang[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

All chitinozoan chambers were sealed by a plug at the aperture side. The plugs are named operculum or prosome, which are of decisive significance in both chitinozoan systematics and exploring their biological affinity. According to the current chitinozoan classification put forward in 1999, an operculum is a disk-like plug sealing the aperture at the test lacking a neck and a prosome is an internal plug situated within the neck. Morphologically, the prosome could be as simple as a disk-like feature similar to the operculum, or as complex as a tubular structure with several horizontal septa. Both the operculum and the prosome could have a membrane expansion flaring anti-apertural ward. Hitherto, the descriptions of the morphology of the plugs inside an opaque chitinozoan test are based on optical microscopy (OP) with high light density, near-infrared microscopy (NIR), or scanning electron microscopy (SEM) of broken tests. However, neither OP nor NIR could provide high-resolution imaging, and SEM could not present enough data. We applied NIR, Micro-CT, and focused ion beam scanning electron microscopy (FIB-SEM) to determine the plugs' morphology and ultrastructure. NIR is involved in the first step to detect specimens with plugs preserved intact. Micro-CT is then used to reveal the morphology of the inner plugs without destroying the specimens. FIB-SEM is applied to cut the selected specimens at critical places and obtain high-resolution images of the ultrastructure of the plugs. With new data accumulating by these techniques, novel findings are expected to better understand the plugs' functional morphology and the biological affinity of chitinozoans.

Keyword

chitinozoans, functional morphology, new techniques, biological affinity

Silurian conodonts from western Yunnan and Xizang (Tibet), China

Zhongyang CHEN[1]*, Nanjing Institiute of Geology and Palaeontology, Chinese Academy of Sciences (zychen@nigpas.ac.cn)
Peep Männik[2], Tallinn University of Technology
Xiang Fang[3], Nanjing Institiute of Geology and Palaeontology, Chinese Academy of Sciences
Wenkun Qie[4], Nanjing Institiute of Geology and Palaeontology, Chinese Academy of Sciences
Yichun Zhang[5], Nanjing Institiute of Geology and Palaeontology, Chinese Academy of Sciences
Yuandong Zhang[6], Nanjing Institiute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The Wenlock to Pridoli conodont biozonation has been well established in many areas of the world but has been poorly studied in China. The Silurian succession in western Yunnan and Xizang (Tibet) is relatively continuous and complete, but conodont biostratigraphy in these regions has not been extensively researched. In this study, conodont samples were collected from the Laojianshan section in Baoshan of western Yunnan, the Yalai West II section in Nyalam of southern Xizang, and the 5,118 Highland section in Xainza of northern Xizang. Analysis of the Laojianshan section identified seven distinct conodont zonal units within the "Lichaiba" and Niushiping formations, including the Pterospathodus amorphognathoides amorphognathoides Zonal Group, the Pterospathodus pennatus procerus Superzone (likely only the Lower Pterospathodus pennatus procerus Zone), the Ozarkodina sagitta sagitta Zone, the Kockelella ortus absidata Zone, the Kockelella crassa Zone, the Polygnathoides siluricus Zone, and the “Ozarkodina” eosteinhornensis s.l. interval Zone. Similarly, the Yalai West II section revealed five recognized conodont zonal units within the Pulu Formation, encompassing the Ozarkodina sagitta sagitta Zone, the Kockelella crassa Zone, the Kockelella variabilis variabilis–Ancoradella ploeckensis Zonal Group, the Polygnathoides siluricus Zone, and the “Ozarkodina” eosteinhornensis s.l. interval Zone. In the 5,118 Highland section, three conodont zones were identified, including the Kockelella crassa, Kockelella variabilis variabilis, and Polygnathoides siluricus zones. Utilizing these conodont findings in conjunction with graptolites from underlying strata, the "Lichaiba Formation" was assigned to the upper Llandovery (upper Telychian)-upper Wenlock (upper Homerian), the Niushiping Formation to the Ludlow-Pridoli, the Pulu Formation to the upper Llandovery (upper Telychian)-Pridoli, and the Zhanongema Formation to Ludlow. Additionally, the late Telychian conodont fauna from the Laojianshan section suggests a distal, open-shelf depositional environment. The widespread distribution of Wenlock to Pridoli conodont species across the Baoshan, Nyalam, and Xainza regions indicates that the cosmopolitan characteristics of the conodont fauna during this period were likely influenced by the circulation of ocean currents.

Keyword

Silurian, conodont, Western Yunnan, Xizang (Tibet)

Uppermost Darriwilian radiolarians from the lower part of Wulalike Formation, NW Ordos Basin, North China

Xuejin WU[1]*, Nanjing Institute of Geology and Palaentology (xjwu@nigpas.ac.cn)
Zhengliang Huang[2], Exploration and Development Research Institute of Petro China Changqing Oilfield Company
Hui Luo[3], Nanjing Institute of Geology and Palaeontology
Zhenghong Cai[4], Exploration and Development Research Institute of Petro China Changqing Oilfield Company
Yaoxuan Guo[5], Research Institute of Exploration and Exploitation of Yumen Oilfield Company of China National Petroleum Corporation
Yang Liu[6], Exploration and Development Research Institute of Petro China Changqing Oilfield Company
Yujing Wang[7], Nanjing Institute of Geology and Palaeontology
Jonathan C. Aitchison[8], University of Queensland
Yuandong Zhang[9], Nanjing Institute of Geology and Palaeontology

Abstract

A well-preserved radiolarian assemblage is described from argillaceous limestone of the Wulalike Formation in the NW Ordos Basin, North China. A total of seven genera and nine species are described, including Inanigutta gansuensis, I. quadrispinosa, I. complanata, Inanibigutta pinglianensis, Oriundogutta bella, Triplococcus acanthicus, Haplentactinia juncta, Syntagentactinia pupila n. sp. and Kalimnasphaera maculosa. Three-dimensional X-ray micro-computed tomography (Micro-CT) is used to make a detailed examination of the new species. Micro-CT examination results suggest that the Syntagentactinia pupila n. sp. is exclusively constructed from five initial spicules and two spheres with a pylome surrounded by an extensive net. And detailed structural analysis reveals that inner sphere is ectopic to outer sphere. This taxon is thus far known only from the Middle Ordovician rocks of the northwestern Ordos Basin, North China. This new species in the radiolarian assemblage from the Wulalike Formation at Well E-98 drill core, northwestern Ordos basin potentially provides a diagnostic tool for stratigraphic correlation and insight into the development of Paleozoic radiolarian taxonomy. Besides, this is the first documentation of radiolarian fossils from the Wulalike Formation and will contribute to better understanding of the features of Ordovician radiolarian faunas and facilitate stratigraphic correlation and subdivision in the Ordos Basin.

Keyword

Radiolarian, Wulalike Formation, uppermost Darriwilian, Ordos Basin, shale gas

The Ordovician radiolarians from Qilian Orogenic Belt

Hui LUO[1]*, Nanjing Institute of Geology and Palaeontology (huiluo@nigpas.ac.cn)
Xuejin Wu[2], Nanjing Institute of Geology and Palaeontology
Yuandong Zhang[3], Nanjing Institute of Geology and Palaeontology

Abstract

In China, the study of the evolution and extinction process of the Proto-Tethys Ocean has been one of the hot topics of geoscience research on the Tibetan Plateau, but it is still quite weak. There is still a great deal of controversy about when it opened, how it evolved, and how it disappeared. A number of Early Paleozoic suture zones have been found in the Qilian Orogenic Belt and its adjacent areas in China, in which a large number of ophiolites, mélange and radiolarites etc. related to the Proto-Tethys Ocean are exposed, which record the evolution history of the Proto-Tethys Ocean. So far, there is a lack of systematic research on radiolarians in these siliceous rocks. In recent years, we have done preliminary collection and systematic paleontological research on radiolarians in different suture zones in this area, and found that there are rich radiolarian fauna in the Ladong section and the Donggoukou section of the northern belt, including Middle to Late Ordovician Spumellarian and Entactinia; In the Shihuiyao section of the southern belt, some Late Ordovician Spumellarian are found. The discovery of these radiolarian fossils will provide important biostratigraphic constraints for determining the expansion and extinction time of Proto-Tethys, and help to reveal the complete evolution process of Proto-Tethys Ocean in the Qilian Orogenic Belt and its adjacent areas.

Keyword

Radiolarians, Biostratigraphy, Proto-Tethys, Qilian Orogenic Belt, shale gas

The last episode of coral-stromatoporoid biostromes and faunal changes across a Devonian-Carboniferous Boundary section of South China

Kun LIANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (kliang@nigpas.ac.cn)

Abstract

This study reports the final occurrence of coral-stromatoporoid biostromes and the faunal and facies change across the Devonian-Carboniferous Boundary (DCB) at Changtanzi Section, Longmenshan area of South China. The final biostrome occurred in the third member of the Changtanzi Formation, represents the uppermost Famennian in age, and is characterized by a reefal environment composed of abundant and high diversity stromatoporoids and tabulate corals, which were subsequently greatly affected with the appearance of end-Devonian carbon isotope excursion (EDICE). Stromatoporoids and tabulate corals struggled to survive through the Famennian and their association was eventually terminated in the Lower Hangenberg Crisis (LHC) by extinction of Famennian stromatoporoids. Biotic recovery is found to occur as early as in the upper UHC, represented by solitary rugose corals Hebukophyllum sp., Neozaphrentis sp. and Uralinia sp., as well as abundant brachiopods, gastropods and an unknown tube organism, in general belonging to post-disaster fauna of low species level diversity. This study shows distinctive faunal and lithofacies changes during the Hangenberg Crisis, and examines the strong link between faunal, facies and environmental changes. The result reveals that the EDICE and Hangenberg Crisis caused sudden and significant impacts on marine ecosystems, leading to the disappearance of coral-stromatoporoid metazoan reefs that emerged during the Great Ordovician Biodiversification Event (GOBE).

Keyword

metazoan reef, mass extinction and recovery, Hangenberg Crisis, Carbonate microfacies, Biotic interaction

Early Darriwilian evolution of North China conodont bioprovince: insights from sedimentology and conodont biostratigraphy

Sehyun Cho[1]*, Department of Earth and Environmental Sciences, Korea University (whtpgus307@korea.ac.kr)
Byung-Su LEE[2], Department of Earth Science Education, Jeonbuk National University
Suk-Joo CHOH[3], Department of Earth and Environmental Sciences, Korea University

Abstract

Ordovician strata of North China Block contain middle Floian-lower Darriwilian platform wide hiatus. Conodont biostratigraphy above the hiatus described the emergence of many new types and multimolecular complex and evaluated the new stage of evolution of North China conodont and distinct differentiation of North China Province from other continents. This study attempts an integrative study of sedimentology and conodont biostratigraphy in the middle Ordovician Makgol Formation immediately above the hiatus at the eastern margin of the North China Block and aim to evaluate the separation of the bioprovince and the evolution of numerous endemic taxa from sedimentological perspective.

We investigated 205 m-thick composite intervals of the lower to upper members of the Makgol Formation at the five sections distributed in the Taebaek and Yeongwol areas. The formation is mainly composed of micritic limestone such as massive to bioturbated lime mudstone and wackestone, with subordinate peloid-bioclast packstone to grainstone, tidal laminite, stromatolite, and caliche and carbonate breccia, which is interpreted as a micrite dominated inner platform carbonate tidal flat deposits. The Makgol Formation is characterized by repetitive accumulation of subtidal and peritidal meter-scale cycles, and the vertical stacking of peritidal cycles dominated lower and upper part, while subtidal cycles constitute middle part, suggesting that the Makgol Formation record overall transgressive-regressive sequence with subsequent transgression to deeper subtidal deposits of the overlying Jigunsan Formation.

Conodont biostratigraphic data is related to facies and type of meter scale cycles. The lower and upper part dominated by peritidal cycles show very poor conodont recovery, which was defined as conodont barren intervals. The lower Darriwilian endemic conodonts in the North China including Tangshanodus tangshanensis, Triangulodus changshanensis and Rhipidognathus laiwuensis are abundantly yielded from the middle part, and Tangshanodus tangshanensis-Histiodella holodentata Biozone was established. These results indicate depositional environmental factors for conodont distribution and habitat.

Conodont barren interval and endemic conodont dominated biostratigraphy is not confined to the Taebaek area. Similar biostratigraphic characteristic is also recognized in northern and southern part of North China, where peritidal to shallow subtidal depositional facies including laminite, carbonate breccia and bioturbated limestone are described in corresponding interval. Therefore, it is suggested that shallow marine environment similar to the current study area also covered significant portion of the North China Platform, and that re-inundated shallow water conditions

may have provided niches for conodont evolution. The integrative study of biostratigraphy and sedimentology provide diverse perspective on the evolution of the bioprovince and we suggest that similar integrative study needs to be conducted in other regions of North China.

Keyword

North China, Darriwilian, conodont

Mollusk-dominated skeletal contributions during the Great Ordovician Biodiversification Event (GOBE) in the Darriwilian Sino-Korean Block

Myung-Jun Seo[1]*, Department of Earth and Environmental sciences, Korea University (joshuaseo0123@gmail.com)
Sehyun CHO[2], Department of Earth and Environmental sciences, Korea University
Sukjoo CHOH[3], Department of Earth and Environmental sciences, Korea University

Abstract

The Great Ordovician Biodiversification Event (GOBE), known for its unprecedented increase in marine biodiversity and complexity, also includes significant changes such as variations in life modes, the extent and intensity of bioturbation, and the skeletal contribution to carbonate production. These changes have been documented across continents. However, due to the middle Floian–lower Darriwilian depositional hiatus, which is followed by the thick overlying peritidal strata, the Ordovician records of the Sino-Korean Block (SKB) have been less understood in terms of biodiversity.

The middle Darriwilian Duwibong Formation located in South Korea, the easternmost part of the SKB, primarily composed of subtidal limestone deposits yielding various allochems (e.g., cortoids, oncoids, ooids, peloids, and bioclasts). The Duwibong Formation correlates with the Majiagou Formation in North China, characterized by low-energy shallow-shelf carbonates with extensive tidal flat dolomites and lagoonal evaporites. We investigated the Duwibong Formation at three sections through microfacies analysis, conducted on every specimen sampled at approximately 20 cm intervals in each section, to visually estimate component proportions.

The diversity and abundance of skeletal components in the Duwibong Formation significantly increased compared to the basal member of the Makgol Formation, composed of early Floian subtidal limestone deposits which currently occur in the field as a massive dolostone interval. Notably, mollusks and echinoderms show major increase, accompanied by the emergence of bryozoans, brachiopods, and algae. This trend, the quantitative increase and/or the addition of new components, is comparable to that observed in other continents, yet is driven predominantly by mollusks and echinoderms relative to the coeval strata in other continents. This study, by highlighting the shift towards a skeletal-dominated carbonate platform in the SKB during the Middle Ordovician, contributes insights into the marine-environmental evolution during the GOBE.

Keyword

GOBE, Darriwilian, North China

Early Paleozoic reef evolution in the Taebaek and Yeongwol groups, Korea: Insights into the peri-Gondwanan reef development

Jeong-Hyun LEE[1]*, Chungnam National University (jeonghyunlee@cnu.ac.kr)
Suk-Joo CHOH[2], Korea University
Jongsun HONG[3], Kangwon National University
Juwan JEON[4], Korea University
Jino PARK[5], Kangwon National University
Jusun WOO[6], Seoul National University

Abstract

Various early Paleozoic (Cambrian Series 2 to Middle Ordovician) reefs are found in the Taebaek and Yeongwol groups of Korea. In the Taebaek Group, reefs occur in every carbonate-dominant lithostratigraphic unit, but their morphology and composition differ markedly. The earliest Phanerozoic reefs in Korea are found in the Myobong Formation (Cambrian Stage 3?), where small columnar stromatolites develop in an intertidal setting. The Daegi Formation (Drumian) contains Epiphyton-lithistid sponge reefs formed in a shallow subtidal environment. The Sesong Formation (Guzhangian) and Hwajeol Formation (Jiangshanian–Cambrian Stage 10) contain several small dendrolites that formed in relatively deep subtidal environments. During the Early Ordovician (middle Tremadocian–early Floian), microbialite-lithistid-Calathium patch reefs develop in the shallow to deeper subtidal environments of the Dumugol Formation. A relative sea-level fall in the Middle Ordovician (Floian–early Darriwilian) established peritidal environments with microbial mats and stromatolites in the Makgol Formation. The Middle Ordovician (middle Darriwilian) Duwibong Formation exhibits some of the earliest skeletal reefs built by the stromatoporoid Cystostroma and bryozoan Nicholsonella around shoals. In the Yeongwol Group, reefs have recently been increasingly reported. The Wagok Formation (Cambrian Stage 10) contains stromatolite biostromes possibly formed in a peritidal environment. Stromatolite-like columns and thrombolite-like mounds composed of microbial carbonates, keratose sponges and minor lithistids develop in the Lower Ordovician (Tremadocian) Mungok Formation. The Yeongheung Formation (Darriwilian) contains several labechiid stromatoporoid-dominant reefs and microbial mats. These reef distributions can be compared to the coeval successions in North China, where various reefs and their evolutionary patterns are recorded throughout the Cambrian-Ordovician strata. The Taebaek and Yeongwol reefs demonstrate the evolution of reef ecosystems represented by the interplay between microbial and skeletal reef-builders during the early Paleozoic. They provide a window to understand peri-Gondwanan reef development that warrants further detailed study and comparison with coeval reefs globally to better understand the spatio-temporal patterns and drivers of early Paleozoic reef evolution.

Keyword

Early Paleozoic, Reef evolution, Taebaek Group, Yeongwol Group, Korea

Recovery of the earliest Silurian paleo-ocean: coupling evidence from both benthos and redox conditions in South China

Wenhui Wang[1]*, Central South University (whwang@csu.edu.cn)
Yong Wang[2], Central South University

Abstract

The Early Paleozoic witnessed a major diversity reduction in the Hirnantian-age Late Ordovician Mass Extinction (LOME), followed by subsequent post-extinction recovery cross the Ordovician-Silurian boundary. Understanding the pattern of post-LOME recovery is complicated by heterogeneity of patterns in time, and for different fossil groups. Different groups show strongly differentiated facies dependance, and thus show very different recovery patterns. Benthic fossil groups, which are the most severely affected by oxidative stress, offer the best opportunities for understanding both biological and ecological recovery after the LOME. Among benthos, many sponge-dominated community in South China have been found in the past decade, thriving immediately after the LOME and into the early Silurian. How the sponge proliferation is linked to the evolution of oceanic redox conditions during the earliest Silurian is unclear. In this study, in order to further explore the lateral and temporal distributions of sponges, and ecological effects of benthic recovery during this critical interval, we report two new localities (the Nanba section and TD 2 well, both in Hunan Province, South China) that have yielded sponge fossils. In addition, a combination of geochemical analyses reveals the bottom water redox conditions in which these sponges lived. The sponge communities show a relatively deep-water affinity and are preserved by pyritic spicule replacements. Geochemical analysis (total organic carbon (TOC) and major and trace element composition) in both sections show similar trends, indicating a shift in redox state of the bottom-water from persistent anoxia or intermittent euxinia in the earliest Rhuddanian, becoming oxygenated in the early Aeronian. Based on the present study and published data, the distribution of early Silurian sponge assemblages in South China demonstrates a gradual expansion towards deeper regions when ocean redox conditions ameliorated. The pioneering colonization of sponges in low-oxygen environments after the LOME may have set the stage for the subsequent recovery of other benthic organisms. This study contributes to the understanding of the main links between the development of the sponge faunas and changes in the marine environment.

Keyword

Llandovery, South China, Proliferation, Geochemistry, post-extinction recovery

First report of Late Ordovician sponge spicules assemblage from the Yangtze Platform, South China

Lixia LI[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (lxli@nigpas.ac.cn)
Guanzhou Yan[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Xin Wei[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Fangyi Gong[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Rongchang Wu[5], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

Sponges have played an important role in marine benthic ecosystems since the Precambrian. Most of our knowledge about the fossil record of sponges has long been based on the well-preserved sponges with whole skeletons from the outstanding fossil Lagerstätten. However, these remarkable fossil Lagerstätten are just a drop in the ocean, and most of the evidence for early sponges is from isolated spicules.

Previous studies have shown that the Early Paleozoic sponge fauna is dominated by siliceous sponges and a large number of siliceous spicules constitute the main part of the sponge body. However, in most cases, isolated spicules may not taxonomic significant unless they could be well matched to body fossils preserved together. It is also needed to put more effort into reassessment about the taxa previously established based on isolated spicules, in order to remove too many synonyms and form-taxa. In addition, the evolution of sponge spicules is high conservative, the relatively simple Cambrian types are still quite abundant and geographically widespread in the modern deep-water ecosystems. Therefore, although recent studies suggest that the Early Paleozoic sponge spicules are far more diversified and complex than previous expected, isolated spicules cannot play a prominent role in biostratigraphic and paleogeography. In view of this, there have been few studies on the sponge spicule assemblages for a long time, and not enough attention has been paid to this quite important group.

A diverse and abundant isolated sponge spicule assemblage of Late Ordovician age is first reported from the western margin of the Yangtze Platform in South China. The spicule assemblage was recovered from the argillaceous limestone dominated by conodonts, including 14 types which can be grouped into two categories: hexactinellid spicule types and demosponge spicule types. The assemblage is mainly composed of hexactines and their derivatives, including not only some distinctive types such as Kometia cruciformis, but also a large number of diagnostic spicule types that are quite common in hexactinellids, e.g. echinate hexactines, swollen hexactines, curved hexactines, stauractines. Demosponge spicule types are represented by tetraxons, a variety of desmas unique to lithistids also occurs. The highly modified hexactines, i.e. Kometia cruciformis, is recovered for the first time from China. This assemblage is currently the only spicule assemblage from coeval strata worldwide except the Australian one. The presence of unique modified hexactines (Kometia) in both assemblages suggest that particular spicules probably have great potential in biostratigraphy and show important biostratigraphic significance.

Furthermore, they also indicate that spicule assemblage represented by the unique modified hexactines may migrate multiple times along the periphery of Gondwana due to the Ordovician ocean currents, and have important paleobiogeographic significance. This spicule assemblage provides a new perspective for investigating the phylogeny, biostratigraphy, and paleobiogeography of Paleozoic sponges, and promoting the understanding of the siliceous sponge macroevolution.

Keyword

sponge spicules, paleobiogeography, biostratigraphy, Late Ordovician, South China

Carbon isotope stratigraphy of the Lower Ordovician Dumugol Formation: Implications for global correlation

Eunsoo LEE[1]*, Department of Geology, Kangwon National University (esu@kangwon.ac.kr)
Jongsun HONG[2], Department of Geology, Kangwon National University

Abstract

Stable Carbon isotope excursions have been widely used in chemostratigraphic studies for intervals where age-diagnostic proxies are ambiguous. While these excursions have been widely explored from the Ordovician successions over the past two decades, understanding those in the Lower Ordovician, including their potential for global correlation, remains unclear due to their small magnitudes. In this study, we report δ13C values from the two sections of the Lower Ordovician Dumugol Formation, and discuss their relevance for global correlation. The Dumugol Formation represents a middle to outer ramp succession composed mainly of shale to marlstone, lime mudstone-shale interbed, and lime mudstone, with intercalating grainy carbonate. The depositional age of this formation is identified as middle Tremadocian to early Floian in age based on conodont biozone. The δ13C trend has three distinct fluctuations recognized in Dumugol Formation: 1) a δ13C shift is observed at Chosonodina herfurthi-Rossodus manitouensis biozone, indicating an increase of ~1.26‰ above the baseline value (rising from -0.62 to 0.63‰), 2) at the base of the Scalpellodus tersus biozone, maximum δ13C values increase by ~1.68‰ from the baseline value (rising from -1.55 to 0.18‰), 3) a prominent δ13C decrease of 0.85‰ below the baseline value (falling from -1.27 to -2.12‰) in the uppermost of the Scalpellodus tersus to the base of the Serratognathus bilobatus conodont biozone. These δ13C data show similarities in trend and magnitude to observed δ13C trends in coeval successions elsewhere. The first shift, correlatable with those of Laurentia, Precordillera, and other regions of peri-Gondwana (South China), is identified as the Top Skullrockian positive Isotopic Carbon Excursion (TSICE). The other two shifts appear to correspond to the Late Stairsian positive Isotopic Carbon Excursion (LSICE) and Late Tremadocian Negative Isotopic Carbon Excursion (LTNICE), recognizable in the Precordillera, peri-Gondana, and Baltica. These three prominent δ13C excursions identified in this study suggest that not only TSICE, previously considered to have strong potential for global correlation, but also other excursions (i.e., LSICE and LTNICE), once deemed uncertain for global correlation, can be valuable for the inter-continental stratigraphic correlation.

Keyword

Early Ordovician, Carbon isotope excursion, LSICE, LTNICE, Global correlation

Biogeographic shifts of marine invertebrates during the Ordovician-Silurian transition

shasha LIU[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (ssliu@nigapas.ac.cn)
Qijian LI[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Lin NA[3], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Wolfgang KIESSLING[4], Department of Geography and Geosciences, University of Erlangen-Nuremberg

Abstract

The first of the five major Phanerozoic extinction events unfolded near the Ordovician/Silurian (O/S) boundary, leading to approximately an 85% decline in marine species, it's common knowledge that a sharp global temperature plunge triggered this extinction event. The Impact of the extinction varied across higher taxa, with complete loss in some groups, partial declines in many, and others navigating through the end-Ordovician extinctions relatively unscathed. However, the translation of these changes into first-order biogeographic patterns remains elusive. Using network analysis and a large compilation of fossil occurrences from Paleobiology Database, we delineate bioregions of marine invertebrates across the O/S boundary. Simultaneously, by integrating the spatial and temporal dynamics of diverse biological assemblages, including sampling-standardized global diversity, beta diversity, and alpha diversity, we scrutinize how faunal turnover and nestedness influence paleontological spatial patterns. Our findings indicate that the decline in beta diversity during the Hirnantian and the Rhuddanian stages was primarily driven by a significant drop in spatial turnover of marine invertebrates. Environmental stress during the main pulses of the extinction even led to an increase in nestedness, mirroring contemporary cases. These results unveil crucial environmental drivers, providing insights into the co-evolutionary mechanisms of life processes and the environment during mass extinctions.

Keyword

Ordovician extinction, network analysis, biogeography, nestedness, turnover

Graptolite biostratigraphy of the Ordovician Wulalik Formation in western margin of North China

Huaqing WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (hqwang@nigpas.ac.cn)
Yuandong ZHANG[2], University of Chinese Academy of Sciences; Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The Ordovician Wulalik Formation is characterized by predominant black graptolitic shale, and is widely distributed in the western margin of the Ordos Basin in North China. The formation has been targeted for exploration of shale gas by several petroleum companies a few years ago. However, the exploration of the formation is still at a low degree, largely because of the scarcity of geological data and a lack of comprehensive stratigraphic research, especially the graptolite biostratigraphy of the black shale, which appears to diachronous widely. We conducted biostratigraphical studies of one outcrop section and two drill cores of the formation in the western Ordos Basin. At the Dashimen outcrop section B in Wuhai, where belongs to northern part of western Ordos Basin, and the Well Qitan-11 in Etuokeqi, Inner Mongolia, as well as at the Well Huitan-5 in Yanchi, Ningxia in the central part of western Ordos Basin, a total of 144 graptolite specimens were collected for systematic paleontological and biostratigraphical studies. Based on the biostratigraphic occurrences of graptolite species, four graptolite biozones were identified within the formation in ascending order, the Pterograptus elegans, Didymograptus murchisoni, Nemagraptus gracilis, and Climacograptus bicornis biozones.

A biostratigraphic correlation of the Wulalik Formation is conducted between the studied Dashimen section B outcrops and the drill cores of Well Huitan-5 and Well Qitan-11. In addition to those biozonal species, some other species such as Amphigraptus divergens Hall, Dicellograptus angulatus Elles and Wood, D. flexuosus Lapworth, Jiangxigraptus sextans (Hall), Paraglossograptus sp. and Pseudoclimacograptus scharenbergi (Lapworth), are proven of stratigraphical importance due to their relatively short stratigraphical ranges. Didymograptus jiangxiensis Ni play a pivotal role in identifying the base of the D. murchisoni Biozone in Dashimen section B, and Jiangxigraptus sextans (Hall) and Paraglossograptus sp. play a pivotal role in identifying the base of the N. gracilis Biozone in Well Qitan-11, while some other species may also contribute significantly to stratigraphic correlation, but a comprehensive application of several species or other associated species may be needed.

Keyword

North China, The Ordos Basinc, Wulalik Formation, Ordovician, Graptolite biostratigraphy

Fossil evidence reveals sexual dimorphism in Anchiornis huxleyi

Yibo Zhou[1]*, Nanjing University (yibozhou@smail.nju.edu.cn)
Min Wang[2], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Xiaoli Wang[3], Linyi University
Xiaoting Zheng[4], Shandong Tianyu Museum of Nature
Zhonghe Zhou[5], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Yanhong Pan[6], Nanjing University

Abstract

There is a lot of evidence that sexual selection affects the early evolution of birds. Despite the hypothesis that sexual selection has been hypothesized as a driving force behind the occurrence of numerous morphological features across theropod evolution, it has yet to be thoroughly tested due to limitations in sample size and difficulties in identifying the sex in fossils. The feathered dinosaur Anchiornis huxleyi, is represented by a multitude of well-preserved specimens from the Late Jurassic Yanliao biota, with both articulated skeletons and plumages. It is remarkable that some specimens have black spots or stripes in forewing feathers while others do not, thus offering a unique opportunity to explore sexual dimorphism in a non-avian dinosaur closely related to the origin of birds. Here, we present a morphometric study of A. huxleyi based on the largest sample size of this taxon collected up to date. Through careful morphometric analysis, we aim to identify sexually dimorphic traits within this species and understand their implications for mating strategies and social behavior. Our results indicate that the distinctive black spots or stripes observed in forewing feathers may be indicative of sexual dimorphism. Statistically robust inferences have been made about the sexual dimorphism in body size, relative limb length and tail-feather arrangement, providing the earlist known sexual dimorphism in paraves evolution. The findings that males have longer forewings, suggesting that sexual selection may have driven the evolution of wings in dinosaurs, with flight emerging as an unintended consequence of these sexual display structures. Moreover, these results not only enhance our knowledge of Anchiornis huxleyi's biology and ecology, but also offer a comparative framework for understanding the evolution of sexual dimorphism in early theropods.

Keyword

Paraves, Mesozoic, sexual dimorphism, sexual selection

Evolution and dispersal of vertebrates in the Tibetan Plateau and surrounding regions

Tao DENG[1]*, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (dengtao@ivpp.ac.cn)
Feixiang Wu[2], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Shiqi Wang[3], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Zhiheng Li[4], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Danhui Sun[5], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences

Abstract

During the gradual formation of the Tibetan Plateau, the shaping of modern biodiversity in this region was greatly influenced by its uplift, while at the same time, many species originating from the plateau and even the intercontinental spread of ancestors of modern widespread groups were also controlled by this uplift. During the Mesozoic era, the area where the Tibetan Plateau is located today covered with vast oceans, and the Triassic marine sediments in the Himalayas produced vertebrate fossils such as ichthyosaurs and Helicoprion sharks. By the Jurassic and Cretaceous, some areas in southeastern Tibet gradually separated from the marine environment and formed freshwater lakes in the Qamdo Basin, similar to the Sichuan Basin at that time. Reptiles such as dinosaurs lived near the lakes. The collision between the Indian Plate and the Eurasian Plate in the early Cenozoic era gradually uplifted the Tibetan Plateau. At that time, there was a water system connecting the interior of the Tibetan region with the tropical regions of Southeast Asia, resulting in the flourishing of tropical and subtropical fish. With the significant increase in terrain elevation in this area, the environment has become dry and cool, resulting in the extinction of warm-adapting fish and their transformation into snow carps of the Tibetan Plateau. The rapid rise of the Tibetan Plateau has led to the strengthening of monsoon climate, and the climate in the inland regions of Central Asia continues to move towards drought. The Miocene fauna in western China was mainly composed of drought-tolerant grassland mammals, as well as drought-tolerant birds and reptiles coexisting. The Tibetan Plateau finally reached its modern height during the Pliocene, and its climate and environment had the characteristics of a cryosphere, becoming the initial evolutionary center of the Ice Age fauna. The global temperature dropped below today's level for the first time at 2.6 Ma, and animals that have adapted to the freezing environment quickly spread to the surrounding regions of the Tibetan Plateau and more distant areas, becoming the foundation of modern animal diversity. The Tibetan Plateau has undergone complex and large-scale environmental changes during its geological history. A series of tectonic movements and geomorphological evolution have triggered and formed the climate pattern of the Tibetan Plateau and its surrounding regions, which may promote the development of

biodiversity in the region and may also lead to the extinction of organisms.

Keyword

Tibetan Plateau, vertebrate, evolution, dispersal, Cenozoic

Deciphering the Evolutionary Dynamic of Melanosomes in Mammalian hair

Xin LI[1]*, Nanjing University (602023230008@smail.nju.edu.cn)
Shun-dong Bi[2], Centre for Vertebrate Evolutionary Biology, Institute of Palaeontology, Yunnan University
Yanhong Pan[3], Nanjing University

Abstract

Besides primates, mammalian hair color is predominantly determined by two pigments, eumelanin and pheomelanin, typically converging in the melanosome. The melanosomes, robust micron-sized organelles housing pigments, are most commonly encountered in mammalian fossil soft tisues. Melanosomes are considered crucial for reconstructing the paleocolor of fossil species, offering valuable insights into the evolution of mammalian hair color. While prior research has extensively explored the correlation between melanosome morphology and pigment types in non-avian dinosaurs and birds, its validation in both extinct and extant mammals remains limited. Here, we collected hairs from 59 extant species spanning 11 mammalian orders. We measured the color, melanosome morphology, and performed regression analysis to unravel the relationship between melanosome shape, color characteristics, ecological environment, and phylogenetic relationships in mammals.

In contrast to birds, our observations revealed that melanosome length, diameter and ratio did not exhibit significant associations with colors in mammals. Surprisingly, only melanosomes size and its coefficient of variation demonstrated a noteworthy correlation with the redness of the hair. This unexpected finding led us to attribute the variance to the absence of premelanosome protein (PMEL) expression in brown melanosomes. Furthermore, our study uncovered a robust correlation between melanosome morphometrics and habitat types (e.g diurnal habits, grand living, and dietary patterns) in mammals. Diurnal species exhibit larger and wider melanosomes, while dietary patterns also play a role in melanosome structures. These findings have profound implications for interpreting fossilized specimens, offering valuable insights into the ecological characteristics of extinct mammalian taxa. Our analysis of the melanosome morphology and taxonomic relationships, combined with phylogenetic analysis, demonstrated a significant phylogenetic signal in melanosome morphology, with consistent shapes within the same order. Comparisons between extant and extinct species revealed a close resemblance between independently obtained fossil data and reconstructed ancestral forms. This departure from the avian pattern suggests that mammalian melanosome morphology is not solely related to colour expression.

To broaden the scope of our study, we analyzed the melanosome morphology of the hair melanosomes in the Jurassic basal mammaliaform Vilevolodon diplomylos. Its melanosome characteristics closely aligned with the results of ancestral state reconstructions, suggesting that Jurassic basal mammals had a more constrained melanosome morphospace compared to Cenozoic

taxa. While restoring colors from fossils remains a challenging task, our study underscores the importance of capturing even subtle hues for a comprehensive understanding of ancient organisms. The expanded correlation between melanosome morphometrics and diurnal habits, grand living, and dietary patterns allowed us to predict the ecological habitat, aligning with interpretations from the skeletal features of extinct mammalian taxa.

Keyword

melanosome, paleocolor, mammalian color, ecological factor, phylogenetics

The first record of the genus Prosantorhinus (Perissodactyla: Rhinocerotidae) of East Asia

Danhui SUN[1]*, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (sundanhui@ivpp.ac.cn)
Tao DENG[2], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Shiqi WANG[3], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences

Abstract

Prosantorhinus is a genus of small extinct teleoceratine rhinoceroses with shortened limb bones, widely distributed in Europe. However, the Asian evolution of the teleoceratine Prosantorhinus has remained unclear because of a scarcity of fossil records of the genus. Here, we report the first record of Prosantorhinus in East Asia from the Middle Miocene of Tongxin, Ningxia. The new specimen is characterized by a concave dorsal skull profile and elevated nasals; short and stout nasal bones with drooping margins on both sides; the thickened, enlarged, and roughened nasal extremity supporting a small horn; the semi-molarized upper premolars with a lingual bridge between the protocone and hypocone; the metaloph constriction present on P2–4; the protocone equal to the hypocone on P2; the crista present on P3; and the cement on the cheek teeth developed. With all the morphological evidence considered, we establish a new species, Prosantorhinus yei sp. nov.. A phylogenetic analysis based on 282 morphological characters scored for 36 taxa reveals that Prosantorhinus yei sp. nov. is a relatively derived taxon in the genus. Combined with the geological age of the layer where the fossil is located, we speculate that P. yei sp. nov. lived in the Middle Miocene. We hypothesize that Prosantorhinus yei sp. nov. lived in relatively moist environments.

Keyword

Prosantorhinus, Middle Miocene, phylogeny, palaeoecology, China

Molecular taphonomy of Oligocene marine mammal bones from Hokkaido, Japan

Raman UMAMAHESWARAN[1]*, Department of Earth and Planetary Sciences, Hokkaido University, Sapporo, Hokkaido, Japan (raman.u@sci.hokudai.ac.jp)
Takuto Ando[2], Graduate School of International Resource Sciences, Akita University, Akita, Akita, Japan
Tatsuya Shinmura[3], Ashoro Museum of Paleontology, Ashoro, Hokkaido, Japan
Ken Sawada[4], Department of Earth and Planetary Sciences, Hokkaido University, Sapporo, Hokkaido, Japan

Abstract

Molecular taphonomy is the study of decay of organisms across geologic time from the perspective of the chemical constituents of their tissues. In this study, three mammal bones from the late Oligocene (28-25 Ma) Morawan Formation of Hokkaido – two desmostylian (Ashoroa laticosta and Behemotops katsuiei) and one whale – were analyzed by microscopic observation, scanning electron microscopy – energy dispersive X-ray spectroscopy (SEM-EDS), and lipid biomarkers in order to elucidate the taphonomic changes undergone by the fossils at the molecular level.

Petrographic thin sections were made of the samples followed by transmitted and fluorescent light microscopy. The cancellous bone tissue was clearly differentiated from mineralized and in-filled bone cavities under transmitted light. Fluorescent microscopy under UV light displayed weak fluorescence of the bone trabecular matrix which indicates an organic composition similar to amorphous kerogen (or possibly proto-kerogen). Sulphurized concretions (possibly pyrite) were also observed. SEM-EDS was used to chemically map the samples showing calcium-dominated bone cavities. The whale bone and B. katsuiei thin sections notably displayed spherical and elongated structures that, from a preliminary observation, resemble diatoms, particularly those that have been previously reported from the Morawan Formation. For biomarker analysis, the bone samples were first demineralized with 4 molar HCl, crushed to fine power, solvent extracted, and finally separated by silica gel column chromatography into saturated, aromatic, ketone, and polar fractions. All four fractions were analyzed using gas chromatography-mass spectrometry (GC-MS). The sediments constituting the surrounding matrices were also analyzed for comparison.

A methylphenanthrene index of 0.2 for the desmostylians indicated that the fossils had experienced a low level of thermal maturity. Phenanthrene was not detected for the whale bone, indicating even less maturity than the desmostylians. Cholestane, its isomer coprostane, cholestanone, and cholesterol were detected in the whale bone, while its higher homologues were absent, indicating that they are endogenous and possibly derived from the original bone cholesterol. The low maturity of the whale bone resulting in reduced diagenetic alteration could be an explanation for this greater level of biomolecular preservation. While cholesterol derivatives

were present in the desmostylians, C28 and C29 steroids were also observed, thus microbial origin cannot be ruled out. The steroid distributions for the surrounding sediments were different than the bone fossils. Notably, HBI thiophenes, which is a diatom biomarker, were observed in the sediment matrices. Thus, the C29 steroidal input in the desmostylians could potentially have a diatomaceous source, and further bolsters the supposition that the discrete microstructures observed in the thin sections could potentially be diatom fossils trapped within the bone cavities.

Keyword

Molecular taphonomy, Hokkaido, Desmostylian, Oligocene, biomarker

Multidirectional "shuttle dispersal" model and human origins

Xijun NI[1]*, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (nixijun@ivpp.ac.cn)
Chris Stringer[2], Natural History Museum, London

Abstract

Traditionally, it is postulated that there has been no speciation event since the origin of Homo erectus, and that all later human fossils should be included in Homo sapiens. As a result, H. sapiens has become a broad and vaguely defined species name. For a very long time, people have to use "archaic H. sapiens" to refer to Homo neanderthalensis, Homo heidelbergensis, and many Chibanian human fossils, such as Jebel Irhoud, Narmada, Dali, Jinniushan, Xujiayao, and so on. In recent years, more and more researchers have realized that Homo is a genus with quite a large number of species. More recent discoveries, such as Homo floresiensis, Homo antecessor, Homo luzonensis, Homo naledi, and Homo longi, have provided strong evidence that several independent species coexisted with H. sapiens during the Middle Pleistocene. Although the evolutionary relationships between these different Homo species are critical to understanding the origin of H. sapiens, they remain controversial. We developed a phenomic character data matrix containing 632 discrete and metric characters scored for 55 Homo species/populations, and used parsimony analysis and Bayesian tip-dating inference to reconstruct the Homo phylogeny and estimate the divergence time of all Homo clades. Our results suggest that H. sapiens and H. neanderthalensis are monophyletic groups that arose around 770 ka and 737 ka, respectively. Asian H. longi-like Homo, such as Dali, Hualongdong, Jinniushan, and Xiahe form another monophyletic group that diverged from the H. sapiens clade around 949 ka. H. neanderthalensis has traditionally been regarded as the sister group of H. sapiens, but our results showed that the Asian H. longi clade is the sister group of H. sapiens. Based on our newly established Homo phylogenetic tree, we tested 18 biogeographic models and estimated the number and type of biogeographic events. Our simulation suggests that instead of a unidirectional "out of Africa" model, a multidirectional "shuttle dispersal" model is more likely to explain the complex phylogenetic relationships among African and Eurasian Homo species/populations. The common ancestor of H. longi clade and H. sapiens dispersed from Africa to Eurasia between 949 ka and 917 ka. The common ancestor of H. sapiens and H. neanderthalensis dispersed from Europe to Africa between 1007 ka and 978 ka. H. sapiens dispersed from Africa into Eurasia between 490 ka and 416 ka. Africa provided more potential dispersals to other continents, while Asia received more potential dispersals from other continents. From this perspective, we propose that Africa is the "source" of evolution and biogeographic dispersal, while Asia is the "sink" of Homo evolution and dispersal.

Keyword

Human evolution, Homo sapiens, Intercontinental dispersal, Chibanian, multidirectional dispersal model

Stromatoporoids from Upper Ordovician rocks of southern Kazakhstan and their palaeobiogeographical implications

Juwan JEON[1]*, Department of Earth and Environmental Sciences, Korea University, Seoul, 02841, Republic of Korea; The Institute of Basic Science, Korea University, Seoul, 02841, Republic of Korea (juwanjeon@korea.ac.kr)
Ursula Toom[2], Department of Geology, Tallinn University of Technology, Tallinn, 19086, Estonia
Yeongju Oh[3], Division of Earth Sciences, Korea Polar Research Institute, Incheon, 21990, Republic of Korea
Stephen Kershaw[4], Department of Life Sciences, Brunel University, Kingston Lane, Uxbridge, UB8 3PH, United Kingdom/ Earth Sciences Department, Natural History Museum, Cromwell Road, London, SW7 5BD, United Kingdom
Yuan-Dong Zhang[5], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, 210008, People's Republic of China/ University of Chinese Academy of Sciences (UCAS), Beijing, 100049, People's Republic of China

Abstract

Stromatoporoids achieved their wide geographic distribution during the Katian of the Late Ordovician since their first appearance in the Early Ordovician. Their Ordovician diversity peaked in the same time interval, that coincides with the remarkable diversification of reef-builders during the later phase of the Great Ordovician Biodiversification Event. The Kazakh terranes, known for their rich assemblage of Ordovician fossils, have recently emerged as a focus for evolutionary studies, particularly concerning the early evolution and distribution of specific brachiopod groups. Despite their long-recognised presence in southern Kazakhstan, stromatoporoids have been given only limited attention in previous studies of Ordovician fossils, which have predominantly focused on major groups such as brachiopods and trilobites. In this study, we examine stromatoporoids from Upper Ordovician of southern Kazakhstan collected by some geologists between the 1950s and 1970s. A diverse stromatoporoid assemblage previously unknown from Kazakh terranes contains some new species and a few taxa with open nomenclatures. The majority of these stromatoporoids, such as Pseudostylodictyon poshanenese, Labechiella regularis, Thamnobeatricea gouldi, Camptodictyon amzassensis and Ecclimadictyon nestori, share characteristics with the Middle to Late Ordovician stromatoporoids of North China and Australian terranes of peri-Gondwana, confirming the palaeobiogeographic connection between the Kazakh terranes and peri-Gondwana. Furthermore, this assemblage is characterised by the presence of typical Laurentian and Baltic components, such as Stromatocerium and actinostromatid taxa respectively, which were not previously known outside the two continents. Thus the palaeobiogeographic characteristics of these stromatoporoids from southern Kazakhstan demonstrate multiple links between the Kazakh terranes, Baltica, Laurentia and Peri-Gondwana. During the Late Ordovician, the Kazakh terranes most likely acted as a dispersal hub for stromatoporoids, connecting faunas from other continents and terranes.

Keyword

Stromatoporoids, Late Ordovician, Kazakhstan, Kazakh terranes, Palaeobiogeography

Shells for understanding Hong Kong subtidal ecosystem history: a conservation baseline

Pedro Juliao JIMENEZ[1]*, School of Biological Sciences, Area of Ecology and Biodiversity, and Swire Institute of Marine Science (pedro.juliao.jimenez@gmail.com)
Yuanyuan Hong[2], School of Biological Sciences, Area of Ecology and Biodiversity, and Swire Institute of Marine Science, The University of Hong Kong
Wai C Chu[3], School of Biological Sciences, Area of Ecology and Biodiversity, and Swire Institute of Marine Science, The University of Hong Kong
Jason KC Yau[4], School of Biological Sciences, Area of Ecology and Biodiversity, and Swire Institute of Marine Science, The University of Hong Kong
Nicole Khan[5], Department of Earth Sciences, The University of Hong Kong
David M Baker[6], School of Biological Sciences, Area of Ecology and Biodiversity, and Swire Institute of Marine Science, The University of Hong Kong
Kenneth MY Leung[7], State Key Laboratory of Marine Pollution, City University of Hong Kong
Yusuke Yokoyama[8], Atmosphere and Ocean Research Institute, The University of Tokyo
Moriaki Yasuhara[9], School of Biological Sciences, Area of Ecology and Biodiversity, and Swire Institute of Marine Science, The University of Hong Kong

Abstract

Hong Kong is a heavily urbanized city with a long history of occupation. During its development, Hong Kong saw intense degradation of its coastal waters. Discharges of pollutants and activities such as dredging and land reclamation severely impacted the city's landscape and the subtidal communities. Nonetheless, little is known about Hong Kong's baseline pre-anthropogenic impact faunal conditions. In this context, organisms that produce calcareous structures, such as mollusks, provide a glimpse into past conditions and allow us to understand changes in the subtidal fauna due to anthropogenic impacts. Using Accelerator Mass Spectrometry (AMS) radiocarbon dating of dead shells of selected molluscan morphospecies from surface sediments around Hong Kong, we investigated possible changes in the subtidal community of Hong Kong. We collected shells by trawling in three subtidal regions of Hong Kong with different levels of impact: 1) West Hong Kong waters dominated by the Pearl River Delta; 2) South Hong Kong waters more influenced by oceanic waters; and 3) East Hong Kong in the historically polluted Tolo Harbor. Environmental data showed high eutrophication in the Pearl River Delta in western Hong Kong and heavy metal contamination in Tolo Harbour in eastern Hong Kong waters. Our analyses showed contrasting shell fauna composition in the three areas. The shell age analyses revealed that populational decline and possible local extinctions may have happened in certain mollusk species, such as in the species Placamen lamellatum, which lacks modern shells in Northwest Hong Kong, and Pecten excavatus, which has only pre-early 1900s shells in Tolo Harbor. Some baseline conditions species, such as Paratapes undulatus, have a continuous presence in Hong Kong waters. This species shows a mix of old and modern shells in west, south, and east Hong Kong waters. However, Paratapes undulatus may be undergoing a populational decline in areas where old shells dominate, such as in the Pearl River delta and the Tolo Harbor. In contrast, opportunistic species,

such as Murex trapa, Nassarius siquijorensis, and Turritella bacillum, have abundant numbers in modern impacted waters. Our results bring insights into past baseline conditions of Hong Kong subtidal fauna. Our shell age analyses show evidence that the environmental pollution and modification of Hong Kong's coastal landscape led to changes in its molluscan subtidal communities and possibly to the whole subtidal fauna in the city.

Keyword

conservation paleobiology, anthropogenic impacts, radiocarbon dating, benthic community, mollusks

[Keynote] New record of the conifer wood taxon Brachyoxylon from the Middle Jurassic in southwestern China, and a global survey of paleobiogeography of the Mesozoic Brachyoxylon occurrences

Yongdong WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (ydwang@nigpas.ac.cn)

Abstract

Fossil wood is one of the most important proxies for terrestrial vegetation composition and continental paleogeographical reconstruction in Earth's history. The conifer wood Brachyoxylon is commonly found in Mesozoic deposits in Europe, Africa, South America, and Antarctica with more than one hundred known occurrences to date. However, only few occurrences (~5%) are so far documented in China of East Asia. We described a fossil wood from the Middle Jurassic Upper Shaximiao Formation at Yongxin of Chongqing City in southeastern Sichuan Basin, China, obtaining typical Brachyoxylon anatomy with mixed radial tracheid pitting and araucarioid cross-field pitting. According to the characters of radial tracheid pitting, cross-field pitting, and ray height, the wood is recognized as Brachyoxylon trautii (Barale) Philippe 1995. To better understand the paleobiogeography of the Mesozoic Brachyoxylon, a global survey of its occurrences is performed, which shows that Brachyoxylon was globally expanding over time with the widest geographic distribution in the Cretaceous.

The observed pattern indicates that Brachyoxylon has increased its distribution range throughout the Mesozoic, with a dominance of known records in the Northern Hemisphere. However, as previously discussed in the context of other plant-related paleogeographic patterns, i.e. the known occurrences of fossil charcoal as evidence for paleo-wildfires during the Cretaceous, such a pattern, with less data from the Southern Hemisphere, could also indicate some sampling or other researcher related bias. An observation hinting on such large scale biases is the relatively large number of published Cretaceous records from Argentina, a country with a comparatively large and active paleoxylological community. Further analysis of additional and so far understudied occurrences of fossil wood from the Mesozoic of, especially the Southern Hemisphere and other so far understudied regions, would certainly increase our understanding of the paleogeographic patterns observed in Brachyoxylon, but also other genera of fossil wood and plants in general.

Keyword

Brachyoxylon, Cheirolepidiaceae, Hirmeriellaceae, Paleolatitude, Middle Jurassic

Four endemic taxa of chondrichthyans from the Late Ladinian (Middle Triassic) of Guizhou and Yunnan Provinces, South China

Siyan ZHAO[1]*, School of Earth and Space Sciences, Peking University (2301210132@pku.edu.cn)
Zuoyu Sun[2], School of Earth and Space Sciences, Peking University
Jiachun Li[3], School of Earth and Space Sciences, Peking University

Abstract

The Middle Triassic chondrichthyans have predominantly been reported in Europe, whereas those from South China have been much less extensively studied, with only 20 taxa been identified or established based solely on teeth or dermal denticles before. We herein present a taxonomic study of four chondrichthyans based on isolated tooth fossils from the Late Ladinian (Middle Triassic) of Guizhou and Yunnan Provinces, South China. Teeth of an undetermined taxon of euselachian sharks (Euselachii gen. et sp. indet.), an undetermined taxon of Synechodontiform sharks (Synechodontiformes gen. et sp. indet.), an undetermined taxon probably belonging to the Neoselachii (Neoselachii? gen. et sp. indet.) as well as an undetermined taxon of neoselachian sharks (Neoselachii gen. et sp. indet.) are described and illustrated. The first three taxa are previously undescribed, while a tooth of Neoselachii gen. et sp. indet. had already been reported from the Ladinian/Carnian of Guanling City, Guizhou Province before this research. The feeding mechanism of these sharks is deduced through detailed analysis of the morphological characteristics of their teeth. Chondrichthyans from the Ladinian-Carnian intervals of South China are dominated by non-neoselachian sharks and almost devoid of durophagous euselachians as previously proposed. Such a high diverse shark assemblage is related with the Ladinian-Carnian transgression of South China, with many species apparently endemic to the shallow Yangtze Carbonate Platform.

Keyword

Chondrichthyans, Neoselachians, Triassic, South China

New Umenocoleidae (Dictyoptera) from the Jinju Formation, South Korea

SooBin LEE[1]*, Korean Fossil Research Center (dinos20000@naver.com)
GiSoo Nam[2], Gongju National University of Education
André Nel[3], Institut de Systématique, Évolution, Biodiversité (ISYEB) Muséum National d'Histoire Naturelle, CNRS, Sorbonne Université, EPHE, Université des Antilles
Jong kyun Park[4], College of Ecology and Environmental Science, Kyungpook National University

Abstract

The Umenocoleidae family, first described by Chen and Tan in 1973, consists of 18 genera and 31 species. The fossil record of this family comprises taxa from China, Russia, Myanmar, Brazil, Japan, Jordan, Kazakhstan, Lebanon, Mongolia, the Russian Federation, Spain, and Hungary. This family was initially classified in Coleoptera, but a recent study by Luo et al., (2022) determined that it belongs to the Dictyoptera rather than the Coleoptera.

Here, we present three new fossil records of Umenocoleidae from the Jinju Formation on the Korean Peninsula, and attribute them to a new genus and three new species.

Our research revealed a new pattern of forewing venation, which includes: 1) veins M, Cu, and PCu1 fused at wing base, 2) M+Cu+PCu1 is appressed to R, and 3) distally CuP+PCu1 is not strongly concave. These characters were previously not described for the Umenocoleidae.

We also discuss the position of the family Alienopteridae. These share these characters, supporting a sister group relationship between Alienopteridae and Umenocoleidae, as proposed by (Luo et al., 2022). We propose these characters as new apomorphies for the Umenocoleoidea. We also remove the genera *Vitisma* and *Permoponopterix* from this superfamily and move the Permian *Permoponopterix* to the Protelytroptera group.

Keyword

Umenocoleidae, forewing venation, Jinju Formation, Early Cretaceous, Korean peninsula

Revision of Mesopsyche and description of new species of Turbidapsyche gen. nov., from the late Middle Triassic Tongchuan entomofauna: taxonomic and paleogeographic implications

Xinneng LIAN[1]*, Yunnan University (xnlian@nigpas.ac.cn)
Yong Zhang[2], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Chenyang Cai[3], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Zhuo Feng[4], Institute of Palaeontology, Yunnan Key Laboratory of Earth System Science, Yunnan Key Laboratory for Palaeobiology, MEC International Joint Laboratory for Palaeobiology and Palaeoenvironment, Yunnan University, Kunming 650500, China
Diying Huang[5], State Key Laboratory of Palaeobiology and Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

Abstract

Mesopsychids, a long-probosid mecopteran group, associate with the pollination of Mesozoic Gymnosperms. Thought study of the genus Mesopsyche spans over 100 years, only isolated wings have been discovered. Mesopsyche is redefined as a monotypic genus currently housing only one species, Mesopsyche triareolata. The other species previously classified under Mesopsyche are reassigned to the newly established genus Turbidapsyche gen. nov., distinguished by 3-branched Sc compared to the numerous Sc branches Mesopsyche. Herein, we present descriptions and illustrations of new material from the middle part (late Ladinian) of the Middle-Upper Triassic Yanchang Formation, assigned to the newly erected genus. The first Mesopsyche species reported from the Tongchuan entomofauna is revised based on S. Additionally, we erected two new species of Turbidapsyche gen. nov. based on their wing size, shape, and especially the colored patterns. Turbidapsyche orientalis gen. et sp. nov. is characterized by the distinctly shrunken wing base and dense colored markings along anterior wing, while Turbidapsyche sparsa gen. et sp. nov. is distinguished by its relatively larger wing size and the sparse colored spots situated at the forks, areas of crossveins, and apical longitudinal veins. Although hindwings of Turbidapsyche gen. nov. are described and illustrated, they are not formally assigned to any specific species. The species of Mesopsyche also Turbidapsyche are full discussed. The wing color patterns of Turbidapsyche exhibit regional differentiation, with numerous colored spots observed in China, transparency in Kyrgyzstan, and full pigmentation in Ukraine. Based on previous paleomagnetic research conducted in Tongchuan area, we derive a palaeolatitude of 21° in the Middle Triassic. Turbidapsyche distributed along the north of Palaeotethys, near similar palaeolatitude, suggesting inhabitation of comparable climates and perhaps specific ecological requirements or limited dispersal capabilities.

Keyword

Mesopsychidae, Tongchuan Formation, Ordos Basin, Tongchuan City, Paleolatitude

The review of Protopsyllidioidea in China

Minmin Xu[1]*, tate Key Laboratory of Paleobiology and Petroleum Stratigraphy, Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences, Nanjing 210008, China (mmxu@nigpas.ac.cn)
Diying Huang[2], State Key Laboratory of Palaeobiology and Petroleum Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China

Abstract

Protopsyllidioidea, an extinct insect group within the suborder Hemiptera, are characterized by the basal fusion of R with the common stem M + CuA. The superfamily Protopsyllidioidea comprises four families, Permopsyllidiidae, Protopsyllidiidae, Protopsyllidioidea Postopsyllidiidae, and Paraprotopsyllidiidae, spanning from the Artinskian to the Late Cretaceous.

To date, eight species have been described from China, including: Sinopsocus oligovenus Lin, 1976 (upper Middle Jurassic Haifanggou Formation at Beipiao, Liaoning Province), Poljanka hirsute Yang, Yao & Ren, 2012 (upper Middle Jurassic Haifanggou Formation at Daohugou, Inner Mongolia), Poljanka strigosa Yang, Yao & Ren, 2013 (Daohugou), Poljanka strigosa Yang, Yao & Ren, 2013 (Daohugou), Subaphidulum sinica Xu, Hakim & Huang, 2023 (lower Middle Jurassic Yan'an Formation at Yan'an Shanxi Province), Sinopsocus yananensis Xu, Hakim & Huang, 2023 (Yan'an Formation), Poljanka curticapillata Lü, Luo & Yao, 2023 (Daohugou) from the Jurassic Yanliao biota, and one species Paraprotopsyllidium shouchangense Hakim & Huang, 2023 (Lower Cretaceous Shouchang Formation at Zhejiang Province) from the South China.

Research on the evolution and distribution of Protopsyllidioidea is crucial for understanding the insect transition from the Yanliao biota to southern China and eventually to Myanmar. These fossils also serve as important indicators for stratigraphic correlation in the Middle Jurassic due to their abundant occurrences and morphological diversity.

Keyword

Yanliao Biota, Hemiptera, palaeodiversity, entomofauna

Fossil insects from China: a review

Diying HUANG[1]*, State Key Laboratory of Palaeobiology and Petroleum Stratigraphy, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China (dyhuang@nigpas.ac.cn)

Abstract

The study of fossil insects in China can be traced back to 1928, when C. Ping described some Cretaceous fossils from the Laiyang Basin in Shandong Province. Since the establishment of the People's Republic of China, two pioneering palaeoentomologists, Yongchong Hong and Qibin Lin, published new papers on fossil insects in 1965. Hong described dragonfly fossils, namely Sinaeschnidia heishankowensis, from Inner Mongolia, while Lin described two species of Haglidae also from Inner Mongolia. From the 1970s onwards, palaeoentomology gradually became a recognized field within paleontology in China.

Since the beginning of this century, palaeoentomology has experienced rapid development in China, with abundant publications by Chinese scholars. These publications mainly focus on two significant Mesozoic exceptional preservation sites: the Early Cretaceous Jehol biota and the Middle Jurassic Daohugou biota. Approximately 800 insect species (belonging to 24 orders) have been described from Daohugou, representing one of the most diverse palaeoentomofaunas in the world.

Carboniferous insects from China are well-known from the Xiaheyan locality in Zhongwei County, Ningxia. The insects from the Kaiping Basin were first reported by Mathieu in 1939, initially consisting of a few cockroach-like wings. This locality holds special interest for early insect evolution, as recent years have seen the collection of many new and diverse insects. Carboniferous insects are also sporadically found in the Benxi Formation of North China and the lower parts of the Taiyuan Formation.

Permian insects from North China are relatively scarce. The Late Guadalupian Yinping Biota from Chaohu City, Anhui Province, in Central China stands out as the most representative site for Permian insects in China, containing a plethora of insects from the orders Mecoptera, Hemiptera, and Orthoptera.

Triassic insects in China have been discovered in various scattered localities. The most significant Triassic entomofauna is represented by the latest Middle Triassic Tongchuan biota in Shaanxi Province, where at least 16 insect orders have been identified. While the insects from the Tongchuan Biota hold potential importance, currently only mecopterans have been relatively well-studied in this biota.

Early Jurassic insects are relatively rare in China, yielded mainly in the western parts such as Xinjiang, as Early Jurassic strata are largely absent in the eastern and central regions. The Middle-Late Jurassic Yanliao Biota can be subdivided into initial, early, and late stages, each yielding a wealth of fossil insects. These include specimens from the Yan’an Formation, Daohugou biota, and Linglongta biota, from bottom to top, respectively.

Early Cretaceous insects are also prevalent in China, with the Jehol Biota being a prominent example. This biota is believed to be distributed across Northeast China, Northwest China, Central China, and the Southeast coastal areas of China. It appears to be widely distributed, ranging from approximately 135 million to 118 million years ago, although further study is needed to understand its detailed relationships.

Cenozoic fossil sites in China are notably represented by the Miocene Shanwang entomofauna, as well as ambers from Fushun in Liaoning Province and Zhangpu in Fujian Province. Recently, we have also gathered a significant number of insect fossils from

Keyword

entomology, palaeoentomofaunas, biota

The lower Barremian Bkassine (Lebanon) dysodile Konzentrat and Konservat-Lagerstätte: Insights on the fossil continental assemblages and reconstruction of the depositional environment

Dany Azar[1]*, Nanjing Institute of Geology and Palaeontology (danyazar@ul.edu.lb)
Sibelle Maksoud[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing, China
Ninon Robin[3], Géosciences Rennes, Univ. Rennes - CNRS, Rennes, France
Léa de Brito[4], Centre de recherche en Paléontologie, Paris - Muséum national d'Histoire naturelle, Paris, France
Pascal Godefroit[5], Institute of Natural Sciences, Brussels, Belgium
Sébastien Olive[6], Institute of Natural Sciences, Brussels, Belgium
Lionel Cain[7], Muséum d'Histoire naturelle de Genève, Geneva, Switzerland
Nathan Vallée-Gillette[8], Institute of Natural Sciences, Brussels, Belgium
Kevin Rey[9], Archaeology, Environmental Changes & Geo-Chemistry, Vrije Universiteit Brussel, Brussels, Belgium
George Heneine[10], Lebanese Palaeontological and Evolutive Association, Fanar, Lebanon

Abstract

Terrestrial ecosystems acquired their modern structure during the Early Cretaceous. Many species that shape the world we know today emerged and radiated from this period, referred to as the Cretaceous Terrestrial Revolution (Jouault et al., 2024). It is admitted that the Early Cretaceous with its significant global warming, is also the period that witnessed the appearance of most orders of flowering plants (or at least the beginning of their radiation, Barba-Montoya et al., 2018) accompanied with the key families of pollinators within insects (flies, butterflies, beetles and bees; Condamine et al., 2016). Simultaneously, the patterns of the modern-like groups of animals appeared and diversified, outnumbering for some of them former existing species. From this period, while important modern fish groups appeared in the marine environment, including the diverse spiny-rayed fishes (nowadays one third of all vertebrate species), the early diverging ray-finned fish (sturgeons and gar relatives) thrived in freshwaters (Guinot & Cavin, 2016). Non-avian dinosaurs and birds both underwent an extraordinary phase of evolutionary radiation during the Early Cretaceous (Nebreda et al., 2021); while many modern placental mammalian taxa also emerged during this period (Springer et al., 2003).

Dysodiles are sedimentary rocks formed by the superposition of finely laminated millimetric layers and are characterized by their richness in organic matter and well-preserved fossils (Cordier, 1808). Dysodiles are found in different lacustrine deposits in various areas of Lebanon, from the early Barremian. However, their documentation was restricted to a few old references mentioning their presence and their richness in fossils (Botta, 1831; Fraas, 1878; Janensch, 1925; El Hajj et al., 2019, 2021). Afterward, dysodiles were totally forgotten until recently, when extensive geological fieldwork led to their (re-)discovery in Lebanon. We focus herein on dysodiles from the Bkassine locality (South of Lebanon) from the lower Barremian sandstone formation, which deposited when Lebanon was located in the north-eastern part of the Gondwana

supercontinent. These dysodiles are found nearby volcanic deposits suggesting a close relation between volcanism and their deposition and/or preservation.
We present here new information on a fossil assemblage found in the dysodiles. To date, these layers allowed the collection of several tetrapods (anourans, chelonians, lizards, and possibly archosaurian remains), a rich “fish” assemblage encompassing a dozen of coelacanths, possible polypteriforms and small teleosts, pulmonate gastropoda, diverse aquatic related insect assemblage, plant debris (macroflora and palynomorphs) including ferns, algae and spermatophytes, but also ostracods and a concentration of various coprolites. Here, we provide a preliminary reconstruction of the associated depositional environment: a freshwater lake found nearby volcanic edifices, surrounded by a typical Early Cretaceous flora (open forest and savanna-like environment), where lived various lineages of early diverging actinopterygians, and some more derived teleost fishes that will later represent the core of modern ichthyofauna. This fossil setting is important on a local and a worldwide scale as the studied environment and its biota could be compared to the coeval lacustrine shales and limestones of East (Jehol in China) and West Eurasia (Bernissart in Belgium, Las Hoyas in Spain), as well as of the

Keyword

Lower Cretaceous, Lebanon, palaeobiodiversity, palaeoenvironment

The oldest Gondwanan record of durophagous shark Strophodus Agassiz, 1838 (Hybodontiformes) from the Kachchh Basin, western India

Suraj Arjun Bhosale[1]*, Indian Institute of Technology Bombay (suraj.bhosale@iitb.ac.in)
Nibedita Rakshit[2], Indian Institute of Technology Bombay
Abhishek Natarajan[3], Indian Institute of Technology Bombay
Gaurav Chauhan[4], Department of Earth and Environmental Science, K. S. K. V. Kachchh University, Bhuj, India
Mahesh Thakkar[5], Birbal Sahni Institute of Palaeosciences, Lucknow, India

Abstract

The hybodont sharks were one of the most dominant groups of chondrichthyans during the Mesozoic. The genus Strophodus was one of the most successful hybodont sharks that covered marine to coastal, occasionally high salinity niches in the pantropical basins and had adapted an unique dentition for their durophagous diet. Although the European basins are enriched with the genus fossil record, the distribution in the Gondwana basins is scarce and patchy. The hybodont shark Strophodus is reported for the first time from the
Mesozoic sequence of the Kachchh Basin, western India. This record marks the earliest appearance of Strophodus in Gondwana. The southwestern Tethys basins, Kachchh and Jaisalmer, show a diverse assemblage of the genus occupying coastal to marine settings and feeding mainly on invertebrates. It also sheds light on the link between Gondwana and Laurasia with faunal exchange/interchange and confirms the wide cosmopolitan distribution of Strophodus. The migration initiated from western Tethys through the marginal marine part of northern Gondwana and then reached southwestern Tethys. However, a robust palaeobiogeographic reconstruction of the genus requires new findings from the Early−Middle Jurassic Gondwana basins. The present study from the Kachchh and Jaisalmer basins indicates that hybodont sharks, and especially Strophodus, show great species diversification and distribution, negating the previous consensus of a decline of these sharks in the Middle Jurassic. This study is a contribution to the scarce record of the Mesozoic chondrichthyan fauna of the Kachchh Basin and Gondwana.

Keyword

Kachchh, Jurassic, Chondrichthyes, Gondwana, India

Memorial of Prof. Martin G. Lockley: The Dinosaur and Pterosaur Tracks of the Korean Peninsula

Min HUH[1]*, Faculty of Earth & Environmental Sciences & Korea Dinosaur Research Center & Mudeungsan UNESCO Geoturism Center (minhuh@jnu.ac.kr)
Seong-Young Yang[2], Earth Science Education Department, Kyungpook National University
Jeong Yul Kim[3], Department of Earth Science Education, Korea National University of Education
In Sung Paik[4], Department of Earth and Environmental Sciences, Pukyong National University
Koo-Geun Hwang[5], Goheung Middle School
Bo Seong Kim[6], Mokpo Natural History Museum
Kyung Soo Kim[7], Department of Science Education, Chinju National University of Education
Hyun Joo Kim[8], Department of Earth and Environmental Sciences, Pukyong National University
Jongyun Jung[9], Department of Geological & Environmental Sciences & Korea Dinosaur Research Center & Mudeungsan UNESCO Geotourism Center, Chonnam National University
Hyemin Jo[10], Department of Geological & Environmental Sciences & Korea Dinosaur Research Center & Mudeungsan UNESCO Geotourism Center, Chonnam National University
Minguk Kim[11], Department of Geological & Environmental Sciences & Korea Dinosaur Research Center & Mudeungsan UNESCO Geotourism Center, Chonnam National University

Abstract

Korea is renowned for its Cretaceous vertebrate ichnology, featuring a remarkable variety of well-preserved vertebrate tracks, numerous sites with these occurrences, and abundant strata with tracks in the Cretaceous deposits. Professor Martin G. Lockley has conducted research in Korea numerous times, collaborating with Korean scientists on diverse vertebrate ichnofossils in locations such as Goseong, Haenam, Yeosu, Hwasun, and Jinju, leading to significant publications. These collaborations have yielded notable outcomes, including a special issue of Ichnos titled “Tracking on the Korean Cretaceous Dinosaur Coast: 40 years of Vertebrate Ichnology in Korea” (2012, vol. 19, issue 1-2) and 2023 Symposium on Mesozoic Terrestrial Ecosystems (MTE) in Korea, with several other international symposiums.

The initial discovery of a dinosaur track in Korea was made in 1992 at Deokmyeong-ri, Goseong, with the first dinosaur tracksite excavation occurring in 1996 at Uhangri, Haenam. This excavation also revealed the first pterosaur tracks in Asia. The variety of dinosaur tracks identified includes theropods, ornithopods, and sauropods, featuring distinguished ichnogenera such as *Hamanosauripus ungulates*, *Koreanosauripus cheongi*, *Dromaeosauripus hamanensis*, *D. jinjuensis*, *Ornithopodichnus masanensis*, *Caririchnium kyoungsookimi*, *C. yeongdongensis*, *Brontopodus pentadactylus*, *and Dromaeosauriformipes rarus* all originating from Korean discoveries. These tracks have supported various research studies on ecology, behavior, and soft tissue impressions, such as revealing pedal skin textures, demonstrating the theropod’s agility by analyzing their rapid acceleration phase, and gregarious behavior of ornithopods through the parallel trackways.

A significant achievement in 1996 for Asian paleontology was the identification of pterosaur tracks in the Uhangri Formation of the Haenam Basin, with *Haenamichnus uhangriensis*

being acknowledged in 2002 as potentially the largest pterosaur tracks, possibly related to azhdarchids. Further findings have expanded the catalog of pterosaur tracks from various Cretaceous deposits, including *Pteraichnus koreanensis* and *P. gracilis* from the Hasandong Formation and Jinju Formation, respectively. To this day, approximately 20 tracksites, such as Hwasun, Jinju, Gunsan, and Ulsan, have been recorded, with ongoing research efforts.

This extensive ichnofossil record establishes Korea as a pivotal site for Mesozoic vertebrate research, leading to its inclusion on the tentative list for UNESCO World Heritage and as geosites within the UNESCO Global Geoparks in Korea. Professor Martine G. Lockley's collaborative work on Korean vertebrate tracks has significantly influenced the paleontological field and the cultural industry, including museums, expos, documentary films, and movies.

Keyword

Martine G. Lockley, Dinosaurs, Pterosaurs, Vertebrate ichnology, Korea

The earliest calcareous peyssonneliacean red algae fossils from Ordovician: systematics, evolutionary and paleoecological significance

weiling ZHUANG[1]*, Northwest university (201921090@stumail.nwu.edu.cn)
lijing Liu[2], Northwest university
Juan Braga[3], Universidad de Granada
Robert Riding[4], University of Tennessee
yasheng Wu[5], Institute of Geology and Geophysics, Chinese Academy of Science

Abstract

Peyssonnelialeans are a taxon of crustose red algae that grow on rocky or microbial substrates and are the taxon of Rhodymeniophycidae that can deposit aragonite crystals in their cell walls. The Rhodymeniophycidae is one of the most diverse taxa of the Florideophyceae in the Rhodophyta. Molecular clock analysis suggests that Peyssonneliales diverged from their sister group Gigartinales within the Rhodymeniophycidae clade at about 300 Ma. Until now, however, the earliest known undisputed fossil Peyssonneliales are from the Lower Cretaceous (Albian, 113-110.5 Ma). Here we report the earliest peyssonelialean algal fossils, one new genus *Paleopolystrata* gen. nov. and two new species, *Paleopolystrata tarimensis* sp. nov, *Paleopolystrata coarsewirensis* sp. nov. They occur in the Upper Ordovician (~450 Ma) reef facies of Lianglitag Formation in the Tarim Basin, Northwest China. *Paleopolystrata* had a pseudoparenchymatous organization consisting in a single system of dividing filaments showing a feather-like arrangement in longitudinal section. Its preservation suggests that the skeleton was originally composed of aragonite that is now replaced by calcite. The crustose habit, the pseudorparenchymatous organization and the aragonite calcification are characteristic of Peyssonneliales. The record of *Paleopolystrata* advances the fossil record of the large subclass Rhodymenophycidae by 340 Ma.

Additionally, they possess significan paleoecological importance and can form reef-building communities with diverse green algae (*Vermiporella*, *Aphroporella*, etc.), *Solenopora*, stromoforaminifera, cyanobacteria for constructing reef skeletons and providing growth substrates for crinoids, bryozoans, etc. They play an important leading role in the process of reef building. Peyssonnelialeans not only exhibit barrier deposition and bonding effect of calcareous algae, but also has a strong wave resistance structure and a new function of leading the construction of lattice reefs, indicating that the dominant reef-building community in the late Ordovician was the addition of calcareous red algae, which explains the complexity of reef-building community composition during the process of GOBE. It holds immense significance for understanding Paleozoic forms of reef building and ecosystem evolution.

Keyword

Peyssonneliales, calcareous algae, Red algal evolution, paleoecology, reef building

The oldest pig-nose turtle (Carettochelyidae) in the Early Cretaceous of South Korea

Minguk KIM[1]*, Chonnam National University (minguk0921@gmail.com)
Min Huh[2], Department of Geological and Environmental Sciences & Korea Dinosaur Research Center, Chonnam National University and Mudengsan UNESCO Geotourism Center, Chonnam National University
Jongyun Jung[3], Department of Geological and Environmental Sciences & Korea Dinosaur Research Center, Chonnam National University and Mudengsan UNESCO Geotourism Center, Chonnam National University
Hyemin Jo[4], Department of Geological and Environmental Sciences & Korea Dinosaur Research Center, Chonnam National University and Mudengsan UNESCO Geotourism Center, Chonnam National University
Jae-Il Park[5], Animal Facility of Aging Science, Korea Basic Science Institute
Hye-Yeon Jung[6], Animal Facility of Aging Science, Korea Basic Science Institute

Abstract

Carettochelyidae is a crown group that includes the extant pig-nose turtle, *carettochelys insculpta*. Before the family radiated to Asia, Europe, and North America in the Eocene, the oldest fossil of this group was first recorded in the early Paleocene of Asia. Although fossil records of basal pan-carettochelyids were discovered in the Cretaceous of Asia, they were unearthed by fragmentary shells and distinguished from Carettochelyidae by a highly reduced cruciform plastron and the presence of plastral scute. Unlike other Cretaceous fossil records of Asia, the specimen in this study is the oldest definite Carettochelyidae from the Hasandong Formation (the Early Cretaceous) of South Korea. It comprises the almost preserved shell and post-cranium components revealed by micro-CT scanning between the shells. It belongs to Carettochelyidae given the following characteristics: (1) distinct ornamentation that consists of vermiculated ridges; (2) a low midline keel; (3) a single suprapygal; (4) ten pairs of peripheral; (5) an intermediately sized cruciform plastron; (6) the presence of carapace scutes; and (7) the loss of plastral scutes. By discovering the Early Cretaceous Carettochelyidae, we identify that the family already appeared in the mid-Cretaceous and that the crown group existed with the stem group together in Asia. Also, it implies the possibility that their occurrence and divergence took place before the Early Cretaceous in accordance with the result of the molecular phylogenies indicating that pan-carettochelyids originated in the Middle to Late Jurassic.

Keyword

Carettochelyidae, Early Cretaceous, South Korea, Micro-CT

DISCOVERY AND GEOLOGICAL SIGNIFICANCE OF PHOSPHATIZED ANIMAL RESTING EGG FOSSILS IN THE CHANG 73 MEMBER, YANCHANG FORMATION, ORDOS BASIN

Dexiang GAN[1]*, Northwest University (1007529279@qq.com)
Lijing LIU[2], Northwest University
Jin Dong[3], Research Institute of Petroleum Exploration and Development

Abstract

During the Middle and Late Triassic, the Ordos Basin experienced a warm and humid climate, creating a suitable environment. In sedimentary period of the Chang 73 Member of the Yanchang Formation, there was a significant expansion in lake basin development, leading to the deposition of large, thick and high-quality source rocks. The composition and abundance of planktonic algae in the Chang 73 Member and the establishment of complex ecosystem of continental lakes to the exploration of high productivity of the lake during this period have garnered much attention. Many planktonic algae and animal fossils were discovered in the Chang 73 Member of the Yanchang Formation. Phosphatized spheroidal microfossils with regular morphology were previously thought to be green algae. In this study, the fossils have a large diameter, generally 120-μm, with some reaching up to 300 μm. They have a clear and obvious membrane wall structure, and irregular polygonal impressions can be seen on the outer wall of the membrane, which are quadrilateral, pentagon and hexagon structures like football, while no division is seen inside the fossils, and they are filled with uniform phosphate. These results indicate that the cellular structure of 8-part division and 16-part division formed by early cleavage in animals, supporting their interpretation as dormant eggs or embryos of animals. A new genus and species, *Yanchangparapandorina inornata* gen. et. sp. nov., was established through an extensive comparison with with the fossil and living animal eggs, which may be fossils of the eggs of an aquatic arthropod. The analysis of fossil morphology and taphonomy indicates that these nimal dormant egg fossils were formed in the shallow burial stage of early diagenesis, when the organisms'cells and tissues have not decomposed, and the fluid rich in phosphate has mineralized and permeated, which can preserve the division stage of the fossils. The identification of animal dormant egg fossils from the Chang 73 Member clarifies the confusion existing in the previous studies on the planktonic algae fossils in the Yanchang Formation. This discovery has provided new insights into the species diversity within the continental lacustrine ecosystem of the Ordos Basin during the Middle and Late Triassic periods. In addition, the large number of phosphatized dormant egg fossils may be related to the massive influx of volcanic ash, and their discovery is of great significance for the analysis of the various paleoenvironmental parameters at the bottom of the lake basin during the deposition period of Chang the 73 Member, such as oxidation and reduction state, phosphorus nutrient level, heavy metal, salinity, and temperature.

Keyword

Fossil animal dormant eggs, Phosphatized, Terrestrial lacustrine basin ecosystem, Yanchang Formation, Middle and Late Triassic

New discoveries of the fossil lampreys from the Yanliao and Jehol Biotas, North China

Feixiang Wu[1]*, Institute of Vetebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (wufeixiang@ivpp.ac.cn)
Philippe Janvier[2], Muséum National d'Histoire Naturelle, UMR 7207, CP38, 8, rue Buffon 75231, Paris Cedex 05, France
Chi Zhang[3], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Mee-Mann Chang[4], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences

Abstract

Lampreys, one of two living lineages of jawless vertebrates, are hailed as a model for vertebrate evolutionary research. They have been in existence for at least 360 million years; however, they left a meager fossil record, and their evolutionary history remains elusive. The fossil lampreys from the Middle-Late Jurassic Yanliao Biota and Early Cretaceous Jehol Biota were superbly preserved and illuminate the evolution of the feeding apparatus, the life cycle, and the historic biogeography of the group. The best-known fossil lamprey from the Jehol Biota, Mesomyzon mengae has a feeding apparatus adapted for blood-sucking habit. Whereas the fossil lampreys' from the Yanliao Biota have an extensively toothed feeding apparatus that differs radically from that of their Paleozoic and Cretaceous kin but surprisingly resembles the living Southern Hemisphere pouched lamprey, which foreshadows an ancestral flesh-eating habit for modern lampreys. Based on the revised petromyzontiform timetree, it is argued that modern lampreys' three-staged life cycle might not be established until the Jurassic when they evolved enhanced feeding structures, increased body size and encountered more penetrable host groups. The study also places modern lampreys' origin in the Southern Hemisphere of the Late Cretaceous, followed by an early Cenozoic antitropical disjunction in distribution, hence challenging the conventional wisdom of their biogeographical pattern arising from a post-Cretaceous origin in the Northern Hemisphere or the Pangean fragmentation in the Early Mesozoic.

Keyword

Lampreys, Yanliao Biota, Jehol Biota, Jurassic, Cretaceous

Early Cambrian evaporite deposits in the North China Craton and their event stratigraphic, paleogeographic, and paleoenvironmental implications

Wentao ZHENG[1], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Xiaopeng WANG[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Bin WAN[3]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China (binwan@nigpas.ac.cn)
Ke PANG[4], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences, Nanjing 210008, China
Qing TANG[5], School of Earth Sciences and Engineering, Nanjing University, Nanjing 210023, China

Abstract

Evaporites are climate-sensitive sedimentary deposits with event stratigraphic, paleogeographic, and paleoenvironmental significance. The Early Cambrian is characterized by early evolution of animal and extensive evaporite deposits at the end. Widespread evaporite deposits were developed in the lower Cambrian succession in the North China Craton (NCC), which could provide critical constraints on the age of evaporite-bearing strata, the reconstruction of paleogeographic evolution, and the paleoenvironmental change of the NCC during the Early Cambrian. In this study, we systematically synthesized the geographical and stratigraphic distributions of the Early Cambrian evaporite deposits in the NCC based on field collections and published data. The results show that the Early Cambrian evaporite deposits in the NCC mainly include gypsum, halite pseudomorph, and gypsum breccia. They have been found in two sets of reddish layers and geographically distributed in the Jiao-Liao-Xu-Huai region and western Henan region. Integrated evidence of biostratigraphy, chemostratigraphy, and detrital zircon chronology constrains the age of these evaporite deposits within the Cambrian Series 2, Stage 4 (ca. 514–509 Ma). Consequently, these late Early Cambrian evaporite deposits represent drought events that can act as regional event stratigraphic markers to constrain the age of the evaporite-bearing strata near the Great Unconformity and also suggest that the paleogeographic position of the NCC in the Cambrian Stage 4 may be located between 20◦N–30◦N near the western Gondwana with northwest-southeast orientation. Additionally, the hot-arid paleoclimate evidenced by evaporite deposits may be the environmental factors for the decline of benthic organisms in the NCC in the late Early Cambrian.

Keyword

North China Craton, Early Cambrian, Evaporite deposit, Paleogeography, Great unconformity

Taxonomy and taphonomy of fossil fish scales from the Lower to Middle Miocene of eastern part of Shimane Prefecture, Japan

Mami HAMADA[1]*, Shimane University (n22d203@matsu.shimane-u.ac.jp)
Toshiaki IRIZUKI[2], Shimane University
Akira TSUJIMOTO[3], Shimane University
Yoshitaka YABUMOTO[4], Kitakyushu Museum of Natural History and Human History

Abstract

Fossil fish scales have been found from the Lower to Middle Miocene Josoji Formation in the eastern part of Shimane Prefecture, southwestern Japan. The Josoji Formation was formed in a deep–sea environment during the opening of the Sea of Japan from approximately 18 to 16 Ma. However, to date, no taxonomical and morphological studies on fossil fish scales have been conducted.

Considering the aforementioned factors, this study was conducted to identify taxonomic groups of fossil fish scales from the formation based on a comparison with scales of extant fishes and the transition of fossil fish assemblages during the opening of the Sea of Japan. Furthermore, geochemical and microfossil analyses of the sediments were conducted to reconstruct the paleoenvironment of the sea bottom where the fish scales were deposited.

Several well-preserved fossil fish scales were found in laminated black shale from 11 sites of the Josoji Formation.

Various types of fossil fish scales were recognized at these sites. Based on their morphological observations, seven families, namely, Clupeidae, Myctophidae, Macrouridae, Gadidae, Halosauridae, Sparidae, and Scombropidae were identified for the first time.

The results of the analysis of total organic carbon, total nitrogen, and total sulfur contents of rock samples indicated a poorly oxygenated paleoenvironment. Furthermore, several specimens of fossil benthic foraminifera were found in black shale. Upper bathyal species such as Uvigerina cf. proboscidea were dominant. Therefore, the occurrence of well-preserved fossil fish scales can be attributed to their preservation in upper bathyal reducing sea bottoms.

Regarding the temporal changes in fossil fish assemblages, fishes of the family Clupeidae entered the Sea of Japan during the early transgression that began approximately 17–18 Ma. Subsequently, deep-sea fishes, such as the family Myctophidae and Macrouridae, also moved into the Sea of Japan and became dominant, increasing the diversity of fish assemblages.

Keyword

Miocene, Sea of Japan, taphonomy, fossil fish scale, benthic foraminifera

Phylogeny of the Trigonioididae

Seong Young YANG[1]*, #1805/102 the sharp Seocho Apt., Seochojungangro 2gil, 21 Seocho-gu, 06720 Seoul Korea (youngi2x0@nate.com)

Abstract

Since the genus Trigonioides was reported by Kobayashi and Suzuki from the Cretaceous Formation of Korea in 1936, several species have been reported from the non-marine formations in various places including Japan, China, Southeast Asia, Russia and U.S.A. as well as in Korea. Therefore, it has been the subject of much attention among the non-marine bivalve fossils. Trigonioides the type genus of Trigonioididae shows the characteristics of crenulated hinge teeth and V-shape surface ornamentation. In particular, the genus name was given because the hinge structure is very similar to schizodont trigonia, a famous standard fossil of the Mesozoic Era.

Kobayashi(1955) presented the idea that Trigonioides which lived in the marine environments, was partly confined to continental environments due to the early to middle Cretaceous Sagawa Orogeny in Japanese islands and evolved in non-marine environments. Meanwhile, observing the specimens of Trigonioides suzukii from Wakino formation Japan, Cox(1955) suggested that part of the hinge structure of Trigonioides also appears in Unionacea, so it cannot be concluded that it necessarily evolved from trigonia.

A lot of many fossils belonging to Trigonioididae have been reported from the Cretaceous Gyeongsang Group in Korea. That is, the subgenera of it Trigonioides (s. s), Nippononaia, Koreanaia, Wakinoa were found from the single sedimentary basin. Thus we can say safely the stratigraphic relative positions of these subgenera.

From the stratigraphic relations of the subgenera, the phylogeny of the family can be read as following: the angle of V-sculpture is gradually decreased from about 450 to 120, the surface ornamentations covering is from the whole discs through antero-posterio and umbo part to postero-umbo part only. And the hinge structure is changed also lamellar unio type through striation wakinoa type to crenulation trigonioid type, From this phylogeny we can say that the Trigonioididae evolved from the unioinacea not trigoniacea

Keyword

Phylogeny, Trigonioididae, Cretaceous Formation of Korea

New insights into pterosaur cranial anatomy: X-ray imaging reveals palatal structure and evolutionary trends

He CHEN[1]*, School of Ecology, Sun Yat-sen University (chenhe6@mail.sysu.edu.cn)
Shunxing JIANG[2], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Alexander W. A. KELLNER[3], Department of Geology and Paleontology, Museu Nacional/UFRJ
Xiaolin WANG[4], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences

Abstract

Among the least studied portion of the pterosaur skeleton is the palate, which tends to be poorly preserved and commonly only visible from one side (the ventral portion). Even in well-preserved specimens, the bones tend to be fused, with the limits of individual palatal elements obscured. To shed new light on this region, we employed advanced X-ray imaging techniques on the non-pterodactyloid Kunpengopterus (Wukongopteridae), and the pterodactyloids Dsungaripterus (Dsungaripteridae), Hongshanopterus (Istiodactylidae), and Hamipterus (Hamipteridae). Our analyses revealed the presence of sutures between palatal bones in Dsungaripterus and Kunpengopterus, which resulted in different interpretations of the relation between palatine, ectopterygoid, and pterygoid. Those new results led to a new identification of the palatal openings. In addition, our study shows six main observations such as the variation of the angle between the two rami of the palatine and the variation in the relative sizes of the palatal openings. We also point out that the presence of a maxillopalatine fenestra (previously identified as postpalatine fenestra), is unique within Diapsida. Although much more work needs to be done, we showed that advanced X-ray imaging techniques open a window for understanding pterosaur cranial anatomy and provide a new perspective for investigating the evolutionary history of these flying reptiles.

Keyword

pterosaur, pterodactyloid, palate, Dsungaripterus, CT-scan

Tracing Palaeo-Gaseous Mercury Variations through Fossil Plants: Preliminary Analysis of Mercury Concentration Data in Extant *Ginkgo* and Extinct Ginkgoaleans

Li Zhang[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (lizhang.pb@gmail.com)
Yongdong Wang[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Micha Ruhl[3], Trinity College Dublin, The University of Dublin
Emma Blanka Kovács[4], Trinity College Dublin, The University of Dublin

Abstract

Vegetation leaves have long been considered a significant receptor of gaseous mercury (Hg) in the atmosphere, offering the potential to passively monitor palaeo-atmospheric Hg concentrations. Despite this potential, the idea has been discussed very little. In this study, we conducted Hg measurements on two *Ginkgo* leaf collections: one containing leaves from ten sampling sites across China, and the other comprising leaves collected monthly for one year in Nanjing. The results revealed that the foliar Hg concentrations in this study (an average of 61 $ng \cdot g^{-1}$, N = 272) were higher than those observed in previous *Ginkgo* leaf samples collected from Ireland or the USA. Additionally, the leaf age and atmospheric Hg concentration were found to be two primary factors impacting foliar Hg content in *Ginkgo*. These results prompted further investigations into fossil ginkgoaleans. Hg concentrations in fossil cuticular samples (avg. 585.5 $ng \cdot g^{-1}$) were observed notably higher than those in modern *Ginkgo* leaves (avg. 61 $ng \cdot g^{-1}$) and sediments from the same layers (avg. 113 $ng \cdot g^{-1}$). Considering possible Hg migration during fossilization, we suggested that the elevated Hg concentrations in fossil cuticles were attributed to both the retention of Hg in leaves and the loss of leaf content during fossilization. Based on 23 fossil ginkgoalean samples from 6 beds of the Dameigou section (spanning from the Early to the Middle Jurassic), Qaidam Basin, China, we detected a Hg anomaly through Hg concentrations in fossil cuticles during the presumed palaeo-volcanic event (the Karoo-Ferrar Large Igneous Province). This preliminary test suggested that variations in Hg concentrations in fossil cuticles could potentially reflect the gaseous Hg changes in the palaeo-atmosphere triggered by palaeo-volcanism, highlighting the possibility of using fossil plant cuticles as a Hg proxy of the palaeo-atmosphere.

Keyword

foliar/cuticular Hg concentration, Ginkgoaleans, fossil cuticles, Early Jurassic, Karoo-Ferrar Large Igneous Province

Mesozoic Climate change and CO2 concentration variation - paleobotanical evidence from China

Yongdong WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (ydwang@nigpas.ac.cn)

Abstract

The Mesozoic (252 myr – 66 myr) is characterized by a hot Greenhouse climate. It contains a series of geological and environmental changes, such as active volcanic activities, major changes in paleogeography, rapidly increased CO2 concentrations, sea level rise, oceanic anoxic event, flora and fauna turnovers at Triassic/Jurassic boundary, and Cretaceous/Paleogene boundary.

As one of the primary greenhouse gases, CO2 plays a major role in global warming, which affects the surface temperature of the Earth. Reconstruction of atmospheric CO2 using proxies is crucial for understanding the Mesozoic “Greenhouse”. However, at present, CO2 concentration data are less common before the Cenozoic, thus it can be difficult to reliably connect changes in the Earth’s environment with changes in paleo-atmospheric CO2.

Palaeobotanical proxies based on the stomatal features of leaf cuticles show great application value for reconstructing the deep time CO2 level in recent decades. In recent years, several fossil localities from China have been further studied, such as the Upper Triassic Yanchang Formation and the Middle Jurassic Yan’an Formation in Huating County, eastern Gansu Province, nothwestern China, the Lower Jurassic Xiangxi formation in Zigui County, western Hubei Province, South China, and the Upper Triassic Hongweikeng Formation in Nanling region, border of Guangdong and Hunan Province. Based on Ginkgo, Ginkgoites and Sphenobaiera leaves, our estimated paleo-CO2 values are 1962 ppm in the Late Triassic, 900-1200 ppm in the Early Jurassic, and 1320 ppm in the Middle Jurassic.

To test the congruence of paleo-CO2 estimates, all three methods applied to different Ginkgoalean fossil species collected from the same fossiliferous bed. Considering the potential effect of guard cell size to the mechanistic method, the result demonstrates that a likely occurrence of polyploidy in Sphenobaiera huangii may result in underestimated paleo-CO2 when applying mechanistic method due to an increase in the size of the stomatal complex.

In our ongoing research, the fossil leaves in taxa such as Pachypteris, Anthrophyopsis, Pterophyllum, Ptilophyllum, Ginkgoites and Baiera from the new localities in Nanling region also show potential for plant carbon isotope analysis and palaeo-CO2 reconstruction. They will provide climate evidence from south coastal of China during the Carnian age, Late Triassic.

Keyword

Mesozoic, palaeo-CO2, climate change, fossil plants

The linkage between Carnian Pluvial Episode and volcanism recorded by mercury anomalies in South China

Qing LI[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (qingli@nigpas.ac.cn)
Micha Ruhl[2], Trinity College Dublin, The University of Dublin, College Green, Dublin 2, Ireland
Emma Blanka Kovács[3], Trinity College Dublin, The University of Dublin, College Green, Dublin 2, Ireland
Dong Yong Wang[4], Nanjing institute of Geology and Palaeontology, Chinese Academy of Sciences

Abstract

The Carnian Pluvial Episode (CPE) is used to describe the dramatic climate changes and geological phenomena due to intensely increased rainfalls that occurred during Carnian in late Triassic. These phenomena include the carbonate platform crisis, terrigenous clastic input, biotic turnover, sea level changes, negative carbon isotope excursions, and so on. However, the cause of the increased precipitation of Carnian Pluvial Episode is still uncertain. Some researchers think that volcanism, especially Wrangellia Large Igneous Province (LIP) is the main driver, while others think that monsoon is the trigger.

To explore the cause of CPE, we used mercury (Hg) enrichments and mercury/total organic carbon (Hg/TOC) ratios to evaluate whether there exists enhanced Hg loading and whether the increase of Hg coincides with the carbon cycle and hydrological perturbations across the CPE in South China of the eastern Thethys. Our studied profile is represented by the Luojiagou section located at the Zigui Basin, in Hubei Province, which is a foreland basin on the northern margin of the Yangtze Plate in South China. In the Zigui Basin, the Mesozoic sequences are well developed and successively exposed with marine to continental outcrops. Our recent study proved that four negative carbon isotope excursions are presented in the Luojiagou section of the Zigui Basin. Here, we analyzed the mercury concentrations and Hg/TOC ratios from the CPE sequence with transitional facies in the Luojiagou section of Zigui Basin. The Hg/TOC ratios recorded in the studied section display four peaks and have good correlations with the four negative carbon isotope excursions. After reviewing the global mercury concentration perturbations during CPE, we found that the Hg/TOC ratios exactly coincide with the negative carbon isotope shifts, no matter in marine or non-marine sedimentary strata. Hence, our new evidence proved that CPE has a strong correlation with the volcanic activity that was responsible for biological extinctions in Carnian.

Keyword

Carnian Pluvial Episode, Large Igneous Province, mercury enrichments, negative carbon isotope excursions, biological extinctions

The Mesozoic vegetation of Madagascar and the Jurassic vegetation of the Mahajanga Basin, northwestern Madagascar

Vivi Vajda[1]*, Swedish Museum of Natural History (vivi.vajda@nrm.se)
Sylvain G. G. RAZAFIMANDIMBISON[2], Swedish Museum of Natural History
Nicolas RAKOTOSOLOFO[3], Mahajanga University
Hery L RANARIJAONA[4], Mahajanga University

Abstract

The rich biodiversity and endemicity of Madagascar are often attributed to its prolonged isolation as a continental island since the Mesozoic era. Having once been part of the Gondwana supercontinent, Madagascar began its separation from continental Africa and the Indian subcontinent approximately 160 million years ago. Consequently, the flora of Madagascar has been historically perceived as primarily remnants of an ancient Gondwanan vegetation, diverged due to continental drift. Noteworthy examples of endemic plant lineages on Madagascar, such as Takhtajania perrieri (Winteraceae) and Podocarps, exemplify groups with ancestry dating back to the Gondwanan era. This study presents findings resulting from a collaborative endeavor involving paleontologists, geologists, and botanists from the Swedish Museum of Natural History and Mahajanga University, Madagascar.

The geological history of Madagascar plays a pivotal role in elucidating the origins of its flora and fauna, as the island severed ties with continental Africa during the Jurassic period, approximately 165 million years ago, leading to its subsequent evolutionary isolation. While paleobotanical investigations are scarce, primarily conducted in the 1960s and 1970s by Appert, who characterized Upper Jurassic (Oxfordian) assemblages from the Manamana massif in southwestern Madagascar, they provide crucial insights. These studies revealed a predominance of dipteridaceous ferns and conifers of genera including Brachyphyllum, Elatocladus, Cupressinocladus, Cyparissidium, and Araucarites, alongside minor occurrences of "seed ferns" within the impression floras.

Palynological analyses conducted on Jurassic outcrop sections within the Mahajanga Basin unveil well-preserved palynological assemblages showcasing a distinctly continental character. The older assemblage is notably dominated by fern- and lycophyte spores, including Cyathidites, Baculatisporites, Dictyophyllidites, Ceratosporites, and Retritiletes, whereas the younger counterpart is characterized by a prevalence of gymnosperm pollen, constituting approximately 70% of the composition. Notable spore genera within the gymnosperms include Classopollis, Araucariacites, Perinopollenites, and Callialasporites. Based on the identified taxa, the studied assemblage is assigned to the Early Jurassic (Pliensbachian–early Toarcian) Corollina torosa Zone as delineated by Helby et al. (1987). These findings underscore striking similarities between the flora of Madagascar and contemporaneous floras elsewhere, such as those in Sweden and Australia, suggesting a remarkably homogeneous global vegetation pattern during the Late Jurassic period.

Keyword

Madagascar, extinction, nature conservation, end-Triassic, endemism

Atypical element accumulation in fossil leaves from the end-Triassic of Northern Hemisphere

Susan NEHZATI[1]*, Diamond Light Source (susan.nehzati@diamond.ac.uk)
Kajsa G.V. SIGFRIDSSON CLAUSS[2], MAX IV
Vivi VAJDA[3], Swedish Museum of Natural History

Abstract

Intense volcanic activity and continental break-up during the formation of the Atlantic [1] undoubtable affected the elemental balance in the environment during the end of the Triassic. We analyzed the metallome of a number of fossilized plants, both foliage and stems for naturally occurring, but also anomalous levels of toxic metals and metalloids to delineate the conditions of plants during this specific time interval. X-ray absorption spectroscopy (XAS) analysis of sedimentary successions across the Triassic-Jurassic (T-J) boundary showed anomalous levels of various elements with differing chemical forms in the fossilized leaves compared to those in the host sediments.

Several elements are non-essential to plants and in fact toxic to many plant species. Furthermore, some of the elements are highly volatile components of volcanic emissions and hydrothermal brines. Plant biology with respect to elemental accumulation has been largely studied by other workers with growing knowledge on uptake, transport and accumulation mechanisms of specific chemical species [2,3]. Together, this provides a unique opportunity to explore the hypothesis that elevated levels of other elements may have been present signifying the difficult natural terrain caused by massive geological activity over 200 million years ago. Using XAS and X-ray fluorescing imaging (XRF) we report distinctive accumulation patterns which may strengthen the idea that dispersal of specific elements may have been the driving factor in the mass extinction of life.

[1] Vajda, V., et al. Geological Society Special Publication (2016)
[2] Ashraf, MA., et al. Plant communications 1:1-15 (2019)
[3] Zhao, FJ., et al. Annual Review of Plant Biology 61:535-559 (2010)

Keyword

mass extinction, volcanism, fossils, plants, XRF

First fossil foliage record in the red beds from the Upper Jurassic in the Sichuan Basin, southern China

Yongdong WANG[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (ydwang@nigpas.ac.cn)

Abstract

The terrestrial red beds are extensively developed in the Upper Jurassic system of the Sichuan Basin, southern China, where few fossils had been documented. Recently, abundant silicified woods were found in the central Sichuan Basin, but no foliage fossil has been recorded from the same strata. Here we report the first leafy shoot fossil collected from the red beds of Upper Jurassic Penglaizhen Formation in the Shehong City, central Sichuan Basin. Based on careful comparisons with potential Mesozoic conifer fossils, it has been assigned to Pagiophyllum. The generic classification agreed with the paleo-vegetation features of the Penglaizhen Formation which were represented by gymnosperms of Araucariaceae (Agathoxylon-type woods) and Cheirolepidiaceae (Brachyoxylon-type woods). The non-coexistence between the leafy shoot fossil and the large amount of petrified woods depicted a unique process of the fossil preservation, which may be affected by the paleo-flood events of this area. The occurrence of genus Pagiophyllum, as well as the predominated Classopollis pollen from the Penglaizhen Formation indicated that the Shehong City and nearby regions were under a hot and semi-arid climatic condition during the Late Jurassic. The ecological system of this place was considered with more complexity allowing huge gymnosperms trees as well as some megaherbivores dinosaurs to be survived in the central Sichuan Basin area in the Late Jurassic Epoch.

Keyword

Pagiophyllum, leafy-shoot fossil, Upper Jurassic, the Sichuan Basin, Paleoenvironment

Early Jurassic plants response to the Toarcian Ocean anoxic event in the Ordos Basin, China

Yunfeng LI[1]*, Research Center of PaleontologyStratigraphy, Jilin University
(liyunfeng@jlu.edu.cn)
Changlu Zhang[2], College of Earth Sciences, Jilin University

Abstract

The ecological effect of global warming is a hot topic in today's scientific community. The early Toarcian Oceanic Anoxic Event (T-OAE, ~183 Ma) was characterized by abrupt global warming, enhanced weathering rates, expansion of anoxic conditions, elevated extinction rates, potential increase in atmospheric methane concentrations and the worldwide ac-cumulation of organic-rich sediments. It is an important comparative model for the study of this scientific problem. Studies on this event are mainly limited to Marine ecosystems at present, while studies on terrestrial ecosystems are rare. The response of fossil plants to this event is still unclear. The Early Jurassic Fuxian Formation in the Ordos Basin is a natural archive for studying the response of plants to the Early Jurassic Toarcian oceanic anoxia event, with well-developed strata, well-defined stratigraphic ages, well-preserved diverse fossil plants. Paleontologists ascribe the Fuxian Formation to the late Early Jurassic (Toarcian) through the characteristics of fossil assemblages. The preliminary study shows that the flora of the Fuxian Formation in the Ordos Basin is composed of cycas, czekanowskiales and conifers. The declining plant diversity, the increasing proportion of thermophilic plants, and a high content zone of Classopollis show a positive response of the terrestrial ecosystem to the Early Jurassic Toarcian ocean anoxia event.

Keyword

Early Jurassic, Toarcian oceanic anoxic event, Plant diversity, Ordos basin

Preliminary report on pterosaur track from the Cretaceous Jindong Formation, Gyeongsang Supergroup, Goseong County, South Korea

Hyeokpyo JEON[1]*, Chinju National University of Education (jhp9712@naver.com)
Kyung Soo Kim[2], Chinju National University of Education

Abstract

The Cretaceous Jindong Formation, which is the uppermost formation of the Hayang Group, the Gyeongsang Supergroup, is best-known for abundant vertebrate track assemblages and multiple track-bearing layers in the Gyeongsang Basin lake deposits of South Korea. Especially, the Deokmyeongri tracksite (formerly the Deongmyeong-ri tracksite), once called the Samcheonpo tracksite (Dukmyeongri section), where the first dinosaur footprints were discovered in Korea is the lower part of the Jindong Formation. The tracksite have yielded abundant dinosaur and bird tracks on the fine-grained volcaniclastic sediments associated with sedimentary structures such as ripple marks, desiccation cracks, raindrop impressions and cross-bedding.

In October 2021, the second author discovered the small to medium-sized pterosaur tracks and trackways reported herein from the Deokmyeongri tracksite of the Jindong Formation in Deongmyeong-ri, Hi-myeon, Goseong County, Gyeongnam, South Korea. Although it is well-known that the dinosaur and bird tracks are very abundant in the Jindong Formation, pterosaur tracks of the Jindong Formation have been rarely reported. The newly discovered assemblage of pterosaur tracks consists of at least 80 manus tracks attributed to small to medium-sized ichnotaxon. No pes tracks have been identified. Manus-only pterosaur track assemblages are not rare and could be interpreted to reflect differential registration depths of manus and pes and/or suboptimal preservation condition. The small-sized sauropod and the medium-sized theropod trackways registered on the same surface represent the contemporary vertebrate ecosystem during the Cretaceous Jindong lake period.

Keyword

Pterosaur track, Jindong Formation, Cretaceous, Gyeongsang Supergroup, South Korea

Neocomian ammonites from Talesh region (NW Alborz Mountains, Iran)

MAHMOUDREZA ---------- Majidifard[1]*, Research Institute for Earth Sciences in Geological Survey of Iran (m_majidifard@yahoo.com)
SIMA ------ SHAMS[2], Reyhane High School

Abstract

The study area is restricted to the Talesh Mountains in the north-western Iran. The research records several specimens of the Berriasian to Valanginian ammonite from the Lower Cretaceous Kolur Formation exposed near at east of the village of Shal in the Alborz Mts in northwest Iran. At the study section, the thickness is about 270 m. The sediments consist of alternations of thin- to medium-bedded limestone and argillaceous limestone containing numerous ammonite beds. The Kolur Formation conformably overlies the Shal Formation. Its upper boundary with the Cretaceous rocks is conformably. The Kolur Formation contains ammonites, but no detailed studies have been carried out so far. Based on the present study, the age of the formation is early Berriasian to late Valanginian.

An Berriasian to Valanginian ammonite fauna is described for the first time from the Iran (Alborz Mountains). The formation, consisting of alternation of thin to medium limestone and argillaceous limestone with numerous ammonite beds and comprise the families fauna (Phylloceratidae, Lytoceratidae, Haploceratidae, Neocomitidae, Olcostephanidae, Berriasellidae).

Some of the taxa are recorded for the first time from Iran: Phyllopachyceras infundibulum, Phyllopachyceras winkleri, Lytoceras subfimbriatum, Haploceras (Neolissoceras) grasi subgrasi, Pseudosubplanites fasciculatus, Olcostephanus (Olcostephanus) atherstoni, Olcostephanus densicostatus, Campylotoxia campylotoxa, Berriasella subcallisto, Strambergella aff. Carpathica, Neocomites teschenensis, Fauriella cf. floquinensis, Tirnovella cf. allobrogensis, Tirnovella cf. alpillensis and Fauriella gauthieri.

Palaeobiogeographically, these taxa are common in European and North African Tethyan successions.

Keyword

Cretaceous, Palaeobiogeographically, Berriasian, Valanginian, ammonites

NaOH solution: a novel approach to extract microfossil trapped in cherts

Manuel RIGO[1]*, University of Padova (manuel.rigo@unipd.it)
Tetsuji Onoue[2], Kyushu University
Qiangwang Wu[3], University of Padova
Yuki Tomimatsu[4], Fukuoka University
Lisa Santello[5], University of Padova
Yixing Du[6], Chengdu University of Technology
Xin Jin[7], Chengdu University of Technology
Angela Bertinelli[8], University of Perugia

Abstract

Microfossils are important components of sedimentary rocks used for palaeontological, biostratigraphic, palaeoenvironmental and palaeoclimatic investigations. They are usually extracted from rocks by using an acid solution, depending on the rock lithology. A new method using common NaOH (sodium hydroxide) has been developed to extract radiolarians and conodonts by digesting cherts (micro- and cryptocrystalline quartz) instead of the standard technique based on HF (hydrofluoric acid). Hydrofluoric acid (HF) has traditionally been used to extract microfossils from siliceous deposits (radiolarian cherts), but this acid is currently strictly regulated due to environmental and human health concerns. Different concentrations of sodium hydroxide solution (1, 2, 3, 4, 5 mol/L NaOH) have been tested at different temperatures as an alternative chemical to HF. This NaOH method allowed to collect undamaged different kind of microfossils, such as conodonts, radiolarians, teeth and dermal scales, the minerology of which is still preserved (e.g. conodonts in biogenic apatite). The use of soda is thus recommended, is less hazardous, easier to handle and has less impact on the environment and human health than HF. This method can thus be widely used for research, teaching and resource exploration of radiolarian fossils, even in institutions where HF cannot be used due to chemical restrictions.

Keyword

chert, soda, conodonts, radiolarians, method

Study of Quaternary Radiolaria from the Core ABP-06, Station II, Section 1, Central Indian Ocean

DEEKSHA BOHRA[1]*, Kumaun University, Nainital (deekshabohra2@gmail.com)
Girish Kumar Sharma[2], Delhi University

Abstract

A comprehensive study is carried out on the core ABP-06, Station II, Section 1 from Central Indian Ocean. 50 samples of 1 metre length were taken at a depth of 5,179m of Latitude 11°35'37.4"S and longitude 75°10'10.9"E. Lithologically, the studied core consists of fine grained clayey material (siliceous ooze) with white lensoid patches and having radiolaria and sponge spicules in traces.

The samples were disaggregated and boiled with dilute hydrogen peroxide. Then sieved through 63μm mesh stainless sieve and thorough washing was done with running water to clean the radiolaria shell. The final wet residual material is dried in an oven and used it to prepare the glass slides with the help of Canada balsam.

50 radiolarian species are identified and their distribution in the core are described. Taxonomy of 10 stratigraphically important taxa are described in detail. Based on the first morphotypic occurrences (Bm), last appearance (Tm) and consistent abundance of taxa, two radiolarian biozones are recognized namely *Buccinosphaera invaginata* zone and *Collosphaera tuberosa* zone. On the basis of this and radiolarian assemblage, the core belong to Upper Quaternary age. Three reworked species viz. *Spongaster pentas*, *Heliodiscus echiniscus* and *Acrosphaera spinosa echinoides* are present from very rare to rare. Two upwelled species -*Lamprocyrtis nigriniae* and *Tetrapyle octacantha* show their presence throughout the column and one cold water species - *Stylodictya validispina*, is also present in the study carried out so far. It is also interpreted that this area is having upwelling zone and basin is having the cold water currents from the Antarctic region.

Keyword

Upper Quaternary Radiolaria, Bio-zone, Distribution, Paleoceanography, Central Indian Ocean

Ecological impacts of the Early Jurassic climate crises

Sinjini SINHA[1]*, University of Texas at Austin (sinjini@utexas.edu)
William J. Foster[2], University of Hamburg, Germany
Crispin T.S. Little[3], University of Leeds, UK
Travis N. Stone[4], University of Texas at Austin
Tanner Fonville[5], Texas A&M University
Stéphane Bodin[6], Aarhus University
Lahcen Kabiri[7], University Moulay Ismail
Rowan C. Martindale[8], University of Texas at Austin

Abstract

The Pliensbachian/Toarcian boundary event (~184.2 million years ago) and the Toarcian Oceanic Anoxic Event (TOAE, ~183 million years ago) represent two of the most severe environmental perturbations of the Early Jurassic Epoch, leading to marine ecosystem disruption and biotic crises. Previous work on the Early Jurassic biotic crises has regarded warming-induced anoxia as the primary driver for the extinctions, and the two events (i.e., the stage boundary and early Toarcian) are often considered to be causally linked. Recent studies, however, show elevated extinction rates in well-oxygenated basins, such as the Iberian Basin in Spain, and the High Atlas Basin in Morocco. Furthermore, subtle differences in environmental conditions (such as, warming or eutrophication) between the two events have been identified at multiple localities. So far, there have been no quantitative studies on the Early Jurassic macrofauna from Morocco; thus, the extinction dynamics (e.g., ecosystem functioning and recovery), as well as the exact causes of the extinctions in the marine level-bottom communities in this low latitude locality, remain unclear. In this study, we report the occurrences of late Pliensbachian-Toarcian marine invertebrate taxa from the Central High Atlas Basin of Morocco and their associated functional groups. We collected macrofaunal samples from the late Pliensbachian- Toarcian strata, capturing the boundary event and the TOAE, followed by taxonomic identification and functional group assignment. Assessing functional diversity (i.e., how organisms operate in a community) provides data about how marine communities changed in response to environmental stressors (e.g., increased temperature or eutrophication) and what factors dictated survival versus extinction. The functional groups of the macrofauna are documented based on their inferred lifestyle, and niches assigned based using the Bambachian ecospace model. Preliminary results show that bivalves are the most functionally diverse, with eight different functional groups. Unattached epifaunal carnivores and unattached deep-infaunal suspension feeders cross the stage boundary event but disappear at the onset of the T-OAE. Similarly, the facultatively-unattached, epifaunal, suspension feeders appear after the onset of the TOAE, while byssate epifaunal suspension feeders are present throughout the late Pliensbachian-Toarcian interval. The differential survival of functional groups is likely due to the causal mechanisms of the two events. This new paleontological data from tropical, shallow-water macrofaunal communities is critical to our understanding of the extinctions across these two events because most of the comparable data has been collected from deeper-water, extratropical

shales. In addition, this study provides important data about the patterns of biotic change in tropical marine communities and how these communities recovered from significant global events like those we are facing now.

Keyword

Functional diversity, Mass extinctions, Paleoecology, Oceanic anoxic events

Cranial elements of Temnospondyl from the Middle Triassic of Satpura Basin, Madhya Pradesh, India.

Savita Nilkanth CHAURPAGAR[1]*, Geological Survey of India (chaurpagar.nilkanth@gsi.gov.in)
Subhasis Sen[2], Geological Survey Of India
Bhritashree Buragohain [3], Geological Survey Of India
V.V. Shesa Sai[4], Geological Survey Of India
Vidhya Sivadas[5], Geological Survey Of India
Vandana Umredkar [6], Geological Survey Of India

Abstract

Paleontological study on fossil remains of Temnospondyl skeletal elements have been carried out within the Middle Triassic sedimentary rocks of Denwa Formation of Upper Gondwanas in Satpura Basin, Madhya Pradesh, India, as part of the Annual programme of Geological Survey of India, Central Region. With the successful rate of survival, the early amphibians Temnospondyli were one of the clade along with the extant Lissamphibia and Amniota, that survived into the Late Triassic and beyond. The study area was near Tekapar village in Hoshangabad District of Madhya Pradesh, where fragmentary bone fossils and partially preserved skeletal elements of Temnospondyl were found out. The fossil bearing beds here are mainly a 1m thick gritty sandstone horizon within a sandstone- siltstone-purple sandstone sequence. The cranial elements comprise of the ornamented skull roof bones, part of maxilla and mandible with uni- bi-serial teeth while, the post-cranial elements include intercentrums, partial limb bones, femur, partial bone of pelvis and fibula of temnospondyl were also collected and studied. A few skull bones near orbital zone together with that of posterior part are well preserved. Partially preserved occiput at the back of the cranium is found with ossified wall. The occiput is preserved along with the squamosal and quadrate of the skull lying below the postparietal. The mandible bones are long, slender with serrated and tightly ossified sutures. It preserves well differentiated splenial, postsplenial and angular plates. The skull roof bones are moderately thick (max. 1cm.), pitted at places and show intricate network of ridges and grooves on external surface. Near squamosal area, honeycomb pattern is observed. Osteological studies of the recovered bone fossils of the temnospondyl from the present study area indicate a close similarity to the Mastodonsaurus giganteus from the Middle Triassic (Lettenkeuper: Longobardian) of Germany. Associated fossils recovered from the area are of archosaur (Shringasaurus indicus) and conifer plant wood, apart from small coprolites of varied origin. Presence of associated fossils, sedimentary association and bone structures of the temnospondyl suggests that the animal was mainly thrived in an alluvial and lacustrine environment in a relatively warm climate.

Keyword

Temnospondyl,, Middle Triassic, cranial elements, Satpura Basin, Upper Gondwana

A new research on ultra-large ichthyosaur-Himalayasaurus tibetensis

Qinghua SHANG[1]*, nstitute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (shangqinghua@ivpp.ac.cn)
Chun Li[2], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences
Wei Wang[3], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences

Abstract

Himalayasaurus tibetensis was an ultra-large ichthyosaur (Marine Reptile) that lived during the Norian, Late Triassic. This fossil was first discovered in 1960s and subsequently named by Z.M. Dong (1974). It was a member of the Shastasauridae, with a body length reaching up to 15 meters (Motani and Dong, 1999).

Due to the limitation of the scarcity and unprepared materials, the understanding on the species' morphological features and ecological behaviors are still limited. Meantime, because of the remoteness of the collection time and the brevity of the initial descriptions, the fossil's precise stratigraphic position and paleoenvironment are yet to be determined also.

The original holotype specimen (IVPP V 4003) was re-prepared revealing additional anatomical information, particularly regarding the teeth. Combined with the previous one tooth in situ and new revealed three out-of-situ teeth, the shape of the teeth of the Himalayasaurus tibetensis was considered as uniform. Meanwhile, the shape of the tooth roots is similar to other supergiant ichthyosaurs, but the shape of the crowns is highly specialized. The mesial and distal sides of the teeth are edged, while the labial-lingual sides are strongly compressed, resulting in a short dagger-like shape. The crown morphology is relatively similar to Thalattoarchon saurophagis (Fröbisch et al., 2013), but the size of the teeth is much larger than that of T. saurophagis. These newly exposed teeth indicate that the size (length and height) of their tooth root is even larger than that of an Ichthyosauria indet. species (PIMUZ A/III670), which found in the Alps (Sander et al., 2022).

In addition to the vertebrae, a separately preserved neural arch was also discovered, which is similar in size to the neural arch of Shonisaurus popularis found in the western United States, and has a similar shape to Shastasaurus altispinus (Merriam, 1908). This further confirms that Himalayasaurus is an ultra-large shastasaurid ichthyosaur.

Currently acknowledge on ultra-large ichthyosaur are either toothless or possess conical teeth. Himalayasaurus tibetensis is the only species with tightly packed, large teeth with dagger-shaped crowns, earning it the rightful title of a top predator cruising in the Late Triassic Paleo-Tethys.

It was worth to mention that, in 2023, on the original fossil locality, the Tulong region, Nielamu County, Tibet, a detail field investigation was realized on the Late Triassic well exposed strata. Several fragment skeletal fossils were found within a lenstic calcareous siltstone. This confirming that the fossils originated from the middle parts of the Qulonggongba Formation. From the view of the lithology and combine with the invertebrate fossil, such as bivalves and ammonites, the environment was a shallow marine, where located the northern margin of the Gondwana.

Keyword

Himalayasaurus, Ichthyosaurian, Norian, Late Triassic, Qulonggongba Formation, Tibet, Taxonomy and Morphology, Paleogeography

New Pachymeridiidae (Insecta: Heteroptera: Pentatomomorpha) fossils from the Jinju Formation (Lower Cretaceous), South Korea

Jun-Hyeok JANG[1]*, Department of Science Education, Gongju National University of Education, 27 Ungjinro, Gongjusi, Chungcheonnamdo, Souh Korea. (okok2073@gmail.com)
Nozomu OYAMA[2], 2 Centre de Recherche en Paléontologie-Paris (CR2P), MNHN-CNRS-Sorbonne Université, Paris, France/ The Kyushu University Museum, Higashi-ku, Fukuoka 812-8581, Japan
Gi-Soo Nam[3], Department of Science Education, Gongju National University of Education 27 Ungjinro, Gongjusi, Chungcheonnamdo, Souh Korea.

Abstract

Pachymeridiidae is an extinct family-level clade of Heteroptera, known with 43 fossil species until now. They are distinguished from other pentatomomorph bugs by the forewing costal fracture and absence of pulvillus under the claw. Pachymeridiidae fossils are known from Germany, England, Russia, China, Kazakhstan, and Mongolia, spanning from the Late Triassic to the Lower Cretaceous (Barremian).

The Jinju Formation (Albian), is mainly known for extremely diverse vertebrate trackways from trackmakers including dinosaurs, pterosaurs, crocodylomorphs, turtles, lizards, frogs, and hopping mammals, but also bears striking remains of both terrestrial and aquatic insects. Among them, most of the heteropteran fossils remained unstudied. Only a single species of fossil heteropteran with a definitive systematic position has been reported until now from this stratigraphic unit. Here, we present multiple types of new pachymeridiid heteropteran fossils from the Jinju Formation. Each type is morphologically distinguishable from others, mainly based on its size, general outline, manner of forewing venation, and markings on the wing. We suggest these morphotypes may represent new taxa, based on a unique combination of characters. These fossils are the first occurrence of this family-level clade within the formation and expand our understanding of post-Jehol Group aged insect fossil assemblage from East Asia.

Keyword

Heteroptera, Pachymeridiidae, Jinju Formation, Albian

CENOZOIC BIOSTRATIGRAPHY APPROACH FROM EQUATORIAL CARBONATE PLATFORM OF BRAZIL

Orangel AGUILERA SOCORRO[1]*, Universidade Federal Fluminense (orangelaguilera@id.uff.br)
Dayana Alvarado[2], Federal University of Pará
Olga Oliveira De Araújo[3], Federal University of Rio de Janeiro
Ricardo Tadeu Lopes[4], Federal University of Rio de Janeiro
Giovanni Coletti[5], University of Milano Bicocca

Abstract

The off-shore Cenozoic succession of the Pará-Maranhão Basin of the Brazilian equatorial margin in the Atlantic Ocean is studied from PETROBRAS core 1-MAS-16 (Ilha de Sanatana Formation) to investigate skeletal and foraminiferal assemblages during the Oligocene-Miocene interval, one of the fundamental moments in the environmental evolution of our planet. Biostratigraphic and paleoenvironmental analyses of these sedimentary records are often based on the study of foraminiferal assemblages. Foraminifera-based biozones are widely employed in the oil industry to support drilling processes that, alongside petrophysical prospecting, define interval favorable for exploiting hydrocarbon resources. New, faster, and more accurate methods based on microCT analyses have emerged as a valuable high-output tool to obtain high-resolution microfossil records for biostratigraphy and paleoenvironmental reconstructions. The results allowed to clearly constrain the Oligocene – Miocene interval and divide it into four foraminiferal assemblages and seven biofacies useful for both paleoenvironmental reconstructions and stratigraphic correlations (assemblages dominated by nummulitids and lepidocyclinids in the Rupelian; assemblages dominated by *Heterostegina* (*Vlerkina*) *antillea*, lepidocyclinids, and primitive miogypsinids in the Chattian; assemblages dominated by *Heterostegina* (*Vlerkina*) *antillea*, lepidocyclinids, and miogypsinids other than *Miogypsinoides* and *Miogypsinella*, in the Aquitanian; assemblages dominated by advanced miogypsinids in the Burdigalian; post Early Miocene assemblages characterized by the lack of abundant lepidocyclinids and miogypsinids). The paleoenvironmental analysis indicates a common pattern of relative sea-level oscillations with the nearby Foz do Amazonas Basin, highlighting a common behavior of this part of the equatorial passive margin during the Oligocene – Miocene interval. The comparison between the succession of skeletal and foraminiferal assemblages of the investigated core and other successions of the Southern and Central American areas indicated the presence of stratigraphically relevant foraminiferal assemblages that could be useful for improving the correlation between the various Cenozoic successions of the American region. The overall resilience of most of the large benthic foraminifera taxa to the Oligocene – Miocene transition testifies once more to the adaptability of this group of carbonate producers.

Keyword

Micropaleontology, Ilha de Santana Formation, micro-CT, petrography, ; Rupelian–Burdigalian

Paleobiodiversity of the Tamengo and Guaicurus formations (Ediacaran-Cambrian boundary strata, Brazil): paleoecological, paleogeographic and biostratigraphic implications

Rodrigo Rodrigues ADORNO[1]*, Geological Survey of Brazil (rodrigo.adorno@sgb.gov.br)
Dermeval Aparecido do Carmo[2], University of Brasília
Matheus Denezine[3], University of Brasília
Ana Carolina Oliveira[4], University of Brasília
Martino Giorgioni[5], University of Brasília
Detlef Hans Gert Walde[6], University of Brasília
Bernd-Dietrich Erdtmann[7], Technische Universität Berlin
Ivan Cortijo[8], Villuercas-Ibores-Jara UNESCO Global Geopark
Shuhai Xiao[9], Virginia Tech, Blacksburg, VA 24060, USA
Fabricio Caixito[10], Federal University of Minas Gerais

Abstract

The paleobiota of the Tamengo and Guaicurus formations of the upper Corumbá Group (Ediacaran-Cambrian boundary strata, Brazil) was limited, until recently, to only a few species, with most publications dedicated to the study of Cloudina lucianoi (Beurlen & Sommer, 1957) and Corumbella werneri Hahn et al., 1982. Our recent systematic sampling, accompanied by palynological and ichnological analyses, revealed a paleontological diversity that can be considered quite rich for the Ediacaran - Cambrian transition. The number of species from the Ediacaran - Cambrian boundary strata in Brazil is updated, including a total of twenty-six species from the Tamengo and Guaicurus formations at five sections in the Corumbá and Ladário regions: Corcal and Laginha quarries, Porto Sobramil, Porto Figueiras and Ecoparque Cacimba. In addition, paleoecological and paleoenvironmental inferences are presented based on the occurrence of this fossil assemblage and an updated lithostratigraphic description of the upper Corumbá Group. Cloudina carinata, has been documented in terminal Ediacaran successions in Spain, Siberia, as well as the Tamengo Formation at the Porto Figueiras section of Brazil. Cloudina hartmannae, considered a synonym for Cloudina lucianoi, and Cloudina carinata from the Tamengo Formation offer an important tool for paleobiogeographic and biostratigraphic correlation of the Tamengo Formation and other coeval successions in Paraguay, Spain, Uruguay, Argentina, United States, Canada, Namibia, South Africa, Oman, Russia, and China. The paelobiota from the Tamengo Formation is composed of numerous biomineralizing metazoans: Cloudina lucianoi, Cloudina carinata, Corumbella werneri, sponge spicules, and putative sponge gemmules. Four ichnospecies (Gordia marina, Pilichnus cf. P. dichotomus, Didymaulichnus lyelli and Multina minima) are present in the upper Corumbá Group. Three macroalgal fossil species were identified in the upper Corumbá Group: Vendotaenia antiqua from the Tamengo Formation, and Eoholynia corumbensis and Tawuia dalensis from the Guaicurus Formation. The species diversity of the upper Corumbá Group fossil assemblage was complemented by the occurrence of organic-walled microfossils, including Chuaria circularis, Arctacellularia januarensis, Leiosphaeridia ternata, Leiosphaeridia crassa, Leiosphaeridia jacutica, Leiosphaeridia

minutissima, Leiosphaeridia tenuissima, Leiosphaeridia obsuleta, Bavlinella faveolata, Bambuites erichsenii, Synsphaeridium sp., Jacutianema sp., Lophosphaeridium sp., Ostiama microcystis and Navifusa. A dramatic change in paleoenvironmental conditions between the Tamengo and Guaicurus formations possibly contributed to the 95% taxonomic turnover between the two formations. Among all of the Tamengo species, only the ichnospecies Multina minima continues to be present in the Guaicurus Formation. This local disappearance could represent the Ediacaran-Cambrian extinction. The transition from the Tamengo to the Guaicurus Formation is marked by a stratigraphically rapid drop in FeHR/FeT, recording a shift to more oxic bottom waters. The Tamengo Formation represents an environment with anoxic bottom waters, with fragments of biomineralized organisms that lived on shallower, probably mildly oxygenated surface waters, and that were then transported down-slope. Similar to coeval successions (e.g., the Nama Group in Namibia), recently published data support the hypothesis that late Ediacaran biomineralized organisms lived in a thin oxygenated surface layer above a relatively shallow chemocline. The Guaicurus Formation, on the other hand, records an expansion of oxic conditions to deeper waters during a sea level rise.

Keyword

Ediacaran-Cambrian boundary, Tamengo Formation, Precambrian Paleontology

New Record of Elasmobranch (shark) fauna from the early Miocene (Aquitanian) of Kachchh Region (western India): Palaeoenvironmental and Palaeobiogeographic significance

Ketan Avinash CHASKAR[1]*, KSKV Kachchh University (ketan.chaskar@gmail.com)
Ramanand Sagar[2], Birbal Sahni Institute of Paleosciences
Darshit Padia[3], Department of Biology, Shri R.R. Lalan College
Gaurav Chauhan[4], Department of Earth and Environmental Science, KSKV Kachchh University
Vivesh Kapur[5], Birbal Sahni Institute of Paleosciences
Pranav Pandya[6], Department of Biology, Shri R.R. Lalan College

Abstract

Past two decades has witnessed a renewed interest in the Neogene (mainly Miocene) interval of the Kachchh (=Kutch) region owing to its potential to yield numerous records on fishes, reptiles, birds, marine and terrestrial mammals. However, the vertebrate (mainly Piscean fauna) records from the early Miocene (Aquitanian) are quite scanty. The current investigation reveals the most diverse assemblage of shark fauna, to date, from the Aquitanian (~21 Ma) Khari Nadi Formation at Kotada locality, Kachchh Basin. The shark fauna includes genera Galeocerdo, Hemipristis, Carcharinus, and Sphyrna represented by at least seven species. Jaccard similarity coefficient data suggests that the recorded shark assemblage is quite dissimilar to the previously known Middle Miocene (~14 Ma) assemblages of Palasava (JI: 0.28), western India. Overall, the fauna from the Miocene interval of the Kachchh region reveal intermittent palaeobiogeographic connectivity with the Mediterranean Sea. Interestingly, the recorded elasmobranchs faunal assemblage from Kotada comprise the first record of Galeocerdo mayumbensis from India, which has been previously recorded from the Miocene (Aquitanian) Belgrade Formation (USA), early Middle Miocene Pirabas Formation (Brazil), Miocene Maradah Formation (Libya), and Miocene of northwest Madagascar. The records hint at intermittent palaeobiogeographic connections of western India with Madagascar, and Mediterranean during the Miocene.

Keyword

Miocene, Elasmobranchs, Kachchh, Galeocerdo, Aquitanian

Traces of Predatory Drilling Behavior on Middle to Late Pliocene Mollusc Fossils from Santo Domingo, Ilocos Sur, Northern Philippines

David Cabahug POLICARPIO[1]*, National Institute of Geological Sciences; University of the Philippines (dcpolicarpio4@up.edu.ph)
Allan Gil Fernando[2], National Institute of Geological Sciences; University of the Philippines
Tomoki Kase[3], National Museum of Nature and Science

Abstract

A recently described Middle to Late Pliocene fossiliferous massive sandstone unit in Santo Domingo, Ilocos Sur, northern Philippines was found to contain abundant mollusc shells with circular to elliptical drill holes. The majority (72%) of the drill holes analyzed were found on the surface of different species of conid gastropods. Most of the drill holes exhibit wider exterior openings (1.59 to 4.24 mm in diameter) compared to the interior holes (0.97 to 2.31 mm). Based on their morphological characteristics, the drill holes were classified mainly as *Oichnus ovalis* Bromley, 1983 (circular to elliptical drill holes with conical interiors and linearly grooved surfaces) and *Oichnus paraboloides* Bromley, 1981 (circular to elliptical outlines parabolically tapering inwards with smooth interiors). The drill holes on the surface of the conid shells are concentrated along the top of the body whorl, typically along the left side of the shell. The traces are attributed to naticid gastropod predatory behavior, which probably function as tertiary consumers in the study area's ancient ecosystem. This is supported by the abundance of several species of naticid gastropod within the fossil assemblage. While the holes can also be attributed to octopus predatory behavior, no octopod remains were found which is most likely due to their poor preservation potential. High predator success rate (89%) is inferred based on the high abundance of drill holes that completely penetrate the shell. *Oichnus ovalis* ichnofossils were observed to have two distinct scraping directions, suggesting reorientation of the prey during the drilling process. Larger prey shell specimens were observed to contain drill holes with larger diameters.

Keyword

Oichnus, Gastropods, Philippines, Pliocene, prey-predator interactions

Response of foraminifers to the Hangenberg mass extinction during the Devonian-Carboniferous transition in South China

Yang SHEN[1]*, China University of Geosciences (Beijing) (shenybj@126.com)
Huixin TANG[2], China University of Geosciences (Beijing)
Zidong YU[3], China University of Geosciences (Beijing)

Abstract

The Devonian-Carboniferous global Hangenberg event is one of the most significant mass extinctions in the Phanerozoic eon. There has been an important shift in the global ecosystem, resulting in about 50% of all genus-order marine animal extinctions. Foraminifers, as a class of single-celled protozoa, are at the bottom of the food chain. Their response to major extinction events implies key information affecting the stability of the ecosystem, leading to great significance for research on them. However, the study on the response of foraminifers to the Hangenberg extinction event is lacking in the world till now. This study will focus on this issue. There are several well-preserved Devonian-Carboniferous sections in South China, among which the Huilong section in Guangxi is the representative section of the shallow water platform facies. The Devonian-Carboniferous boundary was located between the Etoucun Formation and the Yaoyunling Formation, and the Hangenberg event occurred immediately below the boundary in the Huilong section. Research results have shown that the Huilong section contains abundant and diverse foraminifers from the Famennian to the Tournaisian, and the foraminiferal biostratigraphic sequence is clear. In ascending order, they are the Quasiendothyra communis zone, the Quasiendothyra kobeitusana zone, and the Bisphaera zone. In the Quasiendothyra kobeitusana zone, before the Hangenberg event, the foraminifers are characterized by the large volume and complex morphology, such as the development of double-walled Quasiendothyra kobeitusana and Quasiendothyra konensis. After the Hangenberg event, the foraminifers of the Bisphaera zone are mainly small single-chambered foraminifers with simple structures, and characterized by a large number of Bisphaera, occurred from the top of the Etoucun Formation to the bottom of the Yaoyunling Formation. Based on the study of the features of foraminifers before and after the Hangenberg event in the Huilong section, it is confirmed that foraminifers were clearly affected by the Hangenberg event, which led to the almost complete extinction of large and complex foraminifers. The study also shows that foraminifers suffered the “Lilliput effect” in the Hangenberg event and were significantly reduced in body sizes across the extinction horizon.

This study was supported by the National Natural Science Foundation of China (grant 42172037, 41702023).

Keyword

foraminifer, Devonian, Carboniferous, Hangenberg mass extinction, South China

Bone Histology of the Sabertooth and from Brazil

Virginia Silva Maciel[1]*, Postgraduate Program in Geodynamics and Geophysics - PPGG/CCET (virginiamaciel13@gmail.com)
Claude Luiz de Aguilar Santos[2], Câmara Cascudo Museum, Federal University of Rio Grande do Norte (UFRN). Natal, Brazil
Tito Aureliano[3], Diversity, Ichnology and Osteohistology Laboratory (DINOlab), Department of Geology, Federal University of Rio Grande do Norte (UFRN). Natal, Brazil
Aline Marcele Ghilardi[4], Diversity, Ichnology and Osteohistology Laboratory (DINOlab), Department of Geology, Federal University of Rio Grande do Norte (UFRN). Natal, Brazil

Abstract

Climate change in the Quaternary has had a major impact on mammal populations over the last 50,000 years. Among the groups most affected are the large felids. It is essential to study adaptive variations in saber-toothed cats and surviving taxa of large felids to understand the impact of environmental pressures on extinction. In this study we describe the femoral histology of the largest sabertooth taxon, , and compared it with a fossil cougar, , both from Pleistocene deposits of equatorial Brazil to discuss the impact of the paleoenvironment on the paleoecology of both taxa. MCC-868V is a femur of . (total length = 350 mm). MCC-991V is a fragmentary femur of . (reconstructed total length = 307 mm; simple scaling). The presence of an EFS (External Fundamental System) in MCC-868V, the abundant presence of remodeled bone tissue, especially in the middle and inner portion of the cortex, and the three generations of secondary osteons, suggest that the individual was a young adult at the time of death (Type F bone tissue, HOS-11). MCC-991V also has an EFS, advanced secondary remodeling, and four generations of secondary osteons (Type G bone tissue, HOS-13), suggesting that it is an adult. The high rate of bone remodeling suggests that both specimens had ideal environmental conditions for their development into adulthood. Body size in large carnivores seems to be more directly related to the availability of resources than to climate. The histology of extinct cave bears suggested that those individuals that inhabited higher altitudes tended to be smaller and grow slowly due to slow bone resorption during hibernation. Therefore, we suggest that . must not have faced great difficulties in feeding in the face of constant environmental changes throughout the Quaternary as it is a smaller generalist carnivore compared to . , a specialist carnivore. This factor might help explain the survival of . and the decline of . . Future studies in the histological variation in panther populations from different biomes will be key for detailing environmental pressure in large felid populations.

Keyword

Pleistocene, Carnivora, Paleohistology, Paleoecology

Pleistocene-Holocene Molluscan Fossil Assemblage and Paleoenvironment Analysis of the Damortis Uplifted Marine Terrace Sequence in Santo Tomas, La Union, Philippines

John Paul Martinez Mondala[1]*, National Institute of Geological Sciences, University of the Philippines Diliman (jmmondala@up.edu.ph)
Allan Gil Fernando[2], National Institute of Geological Sciences, College of Science, University of the Philippines Diliman, Quezon City, Philippines
David Policarpio[3], National Institute of Geological Sciences, College of Science, University of the Philippines Diliman, Quezon City, Philippines
Tomoki Kase[4], 3-27-1 Rokkakubashi, Kanagawa-ku, Yokohama, Kanagawa, Japan 221-8686

Abstract

An uplifted marine terrace sequence in Damortis, Santo Tomas, La Union, Philippines reveals a molluscan paleocommunity consisting of 39 families, 68 genera, and 98 species from a total of 1000 mollusc specimens collected. Two ichnogenera have also been documented to occur in the specimens. The uplifted marine terrace succession, which spans the Pleistocene to Holocene interval, exhibits four (4) sedimentary units, namely (1) the west-dipping sandstones of the Pleistocene Damortis Formation; (2) conglomerate layer; (3) an uplifted Holocene coral reef; and (4) an interpreted tidal flat layer. This succession represents a change of depositional environment, reflected in the molluscan paleocommunity, throughout the Late Quaternary Period.

Based on sedimentological and paleontological analyses, the Damortis Formation is inferred to have been an intertidal to subtidal siliciclastic beach environment with low molluscan paleodiversity. The assemblage consists mostly of infaunal and burrowing corbulid, mactrid, and ungulinid bivalves and mud-bottom dwelling turreted gastropods such as turritellids and terebrids, as well as ringiculid micromolluscs. The conglomerate horizon and the uplifted coral reef horizon reflect a patchy reef paleocommunity that is high in molluscan paleodiversity with abundant predatory drillholes represented by the ichnogenus *h*. The patchy reef assemblage is inferred to have transitioned to a rocky shore assemblage subsequent to uplift due to the presence of rocky shore-dwelling species such as sp. No molluscs were observed in the uppermost tidal flat horizon, interpreted to represent a choked and low energy environment, possibly due to interseismic subsidence of the area after uplift. Result of Q-Mode multivariate cluster analysis supports the very distinct vertical/temporal molluscan assemblage change, as well as the change in the relative abundance of the mollusc species throughout the sequence.

Keyword

Paleontology, Quaternary, mollusc assemblage, ichnofossils

Thermal maturity and taxonomic insights from palynomorph coloration: Preliminary results for the immature sediments of the Cretaceous, Yezo Group

Maho HAYAKAWA[1]*, Graduate School of Science, Hokkaido University
(fastriver10000@eis.hokudai.ac.jp)
Hideto Nakamura[2], Faculty of Science, Hokkaido University
Masashi A. Ikeda[3], Faculty of Science, Hokkaido University
Ken Sawada[4], Faculty of Science, Hokkaido University
Reishi Takashima[5], The Center for Academic Resources and Archives, Tohoku University Museum, Tohoku University
Hiroshi Nishi[6], Institute of Dinosaur Research, Fukui Prefectural University

Abstract

The color tones and brightness of palynomorphs in sedimentary matrices serve as indicators for the thermal maturity of organic matter (OM), as demonstrated by indices including the Thermal Alteration Index (TAI) and Palynomorph Darkness Index (PDI). The TAI, while utilizing both brightness and color tone information, relies on subjective visual matching to a standard gauge, resulting in lower numerical precision. Conversely, the PDI offers a more precise quantitative measure, albeit without incorporating color tone information. Meanwhile, the color of palynomorphs might also encode other types of information, such as taxonomic and ecological variety of source plants, as well as differences in diagenetic processes, because palynomorph color within a single sedimentary rock shows significant variation. This study aims to decipher such information by quantitatively assessing changes in hue and brightness in Cretaceous pollen fossils against maturity, highlighting the potential of these characteristics as novel paleontological indicators.

Utilizing image analysis, we quantitatively assessed the brightness and color tones by calculating PDI and hue values for pollen fossils extracted through acid and alkali treat ments from Turonian and Campanian mudstone samples of the Late Cretaceous Yezo Group in Hokkaido, Japan. The analysis targeted Classopollis sp. and bisaccate pollen for conifers, and tricolpate pollen for angiosperms, evaluating the implications of plant taxa on the observed changes. Analyzed sedimentary rock samples have been studied previously for biomarker maturity indices showing advanced thermal maturation in older samples.

Initial findings indicated that at the immature Campanian stage, conifer pollen exhibited slightly higher PDI and lower hue (darker and redder tones) compared to angiosperm tricolpate pollen. As the analysis extended to the older Turonian sample, a shift towards darker and redder hues was observed across all pollen groups. However, the magnitude of this shift in PDI and hue was more pronounced in conifer pollen than in angiosperm pollen, underscoring significant taxonomic differences in the response to thermal maturation.

Considering the inherent colorlessness of modern conifer and angiosperm pollen walls, the observed variations in coloration might suggest lineage-specific differences in the concentration of potential molecular sites within the pollen walls that susceptible to post-depositional alteration to

become chromophores. Previous UV and IR spectroscopic study on modern pollen and spores demonstrated variations in sporopollenin components between ferns and seed plants, providing corroborative evidence for the taxonomic differences in structural and composition of pollen walls that may lead to the observed variations in color withing the visible spectrum.

Keyword

Image analysis, Cretaceous, thermal maturity, palynomorph, pollen fossil

OPal: Open Palaeontology – a community-driven diamond open access journal with preregistration

Harriet Bethany B. DRAGE[1]*, University of Lausanne (harriet.drage@unil.ch)
Joseph N. Keating[2], University of Bristol
Morten Lunde Nielsen[3], Independent researcher outside academia, now working in government, Denmark
Farid Saleh[4], University of Lausanne
Thomas W. Wong Hearing[5], University of Leicester

Abstract

We are establishing a new diamond open access journal, OPal: Open Palaeontology. OPal's scope will cover all aspects of palaeontological research and the journal will have a flexible publishing model with a range of publication types, preprinting, and transparent peer review. The founding principles of OPal directly address concerns that the current academic publishing landscape is systemically unfit for purpose, dominated by a few large publishing houses that extract substantial profit from public resources for little return value, remove copyright from authors, and hinder innovation. Traditional publishing models bake-in gatekeeping practices controlling who and what is published; single-blind peer review has long been suggested to suppress original thought, be biased against marginalised groups, and be ineffective at improving the quality of flawed work. There is also increasing recognition of a reproducibility crisis in science, partly driven by pressure to publish novel work in high-impact journals. The result is systemic inaccessibility, opacity, and lack of accountability – all supported by the academic publishing system. But all is not lost: there is a wealth of established and emerging good practice across the academic publishing landscape, and OPal will draw on these across its publishing model. OPal's ethos is rooted in financial accessibility, transparency, and accountability in academic research. OPal's model draws on established and emerging good practice from across the academic publishing landscape, including diamond open access to mitigate financial inaccessibility, interactive and transparent peer review procedures, and research preregistration integrated with article publication. We also propose a flexible approach to publishing research at various stages of intellectual development and in different formats. We hope that OPal will help transform our understanding of how palaeontological research can be rigorously assessed and published. Here, we put out an open call for those interested in working with us on this new journal. In particular, we seek people interested in working on the OPal editorial board to manage journal editorial processes and those wishing to act as handling editors. We particularly encourage early-career researchers, those working in non-academic positions, and people working outside Europe and North America to get in touch!

Keyword

Journal, Diamond open access, Preregistration, Preprinting, Peer review

METHODOLOGICAL DEVELOPMENT FOR EXTRACTING THREE-DIMENSIONAL SPECIMENS OF CLOUDINA LUCIANOI (BEURLEN E SOMMER, 1957)

Ana Carolina Valadares Maciel de Oliveira[1], University of Brasília
Dermeval Aparecido Do Carmo[2], University of Brasília
Matheus Denezine[3], University of Brasília
Martino Giorgioni[4], University of Brasília
Rodrigo Rodrigues ADORNO[5]*, Geological Survey of Brazil (rodrigo.adorno@sgb.gov.br)
Shuhai Xiao[6], Virginia Tech

Abstract

This study presents a new 3D method for calcareous skeleton Cloudina lucianoi (Beurlen & Sommer, 1957) extraction. These skeletons occur in limestone matrix of Nama Group, Namibia and Corumbá Group, Brazil, Ediacaran sections. This work improves morphological analysis and provides insights into phylogenetic affinities. New protocols for samples preparation and 3D calcareous skeletons extraction from limestones matrix is presented. Cloudina lucianoi is an Ediacaran fossil attributed to the phylum Cnidaria or Annelida. The studied material came from outcrops of the Tamengo Formation in Mato Grosso do Sul of Brazil and from the Nama Group in southern Namibia, both sections are attributed to the uppermost Ediacaran. The extraction of Cloudina lucianoi specimens from limestones consisted of a series of physical and chemical procedures aiming at separating skeletons from the rock matrix. The samples were submitted to a chemical treatment comprising two methods: Solution Drip System (SD) and Immersion System (SI). Different concentrations of acetic acid (1.8% and 4%) were used in both systems in order to evaluate the effectiveness of different acid concentrations in disaggregating the studied samples. The attacks under both SD and Si modalities took place simultaneously in order to observe the reactions and evaluate the effectiveness of the disaggregation process. The results of this treatment of the samples are promising, with the recovery of three-dimensional Cloudina lucianoi specimens, internal molds and external surface of the skeletons. These specimens allow the observation of important morphological features, such as the funnel-in-funnel construction, lamellar structure of funnel walls, and annular striations on outer funnel walls. In a preliminary analysis, the drip system with a 4% diluted acid solution has proven to be more effective. A geochemical analysis (EDS) of samples from the Tamengo Formation and the Nama Group revealed a lower magnesium carbonate (<2%), although the skeletons have a significantly higher amount of magnesium (>15%Mg), which appears to provide greater resistance to acid attack when compared to the calcium carbonate matrix. This different Mg concentration appears to be related to the differential disaggregation of the matrix allowing the separation of the skeletons in 3D. In conclusion, the integration of thin section observations and morphological characterization of chemically extracted three-dimensional skeletons can provide key morphological information about some of the earliest known animal skeletons.

Keyword

Paleontology, Ediacaran, Cloudina lucianoi, 3D Fossil extraction

Growth behaviour and palaeoecological role of microproblematica Palaeoaplysina in the Late Carboniferous to the Early Permian of Svalbard

Juwan JEON[1]*, Department of Earth and Environmental Sciences, Korea University, Seoul, 02841, Republic of Korea; The Institute of Basic Science, Korea University, Seoul, 02841, Republic of Korea (juwanjeon@korea.ac.kr)
Hyojin LEE[2], Department of Earth and Environmental Sciences, Korea University, Seoul, 02841, Republic of Korea/ Laboratory Research Institute, Dong-A Consultants Company, Gyeonggi-do, 16006, Republic of Korea
Jeong-Hyun LEE[3], Department of Geological Sciences, Chungnam National University, Daejeon, 34134, South Korea
Jusun WOO[4], School of Earth and Environmental Sciences, Seoul National University, Seoul, 08826, Republic of Korea
Suk-Joo CHOH[5], Department of Earth and Environmental Sciences, Korea University, Seoul, 02841, Republic of Korea

Abstract

Late Carboniferous to Early Permian reefs are mostly devoid of large, massive reef-building organisms, but are instead dominated by relatively small organisms such as calcareous algae, sponges and bryozoans. During this period, Palaeoaplysina, an enigmatic fossil with a presumed biological affinity to hypercalcified sponges, is the key builder of these buildups. The palaeogeographic distribution of Palaeoaplysina is concentrated in the northern margin of Pangea, thus in positions regarded as higher latitudes, but extends into the subtropical-tropical range. The classic locality for the well-preserved Palaeoaplysina is in the Broggerhalvoya Peninsula, Spitsbergen Island, Svalbard, in the Wordiekammen Formation (Moscovian–Sakmarian), where it forms a biostrome up to 5 m thick and extends laterally for a few kilometres. This study re-examines the growth behaviour of Palaeoaplysina and discusses its palaeoecological role. Palaeoaplysina characteristically possesses platy growth morphologies with its unique cellular microstructure of skeleton and canal systems. Individuals are about 20 cm wide and 2 to 3 mm thick, with their edges thinning toward the margin. Densely stacked skeletons of Palaeoaplysina form platy bands up to 6 cm thick alternating with layers of peloidal wackestone to packstone. Pores of Palaeoaplysina are orientated side-upwards, indicating their in-situ preservation. Downward-growing epibionts, such as bryozoans and benthic foraminifera below platy Palaeoaplysina, are interpreted to indicate the presence of small primary cavities. Taken together, these observations indicate that Palaeoaplysina, which grew over the seafloor with its palaeoecological role of stabilising substrates by binding, constructed a transient reef community, as stromatoporoid-grade hypercalcified sponges did prior to the Late Devonian mass extinction, culminating at a time when large, massive reef builders were largely absent during the Late Carboniferous to Early Permian interval.

Keyword

Palaeoaplysina, Late Palaeozoic, Svalbard, palaeoecology

Glossifungites : Tracing the Subterranean Artistry of Ancient Ecosystems from the Baisakhi Formation of Jaisalmer Basin, Rajasthan, India

ANSHUL HARSH[1]*, Jai Narain Vyas University, Jodhpur, Rajasthan, India
(anshulharsh11295@gmail.com)

Abstract

The ichnospecies *Glossifungites* is describes from the coastal plain distributary deposition of the upper Jurassic sedimentary sequence of the Lanela Member of the Baisakhi Formation, Jaisalmer basin, India. This trace fossil is restricted to a single stratigraphic horizon and constitutes a typical firmground ichnoassemblage of the *Glossifungites* ichnofacies. This abstract delves into the allure of *Glossifungites*, exploring its significance as a trace fossil and bioglyphs the valuable insights it provides into the behaviors of long-extinct organisms. *Glossifungites* trace fossils, characterized by the presence of scratch imprints, passive fill, a tongue-shaped structure, and distinct morphological features, represent enigmatic biogenic structures. *Glossifungites* serves as a geological canvas, portraying the subtle nuances of burrowing and tunneling activities that once shaped the sub-surface landscapes. Well-preserved specimens have been recovered from the whitish to brownish medium to fine-grained ferruginous sandstone of Lanela scarp section. These *Glossifungites saxicava* and *Glossifungites gingrasi* trace fossils bearing Lanela Member is located near Kathodi village about 72 km away from Jaisalmer city. The producer have been identified as suspension filter-feeding, possibly crustaceans like animal, probably mayfly burrows which supports the assertion that burrowing mayflies traces. The *Glossifungites* provides a way to distinguish bioturbation by marine-recruited fauna from that produced by freshwater fauna in the rock record. The trace fossils represent an environmentally stressed benthic community in a marginal marine setting. Based on the *Glossifungites saxicava*, *Glossifungites gingrasi* and associated trace fossils assemblages, this study suggests fresh water shallow marine environments for the Lanela Member of the Baisakhi Formation.

Keyword

Glossifungites, Trace-fossil, Lanela Member, Baisakhi Formation, May-fly burrows

Miocene vertebrates of Kutch, Gujarat, India: An implication on Indian-Asian post collision faunal diversification and paleobiogeography

Kongrailatpam Milankumar SHARMA[1]*, Department of Geology, Central University of South Bihar, Gaya, India (milankumar.sharma@gmail.com)
Nongmaithem Amardas Singh[2], Department of Geology, Central University of Punjab, Bathinda, India
Rajeev Patnaik[3], Department of Geology, Panjab University, Chandigarh, India
Ningthoujam Premjit Singh[4], Biostratigraphic Division, Wadia Institute of Himalayan Geology, Dehradun

Abstract

Globally, Miocene time is significant for its intense tectonism as a continuation of collision tectonic of Indian and Asian plate taken placed during the Eocene time. These events and subsequent tectonism are considered to be associated with changes in climate, geodynamic shifting of Indian-Asian-African plate and changes in resultant paleogeographic set up such as the upheaval of the mighty Himalaya, formation of Landbridge between Africa and Eurasia., migration and diversification of fauna, etc. The Miocene deposits of Kutch are divisible into three formations namely Early Miocene Khari Nadi Formation, Middle Miocene Chhasra Formation and Late Miocene Sandhan Formation. These deposits are known for its diverse assemblage of vertebrates including fishes, reptiles, lizards, amphibian and mammals. The present paper tries to discuss the paleobiogeographic significance of Miocene vertebrates from Kutch and its correlation with those of correlatable formations. These deposits are also known for its diverse assemblage of vertebrates including fishes, reptiles, lizards, amphibian and mammals. The early Miocene Khari Nadi Formation of Kutch yielded fossil fishes (Chondrichthyes and Osteichthyes), reptiles (tomistomid crocodiles) and mammals (Deinotherium sp., Gomphotheriidae indet. and Brachypotherium sp.). Certain chondrichthyan and osteichthyan fishes, reptiles (Lizard, Snake and Crocodiles) and mammals, etc. were reported from the middle Miocene Chhasra Formation of Palasava locality. Piscean (chondrichthyan and osteichthyan) remains such as Carcharhinus brevipinna, C. falciformis, C. cf. leucas, C. aff. perezi, Carcharhinus sp., Negaprion sp., Aetobatus sp., Myliobatis sp., Dasyatis probsti, D. rugosa, Himantura menoni, Pastinachus sp., and Taeniurops sp., teleost of the families Bagridae, Channidae, Characidae and Cyprinidae, and mammals such as Sanitherium, Sivameryx, Brachypotherium, Zygolophodon, Gomphotherium, and Deinotherium are known from Palasava sites. The late Miocene Sandhan Formation of Tapar locality also yield certain mega-mammals (Deinotherium, Gomphotherium, Listrodon, Zygolophodonts, etc) and micromammals assemblages, reptiles, amphibians, lizards, etc. and elasmobranch such as Myliobatis, Aetobatis, Dasyatis, Pastinachus, Himantura and Pristis, etc. The early Miocene elasmobranchs from Kutch shows close affinities with those from Mediterranean Sea suggesting a well connection of Tethyan seaway passages till the early Aquitanian and the presence of the remnant waterbody connecting the Mediterranean Sea and Indo-Pacific. Similarly, in the Indian Ocean region Miocene fauna of Kutch shows close similarity

with those of Baripada Beds, Orissa, Bhuban Formation of Mizoram, Gogha Coast, Piram Island and Madagascar. A short-lived reopening of the marine pathway between Indian and Mediterranean Sea is suggested by the good similarity index of Middle Miocene elasmobranch comparing with their counterparts in the Mediterranean Sea. However, a much higher faunal affinity with those of Eastern Pacific indicates a gradual shift in migration path through the Pacific Ocean to Indo-Pacific region after the permanent Landbridge was formed. A closer affinity of late Miocene terrestrial mammalian fauna of Kutch with those of Africa, Europe and Indo-Pakistan may be due to Miocene dispersal across the ‘Gomphotherium Landbridge’.

Keyword

Miocene,, vertebrate,, Paleoenvironment,, Kutch,, India

Discovery of the *Fictovichnus from the Fatehgarh Formation of Barmer Basin from India*

PAWAN KUMAR[1]*, Jai Narain Vyas University, jodhpur, rajasthan, india (pawanvaishnav932@gmail.com)

Abstract

The Cretaceous deposits within the Fatehgarh Formation of the Barmer Basin, Fatehgarh, are composed of calcareous to ferruginous sandstone, wherein two distinct ichnospecies of insect trace fossils were found: *Fictovichnus gobiensis* and *Fictovichnus aragon*. *Fictovichnus gobiensis*, are 18-30 mm in length and 8-10 mm in width, presenting ellipsoid casts with a smooth surface. One end is rounded, whereas a truncated tunnel protrudes from opposite end. *Fictovichnus aragon* exhibits a rounded end on one side and a pointed end on the other, with dimensions of 9-20 mm length and 6-10 mm width. The study area is located near the Sandha village, which lies about 15km from Fatehgarh. This trace fossil is reposited in two stratigraphic horizon and constitutes a typical firmground ichnoassemblage of the *Fictovichnus* facies. These both species are deposited in a gregarious nature parallel to the horizon. Well-preserved specimens have been recovered from the yellowish to brownish medium to fine-grained ferruginous sandstone of sandha village section. Possible producers of *Fictovichnus gobiensis* are coleopterans, whereas *Fictovichnus aragon* was probably produced by pompilid or sphecid wasps. In the contact with the matrix, specimens show micritic layers, interpreted as the remains of the original silky wall constructed by the wasp larva In both ichnospecies. Based on presence of the *Fictovichnus gobiensis*, *Fictovichnus aragon* and associated trace fossil assemblages, this study proposes continental shallow marine environments for the Sandha Section of the Fatehgarh Formation.

Keyword

Fictovichnus, Trace-fossil, Wasp-Larva, Fatehgarh Formation, India

Microconchid-cement reefs from the Visean of Belgium

Jeong-Hyun LEE[1]*, Chungnam National University (jeonghyunlee@cnu.ac.kr)
Jaegab Seol[2], Department of Geological Sciences, Chungnam National University
Mar Simonet Roda[3], Research Institute of Natural Sciences, Chungnam National University
Juwan Jeon[4], The Institute of Basic Science, Korea University

Abstract

Microconchids are a type of problematic tubeworm that flourished from the Ordovician to the Jurassic. Reefs formed by microconchids have been rarely described, as these organisms were more commonly secondary framework builders within microbialites from the Devonian to the Triassic. In this paper, we describe microconchid-cement reefs from the Anhée Formation (Upper Visean), southern Belgium. The reef appears as small domes, approximately 20 cm in diameter, within the middle of the Anhée Formation at the top of 4th-order parasequences. The reef is composed of microconchids encased in a few-millimeter-thick layer of isopachous fibrous cements, creating an overall branching, clotted-like fabric. Although various corals, brachiopods, trilobites, and molluscs have been identified in the formation, they are absent from the reef, with the exception of rare bivalves and foraminifera, which are also encased in cements. Surrounding the microconchids and enclosed by cements, minor peloidal to clotted micrite is observed. The spaces between the cement layers, which can be up to a few centimeters wide, are filled with micrite, peloidal packstone, and cement. It is inferred that these microconchid-cement reefs likely flourished at times when other benthic animals struggled to survive. The extensive precipitation of abiotic cement during the Carboniferous would have contributed significantly to supporting the overall structure of the reef.

Keyword

microconchid, reef, Carboniferous, Belgium

PERSEPHONE – Autonomous Exploration and Extraction of Deep Mineral Deposits

Marko KOMAC[1]*, INTRAW (m.komac@telemach.net)
Vitor Correia[2], INTRAW
Eberhard W. Falck[3], INTRAW
George Nikolakopoulos[4], Lulea Tekniska Universitet

Abstract

The continuous effort and increased demand of the raw materials are directing mining companies to excavate minerals at greater depths, especially in Europe, where shallow-seated deposits have either been depleted, are non-economic to exploit, or represent environmental protection and societal obstacles. This trend is challenging the current mining operations and the existing traditional technologies towards the objective to retain profitability, while achieving the latest Green Deal environmental vision and securing workers safety. A key enabler, to address these challenges and to foster a sustainable development of the mining industry, is the development and deployment of innovative technologies for resource efficient extraction of mineral raw materials in the EU, as well as near-mine exploration for critical raw materials in currently not extracted ore bodies at existing or in closed or abandoned mines.

PERSEPHONE, a 3-year project funded by the EU, is addressing these challenges by developing pioneering technologies that push the limits of the EU mining industry. This includes autonomous and integrated near mine exploration capabilities to access deep deposits of critical raw materials in hard-to-reach deep occurrences and in abandoned mines. The overall concept and vision of PERSEPHONE aims to reduce the size of mining machines, which are currently adapted to the human scale, and to embed risk-aware, autonomous navigation of machinery and full digitalisation of the extraction process by digital twin creation. The key enabling technologies are expected to be validated at TRL 5. Additionally, the project is introducing novel approaches to on-line near-mine exploration core analysis and overall integration of at face data gathering and analytics to steer the mine development. Thus, it helps to foster the Green Transition by targeted extraction and reduction of waste generated from deep mining operations. The vision is a low-visibility and low-impact mine with near-zero human presence in highly hazardous areas.

The overall goal of PERSEPHONE is to digitalise and automate the extractive value-chain by creating energy-efficient autonomous drilling machines with advanced perception capabilities for navigation, face-drilling, core extraction, and at the face geochemical analytics. The digitalisation will enable a data-driven digital twin creation and geological modelling as means of enhanced decision support and optimal extraction planning. In turn this will enable near real-time assessment of resources and reserves to aid more realistic financial and investment decision making.

Keyword

Exploration Drilling, Excavation Drilling, Robotics, Geomodels, Responsible Sourcing

Gallium distribution and enrichment in skarn iron deposits: Insights from the Zhuchong deposit, Eastern China

Wang FANGYUE[1]*, Hefei University of Technology (fywang@hfut.edu.cn)
Liang Xian[2], Hefei University of Technology
Zhang Long[3], Hefei University of Technology

Abstract

Global gallium (Ga) is mainly mined from bauxite deposits and sediment-hosted zinc deposits, but rarely from skarn deposits. The Middle-Lower Yangtze River Valley Metallogenic Belt (MLYB), eastern China, is an important skarn iron ore producer, where skarn iron deposits are often associated with critical metals such as Ga and Co. The Zhuchong iron deposit is a typical high-grade skarn iron deposit with Ga enrichment in this belt. This deposit contains 50 Mt Fe ore @ 50.1%, and ~ 1718t Ga metal with an average grade of 33.62 g/t. However, the distribution and enrichment mechanism of Ga in this deposit remain unclear. Our study indicates that the Ga at Zhuchong is mainly enriched in the magnetite ore layer with Ga concentrations of 39.1~70.9 ppm (Avg. = 54.4 ppm). The average Ga contents in hydrothermal minerals, from the highest to the lowest, are as follows: epidote (121.9 ppm), magnetite (71.9 ppm), garnet (33.2 ppm), diopside (8.70 ppm), sphalerite (4.52 ppm), chalcopyrite (1.01 ppm), pyrrhotite (0.38 ppm), and pyrite (0.04 ppm). Whole-rock chemical mass balance calculations suggest that magnetite is the predominant mineral hosting gallium within the Zhuchong deposits. Magnetite can be categorized into three types: massive magnetite within magnetite ore (57.2-140 ppm, average = 88.7 ppm) > disseminated magnetite in skarn (10.7-62.6 ppm, average = 24.4 ppm) > veinlet magnetite in altered diorite (7.58-27.3 ppm, average = 20.9 ppm). This study indicates that the dominant substitution mechanism for the incorporation of Ga into magnetite is $Ga^{3+} \leftrightarrow Fe^{3+}$, and that the enrichment of Ga in magnetite at Zhuchong is mianly controlled by temperatures. During the development of the skarn iron deposit, it is crucial to focus on investigating the gallium (Ga) occurrence within magnetite, as this insight will enable the maximization of resource utilization.

Keyword

Skarn iron deposit, Gallium enrichment, Magnetite, Zhuchong iron deposit, Eastern China

Carbonatites and their potentiality for Niobium mineralisation in Central block of eastern Ambadungar: Indicated Resource for critical mineral

Prabhakar LAKRA[1]*, Geological Survey of India (prabhakar.lakra1@gsi.gov.in)
Bijay Kumar DAS[2], Geological Survey of India
Shilpa P Mandlik[3], Geological Survey of India
Sudhangsu Sekhar Dutta[4], Geological Survey of India

Abstract

The Ambadungar Carbonatite Complex (ADCC) forms a part of large alkaline sub provinces in Deccan Flood Basalt Provinces, Gujarat, India. The ADCC comprises different variant of carbonatites like, carbonatite breccia, calico-carbonatite, ferro- carbonatite, siliceous carbonatite and fenites. Worldwide carbonaitite are well known for potential source of REE mineralisation. In the ADCC, REE bearing variants of carbonatite also contains appreciable amount of rare metals (Niobium) which have received considerable attention in view of its vital importance and military applications. During field season 2021-22 for the first time GSI has successfully encountered carbonatites beneath the basalt of Deccan Traps at a vertical depth of 85 m and established indicated resources in the central block of eastern Ambadungar Carbonatite Complex for Niobium @ 0.02% cutoff grade. Based on the subsurface exploration work and analytical results of core samples, PCS samples, petrological samples, XRD and EPMA studies resource was finalized. All the ten vertical boreholes intersected carbonatite zone with niobium mineralisation in the central block of eastern Ambadungar area during this exploration activity. The resource was estimated for niobium minerals by extended area, LVS and cross section method at 0.02%cut off is 81 MT with average grade of 0.05% in the above block.The objective of this paper is necessarily brief owing with the established resources for Niobium beneath the Deccan Traps of ADCC in the state of Gujarat under critical mineral commodities.

Keyword

Niobium., carbonatite, Deccan Traps

FUTURAM: Developing methodologies for mining waste characterisation

Anna LADENBERGER[1]*, Geological Survey of Sweden (anna.ladenberger@sgu.se)
Ronald Arvidsson[2], Geological Survey of Sweden
Roger Hamberg[3], Geological Survey of Sweden
Stefan Sädbom[4], Lovisagruvan AB
Teemu Karlsson[5], GTK
Tero Korhonen[6], GTK
Erik Ronne[7], Boliden
Björn Wiberg[8], Geological Survey of Sweden
Christina NYSTEN[9], Geological Survey of Sweden
Per NYSTEN[10], Geological Survey of Sweden

Abstract

FUTURAM is a HORIZON EUROPE Research and Innovation project and one of its main objectives is to map the supply of Critical Raw Materials (CRM) obtained from recycling of six waste streams: batteries, electrical and electronic equipment, vehicles, mining waste, slag and ash, and construction and demolition waste. The project has 29 partners from 11 countries, encompassing geological surveys, universities, NGOs and research institutes as well as industrial partners.

Majority of the data required to understand effective management of raw material supply is available, but scattered amongst a variety of institutions, including government agencies, universities, think tanks, and industry, and need to be harmonised to be fit for use in Secondary Raw Materials (SRM) availability assessment.

FutuRaM aims to build state-of-the-art methodologies and harmonised datasets for mining waste initiated by the ProSUM and ORAMA projects and now with improved data from national and research projects. Furthermore, improvements in reporting practices are developed to communicate the viability of SRM recovery projects based on the United Nations Framework Classification for Resources (UNFC). FutuRam also considers economic, technological, geopolitical, regulatory, social, and environmental factors to further facilitate the future SRM recovery projects.

FutuRaM has an ambition to integrate SRM and CRM data available in the six waste streams to model current stocks and flows of the major CRMs. This is then utilized for scenarios of potential availability of future CRMs.

Mining waste case studies of tailings and waste piles have been chosen in Sweden, Finland, Serbia and France. Case studies of mining waste characterization have been designed to provide methodologies for stock and flow assessments, such as exploration techniques, waste characterization, waste processing and extraction technologies. recoverability processes, stakeholder interactions and even policy legislation. Site-specific case studies are also used to test the applicability of the UNFC methodology approach.

In Sweden, tailings in Laisvall, Adak and Kristineberg mines were drilled in the autumn 2022. The

sample aliquots have been sent for chemical analyses and SEM-based automated mineralogy was performed with help of QEMSCAN technique.
The waste piles in Håkansboda historical cobalt mine were sampled in the spring 2023. The randomly collected rock chips were sent as a series of bulk samples for chemical analyses and in situ mineral composition of the selected rock types was carried out with the microprobe. A larger, ca 100 kg composite sample was used for beneficiation tests at Geological Survey of Finland.
Preliminary results from tailings indicate that very high primary commodity contents (e.g., Cu, Pb and Zn) in tailings do not guarantee high amounts of associated trace metals identified as CRMs, e.g., In, Ge or Ga. At Håkansboda historical mine, the spatial distribution of metal high concentrations is heterogeneous and high metal concentrations can be found in the neighborhood of very low contents. This implies that pre-requisite knowledge of the primary ore composition and genesis may help to target the right waste sites for recovery projects as well as the detailed surveys are necessary to adequately evaluate the mineral potential and economic value of the waste.

Keyword

FutuRam, mining waste, waste rock, tailings, UNFC

Geochemical characterization of Rare Earth Elements and Rare Metal Potentials, Neoproterozoic, Peralkaline rhyolite of Malani Igneous Suite, Jodhpur, District, Rajasthan

Mukesh Kumar MISHRA[1]*, Geological Survey of India (mukesh.mishra@gsi.gov.in)
Mukesh Kumar Mandal[2], Geological Survey of India
Bijan Jyoti Barman[3], Geological Survey of India
Rohan Das[4], Geological Survey of India

Abstract

Geochemical characterization of Rare Earth Elements and Rare Metal Potentials, Neoproterozoic, Peralkaline rhyolite of Malani Igneous Suite, Jodhpur, District, Rajasthan

The acidic volcanic rock exposedin and around Tena village of Jodhpur district Western Rajasthan is considered as a part of Malani Igneous Suite of Neoproterozoic Age has resulted in enrichment of Rare Earth Elements (REE) and Rare Metal (RM).The analytical result of core samples and bed rock samplesshow encouragingvalue of total REE ranging from 2636 ppm to 5445 ppm with the mean value 3893 ppm, and rare metal such as Nb and Y. The maximum value of Nb is 605 ppm and Y 1231 ppm.The main REE bearing mineral phases hosted by acid volcanics are bastanesite, REE bearing ilmenite (titanium oxides), britholite (phosphate), parisite (carbonate), monazite (phosphate) and allanite (silicates).

The peralkalinefelsic volcanic magmatism predominantly contains a pink and grey coloured rhyolite, with a calc-alkaline affinity. The rhyolite showaphinitic to porphyritic texture and contains an assemblage mainly of glass and phenocryst of k-feldspar, quartz, hornblende and biotite. Sericite, muscovite and epidote is present as secondary mineral and allanite, zircon and apatite occur as accessory minerals. The opaque minerals (hematite and magnetite) are abundant. The inverse correlation of major oxides, especially CaO, Fe2O3, TiO2, Al2O3 and MgO against SiO2 suggest a magmatic differentiation of the parental melt. Whereas, alkalies K2O and P2O5 shows scattered trend against SiO2, probably suggesting the mobile nature of potash may be due to post-crystallization processes / fluid activity in the area. The chondrite normalized Rare Earth Elements (REE) patterns exhibits the highly fractionated LREE and nearly flat HREE and distinctive negative Eu anomaly. Spidergrams show similar peaks in which Nb negative Pb positive and Ti negative anomalies are observed. All these trace elements characteristics indicate feldspars, titano-magnetite and apatite fractionation and influence of some crustal component in these studied rocks.

Keyword

Malani Igneous Suite(MIS), acidic volcanic, calc-alkaline, Rare Earth Elements, Rare Metal

Unlocking the Exploration Potential of Critical Minerals in South Korea

Robert SMILLIE[1], Iondrive Ltd
Manuel Knorsch[2], RSC Ltd
Andrew Kim[3]*, Korea Metal Resources (andrew.kim@kmres.co.kr)
Hyosang Kim[4], Korea Metal Resources
John Ju[5], Korea Metal Resources
Michael Gazley[6], RSC Ltd

Abstract

Southern Korea is commonly considered “resources poor” in contrast to the northern Korean Peninsula. Recent and ongoing exploration by ASX-listed junior explorer Iondrive Ltd (ION), leveraging published South Korean government research and regional data sets, is rapidly changing this long-held view. A minerals system approach across the whole country narrowed down the most prospective areas following a review of the tectonic history, geology, structures, academic papers, government reports from the Korea Institute of Geoscience and Mining (KIGAM), geochemistry, geophysics, radiometrics, and historical mining activities. Focus was set on narrowing down the search space for REE carbonatite and alkaline intrusions and LCT pegmatite mineralisation. Two of the high priority projects are described below, with the Li project now under Joint Venture with KoBold Metals Ltd.

The Hongcheon carbonatite is the only mineralised carbonatite described in South Korea. The Hongcheon REE carbonatite dykes are 20–50 m wide, ~2,500 m long, and intrude Precambrian basement gneiss along the deep-seated Hongcheon Fault (Kim et al., 2016). The area surrounding the Hongcheon carbonatite along the Hongcheon Fault is highly prospective due to the presence of Th and magnetic anomalies, fenite alteration in outcrop along the Hongcheon river, continuity of the Hongcheon Fault, and sparse outcrop. SAU recently discovered mineralised REE carbonatite and ironstones within its licence areas along strike of the Hongcheon Fault up to ~6 km south of the known Hongcheon deposit.

LCT pegmatites at the Boam mine were mined for Li from 1945–1963. Analogous the Hongcheon carbonatite, the vicinity around the Boam Li mine is underexplored and further outcropping pegmatites within SAUs application licences (bordering the mine) were not analysed for their LCT affinity. The Uljin pegmatite swarms at Boam contain lepidolite and spodumene and intrude the Cambrian Janggun Limestone Formation (Choi et al., 2014). Iondrive's exploration licence applications cover metasediments including widespread amphibole gneiss surrounding the Boam Li mine, which are a favourable host rocks for LCT pegmatites. Further, the local Tonggo Granite is a fertile granite for producing Li mineralisation due to its low K/Rb (36.6) and Nb/Ta (2.6) ratios (Oh et al., 2022).

These two underexplored areas signify the immense REE, Li and other critical minerals potential

in South Korea and with further exploration the potential for securing new sources of future facing commodities.

Keyword

Lithium, REE, South Korea mineral potential, exploration

The Main Type, Characteristics And Genesis of Brine Li Deposits in China's Continent

Chenglin LIU[1]*, State Key Laboratory of Geological Processes and Mineral Resources,China University of Geosciences(Wuhan) (3055794019@QQ.COM)
Dianhe Liu[2], MNR Key Laboratory of Metallogeny and Mineral Assessment, Institute of Mineral Resources, Chinese Academy of Geological Sciences, Beijing100037, China
Xiaocan Yu[3], Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China
Kaisheng Xia[4], Faculty of Materials Science and Chemistry, China University of Geosciences, Wuhan430078, China
Zhen Yang[5], State Key Laboratory of Geological Processes and Mineral Resources, University of Geosciences, Wuhan430074, China
Qishun Fan[6], Qinghai Institute of Salt Lakes, Chinese Academy of Sciences, Xining810008 China

Abstract

Current lithium (Li) salts are produced dominantly from brines in the world due to the low cost of extraction, therefore, the brine Li resource exploration and development are favored by investors. The lowest industrial usage level of Li in brine is 50 mg/L in China. In order to explore more Li-rich brine resources, it is significant to do further research on the types and characteristics of reservoirs, ore-forming conditions and enrichment mechanisms of the brine Li deposits. Up to now, there are already determined four types of brine Li deposits in China, that is, modern salt-lake brine type, confined underground brine type, oilfield brine type, and finally geothermal brine type. The first type predominates in both Li reserves and Li contents, and their reserves have been basically verified, nevertheless the latter three types are explored and appraised in a lower degree. The second and third types are sometimes considered as one thing, and the second type is relatively more deserved to explore in the future. Modern salt-lake brine deposits are nearly distributed on Qinghai-Tibet Plateau, including Qarhan, Taijinaier and Yiliping salt lakes in Qaidam Basin, and Zabuye salt lake in northern Tibet etc. The first-type brine Li deposits were formed by the similar conditions and mechanisms: dry climate, replenishment of hot & warm spring waters that usually have a high Li content of n mg/L, and sustained evaporation in the Plateau environment. In many large-scale evaporite-bearing basins in China, such as Tarim, Qaidam, Sichuan and Jianghan basins, the waters separated from oil-water mixture fluids stored in pre-Quaternary strata usually contain some levels of Li, usually equal to or lower than 50-100 mg/L. On the other hand, the pure brines of confined aquifers in the petroleum-bearing strata or the no-petroleum basins contain relatively higher Li contents. Li in brines may be derived from interaction between the subsurface brine and the basalt/mudstone at temperatures of >120°C in the basins. The enrichment processes of Li in brines include: 1) brine evaporation in salt lake; 2) long time interaction between connate water and wall rocks in deep strata; 3) interaction of secondary brines (formed by atmospheric deep-circulation water dissolving ancient salt rock) with wall rocks having abnormal high Li background.

Keyword

Brine Li deposits, Salt lake, Evaporatic basin, Plateau, Interaction of water and rock

Geochemical Variations of Critical Elements in Angouran Zn-Pb Deposit, Iran: Insights from New La-ICP-MS Analysis

Mohammad AMINI[1]*, School of Geology, College of Science, University of Tehran, Tehran 1417614411, Iran. (mohammad_amini720@yahoo.com)
Abdoalrahman Rajabi[2], School of Geology, College of Science, University of Tehran, Tehran 1417614411, Iran.
Shojaeddin Niroomand[3], School of Geology, College of Science, University of Tehran, Tehran 1417614411, Iran.
Raza Nozaem[4], School of Geology, College of Science, University of Tehran, Tehran 1417614411, Iran.
Shahrokh Rajabpour[5], University of concepcion, Chile

Abstract

The world-class Angouran non-sulfide-sulfide Zn-Pb deposit is a significant zinc resource in Iran, situated in the Takab metallurgical province in northwestern Iran. The deposit contains verified and estimated pre-mining resources comprising 7.2 *million tonnes of sulfide ore with grades of* 21.08% *Zn*, 2.1% *Pb, and* 110 *g/t Ag, and* 17.4 *million tonnes of oxidized carbonate ores with compositions of* 22% *Zn and* 4.6% *Pb. This deposit is hosted within Late-Precambrian to Cambrian schists and metamorphosed carbonate rocks, overlain unconformably by a Neogene volcanic and sedimentary sequence. In this region, the Precambrian basement and the subsequent young Mio-Pliocene magmatism play a crucial role in controlling the metallogeny of Zn-Pb, Au, and Fe polymetallic mineralization. New La-ICP-MS analysis on different generations of sphalerite and galena, reveals notable discrepancies in the concentrations of some critical elements such as cadmium, germanium, gallium, cobalt, and indium among the different generations. Particularly, the early stage of sulfides displays significant levels of these elements, distinct from the subsequent generations. Moreover, the average concentrations of silver and stibnite within the galena are notably high, reaching* 678.56 *and* 884.52 *ppm, respectively. The geochemical variations in critical elements between the first stage of sulfides and the subsequent stages represent compelling evidence for their distinct origins.*

Keyword

Angouran, sulfide ores, critical elements, La-ICP-MS Analysis, Iran

The Critical Metal Potential of Pb-Zn Deposits in the Canning Basin: A case study of Goongewa, Lennard Shelf

Jenna McGovern[1]*, University of Queensland (jenna.hoy@uq.edu.au)
Steven Micklethwaite[2], Sustainable Minerals Institute, University of Queensland
Karen Connors[3], Sustainable Minerals Institute, University of Queensland
Gregory Webb[4], School of Environment, University of Queensland

Abstract

The global demand for the metals germanium (Ge) and gallium (Ga) has skyrocketed in recent years, leading to them being classified as critical metals. Despite the high demand and growing number of uses for these rare metals, an understanding on where and how Ga- and Ge- endowed deposits form is still relatively poor.

The Canning Basin in Western Australia is host to several known carbonate-hosted Pb-Zn deposits, which are thought to have formed at low (70°-110°C) temperatures, during compaction-related fluid mobilisation along structures such as fault zones. These deposits share characteristics with Mississippi Valley-Type (MVT) Pb-Zn deposits, and they have been previously classified as such. In other parts of the world, low temperature sphalerite in 'MVT'-like settings has been linked to enrichments in metals such as gallium and germanium, as well as indium (In). Though, no such analyses have been published on the base metal deposits in the Canning Basin (Lennard Shelf region or the Admiral Bay deposit).

Based on the above research gap, this study first documents the Ga and Ge content of samples from the Goongewa Deposit on the Lennard Shelf, then investigates the geochemical controls and mineralogical hosts influencing the concentration of critical metals. Several deposits within the Lennard Shelf have already been mined, but the waste material left behind could contain significant enrichments in these metals. It was found that at least one particular generation of sphalerite contained significant Ga enrichments. This presentation will present these findings and their implications for critical metal exploration in the wider Canning Basin and discuss the potential for trace metal associations to be used as a vectoring tool in similar geological settings, under cover and at depth. We will also examine the genetic drivers of metal enrichment in this under-studied, critical metal endowed region.

Keyword

Critical Metals, Geochemistry, Sphalerite, Exploration Geology, Carbonates

ECONOMIC COOPERATION BETWEEN SOUTH KOREA AND UZBEKISTAN ON CRITICAL METALS.

NAVRUZBEK JAHONGIR UGLI JURABEKOV[1]*, UNIVERSITY OF GEOLOGICAL SCIENCES (n.jakhangirovich@gmail.com)
Arofat Baxtiyarovna Xaydarova[2], UNIVERSITY OF GEOLOGICAL SCIENCES

Abstract

South Korea and Uzbekistan can develop economic cooperation in the field of critical metals. Critical metals are key elements for the production of various high-tech products, including electronics, automobiles, energy systems and drones. Both of these States have significant reserves of some critically important metals, and their cooperation can be mutually beneficial.

Uzbekistan is one of the world's largest gold producers, and also has resources of rare earth metals such as neodymium used in the production of high-power magnets. South Korea, on the other hand, is one of the leading manufacturers of semiconductors and electronics in the world and requires supplies of critical metals for its industry.

Within the framework of economic cooperation between South Korea and Uzbekistan, it is possible to conclude long-term agreements on the supply of critical metals. South Korean companies can invest in the development of Uzbek deposits and technological processes for the extraction and processing of these metals. In turn, Uzbekistan can gain access to new technologies and South Korean experience in the production and use of critical metals.

Such cooperation can contribute to the diversification of Uzbekistan's economy and promote its industrialization and modernization. It will also allow South Korea to ensure a stable supply of critical metals for its industry.

However, successful cooperation requires good infrastructure, legal and financial support, as well as the establishment of reliable trade relations and protection of investors' rights. The development of these aspects may be key to the successful implementation of the partnership between South Korea and Uzbekistan in the field of critical metals.

Keyword

Economics, Critical Metals, Rare Earth Metals, Mining, Production

Phoscorite as a possible source for phosphate and REE: A first report from Chaitma Alkaline Province, Korba district, Chhattisgarh.

NIBIN G TOM[1]*, GEOLOGICAL SURVEY OF INDIA (nibintom80@gmail.com)
TAPAN MOHARANA[2], GEOLOGICAL SURVEY OF INDIA

Abstract

Phoscorite is an exotic ultramafic rock that could serve as a repository for magmatic phosphate and rare metals, usually in association with REE-bearing carbonatites. The Chaitma Alkaline Province is a WNW-ESE trending tectonic domain in the southern part of Central Indian Tectonic Zone, hosting apatite diopside phoscorite (ADP) and syenite between Kadaihpara and Hathibari, Korba district, Chhattisgarh. The poly-deformed and poly-metamorphosed marginal terrain preserve granulite grade rocks and intrusive granitoids. Phoscorite-syenite and pyroxenite extend up to 1.5 km as discontinuous mapable units (250 m wide) in a vast expanse of hornblende granite and exhumed metamorphic rocks. A total of three compressional deformation episodes viz., D1 and D2 resulted in anatexis under amphibolite to granulite facies conditions. The mineral assemblage and reaction sequence indicate a clockwise P-T-t path, typical of collision orogen. The overall path was punctuated by underplating of magma manifested by sills/ dykes.

ADP is vari-textured and comprise of diopside, apatite (11 to 22%), actinolite, epidote, allanite, sphene, zircon and xenocrystic garnet. Biotite is developed along profuse mingling domain with syenite veins. Primary apatite is intercumulus to augite. Allanite-Ce, britholite-Ce, bastnasite-Ce, parasite-Ce and synchisite-Ce form moat around apatite; veins traversing plagioclase, actinolite and inclusion in biotite. Metamict zones are associated with higher modal biotite occurrence. Generally, phoscorite is intrinsically associated with carbonatites and syenite as reported around the world. In case of Chaitma, carbonatites are not associated. However, calcite occur in interstices associated with syenite veins.

High concentration of P2O5 (up to 5.2%), Ba (0.7%; RBa-tREO:0.61), Sr (0.5%) and REO (up to 0.5% tREO) are reported in bedrock samples of Chaitma phoscorite. Chaitma ADP also analyzed 1.86 to 11.62% MgO; 0.43 to 1.57% TiO2; 1.70 to 6.32% K2O; 5.53 to 16.73% CaO; [La/Sm]N range from 0.08 to 133.97 with a moderate negative Eu-anomaly. A total of 65 channel samples around Chaitma and Nunhapara yielded up to 0.3% tREO across 3m zone extending 400m. The phophatic zone assaying 4% over 2m marginally offsets the REO zones (R=0.40 to 0.57). Regolith samples (up to 1m) also analyzed 0.3% tREO (Max. 0.5%). Ore zones show coarse-grained phoscorite (diopside cumulate) with coarse needles of apatite (up to 3cm long), epidote and sphene.

Chatima Phoscorite melts are either derived from upper mantle during D2 deformation that were subjected to mingling and/or melt hybridization over a protracted period by subsequent mantle and /or crustal melts, possibly leading to phosphate-REE-Ba-Sr enrichment. This ADP unit exposed along the southern CITZ could be explored as a new source for LREE and phosphates, similar to Koppal phoscorite, Dharwar Craton of Southern India and Beldih occurrence in Puruliya,

Singhbhum Craton in Eastern India.

Chaitma Phoscorite could be preferred to phosphorite explored in the Mesoproterozoic Chhattisgarh Basin, Central India in terms of grade enhancement and intrinsic value due to co-occurring REE. Further, apatite, LREE-phosphate and carbonates could also be targeted in regolith zones over phoscorite making it an attractive proposition.

Keyword

Phoscorite, REE, Phosphate, Chaitma Alkaline

The study of Critical Raw Materials in the Czech Geological Survey

Michal Poňavič[1], Czech Geological Survey
Anna VYMAZALOVA[2]*, Czech Geological Survey (anna.vymazalova@geology.cz)

Abstract

Like other European countries, the Czech Republic supports intensive research on Critical Raw Materials (CRM) through research projects. One example is the Ministry of the Environment's "Environment for Life" programme. Within this programme, the Czech Geological Survey is working on one of the most important research project: „SS02030023 Rock Environment and Natural Resources RENS“. This project is divided into four research themes: Mineral Resources, Karst Groundwater, Geologic Hazards-Ground Instabilities, and Geologic Hazards-Mine Subsidence Districts.

Research on mineral resources is focused on the study of CRM, i.e. ore and mineral raw materials that are or might be of economic importance for the Czech Republic or the EU. Among the raw materials being studied, fluorite, graphite, lithium, manganese, copper, nickel, uranium, tungsten, gold and feldspar are of particular importance for the Czech Republic. Potentially important are the rare earth elements and germanium.

The study is focused on the research of newly discovered occurrences in our territory, and on further investigation of mineralogical, geochemical, physical and chemical properties of raw materials and the technology of their processing.

The research of newly discovered types of mineralization is mainly focused on the search and identification of Au-W raw material sources in the Moldanubic area (mainly historical districts); the evaluation of occurrences of rare earth elements in heavy minerals; the study of CRM in skarn ores; and the study of Ni mineralization in mafic and ultramafic rocks.

An important part of the study is the verification of the basic parameters for technological treatment of CRM with a particular focus on production of minimum waste and the development of new, environmentally friendly and low-energy methods of their treatment. The attention is mainly focus on germanium, graphite, lithium, tungsten, REE and gold.

Financial support through the project „Rock Environment and Natural Resource (RENS)”, No SS02030023 from the state support of the Technological Agency of the Czech Republic (Environment for Life Programme) is gratefully acknowledged.

Keyword

Critical raw materials, Czech Republic, Processing, Technology, REE

A review of China’s resources of lithium in coal seams

chao LIU[1]*, 01068999005 (1971076064@qq.com)
Zhao Ting[2], CAGS

Abstract

Lithium gains an increasing importance in new energy vehicles and stationary energy storage, and development and utilization of lithium mines has attracted great attention around the world. In addition to the traditional lithium resources,lithium resources in coal seams have great potential in industrial application. Therefore, how to develop and utilize them is strategically significant for guaranteeing supply of lithium resources in China and promoting clean energy transformation. This paper summarizes the metallogenic ages, occurrence,enrichment factors, availability of lithium resources in coal seams in China. Conclusion are obtained as follows. i. coal-hosted lithium deposits discovered in China so far mainly occur in the Carboniferous-Permian strata of North China.They are less concentrated in smaller range in the Permian strata ofQilian-Qinling. ii. In China, coal-hosted lithium is mainly enriched in aluminum-bearing minerals. Lithium in coal seams mainly occurs in the inorganic matter, and some occurs in the organic matter. iii. Lithium enrichment in coal seams is caused by stable supply of aluminum and lithium-bearing minerals and special structural and geological factors. iv. According to China’s national standards on grades of lithium content in coal seams, the metallogenic belts of lithium in coal seams at the southern foothill of Yin Shan and in Qilian-Qinling have the potential of lithium development and extraction, covering Junger mining area in Inner Mongolia, and Pingshuo and Ningwu mining areas in Shanxi.

Keyword

Lithium, coal, mineral

New developments for minerals discovery in the 21st century

Sandra Occhipinti[1]*, Commonwealth Scientific and Industrial Research Organisation
(sandra.occhipinti@csiro.au)
Discovery Program[2], Commonwealth Scientific and Industrial Organisation

Abstract

The mineral resources industry faces numerous challenges, including uncovering new deposits and extracting metals from diminishing ore grades. The most significant hurdle is orchestrating a global energy transition and addressing climate change while balancing mineral discovery, supply, and demand. This balance shapes commodity prices, employment rates, and research and development prospects. The demand for lithium (Li), copper (Cu), nickel (Ni), and critical minerals has surged, emphasizing the need for prompt action. Challenges present opportunities for collaboration between mineral resources companies, universities, and organizations like Australia's CSIRO. Our team is dedicated to addressing the major challenge of securing sustainable energy and resources for future generations. Collaborating across industry, government, and academia, we apply fundamental research to solve sector-wide issues, leveraging multidisciplinary teams.

Harmonizing expertise across key geoscience fields, regolith, geophysics, geochemistry, mineral mapping, and mineral systems, our emphasis lies in delving into the scientific aspects of emerging advancements (representing the "R" in R&D). Over recent years, we have revamped the applications of this scientific knowledge and incorporated new technologies, including software and machine learning (ML) approaches (constituting the "D" in R&D). These technologies, whether released or under development, are being made universally accessible, reflecting our commitment to global benefit.

To find mineral deposits we need to define new areas of exploration interest. Applying innovative processing techniques for mapping depth-to-basement utilizing geophysical data, plays a crucial role in defining this for practical exploration. These models not only accelerate exploration programs but also furnish comprehensive crustal profiles and images of the Mohorovičić discontinuity (MOHO), offering valuable insights into crustal development and the identification of metal transport zones.

Our teams are leveraging new satellite systems for determining Rare Earth Elements (REE), lithium and nickel prospectivity through mineral mapping. We use ML to interpret results effectively, facilitating the translation of mineral maps into ore deposit vectoring tools. In Australia, we are developing techniques to analyze the distribution of critical minerals, like REE, in both modern and ancient landscapes for further resource discovery.

At CSIRO, we are advancing geochemistry techniques, employing indicator minerals, whole-rock analysis, and mineralogy to detect footprints leading to mineral deposits. Our innovative tools, such as Ultrafine+®, 'Indicator minerals for nickel' (IM4Ni), and ML applications for rapid mineralogy, enhance exploration. We recently introduced a novel approach to delivering lithology

intervals using downhole hyperspectral data (MyLoggerTM). Integrating these data with geophysics and petrophysics is crucial for building robust models that delineate mineral deposits. This presentation will provide examples of these R&D outputs and demonstrate CSIRO's focus to translating scientific advancements into accessible applications, particularly in decision support. We provide greater certainty in mineral exploration and enhance planning for future metal extraction processes, meeting the global mineral challenges through innovation, collaboration and new technological solutions.

Keyword

Exploration, Discovery, Technology, Machine-learning, Critical Minerals

The evolving potential of the Australian REE ecosystem

Ignacio Gonzalez-Alvarez[1]*, CSIRO (The Commonwealth Scientific and Industrial Research Organisation) (ignacio.gonzalez-alvarez@csiro.au)

Abstract

Population growth and technological progress in the last 50 years have increased global demand for mineral resources by 400%. The fluid geopolitical, energy and technology context has made Rare Earth Elements (REE) some of the most strategic mineral resources for the near future.

The global economic reserves of REE have been estimated at 120,000 kt. The largest reserves of REEs are located in China (37%), Vietnam (18%), Brazil (18%), Russia (10%), India (6%) and Australia (3%). Whereas, the actual production is dominated by China (63%), the USA (12%), Myanmar (10%) and Australia (9%). The demand for Dy and Nd, as examples, is projected to increase by >2600% and >700%, respectively, within the next 25 years.

Rare Earth Elements are not rare and are not from Earth. REE form by supernova nucleosynthesis, and the concentration in the upper continental crust and Post-Archean Australian Shale average values are ~150 ppm and ~185 ppm, respectively (excluding Sc and Y). In addition, common wisdom proclaims that REE are immobile under most surface processes, which has been widely proven incorrect. The challenge is not only about finding REE, but also about detecting these deposits in geopolitically favourable areas, with acceptable extraction and concentration costs, minimal environmental impact, and positive social engagement.

Rare Earth Elements deposits can be classified as those associated with (i) magmatic and hydrothermal events at high temperatures (High-T), or (ii) weathering and sedimentary processes at low temperatures (Low-T). Carbonatites are presently one of the most prospective host rocks among these deposit types. Although, ion-adsorption REE deposits are showing signs of soon becoming a significant global source of REE.

From the view of REE exploration, detecting the presence and reducing the uncertainty about where to look for REE-mineralized host rocks, sedimentary environments or weathered landscapes would be a significant step forward. Defining the mappable proxies for mineralization and identifying the most favourable geological (High-T REE deposits) or landscape settings (Low-T REE deposits) is a fundamental framework for which we do not yet have clear answers. How to recognize fertile signs, as well as a deposit's geochemical and geophysical footprint? For example, the small size of carbonatite outcrops and footprints (~3 km2) makes them a difficult target. In addition, the limited availability of regional datasets with appropriate data density makes data analytical techniques challenging in most regions. Effective targeting requires a data analytics approach – combining geometrical, spectral, lithological, geochemical, and geophysical data sets

with knowledge about landscape evolution.

New paradigms are needed. Australia's potential for new discoveries of Low- and High-T REE deposits is massive. With a continental scale, deeply weathered cover blanket overlying most of the surface, the possible latent amount of Low-T REE deposits is phenomenal. Australia has the ability to become a fundamental supplier of REE for most leading technology global domains. However, this will be determined by how Industry, Government Research Institutions, and Universities integrate their efforts, support the REE exploration industry, and facilitate discoveries within the Australian context, and globally through key international collaborations.

Keyword

Rare Earth Elements, Mineral Exploration, Australia, Critical Minerals

Discovery of Ion-Adsorption Rare Earth Element Deposits by Geochemical Exploration in Southwestern China

ZHOU JIAN[1]*, Institute of Geophysical and Geochemical Exploration, Chinese Academy of Geological Sciences (zhoujianbisword@126.com)

Abstract

Rare Earth Elements (REEs), especially Heavy Rare Earth Elements (HREEs), are essential for high-tech industries and modern society. Geochemical methods are used to explore and delineate the targets of HREE-enriched deposits. A total of 9 REE-enriched geochemical provinces were delineated throughout China by Mapping Chemical Earth Program-China Geochemical Baselines project. The targets with 3.5 of LREE/HREE, similar to the ion-adsorption HREE-enriched deposits discovered in South China, located in Honghe, Yunnan province, southwestern China, were selected for follow-up geochemical surveys at scales of 1:250 000 and 1:50 000. A giant ion-adsorbed REE deposit with an average REE grade of 0.14% has been discovered by a drilling program. The ore bodies hosted in regolith range in depth from 2 m to 13 m, which developed from the parent rocks of Indosinian and Yanshanian granites and Proterozoic gneiss and leptynite, and are distributed at gentle slope areas. This is the first discovery of ion-adsorption REE deposits containing LREE (La, Ce, Pr, and Nd) and HREE (Gd, Tb, Dy, and Y) with economic and scientific value in south Yunan, China. This finding shows that global-, regional- to local-scale geochemical surveys by using wide-spaced, low-density, and high-density sampling to provide high-quality data of 16 rare earth elements is a cost-effective method to delineate targets for ion-adsorption HREE deposits.

Keyword

ion-adsorption REE deposit, geochemical survey, discovery, Southwest China

Detailed exploration targeting of LCT pegmatite deposits in the central-part of Rajasthan, India

Alok PORWAL[1]*, IIT Bombay (aporwal@iitb.ac.in)
Rajenderan Kalimuthu[2], NISER

Abstract

Given the recent surge in green technologies and battery metals, rare element LCT pegmatites play a crucial role in providing sustainable supplies of lithium (Kesler et al., 2012; Dill, 2015). As a result, these pegmatites are being explored and mined worldwide. Significant LCT pegmatite deposits, like those found in Tanco (Canada) and Greenbushes (Australia), hold valuable reserves of this metal (Partington et al., 1995; Steiner, 2019). Currently, new deposits are being explored globally. This study reports the results of a project-scale exploration targeting study for LCT pegmatites in the central part of Rajasthan, Western India. A project-scale mineralization model based on the field geological, petrological, geochemical and spectroscopic data was developed to identify the sources, pathways and the controls on the emplacement pegmatites. In addition to multivariate statistical techniques, Compositional Data Analysis techniques were applied to the geochemical data in order to identify the possible sources of the pegmatite fluids and also the vectors to lithium enriched zones within the LCT pegmatites. The study also explored the possible metallurgical techniques for extraction of lithium from lepidolite micas. The results helped in demarcation of the targets for exploratory drilling. This is the first study focused on systematic exploration of lithium bearing pegmatites in India.

Keyword

Critical metals, Exploration targeting, Com[positional data analysis

A Preliminary Overview of the Metallogenetic Provinces of Southern Angola

Enrique Merino Martínez[1]*, Instituto Geológico y Minero de España (IGME-CISC)
(e.merino@igme.es)
Maria João Batista[2], Laboratório Nacional de Energia e Geologia (LNEG)
Iván Martín Méndez[3], Instituto Geológico y Minero de España (IGME-CISC)
Daniel de Oliveira[4], Laboratório Nacional de Energia e Geologia (LNEG)
MariCarmen Feria[5], UTE-PLANAGEO (IGME/LNEG/Impulso)
Carla Fortes[6], Laboratório Nacional de Energia e Geologia (LNEG)
Catia Prazeres[7], Laboratório Nacional de Energia e Geologia (LNEG)
José Luis García Lobón[8], Instituto Geológico y Minero de España (IGME-CISC)
Jose Manuel[9], Instituto Geologico de Angola (IGEO)

Abstract

The distinct mineralisations found in the Republic of Angola make it an area of significant interest due to its metallogenic potential. These occurrences often have a spatial distribution and form mineral associations related to specific geological areas and environments. However, given the growing global demand for mineral resources, it is crucial to comprehend a country's regional mining potential. This knowledge is essential for effective territorial planning and future exploration and research of its resources. For this reason, the Government of the Republic of Angola, through the Ministry of Natural Resources, Oil and Gas (MIREMPET) and the Geological Institute of Angola (IGEO), implemented the National Geological Plan of Angola (PLANAGEO, 2014-2022). The main aim of PLANAGEO was to establish a detailed and comprehensive geological framework, facilitating a thorough interpretation of the identified geophysical and geochemical anomalies, as well as the geological processes responsible for the recognised mineralisations.

The UTE PLANAGEO consortium, comprising the Geological and Mining Institute of Spain (IGME), the National Laboratory of Energy and Geology of Portugal (LNEG), and the Spanish company Impulso Industrial Alternativo (IIA), conducted numerous geological, geophysical, and geochemical mapping surveys in the southern region of the country, covering an area of around 480,000 km2. One of the most important results of the project was the Metallogenetic Map of Southern Angola at a scale of 1:1,000,000. This map provides a summary of the mineral resources of the country and proposes, for the first time, a preliminary approach to the distribution of metallogenetic provinces in the southern region of Angola. These regions are characterised by mineral resources of potential interest, clearly defined and associated with a geological context, that may or may not be genetically related.

The southern region of Angola comprises five major metallogenic provinces, with metallogenic eras ranging from the Neoarchaean to Cretaceous times: i) the metallogenetic province of Au-Fe, mainly related to BIF-type deposits; ii) the metallogenetic province of Cr-Ni-PGE, associated with distinct Proterozoic mafic to ultramafic bodies; iii) the polymetallic metallogenetic province of the Kunene Complex (KC); iv) the metallogenetic province of Cu, related to various hydrothermal

mineralisation events and the Copper Belt of the Lufilian Arc, covered by the Kalahari Basin; v) and the metallogenetic province of Nb-Ta-REE, represented by Cretaceous alkaline-carbonatite structures and selected granite pegmatite fields.
Hence, this work presents an assessment of the metallogenetic potential of the southern region of the Republic of Angola, discussing the various mineral resources within a regional geological context. Although this work focuses on mineral resources that involve natural processes of concentration and/or whose deposits represent an anomaly in the crust, it also includes the potential interest for the exploration of industrial rocks and minerals and ornamental rocks. The primary aim of the metallogenetic map is to offer fundamental knowledge for future mining research planning and to promote the socio-economic development of the country based on the sustainable use of its natural resources. This will favour intra- and inter-community trade relations and have a direct benefit on the economic development of the country.

Keyword

Metallogeny, Mineral resources, Metallogenetic provinces, Angola, PLANAGEO

Uranium Exploration targeting in the Mineral System Approach

Patrick LEDRU[1]*, University Lorraine (patrick.ledru@univ-lorraine.fr)

Abstract

As a High-Field Strength Element, uranium is present in a wide variety of deposit types. The extreme mobility of uranium in oxydizing conditions has strong control on mineralization distribution and preservation. Thus, the footprints are highly diversified and the application of ore deposit models often inappropriate as the genetic models may be unknown or poorly constrained. The mineral system provides an innovative approach that has already been documented on unconformity-related uranium deposits and can be generalized to other environments like sedimentary basins.

In order to explore mineral systems, critical elements for the source, the architecture, the energy source and the trap can be defined by identifying the significant geo-objects and processes, favorable ingredients and spatial proxi. For example, in unconformity-related deposits, the source geo-objects are radioelement-rich lithologies in the basement and the basin, brines and interaction between superficial and deep-source fluid being favorable ingredients while geochemical assessment of lithologies and fluid inclusion constitutes a proxi for targeting at the regional scale. The energy source is critical as fluid flow in inherited or reactivated permeable structures (the process) requires thermal and mechanical gradients that can be traced by fluid-rock interaction (the favorable ingredient), absolute and relative geochronology and detailed mineralogical and structural analysis defining the footprint (the spatial proxi).

The translation of these critical elements to an exploration strategy requires a multiscale approach using different methods of investigation: planning and reconnaissance exploration at the regional scale, follow-up and detailed exploration at the camp and prospect scales, advanced exploration at the deposit scale. In the case of sandstone-hosted uranium deposits, the knowledge of the hydrological and hydrogeological systems will be envisaged at an early stage at the regional and camp scale as it will condition the feasibility of in situ recovery in low-grade uranium enriched permeable strata. At the prospect and deposit scales, ore body delineation, resource estimation and monitoring of the water table will be requested for the valorization of resources into reserve following detailed and advanced exploration.

This systemic approach benefits directly of our ability to integrate in a stable georeferenced data system historical data, information resulting from a combined knowledge and data-driven project generation, geological, geophysical and geochemical datasets collected at all stages of exploration and geomodels processed on the fly. The concept of common/shared earth model aims at reconciling all data sets in 3D geometrical model in which the ore deposit and its properties are defined. Keeping in mind that the first evaluation of the critical elements and spatial proxies may be revised depending of the exploration results and that each new drill hole or geophysical model will reduce the uncertainty of this model is a paradigm shift for exploration. Recent recognition of the role of nuclear energy in in the energy mix has boosted uranium exploration project generation

and several case studies based on GIS-based prospectivity approaches and machine learning illustrate this approach.

Keyword

mineral system, uranium, exploration strategy, common earth model

Indonesian Critical Mineral and Energy Transition

Muhammad Wafid AGUNG NOVIANTO[1]*, Geological Agency, Ministry of Energy and Mineral Resources, the Republic of Indonesia (m.wafid@esdm.go.id)

Abstract

Indonesia stands at the forefront of addressing the surging global demand for critical minerals essential for diverse sectors such as defense, aerospace, and renewable energy. With abundant reserves of key minerals like nickel, bauxite, and copper, alongside the promising potential of natural hydrogen, Indonesia is strategically positioned to capitalize on this burgeoning demand. Through proactive measures aimed at fostering an investment-friendly ecosystem, such as the Critical Minerals Accelerator Initiative and strategic international collaborations, Indonesia is poised to emerge as a dominant force in the critical minerals market. These initiatives not only aim to boost economic growth and job creation but also underscore Indonesia's commitment to meeting global mineral demands sustainably.

Concurrently, Indonesia's Geological Agency is spearheading efforts to explore and harness green energy commodities crucial for the country's energy transition. By prioritizing the evaluation of resources like iron sand, manganese, natural hydrogen, and rare earth elements, the agency is dedicated to translating discoveries into optimized resource extraction. Through a multifaceted approach encompassing targeted exploration endeavors, synergistic partnerships with industry stakeholders, and the application of cutting-edge exploration methodologies, Indonesia is steadfast in its mission to fortify the resilience of its mineral and coal resources. These endeavors not only contribute to the nation's energy security but also align with broader global clean energy imperatives.

By investing in strategic initiatives, bolstering international partnerships, and prioritizing exploration and extraction optimization, Indonesia is charting a course towards becoming a global leader in critical minerals. These concerted efforts not only promise to stimulate job creation and economic prosperity but also reinforce Indonesia's standing as a key player in the global marketplace. As Indonesia navigates challenges such as supply chain vulnerabilities and technical complexities, its unwavering commitment to sustainable mineral resource management remains paramount, ensuring a prosperous and resilient future in the ever-evolving global landscape.

Keyword

Critical minerals, Energy transition, Renewable energy, Strategic partnerships, Resource extraction optimization

Geochemical vectors to LCT pegmatites: the compositional data analysis approach.

Bijal Chudasama[1]*, Geological Survey of Finland (bijal.chudasama@gtk.fi)

Abstract

Exploration of LCT (Lithium-Cesium-Tantalum)-pegmatites is challenging because of their non-distinctive signature in standard geophysical datasets such as airborne magnetics, electromagnetics and gravity. Geochemical data, therefore, is an important exploration dataset for targeting REE deposits related to LCT-pegmatites. These encompass elemental analysis of surface and/or bedrock samples using different analytical methods such as XRF, ICP-AES/MS. However, the multi-elemental analytical data obtained contains detections of elemental concentrations relative to each other. Hence, geochemical data is compositional in nature and therefore contains a constant sum constraint. Although, multivariate statistical analysis of analytical geochemistry data serves as an important tool for geochemical characterization of a region and subsequent identification of geochemical vectors; due to the compositional nature of geochemical data, there occur spurious correlation effects and negative bias relationships between the analyzed elemental concentrations. Hence standard statistical multivariate data analysis methods, based on assessing correlations in a Euclidean space fail to represent the true relations between the elements.

In this study, based on a large-scale whole rock geochemical data, we present a critique of conventional Euclidean distance, and recommend multivariate statistical analysis of whole compositions as well as sub-compositions associated with Li, Cs and Ta (a) in real space based on log-ratio-based transformed data obtained from compositional data procedures and (b) in simplex space using simplical metrics. Multivariate statistical methods based on log-ratio transformations and simplical metrics equitably map the proportionality relations of the compositions and sub-compositions in compositional datasets. Mathematical implications of the above procedures and their manifestation in the statistical results is deduced. Finally, the study identifies anomalies for geochemical characterization of (i) elements with respect to the host lithological units of LCT pegmatites and (ii) elemental signatures vectoring to LCT pegmatites, that have significance towards exploration of critical metals hosted in LCT pegmatites. The geochemical anomalies show correlations with regional structures, indicating underlying structural controls on pegmatite emplacement. This review and analysis have implications for LCT pegmatite exploration globally.

Keyword

LCT pegmatites, compositional data analysis, critical metals, geochemical data analysis, Li-Cs-Ta and REEs exploration

Critical-metal related alteration mineral mapping using hyperspectral data: A new approach using ensemble of Support Vector Machines and Extreme Value Theory

Sandeepan DHOUNDIYAL[1]*, Indian Institute of Technology Bombay (sdhoundiyal@iitb.ac.in)
Alok Porwal[2], Indian Institute of Technology Bombay

Abstract

Hyperspectral data have been instrumental in the identification and mapping of a wide variety of hydrothermal alteration minerals. However, despite their utility, the hyperspectral data remains underutilized due to the significant manual intervention necessary in traditional methods of analysis.

Recently, a variety of machine learning-based methods have been developed to map minerals from hyperspectral data. However, these methods are limited by the need for complex pre-processing or manual feature selection. Furthermore, these algorithms are designed for closed-set mineral identification, which assumes that only the classes seen during training would be encountered during testing/mapping. This is a significant limitation, as a classifier needs to accurately detect samples from previously unseen classes ('outliers') to both mitigate false positives and facilitate the detection of previously unreported minerals in an area.

Therefore, a novel method for identifying minerals from AVIRIS data under an open-set classification regime is proposed. The proposed algorithm then uses an ensemble of Support Vector Machine (SVM) classifiers, each trained over a random subset of fifteen AVIRIS bands, to identify alteration minerals under a closes-set regime. Thereafter, class-wise Weibull distributions (fitted over true positives from the validation set for which the ensemble had the least confidence) are used to predict the probability of an unknown spectrum belonging to an unknown class based on its average distance from the separating hyperplane (the decision boundary learnt by the SVMs).

This algorithm is tested over labelled spectra from the AVIRIS where it performed better than existing machine-learning methods for identifying minerals from hyperspectral data.

The pre-processing consists of (i) denoising; (ii) continuum removal; and (iii) l2-normalization. It facilitates

mineral identification by eliminating variance in the data due to illumination conditions and physical
factors (such as abundance and grain size) while enhancing compositional information.
In its current iteration, the trained model can identify a large variety of clay, silicates and carbonate
minerals (including but not limited to olivine, pyroxenes, phyllosilicates, carbonates, and sulfates), and can
be used to accurately map minerals from AVIRIS data. It may also be used to classify other hyperspectral
datasets.

Keyword

Alteration mapping, AVIRIS, Machine learning

Cassiterite trace element discrimination plots for critical mineral exploration

Avish Avnith KUMAR[1]*, James Cook University (avish.kumar@jcu.edu.au)
Ioan Sanislav[2], Economic Geology Research Centre, James Cook University
Huiqing Huang[3], Advanced Analytical Centre, James Cook University
Paul Dirks[4], Economic Geology Research Centre, James Cook University

Abstract

Cassiterite is a weathering-resistant mineral which can incorporate a variety of trace elements into its crystal structure. To differentiate cassiterite from different sources, trace element data were collected from seven tin fields worldwide. Laser ablation-inductively coupled plasma- mass spectrometry (LA-ICP-MS) was used to measure trace elements from twelve deposits in the Herberton Mineral Field, Australia. These results were combined with published data from six other tin fields, including the Andean Sn belt in South America; the Karagwe Ankole belt in Rwanda; and, from China, the Kangxiwa–Dahongliutan pegmatite field, the Youjiang basin, the Nanling belt and the Da Hinggan Range belt. These deposits in the dataset were categorized into four types: 1) greisen and veins; 2) skarns; 3) Li-Cs-Ta pegmatites; and 4) polymetallic veins. The trace element dataset was analysed using basic descriptive statistics, principal component analysis (PCA), and cluster analysis. Cassiterite grains from greisen and vein deposits are characterized by high concentrations of Ti (avg. 1751 ppm) and moderate concentrations of Al (avg. 97 ppm), whereas cassiterite grains from skarn deposits generally contain lower concentrations of Ti and Al. The cluster analysis allowed us to define compositional boundaries in the trace element dataset. These boundaries differentiate cassiterite grains from different sources. Relative enrichment of Al and Ti in cassiterite was observed in rocks altered by greisenization reactions. This is common in greisen and vein, and skarn deposits. Hence, the Ti vs. Al diagram can be used to differentiate cassiterite grains derived from greisen and vein, and skarn deposits. The Sb vs. V diagram was identified to be useful in differentiating cassiterite grains from polymetallic veins. Zirconium and Nb concentrations are useful in identifying cassiterite grains sourced from LCT pegmatite deposits. The discrimination diagrams developed in this study through cluster analyses indicated that cassiterite grains sourced from different deposit types can be differentiated based on their trace element geochemistry. Thus, cassiterite geochemistry (e.g., stream sampling) can be used in exploration to identify deposit types and provide insight into mineralization processes that are present in a region.

Keyword

Cassiterite, Critical metals, Cluster analysis

Regional-scale exploration targeting of Rare Earth Elements associated with carbonatite-alkaline complexes: a comprehensive prospectivity study in northwestern India

Malcolm Aranha[1]*, Oulu mining school, university of Oulu (malcolm.aranha@oulu.fi)

Abstract

Rare earth elements (REEs) are vital for future industrial growth and are found concentrated in rare igneous rocks called carbonatites, often associated with alkaline complexes. India hosts around 30 carbonatites, categorised into four domains based on their spatio-temporal and tectonic associations -– (1) Northwestern domain (Indo-Seychelles-Madagascar split and the passage of greater India over the Reunion hotspot, producing the Deccan LIP); (2) Northeastern (breakup of Greater India from Australia-Antarctica driven by the Kerguelen mantle plume that also produced the Rajmahal-Sylhet LIP); (3) Southern (comprising of two sub-domains – Paleoproterozoic sub-domain related to extension due to relaxation after the SGT-Dharwar accretion and the Neoproterozoic sub-domain related to the fragmentation of Rodinia); and (4) Southeastern domain (fragmentation of Columbia).

India's REE production mainly relies on secondary monazite-bearing beach placers, but the potential of sourcing REEs from carbonatite-alkaline complex-related deposits remains largely untapped. This study in India's Northwestern carbonatite domain utilises Fuzzy Inference Systems (FIS) and Self Organising Maps (SOM) to assess REE prospectivity. FIS, a supervised, knowledge-based AI technique, identified targeting criteria for REE deposits using a conceptual mineral systems model. The main components of the mineral systems model are: (1) pockets of metasomatised subcontinental lithospheric mantle (SCLM) which form fertile source regions for REE-bearing fluids; (2) extensional geodynamic settings; (3) permeable lithospheric architecture for tapping REE-enriched fluids from the SCLM and focusing them to near-surface levels, and (4) post-emplacement tectonic regime that preserves the deposits. Spatial analysis tools mapped these criteria to assess prospectivity at different probability and confidence levels, considering systemic uncertainties via Monte Carlo simulations and stochastic uncertainties through subjectively defined confidence values. REE prospectivity was mapped at three probability levels, draped over a confidence layer. SOM, an unsupervised machine learning algorithm, autonomously analysed geophysical and topographical datasets to identify prospective areas, corroborating FIS results. The SOM workflow eliminated human bias and time-consuming, labour-intensive data pre-processing by not using any interpreted, processed or manually generated data; instead, it relied on the algorithm to identify crucial features to delineate prospective areas.

Primary findings of the study include recognising REE-fertile domains in India based on common tectonic and spatiotemporal relations among carbonatite-alkaline complexes and validating SOM as a reliable, efficient tool for prospectivity modelling, particularly in unexplored regions. The study pinpointed several high-prospective areas in the Northwestern Domain, recommending detailed ground exploration at Kamthai-Sarnu-Dandeli and Mundwara and its immediate

surroundings. Further exploration suggestions were made for the Siwana ring-complex region and adjacent areas.
This research presents a comprehensive, mathematically-driven prospectivity analysis for REE deposits associated with carbonatite-alkaline complexes, offering a systematic two-fold approach applicable to similar geodynamic settings globally.

Keyword

Rare earth elements (REE), Exploration targeting, Fuzzy inference systems, Self organising maps, Northwest India

Exploration targeting of northern Finland for CRMs hosted in ultramafic-mafic orthomagmatic intrusions

Malcolm Aranha[1]*, Oulu mining school (malcolm.aranha@oulu.fi)
Hanna Silvennoinen[2], Sodankylä Geophysical Observatory
Shenghong Yang[3], Oulu mining school

Abstract

Orthomagmatic mafic and ultramafic intrusions are valuable sources of critical raw materials (CRMs) such as nickel (Ni), cobalt (Co), platinum group metals (PGMs), vanadium (V), and copper (Cu) which are in high demand for modern industries and considered strategically important by the European Union. Given the projected increase in demand and potential shortages, local production of these materials is essential.

Northern Finland is recognised for hosting such CRMs in two types of ultramafic- mafic intrusions: conduit-type deposits, rich in sulphides of Ni-Cu-(PGM)-(Co), and layered mafic intrusion type, with relatively lower sulphide content and containing PGM-Cr-V-(Co)-(Ni)-(Cu). This study employs computer-based prospectivity analyses for both deposit types, utilising Fuzzy Inference Systems (FIS), a knowledge-based artificial intelligence technique.

The FIS models rely on generalised mineral systems models for each deposit type to identify targeting criteria. For conduit-type deposits, the mineral system model includes (1) Primitive, mantle-derived, magnesium-rich rocks (ultramafic and mafic rocks), serving as metal sources; (2) trans-lithospheric faults and chonoliths acting as magma pathways, locally enhanced by varying compressional/extensional tectonic regimes; and (3) dilatational zones of high, fracture-related permeability and localised structures that physically trap the mineralising fluids; along with abundant sulphur-rich crustal rocks serving as chemical traps, providing external sulphur required to form immiscible sulphide melts. Layered mafic intrusion-type deposits have similar mineral systems models but differ in the trapping mechanism within the cratonic lithosphere, where they form large magma chambers forming a layered sequence of ultramafic to mafic rocks due to fractional crystallisation under low regional stress and limited magma-induced sagging. Reef-style mineralisation between the lower ultramafic zone and the upper mafic zone and among mafic rocks is typical; however, contact style or marginal style at the base of the intrusion is also known to occur.

Spatial proxies representing critical processes of each mineral system were mapped from various geoscientific datasets in the form of GIS predictor maps. This study has attempted new innovative predictor maps utilising previously underused datasets such as three-component seismic models. All predictor maps, including the innovative ones developed in this study, were incorporated into the FIS models to generate prospectivity maps. The results effectively distinguish between the two deposit types and highlight promising regions for further exploration, demonstrating the approach's utility in targeting CRM-rich areas.

Keyword

Orthomagmatic deposits, layered mafic intrusions, conduit type, knowledge-driven prospectivity, Northern Finland

Criteria for forecasting and assessment of tin-tantalum-lithium mineralization in Eastern Kazakhstan

NataLya ZIMANOVSKAYA[1]*, D. Serikbayev East Kazakhstan technical university
(nata_zim@mail.ru)
Gulizat Orazbekova[2], Shakarim University
Aizhan Tretyakova[3], KazGeoExploration LLP
Asem Muratova[4], D. Serikbayev East Kazakhstan technical university
Yuriy Belov [5], KazGeoExploration LLP
Nadine Saib [6], Kepler group LTD, Chief Geologist
Arailym Amrenova [7], D. Serikbayev East Kazakhstan technical university

Abstract

Currently, there is an urgent need to strengthen the mineral resource base for rare metal production in the region. Subsoil users are becoming more interested in rare metal objects from Kalba-Narym metallogenic zone in Eastern Kazakhstan due to the growing demand for rare metals globally, especially lithium. One of the promising areas is the practical assessment of “non-pegmatite” rare metal mineralization (Ta, Nb, Be, Li, Sn, etc.) associated with albitized and greisenized granites. Reassessment of a special type of lithium-bearing albite-spodumene pegmatites associated with small intrusions (plagiogranitoids) and dikes of the Kunush complex is also relevant. Similar objects are found in the Karagoin-Saryozek ore zone and are characterized by tantalum-poor and spodumene-rich content. The unconventional type includes both greisen-quartz vein mineralization (Sn, W), superimposed on small intrusions of plagiogranites, and dikes of the Kunush complex under the influence of rare metal-bearing granites of the Kalba complex. All these types can be an additional source of rare metals and should be considered in geological exploration practice.

The main criteria for forecasting and searching for albite-greisen (apogranite) type of tin-tantalum-lithium mineralization were determined during the investigation: 1) favorable geological and structural position of the formation of rare metal objects (supra-intrusive zones, apophyses and domes of hidden granite massifs, recorded by geological and geophysical data); 2) intensive changes in sedimentary rocks in the supra-intrusive zones of hidden granite domes (brecciation, exfoliation, albitization, tourmalinization, fluoritization, sulfidization and quartzification); 3) spatial-genetic connection of lithium-bearing albitite-greisen metasomatic rocks with phase II granites of the Kalba complex based on the gradual transitions established between them; 4) close absolute age of granites of the second phase and lithium-bearing granites; 5) intensive metasomatic transformation of granites (albitization, greisenization, fluoritization, qurtzification) with the introduction of F, Li, Sn, Ta and other elements; 6) mineralogical searching indicators of mineralization (albite, zincvaldite, lepidolite, topaz, fluorite), lithogeochemical anomalies of Li, Rb, Cs; 7) the areal nature of the distribution of rare metal mineralization (Li, Sn, Ta), which increases the prospects of rare metal lithium-fluoride granites in general.

In regional terms, considering the belt distribution of rare metal structures and deposits, it is

advisable to study reserve territories located on the flanks of the Kalba-Narym belt and significantly covered by a cover of loose Meso-Cenozoic sediments. These areas are promising for identifying hidden and buried deposits of various geological and genetic types, including unconventional types of raw materials. To implement forecasts and increase the efficiency of geological exploration work at the present stage, it is necessary to increase the depth of geological study of the territory in the most important mining areas of Kalba and other territories.This research has is funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant N°APAP23484205).

Keyword

criteria, forecast, search, rare metals, East Kazakhstan

Machine learning approach to predict distribution of critical elements : REE + Y contents in the Iranian karst-type bauxite deposits

Maryam KHOSRAVI[1], Department of Mining Engineering, Isfahan University of Technology, Isfahan 84156-83111, Iran
Ouafi AMEUR-ZAIMECHE[2], Laboratoire des Réservoirs Souterrains: P´pétroliers, Gaziers et Aquif`eres, Université de Ouargla, 30000, Algeria
Rabah KECHICHED[3], Laboratoire des Réservoirs Souterrains: P´pétroliers, Gaziers et Aquif`eres, Université de Ouargla, 30000, Algeria
Ali ABEDINI[4], Department of Geology, Faculty of Sciences, Urmia University, 57561-51818 Urmia, Iran
Abdelhamid OULADMANSOUR[5], Department of Earth and Geoenvironmental Sciences, University of Bari Aldo Moro, via Orabona, 4, 70125 Bari, Italy
Giovanni MONGELLI[6]*, Department of Sciences, University of Basilicata, viale dell'Ateneo Lucano 10, 85100 Potenza, Italy (giovanni.mongelli@unibas.it)

Abstract

A recent resource challenge is to guarantee supplies of Critical Raw Materials (CRMs) that perform essential functions in modern engineered materialss, but are subject to short-term supply risks or concerns about long-term availability. According to the latest European Commission Report on CRMs the definition of CRMs applies to several elements, including REE. In the last decade efforts have been devoted to assess the distribution of CRMs in the Iranian karst-type bauxite deposits with a peculiar focus on the distribution of REE. The Iranian bauxite deposits that are deposited within karstic depressions and sinkholes of underlying carbonates, belong to the Irano-Himalayan karst-type bauxite belt, and are similar to the Mediterranean-type bauxites. Mineralogical and geochemical studies on the northwestern Iranian karst bauxite deposits revealed the intense, long-term weathering of parent rocks, mainly of a mafic protolith, generally associated with warm periods of the middle-late Permian, Permo–Triassic, middle-late Triassic, and late Triassic-early Jurassic as wel. This study employs machine learning algorithms to predict contents of REE and Y , as well as the subsets of light REE (LREE: La-Sm) and heavy REE (HREE: Eu-Lu). The prediction models utilize major elements and geochemical indices, specifically the Chemical Index of Weathering (CIW) and the Chemical Index of Alteration (CIA). The dataset underscores the distinct fractionation behavior between LREE and HREE, necessitating separate prediction models. For LREE predictions, the optimal input features indicate a strong and positive correlation between all major elements and CIW (R^2 = 0.85). Conversely, for HREE predictions a strong positive correlation between major elements and CIA (R2=0.82) is observed. Interestingly, the optimal input combination for predicting REE and Y contents is consistent with LREE predictions, emphasizing the dominant influence of LREE on overall trends (R^2 = 0.87). Customizing input features to specific REE subsets enhances prediction accuracy and also acknowledges the distinct behavior and correlations between LREE and HREE. The study underscores the significance of incorporating geochemical indices for predicting REE contents and for considering the role of geological processes during bauxitization. These insights contribute

to the development of robust prediction models, the significance for efficient resource evaluation, exploration, and the understanding of geochemical parameters controlling REE distribution in different geological settings.

Keyword

Iranian karst-type bauxite deposits, Critical Raw Materials, Rare Earth Elements, Machine learning

LocatOre: Mineral Exploration and Vectoring Software

Stephen Alexander COOKE[1]*, University of Tasmania (SA.Cooke@utas.edu.au)
Matthew J CRACKNELL[2], University of Tasmania
Michael J BAKER[3], University of Tasmania
Lejun ZHANG[4], University of Tasmania
David R COOKE[5], University of Tasmania
Ivan BELOUSOV[6], University of Tasmania

Abstract

LocatOre is a new software platform we have developed that enables analysis and estimation of the locations of magmatic heat and fluid sources of porphyry copper deposits. LocatOre employs knowledge-driven and data-driven approaches to logarithmic linear regression to help predict ore-body locations.

Proximitor equation (knowledge-driven) based trace element chemistry of hydrothermal alteration minerals are analysed to generate 2-D and 3-D models that assess converging distance to heat and fluid source estimates. The software attempts to determine the likely location of the source intrusion that supplied the hydrothermal fluids responsible for the mineralisation. Generation of randomly placed “potential” heat sources allows for mass-testing (data-driven) by identifying the most likely location of an ore-body based on the regression of distances from each ore sample to the relevant mineral concentrations of those samples. These heat sources can be filtered according to their R2 values to highlight those where a strong correlation exists between the two variables. Forward-feature-selection searches can be conducted to identify the most influential elements to the heat regression process.

LocatOre enables the manipulation, interrogation, 3-D visualisation, and interpretation of geochemical data obtained from rocks and minerals with the end goal of helping improve mineral exploration success. It is designed for ease-of-use such that users who may have otherwise struggled with geochemistry vectoring calculations can perform them easily and rapidly to identify potential exploration targets. Furthermore, interactive visualisation enables users to understand how these targets may fit in to the broader context of the study site in question with an accessible and intuitive control scheme.

Keyword

LocatOre, Mineral exploration, 3-D Visualisation

The characteristics and use of calcrete as a sample medium for gold exploration in the Karibib area

NAILOKE SHALI[1]*, Osino Gold Exploration and Mining Pty Ltd (nailokeshali24@gmail.com)

Abstract

Calcrete are secondary carbonates dominantly composed of calcite and dolomite formed as a result of climatic fluctuations in semi-arid and arid regions. Several studies in Australia have shown significant occurrences of gold in calcrete which have proven calcrete sampling to be applicable in exploration. In Namibia, the use of calcrete as a sample medium for gold exploration has never been applied before and only now it is being tested by Osino Resources Corp in the Karibib area. The Karibib area is covered by extensive calcrete cover and using calcrete to find gold deposits can be a potential method to establish gold occurrences. Through geophysical anomalies, Osino Resources discovered a new gold trend, now termed as the Karibib Fault, located south west of Twin Hills prospect, one of Osino Resource's gold prospects. Several methods have been proposed to guide in exploration of tracing gold along this gold trend. The methods include soil sampling which revealed a gold anomaly and this was followed up by a calcrete sampling programme and results showed presence of gold concentrations within the calcrete. Nonetheless, the occurrence of gold in the calcrete along the newly discovered Karibib Fault is not well understood and more studies are required to establish the controlling factors of gold mineralization in this area. This project is aimed to show how sampling calcrete as an exploration technique can be used to facilitate the discovery of gold deposits in calcrete covered terrains and to establish how gold values vary with each type of calcrete. Classification of calcrete is necessary in order to interpret the occurrences of gold in calcrete. As part of this study, field work was carried out and this includes pit mapping and sampling, which was necessary to map out the types of calcrete and compare the gold values in each type of calcrete. Mapping of surface calcrete outcrops was used to identify the different types in the area and come up with a conclusion on the environment of formation. Drill core logging and sampling was employed to identify the different types of calcrete and see how gold values vary with depth and with each type of calcrete. Based on observations and geochemical results obtained during this study, calcrete has proven to be a suitable sampling medium for gold exploration in the Karibib area and other calcrete covered terrains. From the geochemical and lithological logging results, the distribution of Au in the area varies with different types of calcrete and there is no strong relationship between the variation of Au and depth.

Keyword

Calcrete, Gold, Exploration, Namibia, Karibib

GEOLOGICAL INVESTIGATION OF THE CHIMBIYA NIOBIUM-TANTALUM (Nb-Ta) ANOMALY IN KASUNGU DISTRICT, CENTRAL MALAWI.

Chrispin Ngwata[1]*, Geological Survey of Malawi (chrispinngwata@gmail.com)
James Mwambananji[2], Geological Survey of Malawi

Abstract

Abstract
This paper describes the results of a geological investigation into a prominent Niobium Tantalum (Nb-Ta) that was identified in Chimbiya village in Kasungu district, central Malawi. The anomaly was revealed by the results of the 2018/2019 geochemical stream-sediment sampling campaign which was conducted under the Geological Mapping and Mineral Assessment Project of Malawi (GEMMAP). Radiometric map of the area also showed anomalous Potassium (K) and Uranium (U) signatures like that of the famous Kanyika Nb-Ta deposit to the north of the area. The paper has been outlined as follows: introduction, outline of the regional and local geology, geochemistry (lithological, soil, and stream-sediments), discussions, conclusion, and recommendations. Annexes contain the U and K radiometric maps of the area. The main objective of the study was to identify the possible Nb-Ta orebody by tracing the source of the anomalous values. This was achieved by conducting a geological mapping and geochemical (stream sediment, soil, and rock) survey of the area. In geological mapping, some rock samples were analysed using the Spectro xepos X-Ray Fluorescence XEP05. The results were grouped into major oxides and were used for rock classification using the Total-alkali Silica (TAS) criteria of Cox et al., (1979) for intrusive rocks. Geochemistry survey involved collecting samples from sediments in active streams at some planned locations (confluences of first order steams) as these were deemed to be representative of the catchment area. A total of 10 samples were collected and these comprised 9 stream sediment samples and one soil sample. The latter was taken from the centre of a uranium anomaly. These were also analysed using the XRF. Geological mapping of the area revealed that the underlying lithology is predominantly supracrustal rocks of a metasedimentary nature. Intrusive rocks were restricted to metasyenite in the northeast and metadolerite in the same vicinity. Analytical results from rock chip samples revealed that Nb and Ta have elevated concentrations in the metasyenite lithology. The stream sediment sampling analysis results also indicated that the samples with the highest values for Nb and Ta were collected from streams that are spatially associated with the Kamwala hill metasyenite body. In conclusion, the geological investigation ascertained that the source of the Nb-Ta anomaly was the metasyenite body which was also found to be the source of the prominent U anomaly in the area. These observations raise the possibility that the mineralization on Kamwala hill could be like, and/or related to the Kanyika orebody to the north. It is therefore recommended that detailed geological mapping of Kamwala hill be undertaken. This should be done concurrently with a ground radiometric survey since the metasyenite has a distinctive K and U signature.

Keyword

Niobium (Nb), Tantalum (Ta), Metasyenite, Geochemistry, Mapping

Mafic ultramafic rocks around Bachihalli-Hulihalli area, Holenarsipur Schist Belt, Western Dharwar Craton, South India: indications for Zn rich environment

KALYAN PAL[1]*, GEOLOGICAL SURVEY OF INDIA (kalyan.pal@gsi.gov.in)
SUKESH RANJAN SARKAR[2], GEOLOGICAL SURVEY OF INDIA
MOHAMED SHAREEF[3], GEOLOGICAL SURVEY OF INDIA
M L DORA[4], GEOLOGICAL SURVEY OF INDIA
Parusharama Gangaikoppa[5], GEOLOGICAL SURVEY OF INDIA
Laxmi Nandan Deori[6], GEOLOGICAL SURVEY OF INDIA
Madhushree Mandal[7], GEOLOGICAL SURVEY OF INDIA
A Karthikeyan[8], GEOLOGICAL SURVEY OF INDIA

Abstract

Archean Holenarsipur schist belt (HSB) comprises of linear ultramafic-mafic enclaves containing subordinate clastic sediments and BIF enclosed by tonalite-trondhjemite-granodiorite (TTG) gneisses. This schist belt is known to host Ti-V magnetite, PGE, gold and Ni occurrences. Recent discovery of polymetallic (Zn-Cu-Pb) mineralization from Kattaya area provides new dimension for mineral exploration in the area. This polymetallic mineralization is reported along the alteration zone at the contact of amphibolite of HSB and TTG gneisses. For understanding the petrogenetic significance of mafic ultramafic rocks in the HSB some of the samples from Bachihalli and Hulihalli area were analyzed for major oxide and trace elements. These rocks especially talc-tremolite schist are showing komatiitic affinity. Interestingly apart from relatively high Ni (up to 1972 ppm), Co (up to 112 ppm), Cr (up to 2917 ppm) and V (up to 200ppm) concentration Zn is also recorded in considerable amount i.e. up to 680 ppm, which is unusual considering their ultramafic lineage. Detailed Petrographic and Scanning electron microscopic studies revealed this rock containing fine disseminated sphalerite associated with both oxide and silicates confirming the Zn source. Two distinct association of sphalerite is present in the rock (1) as inclusion within the Cr-Magnetite and (2) as inclusion in the retrogressed chlorite. The presence of sphalerite indicate Zn rich environment of mafic ultramafic rocks as it is clear from the inclusion of sphalerite associated with Cr-magnetite, followed by remobilization due to hydrothermal activity, which is evident from chlorite-sphalerite association. This study is significant and opens up new avenues for future exploration in the early Archean rocks of HSB and other similar terrains. Further studies are required to understand the genetic linkage between the Zn in the mafic ultramafic rocks and the polymetallic mineralization in the Kattaya area.

Keyword

Zn-Cu-Pb mineralization, Sphalerite, Ultramafic rocks

Analysis of Lithium-Bearing Pegmatite Mineral System in the Alvand Plutonic-Metamorphic Complex, Western Iran

Majid Keykhay-Hosseinpoor[1]*, Indian Institute of Technology Bombay (IIT Bombay)
(majidkeykha@iitb.ac.in)
Alok Porwal[2], Indian Institute of Technology Bombay (IIT Bombay)

Abstract

This study aims to explore the mineralization processes of lithium-bearing pegmatites within the Alvand Plutonic-metamorphic complexes in the pegmatite province of western Iran. Situated in the Sanandaj-Sirjan metamorphic zone, a key Tectono-stratigraphic division predominantly comprising Upper Paleozoic to Mesozoic meta-sedimentary sequences, this area has undergone significant deformation during the Mesozoic and Cenozoic tectonic activities. Despite their relatively small volume, the pegmatitic bodies in this region are noted for their significant variability in texture and mineralogical composition. Although lithium-bearing pegmatites have been recognized in the Alvand complex, their genetic links to other pegmatites and associated granitoids remain underexplored. This area presents a significant potential for lithium exploration within pegmatite dykes, which could serve as critical lithium sources. The pegmatites are found in various settings within the plutonic bodies, including interior, marginal, and exterior zones. The Petrological traits of the dykes intersecting both plutonic and metamorphic terrains manifest characteristics akin to both lithium–cesium–tantalum (LCT) and niobium–yttrium–fluorine (NYF) families of pegmatites, indicating the occurrence of complex geodynamic processes in the region. Petrographic analyses reveal that the lithium-bearing pegmatite veins undergo a transition in both texture and mineral composition from the contact zone with the metamorphic country rock (wall zone) to the central part (core zone). In the wall zone, these veins showcase a quartz-rich granitoid composition which gradually evolves into granite, alkali granite, trondhjemite, and quartzolite as it approaches the core zone. This core zone is characterized by the presence of quartz, alkali feldspar, muscovite, spodumene, beryl, and tourmaline, highlighting the significant variation in mineralogical composition across the vein. This study addresses the mineralization system of lithium-bearing pegmatites in the Alvand complexes, offering insights into their potential for economic exploitation and targeted lithium exploration.

Keyword

Lithium pegmatite mineralization, Mineral system analysis, Alvand Plutonic-metamorphic complexes, Exploration targeting, Iran

Possibility of lignite coal deposits of South Korea as an unconventional REE deposit; preliminary case study of Gyeongju-Yeongil coal field

Woohyun CHOI[1]*, Kyungpook National University (choi313047@gmail.com)
Changyun PARK[2], Kyungpook National University

Abstract

Although global energy trends are shifting towards more eco-friendly and renewable sources, coal and thermal power generation remain primary energy sources for many countries. In addition to its role in energy production, coal is gaining attention as an unconventional source of rare earth elements (REEs).

South Korea's coal deposits consist mainly of anthracite, with some additional lignite deposits in the Northern Gyeongsang province. Previous research has shown that younger and less coalified coal deposits tend to contain higher concentrations of REEs. Therefore, we targeted the Gyeongju-Yeongil lignite coal field for our study.

The Gyeongju-Yeongil coal field comprises two main coal-bearing layers: the upper coal-bearing layer (UC) and the lower coal-bearing layer (LC). The UC is covered by an andesitic tuff layer, with shale formations below the coal seams. The LC consists of a bentonite formation with a coal seam in the middle. Most of the coals in this area are lignite with partial subbituminous. This type of coal deposit, with tuffaceous characteristics, is known to have high concentrations of REEs. X-ray diffraction (XRD) analysis revealed quartz, feldspar, kaolinite, montmorillonite, and zeolite as the major mineral phases in the coal seams and adjacent layers. However, identifying REE-rich mineral phases (e.g., monazite, xenotime, goyazite) was challenging using XRD and EPMA observations, indicating that the majority of REEs are likely absorbed into other mineral phases rather than existing in independent forms.

ICP-MS analysis of rock and coal samples showed elevated concentrations of certain elements in the coal layers. Samples from the UC exhibited over 300 ppm (up to 550 ppm) of total rare earth and yttrium elements (REY), which is the minimum concentration considered economically viable for development. Among the REY elements, light rare earth elements (LREEs) such as lanthanum to neodymium and yttrium showed the highest enrichment. Additionally, significant concentrations of vanadium (V; ~172ppm), barium (Ba;~1034ppm), zinc (Zn; ~172ppm), copper (Cu;~109ppm), rubidium (Rb;~133ppm), strontium (Sr;~410ppm), and zirconium (Zr;~323ppm) were observed.

These preliminary research findings suggest that lignite layers in Korea have the potential to be developed as unconventional REE deposits. However, further detailed research is needed to determine the actual distribution and origins of REY elements within the coal layers.

Keyword

coal, rare earth elements, tuffaceous coal, REE-bearing coal deposits, unconventional REE

deposits

Mineral resources exploration in SW Angola (PLANAGEO Project)

Iván MARTÍN-MÉNDEZ[1]*, IGME-CSIC (i.martin@igme.es)
Enrique Merino-Martínez[2], IGME-CSIC
Maria Joao Batista[3], LNEG
Jorge Fernández[4], IGME-CSIC
Catia Prazeres[5], LNEG
Daniel De Oliveira[6], LNEG
Carla Fortes[7], LNEG
Maria del Carmen Feria[8], UTE-PLANAGEO
Carmen Rey-Moral[9], IGME-CSIC
Raquel Martín-Banda[10], IGME-CSIC
Juan Carlos Gumiel[11], IGME-CSIC
Jose Luis García-Lobón[12], IGME-CSIC
Jose Manuel[13], IGEO-Angola

Abstract

The Republic of Angola has a very diverse and interesting range of minerals determined by their geological and/or geotectonic environments, spanning from the Upper Archaean to more recent times. This makes Angola significant for potential mineral deposits. Over recent decades, exploration and mining activities have led to the discovery of economically valuable deposits of various elements, such as Fe, Au, Li, REE, and diamonds, some of which are currently active.

The National Geological Plan of Angola (PLANAGEO) was a project developed in Angola during the last decade. The UTE PLANAGEO consortium, formed by the Geological Surveys of Spain (IGME) and Portugal (LNEG) and the Spanish company Impulso Industrial Alternativo (IIA), was in charge of the geological, geophysical, and geochemical studies undertaken in the SW region of the country, in an area equivalent to ca. 476.500 km2.

One of the most important objectives of PLANAGEO was the improvement of the geological and mineral resource knowledge of the country. This project integrated regional aerogeophysical mapping (magnetic and radiometric) and innovative geological mapping carried out both at regional scale (44 maps at 1:250,000 scale) and 15 maps at 1:1000,000 scale in key, selected areas, which included raw materials and mineral resources prospecting at 1:50,000 scale.

Three different clusters were defined in order to explore different raw materials in selected regions from the SW part of the country, regarding their interest in metallic mineral resources: cluster 1, for gold and iron; cluster 2, for REE and niobium-tantalum; and cluster 3, for base metals and platinum group elements. These regions were studied by using conventional geochemical exploration techniques (i.e., rock, soil and stream sediments sampling) and by using the most innovative state-of-the-art methodologies (i.e., in situ geochemical analyses by portable X-Ray Fluorescence equipment).

The combined examination of geological, geophysical, and mineral resources information and the geochemical exploration surveys performed in the selected areas has assessed and identified the mineral potential of the various geotectonic terranes of SW Angola. This information has served

to produce not only distinct geological and geothematic maps at different scales, but also to identify the mineral potential of the country. The various mineral associations detected and investigated in SW Angola were used to group selected geological domains or in certain geological environments, leading to propose a preliminary delimitation of the metallogenic provinces that shape the SW portion of the country. As a result, new mineral potential targets have been created in the region.

Keyword

geochemical exploration, soil and stream sediment geochemistry, mineral resources, PLANAGEO, Angola

Structural control on gold mineralisation in the Ngubevu area (South Africa) inferred from micro-scale to regional-scale spatial analysis

Nolukholo Sinovuyo Busakwe[1]*, University of Free State (sinovuyobusakwe@gmail.com)
John Emmanuel Muico Carranza[2], University of Free State

Abstract

The Ngubevu area in the Mfongosi Group in the Natal thrust front shear zone (Tugela Terrane) is weakly mineralised and is under-explored but it hosts structurally-controlled epigenetic gold mineralisation in five abandoned mining sites (Buffalo River, Golden Dove, HMS, Golden Eagle and Champion River). This study aims to establish a link between micro-scale spatial distributions of ore minerals, local-scale structural features at and around mineral deposits and regional-scale geological structures to infer structural control across different scales in the Ngubevu area. Thin section-scale to micro-scale spatial distributions of sulphide minerals (sphalerite) in oriented quartz vein thin sections were examined using point pattern, Fry, fractal, and shape analyses. The results show a non-random and a clustered ore mineral spatial distribution. The rose diagrams of Fry points of sulphide minerals in thin sections indicate significant NNE–SSW to NE–SW, NE–SW to ENE–WSW, and NNW–SSE to WNW–ESE trends. These trends are similar to the NNW–WNW and NNE–ENE trends determined by shape analysis of sulphide minerals in thin sections of vein material samples in Ngubevu area. These trends correspond to the orientations of local- to regional-scale N- to NNE- and ENE-trending D1 and D2 deformation shear–zone structures. The results of fractal analysis suggest that ore minerals in the area have bi-fractal characteristics with two fractal dimensions of 0.521 – 1.051 at a scales less than 0.2 cm and 1.253 – 1.550 at scales greater than 0.2 cm. This study confirms (a) that there is link between spatial patterns of mineral deposits across different scales and (b) that local- to regional-scale structural controls of mineralisation can be deduced from thin section-scale to micro-scale analyses of ore mineral distributions. These findings have implications for mineral exploration in poorly explored frontier regions of terranes that are geologically permissive for mineralisation.

Keyword

gold mineralisation, point pattern, fry analysis, fractal analysis, structural control

Geology and Copper-Sulphide mineralisation within the Mutale area, Soutpansberg Group, South Africa

Thangeni Mphanama[1]*, University of Venda (thangeni95@gmail.com)
Humbulani Rejune Mundalamo[2], University of Venda
Jason Samuel Ogola[3], University of Venda

Abstract

The Mutale Copperfield, situated within the Vhembe District of Limpopo Province, South Africa, represents a significant geological site within the Soutpansberg Group. Spanning an area of approximately 320 square kilometres, this region has been historically renowned for copper mining activities from the early 1900s until the 1970s, particularly around the Mutale River area. More than 30 known occurrences of copper mineralisation persist within near-vertical quartz veins and fractures within the Soutpansberg Group's lavas and sediments.

This study investigates the geology and copper-sulphide mineralisation within the Mutale Copperfield. Fifteen samples from waste rock dumps, obtained through grab sampling method from three distinct workings, underwent X-ray Diffraction (XRD) and X-ray Fluorescence (XRF) techniques at the University of Venda's Mining and Environmental Geology Laboratory. The XRD analysis revealed the presence of various sulphide minerals including chalcocite, bornite, malachite, covellite, and native copper. However, only one sample exhibited a copper concentration above the typical economic grade of 1%, measuring at 1,412 wt%. The remaining samples displayed copper concentrations ranging from 0.537 to 0.01 wt%. Although waste rock dump samples imply low copper concentrations overall, a more precise evaluation of the deposit's copper content can be achieved by sampling directly from ore faces or examining core logs.

Keyword

Mutale Copperfield, copper mineralization, Soutpansberg Group, X-ray diffraction, X-ray fluorescence

Identifying target areas for copper mineralization using ASTER and geochemical data in Musina Area, Limpopo Mobile Belt, South Africa

Humbulani Rejune MUNDALAMO[1]*, University of Venda (humbulani.mundalamo@univen.ac.za)
jason Sammuel OGOLA[2], University of Venda
Klaus Maas[3], Hochschule Ostwestfalen-Lippe, University of Applied Sciences

Abstract

The study focused on the structural and geochemical investigation through integration approach of the remote sensing data and soil geochemistry study within and around the copper-sulphide deposits in the Musina area, located in the Central Zone of the Limpopo Mobile Belt of South Africa. The Messina copper deposits are located in the eastern part of Limpopo Province near the border with Zimbambwe.

Different research methods have been applied in the current study so as to identify the area with high copper mineralization for further exploration purposes. This included fieldwork, remote sensing data acquisition, laboratory work, and data analysis and interpretation. Application of ASTER imageries and Arch GIS 10.4.1 was conducted for mapping structural features and alteration zones. Fieldwork involved soil geochemical survey for anomalous concentration determination of copper sulphide metals. A total of 295 soil samples were collected for laboratory investigation.

Data analysis and interpretation of laboratory results involved the use of: Desktop ArcGIS 10.4.1 for geochemical data interpretation as well as ENVI 5.1 and ArcGIS 10.4.1 Softwares for remote sensing data. Remote sensing data interpretation revealed spatial distribution and intensity of epidote alteration within the study area and in places coincided either with the known copper deposits or structural features. Soil geochemical survey revealed geochemical anomalies for Pb, Zn, Cu, As and Ni over the known copper deposits in the area as well as over six other areas that have not been associated with any sulphide mineralisation. The locations where intensity of epidote alterations, structural features and high concentration levels of metals coincided led to the identification of target areas for future mineral exploration in the Musina area.

Keyword

Exploration target areas, Remote sensing, Limpopo mobile belt, Musina copper deposits

Reconnaissance Phase of Chromite Potential in Iran

SHAFIGHEH TARKIKORDEDEHI[1]*, Master (shafighetarki62@gmail.com)

Abstract

Abstract

Chromite ore is the only source of chromium, which is of high value in making alloys and preparing special steels. The collection of ophiolitic rocks in Iran has been greatly expanded and developed, and they are often placed in different geological time and place positions with other tectonic units.

The Geological and Mineral Exploration Organization of the country, as the trustee of exploration, is following up the task of identifying new potential areas for mineralization. The project of finding the potential of chromite in Iran has been started in the identification phase since May 2016 by the exploration site of the Applied Research Center of the Geological and Mineral Exploration Organization of the country.

Different layers of information were used to conduct office studies and introduce the potential areas of chromite mineralization, which include digital geological data (lithology) 1:100000 And if not, 1:250,000 maps, remote sensing information layer, indices layer and suitable mines and environments for chromite mineralization with a scale of 1:1,000,000 prepared by the Geological and Mineral Exploration Organization of the country were used. The most important discovery criterion in the phase of identifying and searching for chromite mineralization is the geological layer (lithology and structure), which was used as the main layer due to the specificity of the spatial expansion and distribution of rock units related to chromite mineralization.

According to the metallogenic belts of chromite in Iran, the most important axes include the Esfandaghe-Faryab-Haji Abad axis, which includes from the east of Minab in Hormozgan province to the Kerman region, the eastern axis of Iran (Birjand-Nehbandan), which extends from Birjand in South Khorasan province to Iranshahr. It is drawn in the province of Sistan and Baluchistan the southeastern belt of Iran (or Sistan-Makran), which is the largest concentration of chromite deposits and deposits in this axis in the west of Fanuj in Sistan and Baluchistan province, and the Sabzevar-Torbat Heydarieh ophiolitic belt, which is the largest concentration of chromite mineralization in the north of Sabzevar. And north of Torbat - Heydarieh.

By processing the above layers of information in the present project, areas prone to chromite mineralization were introduced. Based on this, suitable 1:100,000 sheets (114 sheets) were analyzed and processed for information layers separately. Based on geological data and suitable environments for chromite mineralization, three priorities were introduced, the first priority includes rock units of dunite, serpentinite, serpentinized donite, harzburgite, and serpentinized harzburgite. The second priority includes peridotite and serpentinitized peridotite rock units and the third priority includes ultrabasic rocks and colored mixtures. Prone rock units were introduced as hosts of chromite mineralization with an area of 6084 square kilometers. Among the identified potential rock units, in general, an area of 3462 square kilometers of first-class chromite potential

area was introduced for the whole country.

Keyword

Chromite, ophiolitic & ultrabasic rocks, serpentinized, dunite, harzburgite

Quantitative Data for Geochemical Exploration of critical elements: The Contribution of Handheld LIBS

Naila MEZOUED[1]*, Georessources, Université de Lorraine (naila.mezoued@univ-lorraine.fr)
Cécile FABRE[2], CNRS, GeoRessources, Université de Lorraine
Jean CAUZID[3], CNRS, GeoRessources, Université de Lorraine

Abstract

Geochemical data are essential in mining operations. However, acquiring this information typically involves: selecting samples from the deposit, transporting the fragments, and thorough analyses using conventional analytical methods in laboratories. A lengthy and costly process that significantly delays strategic decision-making. The Laser-Induced Breakdown Spectroscopy (LIBS) technique and its ability to decipher the chemical composition of a sample by creating a plasma on its surface using a high-energy laser, shows great potential to provide an on-site solution to generate reliable qualitative, quantitative, and mineralogical information on geological materials (ref).

In this context, the handheld LIBS was used to predict the concentration of critical elements targeted for extraction (Li, Cs, Be) in the Beauvoir granite. A rare metal leucogranite, in the northern part of the French Massif Central, characterized by high content of Li, Rb, F, Cs, Nb, Ta, Be, and Sn, currently under study for lithium extraction. The aim was to focus on raw and unprepared samples, including whole core portions measuring up to 4 meters, to minimize the technical constraints required in the field. Reference samples were selected to represent best the variability of the granite samples and an analytical strategy was developed to address the method constraints. The calibration models were built using different spectral parameters and statistical approaches. Then, a comprehensive comparative analysis was conducted to determine the optimal protocol for each element studied. To meet the company's needs, signal variation over successive measurements, and the minimum number of analyses required to maintain a representative LIBS signal of the whole rock composition, were investigated.

The predicted concentrations are consistent with the reference geochemical values obtained through standard techniques (Li => RMSE=0.062 wt% MAE=0.081 wt% Bias=0.064 SEP=0.078 wt%), confirming the ability of the handheld LIBS device to produce relevant geochemical data in a short period, within minutes, directly at the exploitation site, and on unprepared rock sections.

Keyword

LIBS, Quantitative analysis, Critical elements, Lithium, Beauvoir granite

Ore deposits of critical minerals in Indian granitic pegmatites

Yamuna Singh[1], University of Hyderabad
Yamuna SINGH[2]*, University of Hyderabad (yamunasingh1957@gmail.com)

Abstract

The granitic pegmatites of India constitute a potential source for diverse types of ore deposits of critical and strategic minerals in various geographic regions. Systematic exploration revealed localisation of ore minerals of Nb, Ta, Be, Li, Sn, U, and associated ores of Rare Earth Elements (REEs), Th, Bi, Cs, Mo, W in various pegmatite belts of India. Several granitic pegmatites have been commercially mined for Nb, Ta, Li, Be, Sn, U, and other associated ore minerals. Ore minerals of Nb and Ta record a large mineralogical speciation followed by Li ore minerals. Ubiquitous appearance of economic grade Be ore mineral as beryl in pegmatites of almost all the regions is remarkable. The grade of pegmatite ore is low to medium to very high, with moderate to high volumes of individual ore-bearing pegmatites. Most of the mineralised pegmatites bear spectacular imprints of metasomatic alterations and attendant ore concentrations. The ore-bearing pegmatites carry signatures of ‘Rare Earth’ and ‘Beryl’ types of pegmatites, with sub-types of ‘Complex Pegmatite Type’ (CPT), namely, ‘Lepidolite’ sub-type, ‘Spodumene’, ‘Amblygonite’ and ‘Petalite’ sub-types. The ‘Rare Element’ class of pegmatites carry signatures of ‘LCT’ (Lithium Cesium Tantalum) and ‘NYF’ (Niobium Yttrium Fluorine) types of pegmatites. Presence of ore-bearing pegmatites of more than one ‘Family’ together suggest involvement of more than one petrogenetic processes in their formation and ore grade concentrations.

Keyword

Ore mineral deposits, Critical and strategic minerals, Granitic pegmatites, India

New age data for the rare metal pegmatites of the East Sayan rare metal belt

Anna IVANOVA[1]*, Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences, Saint-Petersburg, Russian Federation (anna_al_ivanova@mail.ru)
Ekaterina Salnikova[2], Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences, Saint-Petersburg, Russian Federation
Julia Plotkina[3], Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences, Saint-Petersburg, Russian Federation
Aleksander Kotov[4], Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences, Saint-Petersburg, Russian Federation

Abstract

The problem of timing of ore-forming processes is very important for rare metal objects. In many cases, it is necessary to use non-traditional minerals-geochronometers like Ca-Fe garnet, microlite, cassiterite and columbite-tantalite to solve this problem. U-bearing columbite-tantalite group minerals (CGM) are common in rare metal pegmatites. This research is devoted to U-Pb geochronological studies of CGM and zircon from pegmatites of the spodumene (Li, Ta-Sn-Li, Ta-Cs-Li) and petalite (P-Ta-Li, Ta-Cs-Li) subformations of rare-metal pegmatite formation in one of the largest in the world the East Sayan rare metal belt (ESB), located in the southwest of the Siberian craton. The age of nearby granitoids of the Sayan complex, which were considered the source material for the rare metal pegmatites of the region, ranges according to various data from 1858±20 to 1901±16 Ma. For ESB-pegmatites age estimates from 1475±30 to 1835±35 Ma are known.

The objects of our U-Pb ID-TIMS study are CGM and zircon from pegmatite veins of the Aleksandrovskoye, Vishnyakovskoye (northwestern part of ESB) and Belorechenskoye (southeastern part of ESB) ore fields. Columbite-(Fe), columbite-(Mn) and tantalite-(Mn) are typical for Aleksandrovskoye, tantalite-(Mn) – for Vishnyakovskoye, tantalite-(Fe) – for Belorechenskoye. Preliminary acid treatment of CGM was carried out according to a modified method of Legros et al. (2019) in HF, HCl and HNO3.

Zircon from Aleksandrovskoye is extremely metamictized (Dα=4-13×10^19 α-decay/g) and enriched by U-Th-REE-inclusions, HfO2 up to 16.6 wt%, UO2 up to 2.1 wt%. It was subjected to chemical abrasion (1.5-2 hours) with high-temperature annealing according to unique modified method (Ivanova et al., 2021). Zircon fragmented down to submicron size, retaining no more than 1% of the original volume of the substance, and with longer exposure it dissolved almost completely. The age of zircon is 1803±6 Ma (MSWD=2.9). A similar age was obtained for CGM from the same vein: 1825±3 Ma (MSWD=0.34) for the quartz core and 1817±5 Ma (MSWD=0.001) for the quartz-mica (with tourmaline) zone of intense alteration of the host amphibolites.

The results of U-Pb geochronological study demonstrate the age coincidence for both CGM and zircon evidencing a high potential of CGM for precise and accurate dating of ore forming processes.

For the Vishnyakovskoye deposit, the CGM age of 1838±3 Ma was previously obtained (Salnikova et al., 2011), which clearly indicated that the pegmatites and granites of the Sayan complex were of different ages. Close age (1823±5 Ma) is obtained for the Belorechenskoye deposit.

The obtained data indicate that the ages of rare metal pegmatite of the ESB is for 30-50 Ma younger than the nearby granites of the Sayan complex and are the result of an independent magmatic event 1.82 Ga.

This study demonstrates an advantage of development of high precision geochronological investigation of the non-traditional minerals-geochronometers to understand ore-forming processes of strategic metals deposits: Ca-Fe-garnets in skarns, CGM and microlite in rare-metal pegmatites.

The study was supported by grants No. 22-17-00211 and No. 24-77-00056 from the Russian Science Foundation and by FMUW-2022-0003.

Keyword

U-Pb ID-TIMS geochronological studies, rare metal pegmatites, columbite-tantalite

Deep Learning Application in Predictive Mineral Targeting of Southwestern Uganda: Leveraging Airborne Magnetic and Radiometric Data

Christopher J ALEXIS[1]*, Midwestern State University (chrisjralexis@gmail.com)
Andrew Katumwehe[2], Midwestern State University
Jonathan D Price[3], Midwestern State University
Kashif Mahmud[4], Midwestern State University

Abstract

This research integrates machine learning with established geological methods to overcome the complexities of mineral exploration, particularly in ore and rare earth element exploration within the Mesoproterozoic complex of southwestern Uganda. While crucial, traditional geological mapping faces limitations due to site accessibility, basement exposure, financial constraints, weather conditions, and private sector limitations. The study employs advanced deep-learning techniques alongside traditional geophysical data analysis from airborne magnetic, radiometric, and electromagnetic surveys to address these challenges. This integrated approach aims to enhance mineral mapping predictions' accuracy and precision. The methodology includes the application of various magnetic filters and derivatives, including reducing to the magnetic pole (RTP), first vertical (1VD) and horizontal derivatives (HDR) in the x, y, and z axes, tilt derivatives (TDR), applying the analytical signal (AS) to the magnetic data, and depth to basement estimation techniques, which enhances its interpretability.

In addition to the magnetic methodologies, this research incorporated radiometric data to refine identifying and delineating potential mineralization zones. The study highlighted areas of pervasive potassic alteration by generating composite equivalent thorium-to-potassium ratio (eTh/K) maps and ternary potassium-thorium-uranium (K-eTh-eU) maps. Such alterations are indicative of hydrothermal processes, which are often associated with the formation of mineral deposits. Integrating magnetic and radiometric methodologies enables a multi-faceted approach to exploration, leveraging each method's strengths to overcome their limitations. While magnetic data can reveal structural and lithological information, radiometric data directly measures surface geochemistry. Together, these datasets allow for effectively identifying hydrothermally altered rocks and delineating potential mineralization zones crucial to employing a supervised deep neural network model for predictive targeting.

The supervised deep neural network predictive targeting (SDNN-PT) model combined with traditional geophysical mapping identified potential ore mineralization zones and elucidated the controls of ore localization within the complex geological framework of the region through conventional methods and then predictive machine learning methods. The findings indicated two areas of significant interest where the granitic pegmatites proximal to intrusive granite exhibit pronounced magnetic lineaments derived from the first vertical and tilt derivatives. These lineaments indicate potential ore mineralization in linear structures such as faults, fractures, shear zones, or lithological boundaries. These findings provided a solid foundation for training the deep-

learning model employed in this study. They enhanced the predictive mapping capabilities for identifying similar mineralization zones across broader areas of interest.
Integrating insights from traditional geological methods with the predictive capabilities of machine learning represents a significant advancement in the field of geoscience, particularly in the context of mineral exploration for beryl, columbite-tantalite, cassiterite, and lithium-bearing silicates in pegmatite granites. This innovative approach, as demonstrated in the study of Uganda's Ntungamo District, leverages the strengths of both disciplines to overcome the inherent limitations of each, thereby enhancing the precision and efficiency of identifying potential mineralization zones. The study offers potential economic benefits through this improved exploration strategy in Uganda's mineral-rich regions and supports its aspirations to become an upper-middle-income country by 2040.

Keyword

Mineral exploration, Pegmatite, Deep learning, Airborne magnetic, Airborne radiometric

The legacy of Petr Černý in the study of granitic pegmatites

Tania MARTINS[1]*, Manitoba Geological Survey (tania.martins@gov.mb.ca)

Abstract

Petr Černý was a mineralogist based at the University of Manitoba in Canada and is well known and recognized for his study of granitic pegmatites. From his initial studies in his home country Czech Republic, he studied many other pegmatites in other parts of Europe (e.g., Finland), in Canada (e.g., Manitoba, Northwest Territories) and South America (e.g., Argentina). Most of Petr Černý's career was dedicated to the study of the world-class Tanco pegmatite. The Tanco pegmatite located at Bernic Lake, southern Manitoba, Canada is a well-known deposit for its large size, unique and diverse mineralogy, high degree of fractionation, and productivity.

The Tanco pegmatite was first discovered during a drilling program in the late 1920's exploring for tin. Production of tantalum did not start until late 1960's and continues to today with the focus of production shifting throughout the years between tantalum, cesium and lithium.

The Tanco pegmatite is one of the best studied pegmatites in the world due to Petr Černý's, his students and many other researchers' passion and dedication to the study of this deposit. From the definition of zonation, deep understanding of mineral chemistry systematics (e.g., micas, feldspars, tourmaline, columbite group minerals, phosphates, spodumene), fluid inclusions, metasomatism, structural emplacement controls, and mineralization, all these types of works resulted in a better understanding of the Tanco pegmatite. The results of the studies on Tanco have influenced the way we think about pegmatites, and pegmatite research across the globe.

Despite many studies and publication on the Tanco pegmatite, many questions remain unresolved there, such as: is there a parental granite, where is the feeder system (if existent), what is the relative timing of the different zones, how much has metasomatism affected the pegmatite, what kind of information can we read from fluid and melt inclusions, what more can isotopic systems tells us about the pegmatite (e.g., Pb, N, B, Li isotopes), to cite a few examples.

Keyword

Tanco, pegmatite, Manitoba, lithium, Canada

Multidisciplinary Approach to Exploring for Rare-Element Pegmatites in Western Australia

Paul DUURING[1]*, Geological Survey of Western Australia (paul.duuring@dmirs.wa.gov.au)
Sidy Morin-Ka[2], Geological Survey of Western Australia
Warren Ormsby[3], Geological Survey of Western Australia
Graciany Da Silva[4], Geological Survey of Western Australia
Vaclav Metelka[5], Consultant

Abstract

In Western Australia, rare-element pegmatites play a pivotal role as hosts for Li, Cs, and Ta mineralization, with the Greenbushes mine in the Yilgarn Craton and the Pilgangoora and Wodgina mines in the Pilbara Craton standing out as world-class examples. Western Australia is strategically positioning itself as a hub for battery minerals, leveraging its rich mineral endowment, skilled workforce, and proximity to major markets.

To expand its critical mineral resource sector, Western Australia faces three main challenges: (a) the ongoing need for refining genetic models related to the rare-element pegmatite mineral system, (b) the difficulties in integrating and enhancing the quality of geoscientific data, and (c) the substantial cost and effort required to obtain new data or improve existing datasets using advanced techniques.

To address these challenges, we use the Mineral Systems Approach – a holistic, multidisciplinary strategy – to build an in-depth understanding of geological processes that control the rare-element pegmatite mineral system. This approach benefits from integrating new findings from mineral deposit studies, thereby refining analysis and exploration strategies. It emphasizes the importance of coordinated data acquisition and the effective use of data at various scales to inform exploration priorities.

The Geological Survey of Western Australia (GSWA) implements three approaches to bolster mineral rare-element pegmatite exploration across the state:

Enhancing understanding of genetic models: By conducting thorough mineral systems analyses, GSWA aims to dissect the complex geological processes leading to the formation of critical mineral-rich pegmatites. A cornerstone of this effort is the online GIS-based Mineral Systems Atlas (www.dmirs.wa.gov.au/mineralsystemsatlas), which serves as a dynamic platform for explorers. This atlas, enriched with insights from collaborative research, offers a deep dive into the genesis of pegmatite deposits, focusing on aspects like fertile magma sources, structural pathways, trapping mechanisms, and preservation of mineralized pegmatites. It enables explorers and researchers to conduct targeted prospectivity analyses by integrating the provided GIS layers, prepared for immediate application, with their own datasets. This streamlined access facilitates the

identification of areas with higher potential for rare-element pegmatite discoveries.

Data quality and accessibility improvements: GSWA's data initiatives aim to revamp digital databases and integrate Artificial Intelligence and Machine Learning techniques to improve data reliability and usability. These efforts are expected to reveal hidden correlations within complex datasets, informing future data collection and exploration strategies.

Strategic data acquisition and enhancement: Some new datasets for pegmatite exploration include identifying deep structural pathways using passive seismic and magnetotelluric data, re-analyzing existing granite and lateritic samples for granitophile elements with enhanced detection levels, and creating isotopic maps for Nd, Hf, and O. Additionally, the chemistry of indicator minerals and the use of PRISMA satellite data for mapping pegmatite outcrops are key to refining exploration strategies.

Through these strategies, GSWA demonstrates a committed and innovative approach to overcoming the challenges inherent in the exploration of rare-element pegmatites. By improving genetic models, enhancing data quality, and strategically acquiring new data, we aim to further unlock the mineral potential of Western Australia, supporting its development as a leading hub for critical minerals.

Keyword

Mineral, Systems, Approach, Data, Integration

[Keynote] Lithium pegmatites of Africa - a review

Kathryn Goodenough[1]*, British Geological Survey (kmgo@bgs.ac.uk)
Richard Shaw[2], British Geological Survey
Anouk Borst[3], K U Leuven
Paul Nex[4], University of the Witwatersrand
Judith Kinnaird[5], University of the Witwatersrand
Marieke van Lichtervelde[6], Geosciences Environnement Toulouse

Abstract

The continent of Africa records a long history of craton development and continental collision, which has allowed the formation of several swarms of lithium pegmatites of a variety of ages, including some of the largest known global examples. We have been working on many of these pegmatites, and in this talk will summarise what is known about the controls on their formation over time. The oldest lithium pegmatites in Africa are Neoarchaean in age, occurring in the West African and Kalahari cratons, and including the Bikita pegmatite in Zimbabwe that has been mined for many years. These pegmatites record complex parageneses with a variety of lithium minerals. Palaeoproterozoic pegmatites are widespread in the Birimian terranes of West Africa, where simple spodumene-bearing pegmatites are common. During the Meso- to Neoproterozoic, numerous orogenic belts developed across Central and Southern Africa; lithium pegmatites in these regions can be very large (for example, Manono-Kitotolo in the DRC) and have in many cases been mined for tin and tantalum in the past. The Neoproterozoic to Cambrian (Pan-African) orogenic belts are characterised by a wider mineralogical variety of pegmatites, with lepidolite and other lithium minerals being important. Finally, Palaeozoic pegmatites occur in the Variscan belts of Morocco, and are phosphate-rich. It is notable that each craton or orogenic belt appears to have a distinctive lithium pegmatite ‘fingerprint’ and we consider this to be linked to the particular sources, and partial melting conditions, for the different pegmatites. This talk will consider the likely source materials and processes by which this variety of lithium pegmatites formed.

Keyword

Pegmatite, Lithium, Africa

Rare metal potential of North-Western Kalba (Eastern Kazakhstan)

Tatyana Oitseva[1]*, D. Serikbaev East Kazakhstan Technical University
(tatiana.oitseva@gmail.com)
Oxana Kuzmina[2], D. Serikbaev East Kazakhstan Technical University
Marina Mizernaya [3], D. Serikbaev East Kazakhstan Technical University
Ainel Bissatova[4], D. Serikbaev East Kazakhstan Technical University

Abstract

In the modern world, rare metals are a sought-after sector. They are used in the production of lithium-ion batteries, which are widely used in smartphones, laptops, electric vehicles such as hybrid cars, electric cars or e-bikes. Consumption of rare metals in the world will increase rapidly in the coming years. But, like all other resources, rich rare metal deposits can be depleted quite quickly. Calculations of statistical indicators and resource accounting databases have shown that the known rare metal ores in the world will run out in about 25 years, and the reserves of explored resources - in about 50 years. Thus, there is a tendency towards the discovery of new and detailed additional exploration of already known rare metal deposits. Since the main rare metal structure of East Kazakhstan is the Kalba-Narym belt, this justifies the relevance of its study. In metallogenic terms, the Kalba-Narym belt is divided into the following ore districts: Shulba, North-West Kalba, Central Kalba and Narym. The Central Kalba region has been well studied and developed thanks to well-known industrial deposits (Yubileinoe, Bakennye, Belogorskoe, etc.). The remaining areas are by no means unpromising for rare metal mineralization. North-Western Kalba, as well as the entire Kalba-Narym metallogenic zone, is characterized by a rare-metal profile of ore mineralization associated with the formation of granites of the Kalba complex. The North-Western Kalba ore district is located northwest of the Central Kalba region and combines pegmatite rare metal and hydrothermal (W-Sn) occurrences. The most promising seems to be the Ubinsko-Kaindinsky ore cluster, which includes the Kovalevskoye ore field of lithium-bearing pegmatites, the deposits Kvartsevoye, Kaindy, Novokaindy, Malo-Kaindinskoye, Ubinskoye, Alypkel, etc. The quartz deposit of rare metal pegmatites (microcline-albite-muscovite subformation) is characterized by greisen mineral zones with rich in tantalite. Another group of occurrences with albite-spodumene mineralization is of practical interest for lithium raw materials (Aktobe ore field). The Monastyrsky ore cluster represents placers of monazite of alluvial and alluvial-proluvial origin (Kanaika, Uzunbulak, Sartynbek, etc.), discovered by G.N. Shcherba (1939). As a result of a detailed study of the geological structure, formation conditions, mineralogical composition, collection of historical materials and field research last year, the North-Western Kalba area was considered as promising for the discovery of industrial rare metal mineralization.
This research has been funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19676805).

Keyword

North-Western Kalba, rare metal, granitoid, genetic type, perspective

Pressure relevance of pegmatite melt evolution: new insight about melt-melt-fluid immiscibility imprinted in pegmatite quartz

Woohyun CHOI[1]*, Kyungpook National University (choi313047@gmail.com)
Changyun PARK[2], Kyungpook National University
Jeongmin KIM[3], Korea Basic Science Institute

Abstract

This study investigates the microtextural and geochemical characteristics of pegmatitic quartz from the Boam mine area to elucidate the evolution of the Uljin Li-pegmatite melt.

Quartz, a ubiquitous mineral present from the initial stages of pegmatite formation, records significant evolution in texture and composition. Cathodoluminescence (CL) observations of quartz from the Main Orebody (MO) and Eastern Orebody (EO) of the Boam mine area reveal at least four distinct formation stages. Large pegmatitic quartz exhibits rhythmic layered textures, displaying interlayered banding with lepidolite and albitite. These quartz grains exhibit three distinct CL colors. The blue CL zone, characterized by a coarse-grained, massive appearance, diminishes in dominance from the border zone to the core zone. High Li and Al content, coupled with the lowest δ18O values, suggest a silicic melt origin. The green CL zone, displaying fine-grained textures and sharp boundaries with the blue CL zone, exhibits mosaic and fracture-healing textures, indicating pressure drops during crystallization. The yellow CL zone, predominantly fine-grained and characterized by fracture-filling and healing textures, displays diffusive characteristics indicative of a flux-enriched aqueous melt phase. Steady B composition in pegmatitic quartz suggests non-isobaric segregation of melts, maintaining pressure change intervention during melt immiscibility.

In addition to large pegmatitic quartz, secondary hydrothermal quartz is associated with fine-grained muscovites. These quartz grains exhibit similar CL intensities to the yellow CL zone of pegmatitic quartz, along with the highest δ18O values. Decreased Na composition suggests crystallization post-albitite formation, while the highest Ge composition indicates the lowest formation temperature, indicating a aqueous fluid origin. Consistent increases in δ18O throughout evolution suggest limited external fluid input during pegmatite formation.

These textural and geochemical findings of quartz from the Boam mine area highlight the significant role of pressure changes during pegmatite melt evolution, triggering melt-melt-fluid immiscibility. Furthermore, oxygen isotope analysis of quartz suggests minimal intervention of meteoric water throughout pegmatite formation.

Keyword

Li-pegmatite, quartz, cathodoluminescence, oxygen isotope, melt-melt-fluid immiscibility

Mineralogical and geochemical properties of the pegmatite zircons: Implications for the formation of immiscible melt and fluid during pegmatite evolution

Youseong Lee[1]*, Kyungpook National University (hatoz9@knu.ac.kr)
Changyun Park[2], Kyungpook National University

Abstract

In this study, we investigate zircons found in the Li-bearing pegmatite at the Boam Mine, Uljin. The microtextural and geochemical features of these zircons reflect the three-phase immiscibility (silicic melt – aqueous melt – aqueous fluid) that occurred during the evolution of the pegmatite system. These zircons are categorized into Type-A and Type-B based on their REE patterns, while displaying identical textural characteristics (T1, T2, T3 domain). The primary texture, T1 domain, is identified as relatively bright bands in oscillatory zoning and sector zoning. The T1 domain of the Type-A crystallized from the silicic melt, showing a positive Ce anomaly and a steep increase in concentration from LREE to HREE. In contrast, the T1 domain of the Type-B crystallized from the aqueous melt, exhibiting a negative Ce anomaly and a relatively LREE-enriched and flat REE pattern. Unlike the T1 domain, which crystallized from the immiscible melt, the T2 and T3 domains were formed through interaction with the aqueous fluid. The T2, a domain formed by a diffusion-reaction process, is characterized by the lowest crystallinity, porous and mottled texture. It shows the highest concentrations of U, Th, Ca, Al, Fe, and F among the three domains. Furthermore, both T2 domains of Type-A and Type-B exhibit a characteristic of total REE enrichment compared to the T1 domain. On the other hand, the T3 domain, formed by coupled dissolution-reprecipitation, displays embayment and inward-penetrating textures, exhibiting the highest crystallinity among all domains. This domain typically overprints T2 selectively, showing lower total REE and trace element concentrations, indicative of recrystallization. The formation of the T3 domain, which dissolved the pre-existing region, indicates an increasing abundance of F and alkali elements in the aqueous fluid. This is supported by the crystallization of mineral inclusions such as apatite, muscovite, and K-feldspar in this domain.

Keyword

zircon, Li-bearing pegmatite, 3 phase immiscibility

Metallogenesis of superlarge W-Cu ore systems in South China: Exampled by Zhuxi and Dahutang ore deposits

Xiaofei PAN[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(pan_smile0551@sina.com)
Yanshen Yang[2], University of Science and Technology Beijing
Xianke Fan[3], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

As one of the most important metal resources, the W-Cu deposits are rarely mentioned, especially on the regional tectono-dynamics, mechanism of magmatic mineralization and origin of the ore-forming material including W and Cu. The two super-large newly-discovered deposits Zhuxi and Dahutang W-Cu are located in the north Jiangxi province, which belongs to the superimposed part of foreland nappe thrust zone of the southeast coast of Eurasian continental Plate, and the Precambrian Suture between the Yangtze and Cathaysian Plates. The granites in the two deposits are complicated multiphase intrusions and their roles on the metallogenesis of tungsten a copper are unclear. And the pegmatite veins or shells, which represent the direct product of the transportation from magma to hydrothermal fluid, have been found out in the two deposits. Therefore, the Zhuxi and Dahutang W-Cu deposits have been studied in this project to clarify the metallogenic age and sequence, and magma-hydrothermal evolution. The Dahutang ore deposits consists of several sub-ore deposits and have already experienced multiple magma-hydrothermal events during 153-128 Ma. The granites in Dahutang area could be subdivided into early stage granites (151-138Ma) and late stage granites (138–128 M). Most of the ore bodies in the Dahutang W-Cu deposit were formed during 143-133 Ma, simultaneously to the early granites (151-138Ma). Extreme magmatic exsolutions have occurred in the Dahutang W-Cu area so that greisenization widely developed, and multiple pegmatite shells and thick-bedded UST quartz bands with several meter wide grew. Microthermometer of fluid inclusions indicate that the hydrothermal fluids are high temperature (>550 ~ 397℃) with two gups of salinity with 6.9 ~ 9.9 wt% NaCl eq. and 45.6~59.9 wt% NaCl eq., respectively. Strong water-rock reaction have occurred during the scheelite precipitation process, while fluid cooling and immiscible processes might happened to influence the precipitation of metal sulfide with minor scheelite during the hydrothermal quartz-sulfide±scheelite stage. The in-situ LA-ICP-MS analysis of fluid inclusions and UST quarts suggests that the magmatic fluid carried large amounts of copper enough to provide the copper source in Dahutang. The in-situ LA-ICP-MS analysis of sulfide have showed that the whole cryptoexplosive breccia type of sulfides, and most of the quartz-vein type of sulfides and disseminated sulfides are δ34S=−3 ~ +2‰, belonging to the magmatic origin. However, there are a few of extremely low negative sulfur isotope values (e.g. −36.34‰ to −8.25‰) in the quartz-vein type of sulfides and disseminated sulfides, showing that some sedimentary sulfur have been evolved into the two types of sulfide. The in-situ LA-ICP-MS U-Pb daing of wolframite and zircon, and mica Ar-Ar dating reveal that there are two ore-forming stages of 153-147 Ma and

143-141 Ma and a two-stage ore-forming model have been provided for Zhuxi deposit in this study.

Keyword

W-Cu deposit, fluid inclusion, In-situ La-ICP-MS analysis, Wolframite U-Pb dating, mica Ar-Ar dating NSFC-REPORT

The use of lithium as a Critical Mineral in Granitic Pegmatite

Alla DIAW[1]*, National Geological Survey in Senegal (alla.diaw@sgns.gouv.sn)
Rokhaya Samba DIENE[2], Organisation of Africa Geological Survey
Raymond SAGNA [3], National Geological Survey in Senegal

Abstract

Among critical mineral deposits found in granitic pegmatites, lithium is the most common due to its genesis. Granitic pegmatites exhibit the highest abundance of lithium.
Lithium is currently one of the most sought-after minerals globally due to its strategic position in sectors such as:
• Glass and ceramics (35%);
• Batteries and cells (31%);
• Greases and lubricants (8%).
Additionally, lithium plays a role in industrial chemistry processes.
The battery manufacturing, smartphone, and tablet sectors, along with the increased production of electric vehicles, have driven an 18% surge in lithium demand since 2010.
The mining sector is crucial in the transition toward a low-carbon economy. Solar panels, wind turbines, and electric vehicles heavily rely on minerals like cobalt, copper, lithium, nickel, and others. According to the International Energy Agency, limiting global warming to less than 2°C may require a fourfold increase in mineral supply for clean energy technologies over the next two decades.
In this context, these minerals play a vital role in Africa's energy transition. According to UBS AG, as reported by Bloomberg:
• Africa could enable China to control over 30% of the global lithium supply by 2025 (compared to 24% in 2022);
• By 2025, mines controlled by Chinese interests are expected to produce up to 705,000 tons of lithium, compared to 194,000 tons in 2022.
It is important to note that in the Ilymalo sector, south eastern part of Senegal, various studies conducted by BRGM in 1962 revealed a lithium-bearing silicate ore called spodumene within pegmatites associated with the Saraya Granitic Massif.
The lithium oxide (Li_2O) content is approximately 6%, and significant reserves are estimated to be over 5,000 tons.
For further lithium exploration, the focus should be on the borders of granitic pegmatite formations.

Keyword

Critical Mineral Deposit, Granitic-Pegmatite, Lithium Deposit, Energy Transition, Resources of Lithium

Genesis of the Koktokay pegmatitic rare-metal deposit (Altai, China): Constraints from the newly-recognized Triassic rare-metal leucogranite

Ping SHEN[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (pshen@mail.iggcas.ac.cn)

Abstract

Rare-metal granitic pegmatites are commonly associated with granites. However, for the Koktokay No. 3 pegmatite in the Chinese Altai, hosting a giant Li–Be–Nb–Ta–Cs–Rb–Hf deposit, the parental granites have not yet been found. The genesis of the No. 3 pegmatite has been controversial for many years. We conducted geological, geochemical and chronological research on the intrusions and the Middle Ordovician metamorphic rocks of Habahe Group in the Koktokay district. We recognized the Be-Nb-Ta-bearing highly fractionated leucogranite in the open pit in the Koktokay deposit based on detailed field and petrographic observations. The leucogranites consist of fine- to medium-grained muscovite albite granite and fine-grained albite granite in which beryl (Be) and coltan (Nb–Ta) occur. The muscovite albite granite is the main body of the leucogranite, and the albite granite is restricted to the margin of the muscovite albite granite. Six coltan U–Pb ages of the leucogranites from the open pit fall at Koktokay in a narrow range of 224.2 ± 2.7–220.7 ± 4.0 Ma which are in good agreement with our one coltan U–Pb age of 219.8 ± 1.3 Ma of the No. 3 pegmatite and the previously published ages of the No. 3 pegmatite with zircon and coltan U-Pb ages of 220–218 Ma. The muscovite 40Ar/39Ar ages from the same leucogranite samples yield the age range of 181.1 ± 1.4 Ma ~ 177.2 ± 1.2 Ma, indicating a new early Jurassic hydrothermal event. Therefore, the emplacement of the leucogranites and associated mineralization occurred in late Triassic which was followed by a new mineralization at early Jurassic at Koktogay. These leucogranites are characterized by high Al2O3 and Na2O and show well-developed convex tetrad effect. They are volatile-rich, peraluminous S-type granites and are formed by highly fractional crystallization and underwent melt and fluid interaction. The leucogranite is enriched in lithophile (Li, Be, Nb, Ta, Cs, and Na) and volatile elements (e.g., B, F, P, H2O) with extremely low ratios of Zr/Hf (8.2–13.8) and Nb/Ta (0.8–5.9), indicating a fertile rock. In addition, the metamorphic rocks of the Habahe Group are mainly composed of mica schist. Their trace element contents are similar to that of the continental crust. Therefore, it is impossible to directly form mineralizing magma through partial melting of these metamorphic rocks. Both leucogranite and No. 3 pegmatite are similar in ages, mineral assemblage and geochemistry. It indicates that they are contemporaneous and cogenetic, implying a common magmatic source. A much larger, unexposed parental granite, from which the leucogranite and No.3 pegmatite have fractionated, must lie at inaccessible depths. A granite-pegmatite model is established that the parental granite at depth is connected with leucogranite and pegmatite at shallow which is likely responsible for the formation of the giant Koktokay No. 3 pegmatite.

Keyword

Rare-metal leucogranite, Pegmatite, Highly fractional crystallization, Coltan U-Pb age, Koktokay deposit

[Keynote] Origin of Cu-Co mineralization in the Central African Copperbelt: Neoproterozoic syn-sedimentary-diagenetic processes overprinted by Pan-African orogenic mineralization events

Huimin SU[1]*, China University of Geosciences (Wuhan) (suhm@cug.edu.cn)
Shaoyong Jiang[2], China University of Geosciences (Wuhan)
Guoxiang Chi[3], University of Regina

Abstract

The Central African Copperbelt (CACB) hosts the majority of the Co resources in the world, however, whether these Cu-Co deposits were formed during the syn-sedimentary-diagenetic stage or by later hydrothermal processes at the orogenic stage is a matter of debate. The Luiswishi deposit, hosted in the least deformed and metamorphosed host rocks of the Katanga Supergroup within the CACB, was selected in this study to explore this issue. Petrographic observations indicate a certain correlation between the mineralogical compositions of the veins and their host rocks, with quartz-, dolomite-, and magnesite-(sulfide) veins occurring in silicic, dolomitic, and magnesitic host rocks, respectively. Four paragenetic stages were identified, i.e., the pre-ore stage with pyrite (Py0), syn-sedimentary-diagenetic Cu-Co stage with chalcopyrite (Ccp1), syn-orogenic Cu-Co stage with pyrite (Py2) and chalcopyrite (Ccp2), and post-ore stage with pyrite (Py3) as the dominant sulfides. U-Pb dating of hydrothermal monazites associated with the main vein-type mineralization and post-ore pyrite yielded ages of 523 Ma and 506 Ma, respectively, coinciding with the peak metamorphism of the Lufilian orogeny. Py0 exhibits elevated contents of Co and As but low Cu and Ni, with variable δ34SCDT values from -9.1‰ to +12.0‰. The δ34S values for Ccp1 vary with the lithology of the host rocks (avg. -1.3‰ for quartz siltstone; avg. 3.6‰ for dolomitic sandstone/dolostone; avg. 5.6‰ for magnesite rock). The coarse-grained Ccp2 from the discordant veins shows higher Sn and In contents than Ccp1, indicating that Ccp2 formed in a hydrothermal fluid with increased temperature. Py2 shows a gradual decrease in Co and As from the early phase (Py2a) to later phase (Py2c), reflecting the gradual depletion of these elements in the hydrothermal fluid. The sulfides in syn-orogenic vein-type ores show similar δ34S values as their corresponding syn-sedimentary-diagenetic sulfides disseminated in the stratiform ores, indicating that the sulfur for orogenic mineralization was mainly derived from the syn-sedimentary-diagenetic sulfides. Overall, the current study supports a model in which the sediment-hosted Cu-Co deposits in the CACB formed from Neoproterozoic syn-sedimentary-diagenetic processes overprinted by Pan-African orogenic mineralization events. The bulk of the metals and sulfur in the deposits were introduced in the syn-sedimentary-diagenetic stage, and the orogenic mineralization process mainly played the role of remobilization and upgrading of the syn-sedimentary-diagenetic mineralization.

Keyword

Sediment-hosted Cu-Co deposit, In-situ trace element analysis, In-situ S isotope analysis, Luiswishi deposit, Central African Copperbelt

Geochemical anomalies related to cobalt-nickel mineralization in the Eastern Kunlun Orogen, China

Yue LIU[1]*, CUG (liuyue7870@cug.edu.cn)

Abstract

The demand for Co and Ni metals is rapidly increasing worldwide, yet future metal supply remains uncertain due to the difficulty in discovering new deposits using traditional methods. The Eastern Kunlun Orogen (EKO) stands as a significant metallogenic domain located in the western segment of Chinese central orogenic belt. Since the discovery of the Xiarihamu super-large Ni-Cu-Co deposit in 2011, it has triggered a surge in intensified efforts to explore cobalt and nickel deposits in the EKO. Cobalt and nickel deposits can be roughly grouped into two genesis types: (i) magmatic Co-Ni sulfide deposit, and (ii) hydrothermal Co polymetallic deposit. In this study, advanced data processing methods including centred log-ratio (clr) transformation, compositional hierarchical clustering analysis (CHCA), compositional balance analysis (CoBA), local singularity analysis (LSA) and concentration-area (C-A) fractal analysis were applied to recognize Co-Ni mineralization-related geochemical anomalies from different perspectives based on stream sediment geochemical data. The clr-transformed method was used to eliminate the closure effect of compositional geochemical data. The CHCA and CoBA methods are employed to reveal Co-Ni mineralization-related multi-element combination pattern and constructed interesting compositional balances for anomaly mapping in space. The LSA is applied to recognize weak and concealed Co and Ni anomalies, and the C-A model was used to separate Co-Ni anomaly from geochemical background. Aided by the results of geochemical anomaly recognition, Co-Ni ore-forming characteristics of different genesis types were investigated, which allowed for delineating favorable prospecting zones with the purpose of exploring magmatic Co-Ni sulfide deposit and hydrothermal Co polymetallic deposit in the EKO.

Keyword

Critical metals;, Geochemical anomaly, Eastern Kunlun Orogen, Magmatic Co-Ni sulfide deposit, Hydrothermal Co polymetallic deposit

Major types of Co-Ni deposits and their exploration in China

Shao-Yong JIANG[1]*, China University of Geosciences (Wuhan) (shyjiang@cug.edu.cn)

Abstract

Cobalt and nickel are very important strategic mineral resources worldwide. The world cobalt resource is mostly hosted by sedimentary and metasedimentary rocks, while nickel resource is mainly from laterite type deposits, and these deposits are generally large in scale, high in ore grade, and easy to explore. However, the current mining and utilization of cobalt and nickel in China are mainly from magmatic type deposits, such as the Jinchuan Cu-Ni-Co deposits (150000 tons @ 0.019% Co, 5.526 million tons @ 1.06% Ni), and the Xiarihamu Ni-Co deposits (42900 tons @ 0.025% Co, 1.18 million tons @ 0.68% Ni), occurring in small plutons with low ore grade, small deposit size, and Co mainly as by-product with complex occurrence. Recent studies have shown that metasedimentary rock hosted Co deposits and hydrothermal Co deposits are widely distributed in China, but their occurrence characteristics and enrichment mechanisms are unclear, and the resource potentials and economic values need to be comprehensively evaluated.

In China, the metasedimentary rock hosted Co deposits are mainly found in the Liaoji and Zhongtiaoshan metallogenic provinces in the Paleoproterozoic orogenic belts of the North China Craton, including the Dahenglu large Cu-Co deposit, the Zhoujia medium-sized Fe-Cu-Co deposit, the Tongkuyu, Bizigou, Tongmugou, and Hujiayu large Cu-Co deposits. All these deposits have been modified by multiple magmatic-metamorphic-tectonic events and superimposed hydrothermal events. The hydrothermal cobalt deposits are widely distributed in China. Many of these deposits are independent cobalt deposits or deposits with cobalt as the main metal resource, which have great prospecting significance and potential economic value, including the Tuolugou Co-Au deposit (20000 tons @ 0.066% Co) and De'erni Cu-Co deposit (28500 tons @ 0.089% Co) in the East Kunlun Mineralization Belt, and the Qibaoshan and Wubaoshan Cu-Pb-Zn-Co deposits (15000 tons @ 0.403% Co) in Jiangxi province and the Longhua small-scale and high-grade Ni-Co deposit (3226 tons of Ni and 285 tons of Co @ 17-27.9% Ni and 1.55-1.95% Co) in Guangxi province in the Qinhang Mineralization Belt.

Currently, we have a national key research and development project on going, aiming to reveal the ore-forming mechanism of cobalt and nickel and also the efficient exploration techniques for Co-Ni orebodies, in an attempt to find and evaluate more cobalt and nickel resources in China, to innovate the genetic theory of cobalt and nickel mineralization, establish ore genetic and prospecting models, strengthen the exploration technology and capabilities, and explore potential high-quality cobalt and nickel resources in China.

Keyword

Co-Ni deposits, enrichment mechanism, genetic types, exploration methods, China

Unlocking critical metal resources from the Avebury metasomatic Ni sulfide deposit, Western Tasmania, Australia

JOSE LUIS LUIS BARILLAS DIAZ[1]*, University of Tasmania- CODES
(joseluis.barillasdiaz@utas.edu.au)
David Cooke[2], Centre for Ore Deposit and Earth Sciences (CODES), University of Tasmania
Lejun Zhang[3], Centre for Ore Deposit and Earth Sciences (CODES), University of Tasmania
Wei Hong[4], Centre for Ore Deposit and Earth Sciences (CODES), University of Tasmania
Yamila Cajal[5], Centre for Ore Deposit and Earth Sciences (CODES), University of Tasmania
Josh Denholm[6], Avebury Nickel Mine
Tony Chisnall[7], Avebury Nickel Mine

Abstract

Hydrothermal Ni systems are relatively rare and poorly studied. However, besides being a significant source of Ni, they may contain critical mineral resources (e.g., Co, PGEs, Bi, Sb). The Avebury Ni deposit is one of the best-known examples of non-magmatic nickel sulfide and cobalt arsenide deposits. It is located in the Zeehan mining district in the Dundas Region of Western Tasmania, Australia, characterized by complex geological evolution and diverse mineralization styles. The Avebury nickel sulfide orebodies formed within Cambrian serpentinized allochthonous mafic-ultramafic complexes and lie in the aureole of the strongly fractionated, reduced Devonian Sn-mineralized ~360 Ma Heemskirk granite.

The correlation of Bi, Sb and Au with Ni is evidence of hydrothermal-remobilized metasomatism at Avebury. The host rocks have been altered to skarn mineral assemblages, including diopside + hedenbergite + augite and tremolite-actinolite, and there has been intense borosilicate metasomatism, primarily axinite-(Mg) with accessory tourmaline. The mineralization occurs in the serpentine and serpentine skarn that replaced the ultramafics and, to a minor extent, in skarn developed in the Crimson Creek formation. The mineralized serpentine shows a positive correlation of Ni/Cr and Ni/Ti ratios from assay data. Prograde metasomatic reactions in mineralized magnesium-silicate skarn of Avebury are characterized by wollastonite + apophyllite, which hosted sphalerite and lesser galena and olivine + augite + diopside associated with nickel sulfides. The silicates in retrograde zones are clinozoisite + prehnite associated with arsenide Ni-Co mineralization.

The mineral textural relations from core logging and SEM/AMICS revealed a complex evolution of Ni and Co mineralization. The dominant nickel sulfide mineral at Avebury is pentlandite, which is associated with pyrrhotite, magnetite, and minor chalcopyrite. Pentlandite is hosted in olivine + clinopyroxene cumulates, which have been serpentinized in most cases where pentlandite occurs mainly as relatively coarse-grained sulfide blebs with pyrrhotite. Pentlandite also occurs in relatively fine-grained shattered disseminations within actinolite. The coarse pentlandite is fractured and encapsulated by magnetite, and Ni-arsenides have partly replaced pentlandite grains.

Pentlandite has altered slightly along grain edges to violarite and pyrite. Chalcopyrite may occur as exsolution intergrowths in millerite and pentlandite. In contrast to typical magmatic Ni deposits, the ratio of pentlandite is exceptionally high compared to pyrrhotite and chalcopyrite. Ni sulfides occur as coarse disseminations in metasomatized clinopyroxene-olivine cumulates in high-grade mineralized zones. Magnetite is associated with the sulfides in metasomatized serpentine. Ni-arsenides, including maucherite, nickeline, and gersdorffite have replaced pentlandite. Bismuth minerals, including parkerite and bismuthinite, and Sb minerals (ullmannite, hauchecornite, and breithauptite) are associated with Ni arsenides inferred to be hydrothermal. Cobaltite and alloclasite are the two main cobalt arsenide minerals, occurring in a mineralized halo within the Neoproterozoic volcanogenic sedimentary rocks of the Crimson Creek Formation proximal to the contact with the Cambrian serpentinite. Textural features demonstrate that the replacement of pentlandite by Ni-arsenides occurred late in the paragenetic evolution of Avebury. Apatite U-Pb ages from 374 ± 14 Ma to 347 ± 15 Ma from mineralized serpentine and skarn imply that hydrothermal remobilization of Ni-Co occurred at Avebury due to hydrothermal fluids derived from Devonian Heemskirk.

Keyword

Hydrothermal Ni-Co deposit, Serpentinized ultramafic, Critical minerals, Metasomatism, Skarn

Resource Potential Evaluation of Magmatic Cobalt and Nickel in the East Kunlun Metallogenic Belt, Northwest of China

Feng ZHANG[1]*, China University of Geosciences,Wuhan (1956606774@qq.com)
Qinglin Xia[2], China University of Geosciences,Wuhan

Abstract

In the Kunlun orogenic belt of the East Kunlun region, multiple magmatic sulfide deposits of cobalt-nickel type, such as Xiarihamu and Shitoukengde, have been discovered along the Kunlun fault. The area still holds significant mineral exploration potential. This study focuses on the East Kunlun orogenic belt, and based on the metallogenic geological background and metallogenic model research, combined with multi-source geological geochemical and geophysical exploration data, it conducts a metallogenic potential analysis of magmatic cobalt-nickel deposits in the study area using a geology-constrained convolutional neural network (CNN) model. In the construction of the CNN model, a hard constraint layer for mafic-ultramafic rocks is added in the convolutional layer based on the characteristic of the magnesium-iron ratio content of basic-ultrabasic rocks in cobalt-nickel deposits, which screens the mafic-ultramafic rocks in the evidence layer and establishes a geology-constrained CNN model, endowing the data-driven CNN model with theoretical interpretability. To ensure sample balance in the prediction data and prevent overfitting during the model prediction process, a sliding window method is adopted to expand the positive samples. Predictive models are established before and after sample expansion, and ROC is used to evaluate the predictive models. The research results show that the accuracy of the geology-constrained CNN model is 92.1%, indicating excellent predictive performance. The results, highly consistent with known deposits, suggest that the model's predictions can be used for resource potential assessment of magmatic cobalt-nickel deposits in the East Kunlun metallogenic belt in northwest China.

Keyword

Resource Potential Evaluation, Convolutional neural network, Hard-constraint, Co and Ni mineralization, East Kunlun Metallogenic Belt

Occurrence patterns and controlling factors of Co in the world-class Panzhihua Fe-Ti oxide deposit, SW China: implications for Co mineralization

Banxiao RUAN[1]*, China University of Geosciences (Wuhan) (bxruan@foxmail.com)
Ruiqin Liu[2], China University of Geosciences (Wuhan)
Xinlu Hu[3], China University of Geosciences (Wuhan)
Xinbiao Lv[4], China University of Geosciences (Wuhan)

Abstract

Cobalt is an important strategic critical metal mineral. The Panzhihua deposit is the world's largest iron and titanium oxide deposit, reported to contain 10,000-20,000 tons of cobalt with grades ranging from 0.01% to 0.02%, and the cobalt and nickel resources in the deposit have been able to be effectively recovered and comprehensively utilized. However, the occurrence of cobalt in this deposit, especially the characteristics of cobalt-containing minerals, is still unclear. We carries out Major and trace element geochemical analyses, SEM-EDS, LA-ICM-MS and mineral mapping for different types of rocks and minerals, and explores the variation of cobalt-nickel content and the state of cobalt-nickel accumulation at the petrographic, lithological and mineral levels. The Panzhihua deposit can be divided into 6 phase zones from shallow to deep, such as Upper zone, Middle zone(a), Middle zone(b), Lower zone, Bottom zone and Marginal zone, etc. Cobalt and nickel are mainly enriched in the Lower zone, with an average cobalt content of 174.95 ppm and an average nickel content of 131.65 ppm. Among the different lithologies in the Panzhihua deposit, cobalt and nickel are mainly enriched in the massive magnetite (massive-dense dipping ore). with average cobalt content of 277.06ppm and average nickel content of 281.09ppm. cobalt may occur independently as minerals such as cobalt pentlandite, linnaeite, and siegenite, or exist in isomorphous forms, substituting for iron (Fe) and nickel (Ni) in pentlandite, pyrrhotite, and pyrite. In chalcopyrite, cobalt exists mainly as microscopic inclusions.

Conclusion based on the previous analysis:

(1)Occurrence and mineralogical characteristics of cobalt. Cobalt predominantly occurs in sulfide minerals, indicating a strong affinity with sulfur. These sulfide minerals are mainly found in magnetite ores and ultramafic rocks.

(2)Differences in mineralization between nickel and cobalt. The mineralization of nickel primarily takes place during the magmatic stage, suggesting that nickel enrichment is mainly associated with magmatic activities, such as sulfur saturation and sulfide segregation. In contrast, cobalt undergoes enrichment both during the magmatic and hydrothermal stages, such as the flow and metasomatism. indicating a more complex mineralization process.

(3)In summary, while cobalt and nickel share some similarities in terms of their occurrence in sulfide minerals, there are significant differences in their mineralization processes. These differences reflect their distinct behaviors and enrichment mechanisms, providing valuable guidance for Co-Ni exploration and development.

Keyword

Cobalt, Occurrence patterns, Panzhihua, Fe-Ti oxide

Mineralization of Ni-Co and other critical metals in Early Cambrian black shales in the Yangtze Block of South China

Jing-Hong YANG[1]*, Nanjing University (yangjh@nju.edu.cn)

Abstract

Black-shale hosted deposits of Ni-Co and other critical metals occur widely in South China, which are either hosted in a thin stratigraphic horizon of the Early Cambrian Niutitang Formation along a 1,600 km-long NE-SW trending belt in the Yangtze Block (e.g., the Huangjiawan and Zhijin deposits in Guizhou province, Sancha and Cili deposits in Hunan province), or as cross-cutting veins locally (e.g., the Longhua Ni-Co deposit in Guangxi Province).

The first and major type of Ni-Co mineralization is the stratiform sulfide ore layers of Ni-Co (up to 7.0% Ni and 0.02% Co) and other critical metals, that were formed during syn-sedimentary seafloor hydrothermal venting and subsequent diagenesis at Early Cambrian in rift basins with Re-Os ages between 532 Ma and 521 Ma reported by various researchers. The black shale sequences are rich in organic matter (up to 10% TOC), sulfur and phosphorus, indicating an anoxic to euxinic ocean environment along the passive margin of the Yangtze Block. The major Ni-Co minerals in these sulfide ore layers consist of MoSC phase ([Mo,Fe,Ni][S,As]2C7), vaesite (NiS2), bravoite([Fe,Ni]S2), millerite (NiS) and jordisite([Mo,Ni]S2).

The second type of Ni-Co mineralization is the hydrothermal veins crosscutting the Cambrain fine clastic sedimentary rocks, representing by the Longhua Ni–Co deposit in Guangxi Province, Southwest China. This type of Ni-Co deposit is small in scale and comprises quartz-Ni(-Co) arsenide and sulfide veins in Cambrian strata with high concentrations of Ni (~ 17.55%) and Co (~1.55%) and a proven reserve of 3226 t of Ni and 285 t of Co. No occurrences of ultramafic, mafic or felsic intrusive rocks are found in the region, and the veins were formed at low temperatures (220-118 oC). The main ore minerals of Ni and Co include niccolite (NiAs), gersdorffite (NiAsS), maucherite (Ni11As8), cobaltite (CoAsS), pentlandite ([Ni, Fe]9S8), skutterudite ([Co, Ni]As2), chloanthite ([Ni, Co]As2), and parkerite (Ni3Bi2S2). Previously, a Re-Os isotope dating of niccolite samples from the quartz veins revealed a formation age of 463±9 Ma, in consistent with the Caledonian orogeny in South China (Huang et al., 2020).

Overall, the mineralization mechanism of Ni-Co and other critical metals in the Early Cambrian black shale sequence in the Yangtze Block of South China possibly includes multiple stages of metal enrichments, with the initial enrichment and/or first stage ore formation of Ni-Co polymetallic sulfides during early Cambrian syn-sedimentary sea-floor hydrothermal event, and the formation of high-grade Ni-Co ore veins during later Caledonian orogenic-driven hydrothermal event. The superimposed hydrothermal activity is of great important for super-enrichment of Ni-Co metals and more attention should be paid in future exploration of such kind

of hydrothermal type Ni-Co deposits in South China.

Keyword

Ni-Co enrichment, seafloor hydrothermal fluids, orogenic-driven hydrothermal fluids, Black shale sequence, South China

Platinum Group Elements and associated magmatic sulfide mineralization in the Tantalite Valley Complex, Southern Namibia

Daniel Reuben Ferreira[1]*, Stellenbosch University (21656118@sun.ac.za)
Bjorn Philip von der Heyden[2], Stellenbosch University
Martin Klausen[3], Stellenbosch University

Abstract

Orthomagmatic sulphide deposits are a primary source of Platinum Group Elements (PGEs), Nickel, Copper, and Cobalt. These elements are crucial for sustainability in a world that is increasingly moving towards a greener future and as such, exploration for these metals is of critical importance to facilitate the green energy transition.

The Tantalite Valley Complex (TVC) is a mafic-ultramafic complex located in southern Namibia. It forms one of four ultramafic bodies in the region belonging to the Kum Kum Suite that emplaced circa 1,2 Ga. Its crystallization history suggests that an immiscible sulfide melt formed and concentrated within an orthopyroxenitic host cumulate in the complex's southeastern sector. These sulphide aggregates manifest as disseminated sulphides (< 2wt. %) found at the interstices of cumulus minerals and are dominated by pentlandite (40 - 85 modal %) followed by pyrrhotite (20 - 60 %) and minor chalcopyrite (10 - 40 %). To date, only the ultramafic cumulates in the southeastern sector have been targeted by previous drilling campaigns. These ultramafic cumulates have a surface expression of less than 10 % compared to their gabbroic counterparts and leave the vast majority of the TVC unexplored.

The present study aimed to investigate the textures of the sulphide aggregates, their paragenesis, the origin of the sulphur within the magmatic system, and the fractionation of precious and semi-precious metals between different sulphide phases, including two known overprinting events. The investigation also aimed to explore the complex's mineralization potential in hosting a disseminated sulphur-poor Platinum Group Element deposit(s) or a sulphur-rich Ni-Cu (+-Co) deposit(s) and whether or not the TVC, and by extension the greater Kum Kum Suite, may be prospective in hosting at least one style of these deposit classes.

The results from in-situ multiple sulphur isotope analysis and whole rock sulphur/selenium ratios suggest that sulphur within the magmatic system is purely mantle-derived and negligible degrees of interaction occurred with sulphur-rich crustal sources. LA-ICP-MS studies indicate that deuteric pyrite is an important host of Ru, Rh, Os, and Ir and that magmatic pentlandite plays host to significant concentrations of Pd in solid solution. The R-factor for the complex is approximately 3,000 indicating an average value for mineral prospectivity. Based on these results the TVC might be considered most prospective for the sulphur-poor PGE-dominated deposit class.

Keyword

sulphide, magmatic, deposit, PGE

Linking Selective Alteration, Mineral Compositional Zonation and Sulfide Melt Emplacement in Magmatic Ni-Cu Sulfide Deposits

Mengmeng Cui[1]*, Institute of Geology and Geophysics,Chinese Academy of Sciences (cuimm@mail.iggcas.ac.cn)

Abstract

The magmatic Ni-Cu sulfide deposits in orogenic settings are characterized by extensive alteration, presence of hydrous minerals, and the nature of hydrous parental magmas. The role of water in the formation of the magmatic Ni-Cu sulfide deposit remains unclear. Here, we present petrological and mineralogical investigations of the Hongqiling Ni-Cu sulfide deposit, a typical representative of such numerous deposits in the Central Asian Orogenic Belt. Observations at various scales of field outcrops, hand specimens, thin sections and microscopes reveal that alterations are selectively exposed in silicate minerals, particularly olivine and pyroxenes that are close to ore bodies and sulfides. It is worth noting that alteration of olivine and pyroxenes becomes weak when hydrous minerals (hornblende and phlogopite) are present. Profile analyses demonstrate that the olivine grains enclosed in or in contact with sulfides have compositional zonation with Fe, Mn, Sc and Zn concentrations higher in closer to the contacts with sulfides relative to the cores and contacts with other silicates, while those grains in sulfide-barren rocks show relatively homogeneous compositions. Sulfides in rocks and ores are all free of alteration and have mantle-like sulfur isotopic compositions. These features suggest that the selective alterations occurring in early crystallized phases were induced by sulfide melt intrusion and crystallization, instead of late-stage processes as previously thought. The sulfide melts segregated at the early stage of the magma evolution were presumably hydrous and buoyant in the silicate magma and therefore were transported upward and penetrated into silicate grains. The hydrous fluids released from the sulfide crystallization to hydrate surrounding mineral phases and rocks, because the crystallized sulfides cannot structurally accommodate hydrous components. The fluids also enhanced compositional exchanges between sulfides and silicates and accounted for the crystallization of hydrous minerals. The characteristics of selective alteration and regular variations in mineral composition have also been found in magmatic Ni-Cu sulfide deposits of craton settings (e.g., the third largest Jinchuan deposit), suggesting the common of selection alteration in magmatic sulfide deposits. It can be considered as a significant indicator of mineralization and exploration in mafic-ultramafic intrusions.

Keyword

Ni-Cu sulfide deposits, Selective alteration, Sulfide melts, Elemental exchange, Hydrous fluids

Ni-PGE enrichment in the Jaguar and Jatobá IOCG deposits, Carajás district, Brazil

Yuri Tatiana CAMPO RODRIGUEZ[1]*, University of Adelaide (ytcampor@unal.edu.co)
Nigel J. Cook[2], University of Adelaide
Cristiana L. Ciobanu[3], University of Adelaide
Kathy Ehrig[4], BHP
Maria Emilia Schutesky[5], University of Brasilia
Sam A. King[6], University of Adelaide

Abstract

Iron-oxide copper-gold (IOCG) deposits encompass a broad range of alteration styles and ore assemblages unified by a dominance of iron oxides (magnetite and/or hematite), and often with elevated concentrations of valuable critical elements such as cobalt (Co) and rare earths. In the Carajás Mineral Province, Brazil, several deposits display relatively high concentrations of nickel (Ni) and/or platinum group elements (PGE). These metals are not typically recognized in IOCG-systems. The uniqueness of the Ni-PGE enrichment in the Carajás deposits lies in their spatial association with crustal-scale altered mafic-ultramafic lithologies.

We undertook petrographic, compositional (LA-ICP-MS) and nanoscale (STEM) study of samples from two Ni-enriched IOCG deposits, Jaguar and Jatobá. Results show similar hybrid-style mineralization expressed by multiple stages of overprinting and substantial reworking of early assemblages. The geochemical and mineralogical signatures of the two deposits do, however, differ significantly. In the Jaguar deposit, hydrothermal evolution is documented by sulphide assemblages/textures indicative of an early magmatic Ni-(Cu) mineralization event superimposed by IOCG-style Cu-mineralization. The main Ni-host in Jaguar is pentlandite with additional Ni occurring within compositionally-zoned pyrite and minor millerite. Less common Ni-Bi-Te minerals, including parkerite and bismutohauchecornite, associated with other Bi-Te-minerals are commonly observed within microfractures in pyrite. Despite the less intense alteration, the Jatobá deposit is more enigmatic. Multi-stage evolution is recorded by sulphide textures and inclusions within magnetite, namely amphiboles and non-classical pyriboles (NCPs). Early magnetite-pyrrhotite assemblages records Mg-Fe amphiboles and NCPs formed within a mafic/ultramafic lithology. Pyrrhotite is extensively replaced by pyrite, the major Ni-bearing sulphide, during the onset of IOCG-mineralization, an event associated with formation of Ca-(Al) amphiboles and Ce-bearing Mg-hornblende. Later (ferro)tschermakite formation is associated with shearing during main ore deposition. Nickel also occurs as bravoite and siegenite in Jatobá. Conspicuously, Ni-Bi-Te minerals are absent. Instead, several platinum group minerals are identified, filling fractures in pyrite and associated with rare earth- and uranium-minerals. All Pd-minerals identified (kotulskite, merenskyite, naldrettite, sudburyite, and borovskite) contain mobile elements such as Te-Bi-Sb. The novel occurrence of Pd and Pt (sperrylite) within sulphide mineralization in deposits considered to be of IOCG-type highlights the potential for additional discoveries in analogous examples of hybrid mineralization outside the Carajás district. The convergence of two

distinct geochemical signatures and superimposed fluid-assisted remobilization events contribute to the significant Ni-budget in both deposits. Moreover, the Ni-enrichment appears not to be restricted to sulphides, with significant Ni also contained within magnetite and amphiboles, a finding that carries implications for ore processing.

Nanoscale study reveals multi-stage generations of amphibole-NCP assemblages occurring as inclusions within magnetite. Their presence emphasizes the interpretive value of magnetite, a refractory mineral, for identification of overprinting events in terranes with protracted geological histories. Likewise, the discovery of Ce-rich hornblende in Jatobá provides new avenues to understand the early, alkali-calcic alteration of IOCG-systems.

Funding acknowledgment: Brazilian Research Council-CAPES, The University of Adelaide, and the Australian Research Council.

Keyword

Ni-enrichment, IOCG, PGE, Carajás Mineral Province

Geology and cobalt occurrence of the Cihai iron-cobalt deposit, eastern Tianshan, Xinjiang, China

Wei MEI[1]*, China University of Geosciences, Wuhan (meiwei09@qq.com)
Banxiao Ruan[2], China University of Geosciences, Wuhan

Abstract

The Cihai iron-cobalt deposit is located in the southern part of the eastern Tianshan, Xinjiang, northwestern China. The major iron orebodies are banded and nearly parallel to each other. The iron ores are hosted in an early mafic dike (i.e., diabase and pyroxenite) and in skarn. Magmatic-hydrothermal activity can be divided into four stages based on geological and petrographic observations:(1)K-Na alteration (stage I) is characterized by pyroxene being replaced by biotite and sodium metasomatism of Ca-rich plagioclase. (2) prograde skarn (stage II) is characterized by formation of abundant garnet and pyroxene, with minor magnetite. (3) retrograde skarn (stage III)is marked by formation of magnetite main ore and amphibole assemblage with minor epidote and zoisite. (4) stage IV is characterized by deposition of a pyrite-pyrrhotite-chalcopyrite-calcite-quartz assemblage, typically as sulfide-rich veins that cut the magnetite ores with lesser cobalt.
Whole rock analysis of the previous research results show that Co-enrichments were also recognized in massive sulfide ore (mean=928.67 ppm Co) and pyroxenite (mean=117.3 ppm Co). EPMA and LA-ICP-MS analyses showed that the main carrier of cobalt was Co-bearing pyrite (mean=6.09 wt% Co) in the form of Fe0.82~0.91Co0.09~0.18S2, and to a lesser extent, pyrrhotite (mean=567.89 ppm Co) and pyrite (mean=536.53 ppm Co), and minor chalcopyrite (mean=6.28 ppm Co). The Co-bearing pyrites occur as two forms: The first Co-bearing pyrites (CoI) occur as anhedral coexisting with pyrrhotite. The second Co-bearing pyrites (CoII) occur along the edges of subhedral pyrite, suggesting the Influence of late hydrothermal action. Formation of the Cihai iron deposit is closely related to post-collisional subvolcanic action and associated Cu-Ni-Co polymetallic mineralization in the eastern Tianshan.

Keyword

cobalt occurrence, Co-bearing pyrite, Cihai iron-cobalt deposit, Eastern Tianshan

The origin and mineralization processes of the Dulenggou copper-cobalt deposit in Eastern Kunlun metallogenic belt, western China

Wei WANG[1]*, China University of Geosciences, Wuhan (1768140159@qq.com)
Shao-Yong Jiang[2], China University of Geosciences, Wuhan
Hui-Min Su[3], China University of Geosciences, Wuhan

Abstract

The eastern Kunlun region in western China stands out as an important polymetallic metallogenic belt hosting gold, copper, iron, cobalt, and nickel resources. Within this belt lies the Dulenggou deposit, a notable copper-cobalt deposit. The ore bodies have lengths ranging from 106 to 335 m and widths ranging from 2.12 to 13.4 m. Copper grades within the deposit range from 0.45% to 28.41%, while cobalt grades range from 0.02% to 0.43%. The exposed formations include the Meso-Neoproterozoic Wanbaogou Group, Lower Triassic sandstone and conglomerate, the Ordovician-Silurian Nachitai Group, and Quaternary sediments. The Wanbaogou Group consists of intermediate basic volcanic rocks such as andesite, andesitic tuff, and tuffaceous limestone. The NaijTal Group consists mainly of andesite, chlorite sericite phyllite, and tuffaceous slate, which is the host strata of the Cu-Co-Ni orebodies.

We identified three cobalt minerals (cobaltine (CoAsS), siegenite ((Ni,Co)3S4), glaucodot ((Co,Fe)AsS)) and four nickel minerals (ullmannite (NiSbS), gerdorffite (NiAsS), violarite (FeNi2S4) and millerite (NiS)) coexisting with chalcopyrite in the Dulenggou deposit. Three stages of pyrites were identified: Py0, PyI and PyII, which are all depleted in cobalt, but PyI can contain Ni contents up to 8814 ppm (with an average of 2490 ppm). The sequence of mineral formation follows Py0 → PyI + Ccp + Co-Ni mineral (the major mineralization stage) → PyII.

The mineralization age of the Dulenggou deposit is determined by in-situ U–Pb dating of monazite occurring close to chalcopyrite and Co-Ni minerals with an age of 457±18 Ma, providing direct evidence confirming that the Cu-Co-Ni mineralization formed simultaneously with the host strata of the Nachitai Group (416 to 538 Ma). The δ34S values of sulfides range widely from 1.9‰ to 22.1‰. From Py0 to PyI to PyII, the δ34S values decrease from 17.6‰–22.1‰ to 9.1‰–14.6‰ to 1.9‰–7.7‰. These findings challenge previous views that this deposit is an epigenetic hydrothermal deposit formed during the Variscan-Indosinian period. This study indicates that the Dulenggou Cu-Co-Ni deposit is a syngenetic sea-floor sedimentary exhalative deposit (SEDEX).

Keyword

the Dulenggou deposit, cobalt-nickel minerals, mineralization age

Mineralogy and geochemistry of nickel laterite deposit in the Acoje block of the Zambales ophiolite, Philippines

Yusuke Suzuki[1], Kyushu University
Akane ITO[2]*, Kyushu University (aito@mine.kyushu-u.ac.jp)
Kotaro Yonezu[3], Kyushu University
Jillian Aira Gabo-Ratio[4], University of the Philippines
Marie Iris Duenas[5], Eramen Minerals Inc.
Jeano Patrick Urgel[6], Eramen Minerals Inc.
Akira Imai[7], Kyusyu University

Abstract

Nickel laterite deposits, formed by chemical weathering of ultramafic rocks, are important Ni resources and potential targets for some critical metals, such as Co and Sc. Nickel laterite deposits are well developed in modern and ancient tropical and subtropical regions, such as New Caledonia, Caribbean countries (e.g., Cuba, Dominica), Western Australia, and Southeast Asia, including the Philippines and Indonesia. Among them, few systematic studies have been carried out for those in Philippines and Indonesia. In this study, we investigated the mineralogy and geochemistry of the Ni laterite deposit developed on the ultramafic rocks in the Acoje block of the Zambales ophiolite, Luzon Island, Philippines, to understand the chemical weathering processes of ultramafic rocks involving Ni enrichment. The Zambales ophiolite is the largest ophiolite complex in the Philippines, exposed in western Luzon Island. Weathered samples and bedrock samples were collected from one weathering profile and three drill cores developed on peridotites with different degrees of serpentinization. Major and some minor element concentrations were measured by XRF, and the mineralogical compositions were analyzed by XRD. Magnetic susceptivity and LOI of the bedrock samples were measured to estimate the degree of serpentinization.

The XRD results show that the bedrock samples are mainly composed of serpentine, olivine, orthopyroxene with minor amount of clinopyroxene, chromite and magnetite, suggesting that the bedrock is serpentinized harzburgite. In addition, the magnetic susceptibility and LOI values of the bedrock indicate varying degrees of serpentinization. To quantify the chemical changes that have occurred during the weathering process, an ultramafic alteration index (UMIA=100×[(Al_2O_3+Fe_2O_3)/(SiO_2+MgO+Al_2O_3+Fe_2O_3)]) was calculated. The calculated UMIA values and the molar ternary diagram (Al_2O_3+Fe_2O_3–SiO_2–MgO) plots follow the typical weathering trend reported for ultramafic rock weathering in tropical regions, indicating weathering from an initially Mg- and Si-rich bedrock to an Al- and Fe-rich surface. Furthermore, the higher UMIA values were observed in the weathering profiles developed on bedrock with a lower degree of serpentinization. Nickel enrichment was observed in the saprolite horizon in all weathering profiles. The weathering profiles with higher weathering intensities and higher bedrock Ni concentrations were associated with higher saprolite Ni concentrations. The saprolite horizon consists of an assemblage of serpentine + smectite + goethite. These minerals are considered to be

Ni host minerals as described in the previous study (Aquino et al., 2018). The elemental transfer calculation of major and minor elements using TiO_2 contents as an immobile element shows that Si and Mg were absolutely lost, with up to ~99 % losses in all weathering profiles during the weathering. Nickel showed high losses to moderate gains in the saprolite horizon, contrasting with the significant gains reported by Aquino et al. (2018). These results suggest that the Ni enrichment is mainly due to residual accumulation and the Ni content in the bedrock is a key factor to form the high Ni weathering profiles in the study area.

Keyword

ultramafic rock, weathering, laterite, nickel, rare metal

AfricaMaVal – Building Africa-EU partnerships on sustainable raw materials value chains: focusing on business network with upstream and downstream companies

Marko KOMAC[1]*, INTRAW (m.komac@telemach.net)
Vitor Correia[2], INTRAW
Eberhard W. Falck[3], INTRAW
Jean-Claude Gillineau[4], BRGM

Abstract

Securing the access to raw materials represents a critical issue for the EU ambition to deliver the Green Deal and perform the energy and digital twin transition. AfricaMaVal, a 3.5-year EU funded project aims to build an Africa-EU business network on whole CRM value chains (CRMVC). The consortium brings together African and European experienced organisations, associations, and networks deeply anchored and involved in the raw material domain with specific expertise, and knowledge.

The project is developing a responsible and sustainable EU-Africa partnership for sourcing minerals for the European industry. It focuses on creating a mutually beneficial environment that prioritises environmental, social and governance standards and results in long-term business opportunities for both, African and European companies. To achieve this, the project studies the mineral resources, financial, environmental, social, institutional, and economic aspects of the CRMVC, with particular emphasis also on artisanal and small-scale mining (ASM). The operational targets are the building of an Africa-EU business network on covering the whole CRMVCs, the development of a strategy for the integration of identified and emerging African-EU CRMVCs relevant for the energy and digital transition, and an identification and assessment of responsible investment opportunities (based on ten African country case studies with the target to evaluate 100 investment opportunities).
A specific work package is dedicated to building an Africa-EU business network with upstream and downstream companies. It aims to steer the development of strategic partnerships and workable business models for Africa-EU industrial value chains integration. The established networks will allow stakeholders in CRMVCs to connect, such as end-users. Strengthening local governance and responsible business environments, together with other institutions and development partners with a focus on the informal sector, is a particular objective. New business models are being developed aiming to integrate Africa-EU CRMVCs, considering both, horizontal and vertical integration. For this purpose, upstream and downstream business ecosystem are being mapped to capture relationships at local and regional levels (i.e., clusters of equipment providers, support services, transport, education, etc.), intra- and inter-cluster network relationships, and the interdependences of industrial and ASM clusters in the ten case study countries. This will help to further promote local content and to enable mining cluster actors to co-create added value, and

new businesses, products, and services by transforming the ways they interact. These measures will increase the entrepreneurial capacity of individuals and organisations within all sectors – research, academia, industry, and government at several dimensions – technological, environmental, economic, and societal.

As a result, project will elaborate on avenues for business relations to be strengthened by proposing a) targeted measures such as possible policy/financial incentives to stimulate the development of international clusters across CRMVC, b) alternative financing models based on integration of various international actors, c) organising targeted face-to-face or virtual B2B networking events vertically and transversally across CRMVC. The overarching aim is to foster win-win partnerships between clusters and value-chain actors in Africa and the EU based on the Raw Materials Networking Platform under development.

Keyword

Africa, Artisanal & Small-scale Mining, CRM Value Chain, Environmental & Social and Governance, Responsible Sourcing

Resource potential of Russian Federation for critical raw materials. Lithium factor

Oleg Vladimirovich KAZANOV[1]*, Russian Mineral Resource Institute – VIMS (kazanov@vims-geo.ru)
Anna Mikhailovna Lapteva[2], Russian Mineral Resource Institute – VIMS
Ekaterina Sergeevna Malysheva[3], Russian Mineral Resource Institute – VIMS
Aleksandr Alekseevich Rogozhin[4], Russian Mineral Resource Institute – VIMS

Abstract

Russian Federation is one of the leading historical suppliers of battery quality nickel and cobalt. But the times have changed. Analysis of public data on the resource potential, exploration activity and public plans of the mining companies reveals that by 2030 Russia will join the group of lithium market leaders due to offensive exploration of the pegmatite deposits in Russian Arctic and Siberia. Further potential deals with non-pegmatite types of lithium deposits including lithium granites and hectorites and historical mine wastes. Hydromineral lithium source is under exploration in Angara-Lena basin's oil fields and North Caucasus where high lithium water composition seems to be DLE (direct lithium extraction) friendly. All potential sources of lithium are being studied by Russian Geological survey focusing on metallurgy and modern extraction techniques. In 2026 Russian Federation will start lithium mining to provide mineral concentrates for the national LCE producers. Based on lithium deposits that have been explored so far by 2030 Russia will be able to produce up to 100,000 tons LCE (lithium carbonate equivalent) affecting global lithium market. Significant part of the Russian lithium is to be consumed within the country as offensive national programs for electric vehicles and battery giga fabrics have started.

Keyword

lithium, battery metals, pegmatite, hydromineral source

CRM-geothermal: Raw materials from geothermal fluids

David Govoni[1]*, European Federation of Geologists (efg.president@eurogeologists.eu)
Pavlos Tyrologou[2], European Federation of Geologists
Maureen Gallagher[3], European Federation of Geologists

Abstract

The energy and digital transitions require a large amount of mineral raw materials, some of which are considered 'critical' by the European Union. These Critical Raw Materials (CRM) are predominantly imported from non-European countries where environmental and ethical standards may be less strict than in the EU. However, the EU has largely untapped resources at its disposal in geothermal fluids, some of which contain significant amounts of CRMs.

The EU-funded CRM-geothermal project therefore proposes to combine the extraction of mineral raw materials and geothermal heat, a renewable energy resource from the ground that is available 24 hours per day. The technology solution developed by CRM-geothermal will thus help Europe fulfil the strategic objectives of the EU Green Deal and the Agenda for Sustainable Development while reducing dependency on imported CRM.

Although Critical Raw Materials are known to occur in geothermal fluids, there are still many uncertainties concerning their occurrence in different geological settings and the sustainability of their extraction. The actual extraction process is also a major challenge, requiring technology development. The Horizon Europe-funded CRM-geothermal project therefore aims to:

• establish an overview of the potential for raw materials in geothermal fluids for a large range of elements across the EU and third countries;

• determine the source of selected CRM, their mobility and potential for sustained extraction from geothermal brines;

• develop and optimise innovative extraction technologies for selected CRM from geothermal brines that can form a business case for European SMEs;

• assess the environmental-social-economic viability, create transparent and traceable value chains, and foster ethical sourcing of CRM;

• demonstrate at a pilot site the extraction technology for at least one CRM at the scale of a mini-plant and evaluate the system's sustainability.

The combined extraction technology will support the European Union and wider economic area in developing a more resilient and ethical CRM supply-chain from domestic sources, reducing its dependency on imports, which are exposed to market and political risks. The proposed solution will also help to bridge the gap between societal resistance to domestic raw materials extraction and increasing demand for raw materials that are critical for the Twin Transition. Finally, the combined extraction of minerals and heat will also increase the number of viable geothermal projects, fostering the green transition and diversifying Europe's energy portfolio.

CRM-geothermal is coordinated by the Helmholtz Zentrum Potsdam Deutsches Geoforschungszentrum (GFZ) based in Potsdam, Germany. The research consortium consists of

20 partners, involving 14 EU-based and 6 associated partners from UK, Switzerland and Kenya, covering academic and industry backgrounds.
CRM-geothermal is funded by the European Union. Views and opinions expressed are however those of the author(s) only and do not necessarily reflect those of the European Union or CINEA. Neither the European Union nor the granting authority can be held responsible for them.

Keyword

Critical Raw Materials, geothermal fluids, EU Green Deal, geothermal brines

Certification of Competencies in Geosciences in Africa: Facts, Fictions, Geopolitical Considerations and African Union Perspectives

Tunde Muritala ARISEKOLA[1]*, African Minerals Development Centre(AMDC), African Union Commission(AUC) Addis Ababa, Ethiopia (Arisekolat@africa-union.org)

Abstract

Certification of Competencies in Geosciences in Africa: Facts, Fictions, Geopolitical Considerations and African Union Perspectives
Tunde M. ARISEKOLA FNMGS
Africa Mineral Development Centre
African Union Commission Headquarters
Addis Ababa, Ethiopia
Email: ArisekolaT@africa-union.org
ABSTRACT
Africa is known for its diverse geology and abundant oil, gas, and mineral reserves. It ranks among the top in resources such as bauxite, chromite, cobalt, industrial diamonds, lithium, copper, manganese, phosphate rock, platinum-group metals, rutile, soda ash, and zirconium. Despite these vast resources, Africa has struggled to translate mineral and petroleum wealth into socio-economic benefits for its people. The “resource curse” phenomenon has plagued the continent, with poverty persisting alongside pockets of wealth. A significant portion of recent investments in mineral and energy exploration has focused on Africa, emphasizing the need for these investments to contribute to the overall prosperity of the continent directly.

Several critical areas have been identified as essential for sustainable resource development in Africa. These include the lack of quality resource information, the need for homegrown competent geoscientists, the capacity to negotiate fair deals, good governance, infrastructure development, and artisanal and small-scale mining support. African countries lack a comprehensive understanding of the true value of their mineral resources due to external assessments and certification processes that leave them vulnerable to the interests of multinational companies. This situation necessitates adopting measures that promote transparency, equitable exploitation, and optimal utilization of Africa's mineral resources.

The Africa Mining Vision (AMV), adopted by African Heads of State and Government in 2009, aims to achieve transparent, equitable, and optimal exploitation of mineral resources to foster sustainable growth and socio-economic development. The AMV emphasizes harmonising strategies, policies, instruments, and practices to enhance the participation of Africans and African countries in regional and global value chains. AMV Action Plan aims to improve Geological and Mineral information systems to underpin investment in exploration and mine development. However, the lack of a comprehensive resource classification and management system across the

continent, except for South Africa, poses a challenge. The Africa Mineral and Energy Resource Classification and Management System (AMREC) seeks to bridge this gap and become the first system to encompass oil, gas, minerals, and renewable energy resources in a single package. It also includes the implementation of the Pan-African Resource Reporting Code (PARC) for transparent financial reporting.

Therefore, there is a need to focus on the importance of certifying geoscientists as qualified or competent professionals, the requirements and assessment processes for certification, geopolitical considerations, and the perspectives of the African Union. It explores the paradox of Africa's mineral wealth existing alongside pervasive poverty and the exploitation of Africa's minerals by commodity business models. The discussion also delves into how Africa can overcome these challenges, adapt to the changing role of minerals in the world, and prepare for the new geopolitical landscape. The visionary agenda for minerals development in Africa, as outlined by the African Union, is presented, highlighting the role of the AMV and the African Minerals Development Centre (AMDC).
This presentation examines the importance of geosciences competencies for African

Keyword

AMV, AMREC, PARC, AMDC

Major global producers of critical minerals in extraction and processing stages

JI WON MOON[1]*, U.S. Geological Survey (jmoon@usgs.gov)
Sean Y. Xun[2], U.S. Geological Survey
Jaewon Chung[3], U.S. Geological Survey
Steven D. Textoris[4], U.S. Geological Survey

Abstract

Under the global condition of continued conflicts in Europe and the Middle East region, high global price inflation, mixed recovery post COVID-19 and variant-wave, energy and mineral resources protectionism, minerals' criticality has resurged in studies to address the need to sustain advanced technologies, develop the economy, and ensure national security. Major global producers of critical minerals at the extraction and processing stages were investigated among 50 commodities of U.S. critical mineral list in 2022, which was determined by locality of concentrated production, significant consumption of the U.S., and high-cost raw material supply over low profit for manufacturing. Combined production dominance and net import reliance with major import partners would help determine which commodities may require more import diversification to lessen potential supply disruption. Commodities, of which China was leading producer in either of extraction and processing stages and leading import partners of the U.S., were found to be gallium, rare earths, bismuth, antimony, tungsten, magnesium, germanium, graphite, and barite. Vanadium and mica were commodities that China was the leading producer and the second-ranked import partner. Over the past few years there have been announcements of China's new and expanded export control policies. In 2020, these included the rare earth elements which are key to permanents magnets used in motors and generators and tungsten which is key to armaments and superalloys. In 2023, these were for gallium and germanium which are key for the semiconductor industry and for graphite, key for rechargeable batteries. While future supply disruptions cannot be predicted, based on this investigation, some mineral commodities face ongoing high production concentration and these include bismuth, antimony, magnesium, and barite.

Keyword

critical minerals, extraction and processing stages, production dominance, net import reliance

Rare Earth Elements and Yttrium (REY) enrichment in mining wastes from Tinto river area (SW Spain)

ESTHER SANTOFIMIA[1], Instituto Geológico y Minero de España (IGME-CSIC)
Paula García-Sarzosa[2], Instituto Geológico y Minero de España (IGME-CSIC)
Blanca Rincón-Tomás[3], Instituto Geológico y Minero de España (IGME-CSIC)
Ángeles Aguilera[4], Centro de Astrobiologia (CAB), CSIC-INTA
Elena González-Toril[5], Centro de Astrobiologia (CAB), CSIC-INTA
Francisco Javier González[6]*, Instituto Geológico y Minero de España (IGME-CSIC)
(fj.gonzalez@igme.es)

Abstract

Rare earth elements and yttrium (REY) were analysed along the Tinto river, affected by acid mine drainage (AMD) originated from several leach inputs from waste-rock piles. While the Tinto river and AMD showed acid pH (0.73–2.46), AMD presented higher electric conductivities than the Tinto river (20.17–56.14 mS/cm and 9.34–3.42 mS/cm, respectively). Total ΣREY measured concentrations were up to 2600 ug/L in the Tinto river and 17056 ug/L in AMD. The AMD presented higher Ce, Nd, La, Y and Sm concentrations, with values up to 6196, 3485, 2604, 1465 and 845 ug/L, respectively.

Iron precipitates sampled on the Tinto river bed were characterized as schwertmannite (Fe8O8(OH)8-2x(SO4)xO16•nH2O), goethite (α–Fe3+O(OH)) and jarosite (KFe3(SO4)2(OH)6). These minerals showed an enrichment of critical raw materials (CRMs) such as Mn (up to 3%), Cu, Zn, As and Co (up to 3630, 3400, 2004, 106 ug/g, respectively). In addition, these iron precipitates also presented low REY contents such as Y, Ce, La, and Nd, despite these elements do not have a predisposition to be removed from solution through Fe precipitates. Schwertmannite is a mineral with a high specific surface area, which is positively charged at low pH. Hence, this precipitate can be capable of eliminating dissolved REY, as sulphated anionic complexes (e.g. REY(SO4)2-) by adsorption.

Waters and precipitates show an enrichment in MREE signature, followed by HREE with respect to NASC (North American Shales Composite) normalized REE patterns. The REE NASC-normalized patterns of the Tinto river water samples resemble those of the AMD samples, although the latter present an enrichment of LREE.

The characterization of acid waters and mineral precipitates is crucial to understand their potential as sources of strategic and CRMs. Furthermore, assessing the feasibility of recovering these materials would contribute to the promotion of a circular economy.

This work has been supported with funds from the Horizon Europe project GSEU (HORIZON-CL5-2021-D3-02-14, Project 101075609) and by grants of the Spanish Ministry of Science and Innovation/State Agency of Research MCIN (PID2022-138986OB-100). Paula García-Sarzosa has been financed by JAE Intro 2023 programme (CSIC).

Keyword

Rare earth elements, Acid mine drainage, Iron precipitates, Critical raw materials

Serpentinization in the Malawi Rift- a potential to power the energy transition.

Chikumbutso Cyril KAMBILONJE[1]*, Malawi Geological Survey Department
(chiku.kambilonje.gsd@gmail.com)
chifundo Njala[2], Malawi Geological Survey Department

Abstract

Serpentinization, a geological process involving the hydration and metamorphism of ultramafic rocks, presents a promising avenue for sustainable energy production. The Malawi Rift, characterized by its tectonic activity and abundance of ultramafic rocks, emerges as a potential hotspot for leveraging serpentinization to drive the transition towards clean energy. This abstract explores the transformative potential of serpentinization in the Malawi Rift region and its implications for the global energy landscape.

The primary focus of this study is to investigate how serpentinization can serve as a cornerstone for transitioning towards a low-carbon economy. By harnessing the inherent properties of ultramafic rocks and the presence of water in the rift, hydrogen gas—a clean and versatile energy carrier—is produced through serpentinization. This hydrogen can be utilized in various applications, including electricity generation, transportation, and energy storage, thereby reducing dependence on fossil fuels and mitigating greenhouse gas emissions.

Through a comprehensive analysis of geological, technological, and socio-economic factors, this abstract delineates the feasibility and potential of serpentinization-based hydrogen production in the Malawi Rift. It elucidates the geological characteristics of the rift conducive to serpentinization, highlighting the abundance of ultramafic rocks and hydrothermal systems essential for the process. Furthermore, it examines the technological advancements required for efficient hydrogen extraction and utilization, emphasizing the need for scalable and cost-effective solutions to realize the full potential of serpentinization.

In addition to its technical aspects, this study explores the socio-economic implications of serpentinization in the Malawi Rift. It discusses the opportunities for local economic development, job creation, and infrastructure investment associated with establishing hydrogen production facilities in the region. Moreover, it underscores the importance of international cooperation and investment in supporting the development of serpentinization-based energy projects, fostering technology transfer, and capacity building.

Furthermore, this study addresses the environmental benefits of serpentinization-based hydrogen production, emphasizing its role in reducing greenhouse gas emissions and mitigating climate change. By displacing fossil fuels in various sectors, hydrogen derived from serpentinization contributes to cleaner air, improved public health, and enhanced environmental sustainability.

However, the study also acknowledges the challenges and uncertainties inherent in leveraging serpentinization for clean energy transition. Technical hurdles, such as optimizing hydrogen extraction methods and scaling up production processes, must be overcome. Additionally, socio-economic considerations, including regulatory frameworks, market dynamics, and community engagement, play a crucial role in shaping the success of serpentinization-based energy projects.

In conclusion, this study underscores the transformative potential of serpentinization in the Malawi Rift as a catalyst for advancing the global energy transition towards sustainability. By capitalizing on the natural geological processes of the rift, coupled with technological innovation and strategic collaboration, serpentinization offers a pathway towards a cleaner, more resilient energy future.

Keyword

Rifting, Energy, Hydrogen, sepentinization

Differential hydrocarbon accumulation and enrichment in the northern Kuqa foreland basin, western China

Xinzhuo Wei[1]*, China University of Petroleum (East China) (18562066560@163.com)
Xianzhang Yang[2], Tarim Oilfield Company, PetroChina
Jianliang Liu[3], China University of Petroleum (East China)
Haijun Yang[4], Tarim Oilfield Company, PetroChina
Xiujian Ding[5], China University of Petroleum (East China)
Keyu Liu[6], China University of Petroleum (East China)

Abstract

The Kuqa foreland basin in western China is located in the northmost margin of the Tethys Geodynamic belt, the evolution of the basin and its petroleum system development were closely related to the closure of the Neo-Tethys Ocean. The Jurassic terrestrial reservoirs in the northern Kuqa foreland basin contains widespread hydrocarbon accumulations. However, the distribution and enrichment of oil and gas varies significantly among different tectono-structural domains in the foreland basin, including the central anticline belt, southern slope belt and deep sag belt. To understand the differential hydrocarbon enrichment mechanisms among the tectono-structural domains in the area, it is crucial to clarify the hydrocarbon accumulation process and evolution of individual domain. In this study, the hydrocarbon accumulation process of each tectono-structural belt was investigated using integrated quantitative grain fluorescence analysis, fluid inclusion petrography and micro-thermometry, in combination with structural evolution and burial history analysis. Five types of oil inclusion, with orange, yellow, yellow-whitish, blue-whitish and blue fluorescing colors, are widely developed in the central anticline belt. Combined with structural evolution and trap development history, it is believed that the trap was formed early, which determined the direction of continuous oil and gas charge and migration. Owing to differential destruction of oil and gas reservoirs by subsequent tectono-structural deformation, there exists huge differences between hydrocarbon accumulations in the east and west of the central anticline belt. The southern slope belt can be further sub-divided into a slope zone and a low uplift zone. The slope zone contains migration conduits for oil and gas passing through updip with no paleo-oil and gas accumulations. However, in the low uplift zone, small-scale structural traps were formed concurrently with oil and gas charge, thus entrapping oil and gas in this zone. Favorable reservoir and trap development are the key factors controlling hydrocarbon accumulation in this area. In the deep sag area, oil and gas inclusions are not well developed. Given a weak diagenesis and tectonic activity during the early stage, the initially charged low-mature oil was not recorded in the reservoir, but the late oil charge event was recorded by the blue-whitish oil inclusions. The lack of large-scale effective trap development throughout the structural evolution has been identified as the main cause for the absence of any major oil and gas accumulations in the Jurassic reservoirs in the study area.

Keyword

Kuqa foreland basin, fluid inclusion, differential enrichment, accumulation process, petroleum geology

[Keynote] Hydrocarbon enrichment in basins influenced by Tethyan evolution: A comparative analysis of the Persian Gulf Basin and the Sichuan Basin

Zhiliang HE[1]*, China University of Geosciences (hezhiliang@cug.edu.cn)
Zhijun JIN[2], School of Earth and Space Sciences, Peking University; SINOPEC Petroleum Exploration and Production Research Institute
Shuangjian LI[3], SINOPEC Petroleum Exploration and Production Research Institute, SINOPEC Key Laboratory of Geology and Resources in Deep stratum
Guoping BAI[4], School of Earth and Space Sciences, Peking University

Abstract

The hydrocarbon accumulation mechanisms and differences in the Tethyan realm serve as a hot research topic in the petroleum geology community in domestic and abroad. Both the Persian Gulf Basin in the Middle East and the Sichuan Basin in China that exhibiting anomalous hydrocarbon enrichment were situated on the southern and northern sides of the Tethyan realm, respectively. These two basins have recorded the whole geological processes from the opening to the closure of Prototethys, Paleotethys, and Neotethys sequentially. Based on the analysis of the plate tectonic evolution in the Tethyan realm, this study dissects the structures and hydrocarbon accumulation modes of both basins. Followed by a comparative analysis of the factors controlling hydrocarbon enrichment in the processes of plate breakup and convergence in the Tethyan realm, this study proposes petroleum exploration targets hereby. The results are as follows: (1) From the Mesoproterozoic-Neoproterozoic, the Persian Gulf Basin and the Sichuan Basin have undergone similar tectonic evolution in the early stage but diverse in the late stage. Evolution along the formation of the Prototethys, Paleotethys, and Neotethys oceans, both basins experienced multi-stage development and modification, forming two major extension-convergence cycles. Consequently, both basins are characterized by the vertical orderly superimposition of various basin prototypes in the order of rift - intracratonic basin, e.g., passive continental margin - foreland; (2) The fact that the Tethyan realm was located at medium-low latitudes for a long term, and the local anoxic environment formed in the processes of plate breakup and convergence did play a vital role in the formation of extensive source rocks. The source rocks are predominantly distributed in underfilled rifts and deep depressions that were connected to the ocean in the unidirectional continental breakup process, in the basin-slope structures and intra-shelf basins on passive continental margins, in the basinal lows within intracratonic basins, and in underfilled foredeeps of foreland basins. The favorable areas for the formation of carbonate reservoirs include platform margins, submarine highs and paleo-uplifts within platforms, and fault zones. The evaporite cap rocks, intimately associated with the basin evolutionary stages and global dry-hot events, are critical for large-scale hydrocarbon preservation; (3) Under the influence of Tethyan evolution, the Persian Gulf Basin and the Sichuan Basin share similar primary factors controlling hydrocarbon enrichment. The moderate tectono-sedimentary differentiation and structural modification in the process of prototype basin superimposition, as well as the spatio-temporal matching of critical elements for hydrocarbon accumulation, benefit the development of large oil

and gas fields. The macroscopic hydrocarbon distribution is dictated by source rock - cap rock assemblages, while the local hydrocarbon distribution is governed by trap-reservoir assemblages. The critical factors determining the differential hydrocarbon enrichment in the Persian Gulf Basin and the Sichuan Basin include plate size and position, basement stability, eustatic movement, paleoclimate, and tectonic transformation. Besides, variations in tectonic modification are closely related to the type, enrichment degree, and distribution of hydrocarbon reservoirs.

Keyword

Tethyan realm, unidirectional breakup and convergence, basin prototype, structural modification, hydrocarbon enrichment

Post-rifting uplift and inversion of intra-plate basin: implication from the Doseo basin, Central Africa

Yifan SONG[1]*, China National Petroleum Company (songyifan@petrochina.com.cn)
Lirong Dou[2], Research Institute of Petroleum Exploration and Development, PetroChina,
Dingsheng Cheng[3], Research Institute of Petroleum Exploration and Development, PetroChina,

Abstract

There is a growing recognition that the post-rifting phase of basin evolution is far from being tectonically quiescent, as it can involve episodic uplift. However, the dynamic mechanisms responsible for this phenomenon remain a subject of controversy, particularly for intra-plate basins situated distant from active plate boundaries. Accurately determining the timing and magnitude of uplift is essential for elucidating the driving model behind these processes. In this study, we document the thermal history of the Doseo basin within the West and Central Africa Rift System (WCARS) using a combination of apatite fission track analysis and vitrinite reflectance data. Our findings reveal a period of accelerated exhumation during the late Eocene to Miocene epoch (~45-20 Ma), characterized by kilometer-scale uplift, which corresponds to the formation of angular unconformities, folds, and fault-related anticlines. This specific time interval appears to be critical for the Cenozoic petroleum system, coinciding with the peak maturation of source rocks and the simultaneous formation of compressional traps. When integrated with the seismic data and previously published thermochronological data, our research reveals two significant cooling and uplift events in WCARS: a Santonian extrusion event and a late Eocene exhumation event. Both of these events have the potential to impact the entire tectonic plate, and Tethys realm. Furthermore, this two-stage exhumation event aligns closely with the timing of the Africa-Europe convergence collision. Consequently, we come to conclude that far-field lateral compression emerges as the dominant driving mechanism for intra-plate uplift, outweighing the influence of the mantle model.

Keyword

Central Africa, patite fission track analysis, Tethys realm, uplift

Two-stage oil accumulation in the Ediacaran Dengying Formation at central Sichuan Basin: Insights from dolomite U-Pb and pyrobitumen Re-Os dating

Bin DENG[1]*, Chengdu University of Technology (dengbin3000@163.com)
Juan Wu[2], Chengdu University of Technology
Pengda Lu [3], Chengdu University of Technology
Holly Stein [4], AIRIE Program, Colorado State University, Fort Collins, CO, USA.
Shugen Liu[5], Chengdu University of Technology

Abstract

Neoproterozoic-Early Cambrian petroleum systems are generally poorly known, although there have been several studies outlining proven ancient petroleum systems across the world, in particular along the Peri-Gondwana margin in present-day Australia, Pakistan, Oman, North Africa, and South China. The Sichuan Basin contains abundant evidence in the Lower Cambrian Qiongzhusi and Ediacaran Dengying formations for the existence of the oldest petroleum system in China. Using laser ablation-inductively coupled plasma-mass spectrometry (LA-ICP-MS) in situ U-Pb dating, we obtained high-precision age of four-stage dolomites, i.e., 551±20 Ma for the fibrous dolomite (FD), 509±38 Ma for the isopachous crust dolomite (ID), 453±52 Ma and 240±34 Ma for the coarse-crystalline dolomite (DD) and saddle dolomite (SD), respectively, in the Dengying Formation of the Pengtan gasfield at Central Sichuan Basin. Furthermore, the Re–Os isotopes of pyrobitumen yield two isochron ages of 333 ± 21 Ma and 140.5 ± 2.3 Ma, which represents the first stages of oil-destroyed event related to the Caledonian movement, and a followed thermal cracking event with the final timing of dry gas generation in the Central Sichuan Basin. Combined with fluid inclusion data and thermal-burial models, it constrains the time of second stage of oil-filling event during Early Permian-Triassic times. Thus, the development of the Leshan-Longnvsi paleo-uplift focused hydrocarbon migration to charge the paleo-oil and then cracked to gas fields, with two-stage of oil-fill process during the Paleozoic time across the basin center. This work highlights that the U-Pb and Re-Os geochronology has great potential to constrain the absolute timing of evolution of the oldest petroleum system. This work documented the whole U-Pb and Re-Os geochronology constraining the complex evolution history of the oldest petroleum system in the world.

Keyword

petroleum accumulation, Two-stage, U-Pb and Re-Os dating, Dengying Formation, western China

Characteristics and Resource Potential of East Indonesia Basin Group in Eastern Tethys: A Comprehensive Assessment

Shijie ZHAO[1]*, State Key Laboratory of Marine Geology, Tongji University
(zhaoshijie9267@tongji.edu.cn)
Weilin ZHU[2], State Key Laboratory of Marine Geology, Tongji University
Wenxu PENG[3], CNOOC International Limited
Hefeng SUN[4], CNOOC International Limited
Xiaowei FU[5], State Key Laboratory of Marine Geology, Tongji University
Zengyuan ZHOU[6], State Key Laboratory of Marine Geology, Tongji University

Abstract

Due to the combined influence of the Eurasian Plate, Indo-Australian Plate, and Pacific Plate, a series of multi-type and strongly reformed basins have developed in eastern Tethys (Southeast Asia). The East Indonesian Basin Group (EIBG) is situated at the convergence center of these three major plates and has undergone complex tectonic interactions from the Paleozoic to the Cenozoic, making it one of the basin groups with the longest period and most varied types in the eastern Tethys. This study indicates that the EIBG can be classified into two genetic types: the Australian North West shelf-related Basin Group (NAR) and the Collision-Transformed Basin Group between the North West Shelf of Australia and the Shelf of Sunda (CNS). The Paleozoic-Mesozoic basin types in the NAR are relatively simple, mainly composed of a series of passive continental margin basins such as Bintuni Basin, Timor Basin, North Seram Basin, and Buton Basin. The main source rock in the NAR is the Mesozoic Jurassic shale, followed by the Paleozoic Permian shale, both deposited in the rifted basin under the breakup unconformity before the opening of the Neo-Tethys Ocean. Among them, the Bintuni Basin has the latest breakup unconformity timing, the longest rift period, and the closest sedimentary conditions to the source rocks of the Bonaparte Basin in the North West Shelf of Australia, providing the best conditions for source rocks. The basin types of the CNS are more complex, including Cenozoic rift basins such as Kutai Basin and Banggai Basin, as well as Cenozoic backarc basins such as Sula Basin and Bone Basin, and Cenozoic foreland basins such as Salawati Basin. The main source rock in the CNS is middle-late Miocene Marine shale, which developed during the collision and thrusting phase, undergoing a series of strong tectonic modifications during the Cenozoic. The high heat flow (60-80 MW/m2) caused by late Miocene magmatic activity combined with the tectonic loading from plate collision promoted the maturation of source rocks in the CNS. Compared with other basin groups in Southeast Asia, the degree of hydrocarbon exploration in the EIBG is relatively low. In recent years, significant breakthroughs have only been made in the ultra-deepwater area of Kutai Basin in the CNS, while few discoveries have been made in the NAR. This is in stark contrast to the abundant hydrocarbon resources on the southern margin of the Neo-Tethys Ocean on the North West Shelf of Australia. Therefore, it will be an important direction for hydrocarbon exploration in the EIBG to accurately characterize the opening process of the eastern Neo-Tethys and clarify the evolution of Paleozoic-Mesozoic passive continental margin basins.

Keyword

Southeast Asia, East Indonesia, Resource Potential, Tectonic Evolution, Eastern Tethys

Main Features and Controlling Factors of Hydrocarbon Basins in the eastern Tethys Tectonic Domain

Xiaowei FU[1]*, Tongji University (fu_xiaowei@tongji.edu.cn)
Weilin Zhu[2], State Key Laboratory of Marine Geology
Shijie Zhao[3], State Key Laboratory of Marine Geology
Zengyuan Zhou[4], State Key Laboratory of Marine Geology
Wenxu Peng[5], CNOOC International Limited
Hefeng Sun[6], CNOOC International Limited

Abstract

The Tethys tectonic domain is one of the world's most hydrocarbon-rich regions. However, Yet, its eastern segment exhibits a scarcity in hydrocarbon reserves, characterized by significantly varied petroleum geological conditions in different basins, and a cohesive understanding has been elusive. This study bases on the tectonic evolution of the eastern Tethys, including the collision, rifting, drift, and agglomeration of the main terrains associated with the Gondwana continent, to systematically analyze the development and evolution characteristics of major basins and their petroleum geological conditions on each terrain. The study identified that the morphology and scale of these terrains critically influenced the genesis and conservation of hydrocarbon-rich basins. Large terrains, such as India, South China, North China, and the Tarim block, have the capacity to preserve multi-period superimposed basins related to pre-Gondwana basins, foreland basins during the collision with Gondwana, passive continental margin basins in the drift phase, and even foreland basins associated with the Eurasian continent agglomeration. The basins in these large terrains have significant oil and gas resource potential. In contrast, long and narrow terrains, such as Lhasa, Himalaya, and the Sibumasu block, had been extensively modified by subsequent tectonic activities including collisions and subductions, which severely limits their hydrocarbon potential. In these terrains, only basins formed during the latest tectonic phases related to subduction and other tectonic events can effectively preserved, potentially possessing favorable petroleum geological conditions in localized areas. This research provides a new perspective on the differential enrichment of oil and gas in the eastern Tethys tectonic domain.

Keyword

Tethys Tectonic Domain, Hydrocarbon Basins, Gondwana

The Impact of Tethys Evolution on Petroleum Accumulation in Kuqa, Papua, and Zagros Foreland Basins

shunqi CHAI[1]*, China University of Petroleum (East China) (chaisqi@163.com)
Keyu LIU[2], China University of Petroleum (East China)
Jianliang LIU[3], China University of Petroleum (East China)

Abstract

Understanding the formation and evolution of different types of foreland basins in the Tethys tectonic domain and associated petroleum resource enrichment is of great significance for unravelling the unidirectional splitting and convergence processes of multiple landmasses in the Tethys tectonic domain and uncovering the resource potential. Petroleum accumulation factors of three-type of Meso-Cenozoic foreland basins in the Tethys tectonic domain will be studied comparatively in this project, including the Kuqa regenerated type, the Papua back-arc type and the Zagros peripheral type, based on the geodynamic background of the Tethys tectonic domain. Research suggests that the different stages of tectonic evolution in the Tethys have a significant impact on the sedimentation, structure, and thermal history of the three-type of foreland basins, thereby affecting their petroleum accumulation conditions and enrichment characteristics. The petroleum accumulation in the Kuqa basin is influenced by the structural deformation of the foreland basin. The reservoir formation characteristics of the Papua basin dual influence of structure and sedimentation. The petroleum accumulation in the Zagros basin is mainly controlled by structural traps. (1)The evolution of the Kuqa Basin was indirectly influenced by the collision between the Indian and Eurasian plates. The closure of the Tethys Ocean resulted in strong compressive tectonic activity, forming a typical structure of foreland basins. This structural setting not only controls the distribution of source rocks and reservoirs, but affects the migration path and reservoir efficiency of petroleum. The marine invasion and regression in the Tethys Ocean control the formation and distribution of source rocks. Plate subduction and uplift in the closing process of the New Tethys Ocean resulted in increased basin subsidence and heat flow, and accelerated source rock maturation. The tectonic activity caused by the regional tectonic stress changes is conducive to the formation of sandstone reservoirs and creates a channel for the migration and accumulation of petroleum. (2)Under the influence of the Tethys evolution, the Papua Basin experienced a transition stage between sea and land, accompanied by multi-stage sedimentary filling events, which affected the source rocks and reservoir types. From the end of Mesozoic to the beginning of Cenozoic, the subduction of the remnant Tethys ocean basin to the south and the invasion of the Asian plate led to the intense tectonic compression in Papua, forming the unique conditions for hydrocarbon accumulation. The crustal heat flow changes caused by subduction indirectly controlled the maturation and accumulation of petroleum resources by influencing the thermal evolution history. (3)The north subduction of the Tethys Ocean and the late collisional orogeny caused the change of the deep geothermal gradient in the Zagros basin, and the maturity of source rocks increased rapidly in the Late Cretace-Neogene. Tectonic subduction improves the

reservoir properties of carbonate rock and sandstone in the basin. The sealing capacity of Marine shales and overlying evaporites was enhanced by plate collision and extrusion during the closing of the Tethys Ocean, and the temporal and spatial changes of fold and fault development directly led to the formation and evolution of tectonic traps in the basin.

Keyword

tethys, tectonic evolution, foreland basin, petroleum accumulation

Charging and leakage of natural gas in the YL13-1 structure, Qiongdongnan Basin

Yongbin QUAN[1]*, China University of Geosciences (Wuhan) (quanyongbin@cug.edu.cn)
Xinong Xie[2], China University of Geosciences (Wuhan)
Jinhai Yang[3], CNOOC China Limited, Hainan Branch, China

Abstract

Qiongdongnan Basin is an important natural gas-producing area in the north of the South China Sea. In recent years, many gas fields have been found, including the YL8-1 and YL8-3 gas fields in the Songnan Uplift. YL13-1 structure, which is the largest structure and farthest from hydrocarbon generation depressions, is the ultimate direction of natural gas migration in Songnan Uplift. Unfortunately, no gas was found here. Nevertheless, many natural gas inclusions were found with GGI greater than 5%, which indicates that natural gas accumulation had occurred. The source, accumulation, and leakage process of natural gas in the YL13-1 structure is still unclear, which restricts the further exploration of natural gas in this area.

In this study, the origin of natural gas in the Songnan Uplift is investigated using molecular and isotopic composition of natural gas. The charging time was inferred from the combination of burial history, the homogenization temperatures of coeval aqueous fluid inclusions, and the isotope-specific reaction kinetics of methane. Gas migration direction and pathway were investigated using the geochemical heterogeneity among different gas fields and were predicted by numerical simulation. The sealing capacity of the cap was evaluated by using logging and formation pressure testing data, which was compared with the height of the paleo and present gas column.

Results indicate that natural gas within the YL8-1 structure was generated from the Sonnan Sag in the north. The natural gas in the YL8-3 trap, however, was not only contributed by the Baodao Sag in the north but also by the Songnan Sag in the northwest and Lingshui Sag in the southwest. The main charging time is 5.5Ma. However, the YL13-1 structure cannot receive hydrocarbon supply from the western YL8-1/YL8-3 gas reservoir, because the gas water contact (GWC) analysis shows that the traps themselves are not filled. Both geological and numerical simulation analyses show that the structural ridge is conducive to the transport of natural gas generated in the Lingshui Sag to the YL13-1 structure. Natural gas originating from Lingshui Sag was indeed found in the shallow layer along the migration pathway, i.e. LS18-1 gas reservoir. According to the gas inclusion analysis, the height of the paleo gas column is at least 270 m. The formation pressure analysis, quite interesting, indicated that the maximum height of the gas column that can be sealed by the cap is 270 m. This indicates that the YL13-1 structure has been hydraulically ruptured and natural gas has been rapidly leaked. A gas chimney developed above the YL13-1 structure in the seismic section, indicating the existence of natural gas escape channels. More importantly, the discovery of gas hydrates in thermal genetics within the shallow layer of the YL13-1 structure further confirms the destruction of the ancient gas reservoir.

This study indicates that there are risks in sealing natural gas in the Sonnan Uplift due to the thin thickness and shallow burial depth (<500m). Therefore, further exploration should focus on deeper buried traps closer to hydrocarbon-generating depressions.

Keyword

natural gas, gas hydrates, gas accumulation mechanisms, Qiongdongnan Basin

A machine learning method reveal the variations of organic matter enrichment mechanisms of freshwater vs. saline lacustrine oil shales driven by paleoclimate

Man LU[1]*, China University of Petroleum (Beijing) (luman1021@cup.edu.cn)
Qingyong Luo[2], China University of Petroleum (Beijing)
Guoqiang Duan[3], China University of Petroleum (Beijing)
Xinguang Wang[4], China University of Petroleum (East China)

Abstract

With the consumption of conventional petroleum resources, the exploration and development of unconventional hydrocarbons in recent years have supplemented the shortage of petroleum resources to some extent. In China, lacustrine oil shales have become an important target for the exploration of unconventional oil and gas beyond marine. The majority of Chinese lacustrine oil shales were deposited in saline lacustrine basins. Breakthroughs obtained in the exploration of lacustrine shale hydrocarbons of Upper Triassic Yanchang Formation and Upper Cretaceous Qingshankou Formation demonstrate a good prospect of freshwater lacustrine hydrocarbon exploration. So far, a growing number of research have conducted on organic matter enrichment mechanisms of oil shales mainly based on individual formations distributed within a single basin/region. A comprehensive study investigating differences of organic matter enrichment mechanisms between freshwater and saline lacustrine oil shales is still lacking. Here, we synthesized the geochemical data of seven major oil shales in China from all available publications with 147 proxies of 10985 samples. A Random Forest Classification Method was applied to investigate the differences between freshwater and saline lacustrine oil shales in terms of primary productivity, terrigenous nutrients inputs, redox conditions. Our results show that freshwater lacustrine oil shales were deposited in more oxic water with higher primary productivity and less detrital material inputs under more humid and warmer climatic conditions, that caused higher organic matter enrichment than saline lacustrine oil shales. By combining the major worldwide lacustrine oil shales, we compare the depositional time interval and paleogeographic localities of lacustrine oil shales with long-term climate evolutions during the Phanerozoic era. We found the major worldwide freshwater lacustrine oil shales were deposited during hothouse climate with higher temperature and precipitation than saline lacustrine oil shales, suggesting long-term climate as main factor controlling the different organic matter enrichment mechanisms of freshwater versus saline lacustrine oil shales.

Keyword

oil shale, lacustrine basin, machine learning, organic matter enrichment, unconventional hydrocarbon

The trace metal content in oils: a global approach

Svetoslav Velichkov GEORGIEV[1]*, Geological Institute, Bulgarian Academy of Science (s_georgiev@geology.bas.bg)
Emiliya Raeva[2], Geological Institute, Bulgarian Academy of Science
Gatien L.F Morin[3], Geological Institute, Bulgarian Academy of Science
Lora Bidzhova[4], Geological Institute, Bulgarian Academy of Science

Abstract

Like carbon, hydrogen, nitrogen, and oxygen, many trace metals are also transferred from the source rock into kerogen, bitumen, and oil during the successive stages of thermal maturation and chemical transformation of the original organic matter in the rock. Therefore, the amount of trace metals and certain trace metal ratios in natural petroleum products (crude oil, crude oil fractions, bitumen, tars, etc.) can be used, and have been used to constrain the origin of petroleum. In particular, vanadium and nickel concentrations and their weight ratios are the most widely used inorganic tools for oil-source correlations. Both Ni and V seem to be concentrated in the more polar, more aromatic and chemically complex fractions of crude oil, which also are often the most resistant to biodegradation and water washing. Therefore, V-Ni ratios, unlike the most commonly used organic biomarkers, are quantitatively preserved during secondary alteration of petroleum and are particularly useful for oil-oil and oil-source rock correlations involving biodegraded oils or heavy tar mats, for example.

Despite providing a promising tool for genetic correlations, the knowledge of trace metal contents of crude oils, their precursor and host molecules and their origin and genetic significance is highly fragmented. Apart from V and Ni, and to some extent Re and Os due to their value for geochronology of oil and oil fractions, little to no systematic research has been conducted on other inorganic constituents of petroleum for the purpose of genetic correlations. With few rare exceptions, published data are generally scattered and treated case by case, sometimes with insufficient geologic context or discussion.

Here, we present an extensive dataset of published trace metal data in crude oils and similar products, discussing the origin of trace metal enrichment and outlining new trace metal tools for oil-oil and oil-source rock genetic correlations. In particular, we focus on the distribution of trace metals within the main oil fractions and the host phases of metals in the oil, the mechanisms of metal transfer from source rock to oil and the susceptibility of various trace element ratios to secondary oil alteration. We also outline the main trends in trace metal enrichment depending on the tectonic setting of the petroleum field and the type, age and maturity of the source rock. Our data provide a solid foundation for the interpretation of trace metal content of oils and for the development of novel inorganic proxies for oil-oil and oil-source rock correlations.

Acknowledgements: This research is supported by grant #

КП-06-ДВ/6 of the Bulgarian National Science Fund (PI-SVG).

Keyword

trace element, metal ratio, vanadium, nickel, origin of oil

Genetic mechanism and pore evolution of deeply-buried high-quality conglomerate reservoirs of the Paleocene Kongdian formation, Bozhong Depression, Bohai Bay basin

Xiaojun PANG[1]*, School of Geosciences, China University of Petroleum (East China) (pangxiaojunupc@163.com)
Guanmin WANG[2], School of Geosciences, China University of Petroleum (East China)
Zhi HUANG[3], CNOOC China Limited, Tianjin Branch, Tianjin
Xuefang ZHANG[4], CNOOC China Limited, Tianjin Branch, Tianjin
Meng ZHAO[5], CNOOC China Limited, Tianjin Branch, Tianjin

Abstract

In recent years, a large amount of oil and gas has been discovered in the deeply-buried conglomerate reservoirs of the Paleocene Kongdian Formation (depth>3500 m) in the Bozhong Depression. However, the physical properties of the conglomerate reservoirs are highly heterogeneous. Therefore, this study discusses the formation mechanisms of the high-quality conglomerate reservoir.

Information, including helium porosity and permeability, thin sections, XRD, SEM, particle size analysis, fluid inclusion, stable carbon and oxygen isotope analysis, was used to discuss the porosity evolution of conglomerate reservoirs.

The sedimentary facies in the Paleocene Kongdian Formation in the study area are mainly composed of fan delta. The deeply-duried conglomerate reservoir is characterized by low porosity and low permeability Abundant potassium-rich feldspars, meteoric water leaching, grain dissolution by organic acids, overpressure and fracture are the main factors controlling the development of high-quality conglomerate reservoirs in the study area. The conglomerate reservoirs experienced the following diagenetic processes: (1) porosity enhancement through meteoric water leaching, (2) porosity loss during rapid mechanical compaction, (3) porosity enhancement through grain dissolution by organic acids and hydrothermal fluids, (4) early hydrocarbon emplacement, (5) late cementation, (6) fracture formation and (7) extensive hydrocarbon emplacement. However, the diagenetic evolution and porosity evolution at different areas show significant differences. The conglomerate porosity at the BZ19-A structure decreased from 32.6% to 10.6%. The net porosity loss caused by compaction and cementation is 22%. In comparison, the conglomerate porosity at the BZ25-B structure decreased from 32.8% to 13.2%. The net porosity loss caused by compaction and cementation is 19.6%. Compared with the conglomerates in the BZ19-A structure, conglomerates in the BZ25-B structure experienced relatively weak compaction, stronger overpressure and grain dissolution. Therefore, the conglomerate porosity in BZ25-B structure is better than that of BZ19-A structure. Moreover, the extensive presence of fracture in BZ19-A conglomerates is the main factor resulting in the higher permeability than BZ25-B structure.

A large amount of condensate gas has been found in the deeply-buried conglomerate reservoirs of Kongdian Formation. The gas production in this area indicate the great exploration potential. The

research results can provide theoretical support for reservoir quality prediction in deeply-buried conglomerates.

Keyword

conglomerate reservoir, Kongdian formation, pore evolution, Bozhong Depression, Bohai Bay basin

Integration of Rock physics and Geological processes in reservoir Properties Characterization. A case study applied on Plutonio Field of the West African Congo Basin

Mukhtar HABIB[1]*, Department of Petroleum and Gas Processing Engineering, Kaduna Polytechnic, Nigeria (mukhtarhabib102@gmail.com)
Xie Congjiao[2], Faculty of Earth Resources, China University of Geosciences, Wuhan.
Tianqi Zhou[3], China National Petroleum Corporation Limited, Beijing.

Abstract

This research aims at improving the prediction of reservoir properties from seismic amplitude by integrating geo-statistical modeling principle, extended elastic impedance and rock physics models. This general objective contains four specific goals: 1) To identify the predictable spatial trends of reservoir properties using geo-statistical modeling frame work: 2) To link properties with seismic velocities using extended elastic impedance inversion: 3) To link reservoir properties with seismic velocities through rock physics models and 4) To improve the understanding of seismically derived signatures of reservoir properties, depositional processes as well as digenetic process in the west African deep water environment. In order to achieve these aims, this study attempted to resolve one primary problems, that is how possible can reservoir properties be derived away from well control using the concept of extended elastic impedance inversion? And what do we see when compared with geo-statistically derived reservoir properties?

In order to resolve the problem, Geo-statistics was applied on plutonio field so as to predict the trend of reservoir properties, this was carried out for the purpose of having a bases for comparison with a subsequent model to be developed using extended elastic impedance. The geostatistical modeling process began with petrophysical analysis thereby generating a cut off criteria for reservoir properties, then followed by a Structural model that integrates the stratigraphic framework and fault system of the reservoirs, sedimentary microfacies (or sand bodies) modelling on the basis of drilling and logging data, isochronous stratigraphic correlation unit (as the framework), dynamic integration of parameters and characteristics of channel sand bodies as well as analysis of variation function. It went ahead to apply facies models as basis for reservoir property distribution by determining a rational model on the basis of stochastic simulation.

Again, deterministic seismic inversion and extended elastic impedance (EEI) were applied on the same area so as to obtain quantitative estimates of reservoir properties. To achieve this, the optimum EEI angles corresponding to reservoir properties were analyzed using well logs data, together with a lithology indicator. Pre-stack seismic data were simultaneously inverted into density, acoustic and gradient impedances cubes, through model based inversion algorithm. The last two broadband inverted volumes were projected to the Chi angles corresponding to petrophysical indicators, resulting to two broadband EEI volumes. At Well location, the EEI versus petrophysical parameters linear trends were then used to transform EEI volumes into quantitative porosity and shale volumes based on a specific lithology. A comparison was made

between the properties generated through EEI method with the initial geo-statistical method based properties, which shows that EEI is reliable and can be applied for the purpose of mapping favorable zones that may suggest possible future drilling locations.

Keyword

Geology, Petroleum, EEI, Rock physics, modeling

Structural characteristics and evolution processes of intracratonic strike-slip faults: A case from the Gaoshiti-Moxi area, central Sichuan Basin, SW China

Qingqi ZHAO[1]*, China University of Petroleum (East China) (zqq_zgsydx@163.com)
Yangwen Pei[2], China University of Petroleum (East China)
Zhengshuo Miao[3], China University of Petroleum (East China)

Abstract

Geologists have realized that the development of intracratonic strike-slip faults plays important control on the hydrocarbon migration and accumulation in the past decades. In this research, a case from the Gaoshiti-Moxi area in the central Sichuan Basin was analyzed to understand the structural evolution of intracratonic strike-slip faults. Firstly, the faults' geometry was characterized based on 3D seismic sections and coherent attribute slices of key horizons. The displacements of the primary faults at different depths were also quantified to understand the spatial variation of fault throws. The shearing sense of strike-slip faults was then decided according to both the faults' alignment and horizontal offsets' distribution in plan view. Subsequently, multi-phased structural superposition models and evolution models were proposed. In section view, sub-vertical normal faults and negative flower structures were interpreted beneath the Triassic strata, whereas high-angle reverse faults and positive flower structures were interpreted within the Triassic strata. In plan view, the faults developed in the Lower Cambrian and Upper Permian are characterized with nearly W-E trending faults comprised of a series of soft-linked faults with small offsets. In contrast, the faults developed in the Upper Triassic present en-echelon patterns trending NWW. Three stages of faulting deformation in the Gaoshiti-Moxi area were identified by considering both the statistics of fault offsets and pre-existing regional structural belts in basements. (1) The initial stage from Late Sinian to Early Cambrian was dominated by the NEE trending tensional stress, resulting in the development of dextral transtensional faults. (2) The later stage of Late Permian was dominated by the NW trending tensional stress, and some pre-existing faults were reactivated and reversed into sinistral transtensional faults in the Permian strata. However, the faulting intensity in Late Permian is obviously was decreased compared to the initial faulting stage. (3) In the Late Triassic stage, being controlled by the NW trending contraction due to the uplift of the Longmenshan Mountain, en-echelon transpressional faults with small offsets were developed in the Triassic strata. The structural models proposed in this research may improve understanding in the multi-staged structural evolution of the intracratonic strike-slip fault systems and provide a geological theoretical reference for related hydrocarbon exploration.

Keyword

central Sichuan Basin, intracratonic strike-slip fault, structural characterization, evolution processes

Structure and Stratigraphic Architecture of Lake Edward Basin, Uganda: Implications for Petroleum System Analysis

Lauben TWINOMUJUNI[1]*, China University of Petroleum, East China
(lauben.twinomujuni@mak.ac.ug)
Keyu Liu[2], China University of Petroleum, East China

Abstract

This study delves into the geological complexities of the Lake Edward Basin in Uganda, situated within the Albertine Graben of the East African Rift System (EARS). Despite its potential as a hydrocarbon province, the basin's intricate geology poses challenges for exploration and development. Previous drilling attempt, including a significant wildcat, has yielded crucial data that, when combined with seismic and surface information, can offer vital insights for petroleum geological analysis. The interpretation of two seismic profiles in the strike and dip direction, along with well data, reveals various structural features such as normal and reverse faults, rotated blocks, flower structures, and pop-ups. Stratigraphic analysis delineates seven distinct depositional packages that have formed under varied environmental conditions including alluvial fan, fluvial channel, flood plain, alluvial plain, delta and open lacustrine. This architecture suggests sediment deposition was controlled by paleolake level/base level fluctuations probably forced by rift neotectonics and climatic changes as reported in other segments of EARS. In the context of sequence stratigraphy, the entirety of the depositional package appears to embody a single depositional cycle, characterized by transitions from proximal to distal sedimentary environments, followed by a return to proximal deposition. Analogous to other rift basins within the western branch of the rift valley, the Lake Edward Basin exhibits pronounced asymmetry, characterized as a highly asymmetrical half-graben with a progressive increase in depth towards the west, and the thickness of stratigraphic layers follows this trend. Multiple potential structural traps have been identified within the basin, presenting prospective opportunities for the retention of hydrocarbon reserves. Overall, the study contributes to a better understanding of the Lake Edward Basin's geological evolution and provides valuable information for hydrocarbon exploration and resource assessment in the region.

Keyword

Lake Edward, Petroleum System, Stratigraphy, Structure, Uganda

Organic petrological and geochemical characteristics of lower Paleozoic marine shale

Sherry (Xiaowei) Xiaowei Zheng[1]*, China University of Petroleum, Beijing
(zhengxiaowei1103@outlook.com)

Abstract

The lower Paleozoic shales are important source rocks and unconventional hydrocarbon plays both in China and Northern Europe. The lower Paleozoic shales in Tarim basin and Sichuan basin (China) are deeply buried and overmature, and hence the lacking of immature to early mature samples is a challenge for evaluating the initial source rock potential. However, the Alum shale (Northern Europe) owns various thermal maturities ranging from immature to overmature, which provide the Alum Shale a unique opportunity for detailed organic geochemistry and organic petrology research study. Interdisciplinary geochemical techniques, e.g., Rock-Eval pyrolysis, confined hydrous pyrolysis (gold tube), organic petrological methods, and Inductively Coupled Plasma Mass Spectrometry (ICP-MS) have been employed to unravelling the bulk geochemical parameters, microscopic organic matter properties, and organic-inorganic interactions.

The trace element results of the Th/U and V/(V+Ni) indicate reducing marine environment both in Alum Shale in the Baltic Basin areas and the deeply buried overmature shales in China. The dominant macerals change between the Cambrian and Ordovician Alum Shale, with alginite, amorphous organic matter, bituminite and solid bitumen as the major constituents in Cambrian, while zooclasts become dominant in Ordovician. The development of solid bitumen become dispersed with increasing thermal maturity. An original hydrogen index (HIo) restoration was established with the Alum shale as constraints. The HIo calculation model used is: HI=HI_o [1-exp{-(T_max/β)^θ }]+c, where HIo is 420 mg HC/g TOC (391.2 mg HC/g TOC to 448.8 mg HC/g TOC as 95% confidence bounds) as the most fitting for mature shales from northwestern Tarim basin.

The role of zooclasts in the bulk organic matter composition, kerogen type, and hydrocarbon generation potential are studied. Both non-granular and granular parts are observed in the graptolite periderm. The former is none-fluorescing, while the latter one has a brownish fluorescence and suggests remaining hydrocarbon generation potential. By connecting bulk geochemistry parameters from programmed pyrolysis and semi-quantitative maceral statistics, the abundance of dense zooclastic particles, including non-granular graptolite, chitinozoans and vitrinite-like particles, is seen to correlate with the non-generative organic carbon content. This refractory carbon-rich maceral enrichment represents autochthonous ‘refractory organic carbon dilution’ and leads to Hydrocarbon Index (HI) underestimation. Confined hydrous pyrolysis of a zooclastic cuticle-lean sample and a zooclastic cuticle-rich sample indicate that the former one has higher hydrocarbon generation potential and is oil-prone, while the latter one is gas-prone and

generates more CO2.

Through documenting a continuous graptolite reflectance (GR) of artificially matured graptolite-rich Alum shale after hydrous pyrolysis, a reflectance anomaly in gas window were observed in three different graptolite fractions (non-granular, nodular and granular graptolite). These three graptolite fractions have different trends of reflectance evolution and anomaly degrees, which indicates distinct chemical composition and differing pores generation capability. The GR anomaly indicates a potential underestimation when applying a linear formula between random GR and VR directly, hence a maturity correction should be applied on GR-based maturity measurement in gas and post-gas window.

Keyword

Lower Paleozoic, Marine Shale, Graptolite Reflectance, Thermal Maturity, Hydrocarbon generation

GASEOUS ANOMOLIES FOUND IN AGRICULTURE FIELD AROUND SAGAR Distt., SOUTHERN FRINGES OF BUNDELKHAND REGION, MADHYA PRADESH. INDIA

AKANKSHA SAHU[1]*, MOIL LIMITED (sahu.akanksha3010@gmail.com)
S.K. Sarkar[2], MOIL Limited
Arun Kumar Shandilya[3], Dr. H.S. Gaur University Sagar

Abstract

ABSTRACT
The gaseous anomalies has been recorded in the Agriculture field in Sagar Distt. of M.P..
The discovery of the rare gas helium in hydrocarbon rich zone in the tube wells in agricultural field of Pipariya - Bhutoli Garhakota Tahsil and Meerkheri and Rahatgarh town in Rahatgarh tahsil of Sagar District in M.P., is a unique finding in the history of Earth Science in India. It is remarkable to note that values of helium contents varies from 0.34 % to 0.732 % along with the 72% to 99 % of methane and ethane, and minor amount of oxygen, nitrogen and CO2 gases in the hydrocarbon rich zone are recorded during the geochemical and stable isotope analysis. It has been found in the stable isotope δ C13 value the values for the methane is -43.6 per mil w.r.t. to 54.9 per mil w.r.t. PDB and for the Ethane gas is --24.9 to -- 26.4 per mil w.r.t. PDB in the gas samples collected in the saturated sodium chloride solution in the glass bottles at Rahatgarh, Meerkheri, Piparia, Bhutoli villages in Sagar District. The occurrence of rare helium gas in the Hydrocarbon rich zone is reported first time in Jan, 2007 from the tubewells of Sagar Distt, which were geochemically and stable isotopically analyzed at KDMIPE Dehradun & NGRI Hydrabad. The gaseous hydrocarbon analysis show the presence of moderate to low concentration of methane (C1) 1 to 104 ppb, Ethane(C2)-1 to 14 ppb, Propane(C3) 1 to 10 ppb, i- Butane (i C4) 1 to 9 ppb and nButane (n C4) 1 to 8 ppb in the soil samples collected from different locations.
The Result of the adsorbed soil gas and stable isotopic analysis of Ethane gas in these samples δ C13 value are ranging from -24.9 per mill w.r.t. PDB and -26.9 per mill w.r.t. PDB are indicative that this gas is of thermogenic origin, which must have been formed at very high temperature & pressure condition in the deeper horizon of the Great Vindhyan sedimentary basin of early Proterozoic (>500m.y.) period.

Keyword

Petroleum, Helium Gas, Sandstone, Hydrocarbon in tube wells, Vindhyan Basin

Characteristics of effective fracture development in deep-ultra-deep reservoirs and its impact on gas reservoir productivity

Xixue ZHANG[1]*, China University of Petroleum (East China) (934522670@qq.com)
Chengyan LIN[2], China University of Petroleum (East China)
Lihua Ren[3], China University of Petroleum (East China)
Chunmei Dong[4], China University of Petroleum (East China)

Abstract

In recent years, deep-ultra-deep oil and gas reservoirs in foreland basin thrust belt zones have received attention. Bozi area is located in the first row of thrust belt zones in front of the South Tienshan Mountains in the Kucha depression of the Tarim Basin, with low porosity characteristics of deep-ultra-deep reservoirs of the Lower Cretaceous Bashijiqike Formation and Baxigai Formation. Fracture is a key geological factor to improve the reservoir performance and influence the productivity.In this paper, taking Bozi 1 block as an example, geological data such as core analysis, thin section, imaging logging, well test and leakage are used. On the basis of regional tectonic background and stress field evolution, we carried out a study on fracture characteristics affecting the variability of gas wells' productivity, clarified the types of effective fracture genesis, characteristics and distribution laws, and discussed the influence of effective fracture in deep-ultra-deep reservoirs on the productivity of gas reservoirs.

The study gained insights: (1)Effective fractures in the study area were formed in the mid and late Himalayan period, mostly NW-SE orientated high angle tensional, reticulated and high angle conjugate shearing fractures. (2)Tectonic nature and tectonic type control the planar distribution of effective fractures. Under the effect of piggy-back propagation thrusting, the paleotectonic stress is weakened from north to south, and the fracture combination style shows the transition from conjugate broom type to parallel type, in which the conjugate broom type has the highest effectiveness. Under the effect of lateral extrusion, influenced by the ancient uplift, the strike-slip effect is weakened from west to east, and the small-sized abrupt anticline and large-scale thrust nappe anticline are developed sequentially. The core of the anticline develops high-angle tensional fractures and medium-high angle conjugate shearing fractures, with the best effectiveness. (3)Stress vertical zoning controls the vertical distribution of effective fractures, and tensile stress sections and stress transition sections are developed vertically in Bozi 1 block. The effective fractures in the tensile stress section are mainly tensional high-angle-near-erect fractures, which have the best effectiveness; the transition section is dominated by reticulated fractures and high-angle conjugate shearing fractures. (4)The influence of fractures on the productivity of deep-ultra-deep gas reservoirs in the thrust fault zone of the foreland basin should consider the geological genesis of effective fractures and the mechanical activity of fractures under the control of the present-day geostress. From the geological genesis of effective fractures, the fracture effectiveness of the core part of the abrupt anticline and thrust nappe anticline on the plane is good, and the productivity is high; the fracture opening degree of the vertical formation tensile stress section is

higher than that of the transition section, and the productivity is high. From the present-day stress, the smaller the angle between the fracture direction and the direction of the present-day maximum principal stress, the better the fracture opening degree and the higher the productivity during reservoir reconstruction. This study has guiding significance for the efficient development of oil and gas in the thrust-belt zone of the foreland basin.

Keyword

foreland basin, thrust belt zone, deep-ultra-deep, sandstone gas reservoir, effective fracture

Petroleum system development in the Iranian Zagros Basin in response to the Neo-Tethys evolution

Tianhou LI[1]*, China University of Petroleum, Qingdao 266580, China (17863969592@163.com)
Keyu LIU[2], China University of Petroleum, Qingdao 266580, China
Jianliang LIU[3], China University of Petroleum, Qingdao 266580, China
Beiwei LUO[4], Research Institute of Petroleum Exploration and Development, PetroChina, Beijing 100083, China

Abstract

The distribution of oil and gas in foreland basins along the Tethys tectonic domain is closely related to the evolution of the Tethys geodynamic system. Based on the analysis of the Neo-Tethys evolution, we investigated the hydrocarbon accumulation process of the Dezful Depression in the Iranian Zagros Basin. On the basis of 2D structure restoration, fluid inclusion analysis, and basin and petroleum system modeling, the tectonic evolution stages of the Zagros Basin were reconstructed, and the hydrocarbon accumulation process in the basin was deciphered. The results show that: (1) The passive continental margin basin-slope environment connected to the ocean during the evolution of the Tethys tectonic domain was a favorable location for the development of source rocks in the Zagros Basin during the Jurassic-early Cretaceous when ocean currents at the equator brought nutrient-rich water to the continental shelf. The extensive shelfal carbonate platform reduced the overall ocean wave and current energy and formed a relatively closed low-energy environment, forming multiple sets of high-quality source rocks in the sags. (2) Shallow shelf and slope carbonate platform were favorable areas for carbonate reservoir development. During the passive continental margin stage, the petrophysical properties of carbonate reservoirs were enhanced by dissolution. During the foreland basin stage, extensive tectonic fractures were developed in the carbonate reservoir due to folding and faulting. Deep hydrothermal fluids entered the tight limestone reservoir through these faults and fractures, resulting in dolomitization in the vicinity of the fractures and an improvement of the petrophysical properties of the carbonate reservoirs. (3) Thick gypsum/salt caprocks were well developed in the Zagros basin during marine regression, forming a number of regional caprock layers. The prolonged period of strong evaporation conditions in the middle and low latitude as the Arabian plate drifting northward and the dissolution of the exposed basement Hormuz salt were responsible for the formation of the evaporative caprock layers. (4) The Zagros Basin is characterized by an oil-rich foredeep and a gas-rich uplift. The types of traps are mainly structural (anticlinal) traps. The distribution of oil and gas is primarily controlled by source-caprock combination and local trap configurations. Hydrocarbon charge and accumulation processes during the tectonic evolution can be divided into two categories: Prior to the commencement of the foreland basin orogenic movement, oil and gas migrated locally via unconformity or lithological surfaces; afterwards, folding and thrusting occurred at the top of the anticlines. These faults enhanced the petrophysical properties of the carbonate reservoirs and became the primary conduits for secondary oil and gas migration. Oil and gas migrated underneath the Neogene caprock via major faults, forming numerous reservoir

accumulations.

Keyword

Tethys geodynamic domain, Tectonic evolution, Hydrocarbon migration and accumulation, Zagros Basin, Dezful Embayment

Hydrocarbon charging process and phase evolution in the lower to middle Jurassic in Qiudong Sag, Turpan-Hami Basin, NW China: A response under the closure of the Paleo-Tethys Ocean

Shuxin QIN[1]*, China University of Petroleum (East China) (919600248@qq.com)
Jianliang Liu[2], China University of Petroleum (East China)

Abstract

The Turpan-Hami block, located in southeastern part of the Kazakh plate, developed a foreland basin during the Triassic to Jurassic period due to the dual effects of closure of the Paleo-Tethys Ocean on south side (Songpan-Ganzi orogenic movement) and South Tianshan movement on the north side. As a result, the Turpan-Hami basin developed multiple sets of lacustrine source rocks in the early to middle Jurassic, and entered piedmont depression stage with thick lacustrine clastic rock deposition in the middle to late Jurassic. Multiple sets of source rocks and reservoirs developed intermutually in the early to middle Jurassic, forming favorable source-reservoir-cap assemblage. Located in northern margin of the basin, the Qiudong Sag in the Taibei Depression was proven to have numerous gas resources in tight sandstone in the lower to middle Jurassic. Previous research on hydrocarbon accumulation period and process in that area is weak and diverging, restricting gas exploration in deep strata. In this research, hydrocarbon charging time, paleo-temperature and pressure were determined through systematic study of fluid inclusion petrography, spectroscopy, microthermometry, PVT phase simulation and calcite in-situ U-Pb dating and as well as combining with 1D and 2D basin modeling. The relationship between tectonic-sedimentary response in the early to middle Jurassic in Qiudong Sag and hydrocarbon generation and trap formation under the influence of Paleo-Tethys tectonic movement was first clarified. Oil and gas accumulation model was then established for the Jurassic tight sandstone in the Qiudong Sag. Results show that two types of fluorescent petroleum inclusions, yellow and blue, were developed in this area. From central to north and south sides of the Qiudong Sag, (1) the abundance of petroleum inclusions was gradually decrease; (2) the fluorescence color of oil inclusions was changed from single blue to blue and yellow coexisting; (3) the phase of oil inclusions was changed from condensate gas and liquid oil inclusions coexisting to single oil inclusion phase. One period of oil and gas accumulation occurred in the deep sag belt, mainly being the mixture of oil and gas charging. While for the southern slope zone and northern uplift zone, oil and gas, sourced from both in-suit and deep sag source rocks, was charged into these area in late Jurassic and late Cretaceous stages.

Hydrocarbon in the deep sag zone was in a gas condensate phase in both charging period and the present. While hydrocarbons in southern slope and northern uplift zones were in a liquid phase and normal pressure in the two periods of hydrocarbon charging and the present.

It is considered that high condensate oil-bearing tight gas in deep sag belt was formed by the simultaneous large-scale charging of oil and gas.

The research will promote geological understanding of evolution of the Paleo-Tethys Ocean on

the formation and accumulation of hydrocarbons in lower to middle Jurassic in the Turpan-Hami Basin, and also provide some theoretical support for further exploration in Qiudong Sag in Turpan-Hami Basin.

Keyword

Fluid Inclusion, Hydrocarbon Accumulation, Qiudong Sag

Characteristics and control factors of high poroperm carbonate reservoir of Mishrif Formation in the United Arab Emirates

Beiwei LUO[1]*, RIPEDCNPC (luobeiwei@petrochina.com.cn)
Jiquan YIN[2], RIPEDCNPC
Guangcheng HU[3], CNODC, CNPC
Haigang DUAN[4], RIPEDCNPC

Abstract

Mishrif Formation of Cenomanian Stage is the main oil-rich strata in the Middle East, especially around the Zagros fold and thrust belt. The kinetics of hydrocarbon generation the Cretaceous source rocks in UAE of the Rub al-Khali Basin is relatively weak, and the high poroperm reservoir is act as the key factor for hydrocarbon accumulation. However, previous research focus on the sequence stratigraphy, sedimentary facies and reservoir configuration, while the main geological factors that control high poroperm reservoir should be systematic analyzed. Based on core sections, lab-testing data from the drilled wells in UAE (The United Arab Emirates), the petrology and reservoir characteristics of typical sedimentary carbonate reservoir which have high porosity and high permeability in Mishrif Formation were summarized. In an addition, the evolution process of the high-frequency sequence in the Cenomanian Stage was identified using the new 3D seismic data. It is concluded that, the carbonate in Mishrif formation are mainly composed by sparry bioclastic limestone which associated with the rudist limestone and the pelitic or pelitic marl which contained a large amount of bioclastic. Several typical subfacies, including rudist build-up, high energy shoal, backshoal, foreshoal and inner-shoal can be identified. The rock types are mud microcrystalline limestone, wackstone and packstone, grain limestone and reef limestone. The sparry bioclastic limestone which deposited at rudist build-up and high energy shoal as the high poroperm limestone and their pore-spaces mainly composed by biological cavity, moldic and intergranular dissolution hole. It is infer that the high poroperm reservoirs are mainly controlled by multiple geological factors such as sequence framework, paleogeomorphology and diagenetic effects. There are three third-order sequences and seven system tracts in the Mishrif formation of the study area. Sequence cycles control the evolution and distribution of sedimentary facies, migration characteristics and stacking styles of favorable facies belts such as rudist build-up and high energy shoal around the innner ramp. The paleogeomorphology which restored by the high frequency sequence and residual thickness method shows that, the high energy shoal in SQ3 is inherited deposited and has a good positive correlation between the high energy shoal s inherited from the SQ3 stage and the paleohigh position. Under the influence of seawater, atmospheric fresh water and hydrocarbon fluids, the improvement and maintenance of high quality reservoirs in Mishrif formation are enhanced by both the constructive and reconstructive diagenesis effects. The fine description of the sedimentary features and control factors for high poroperm reservoir in Mishrif Formation provide a reasonable geological idea for the interpretation and modeling of favorable reservoir, and provides important inspiration for the

exploration and development issues in Middle East in future.

Keyword

Western UAE, carbonate in Mishrif Formation, sequence stratigraphy, paleogeomorphology, diagenesis effects

Influence of multi-stage volcanic events on the Late Cretaceous-Paleogene reservoirs and its geological significance in the northern Central Myanmar Basin

Zengyuan Zhou[1]*, State Key Laboratory of Marine Geology, Tongji University (zhou_zengyuan@tongji.edu.cn)
Weilin Zhu[2], State Key Laboratory of Marine Geology, Tongji University
Wenxu Peng[3], CNOOC International Ltd
Hefeng Sun[4], CNOOC International Ltd
Shijie Zhao[5], State Key Laboratory of Marine Geology, Tongji University
Xiaowei Fu[6], State Key Laboratory of Marine Geology, Tongji University

Abstract

The northward subduction of the Neo-Tethys oceanic crust triggered multiple magmatic activities in the West Myanmar Arc, which in turn influenced the deposition of sedimentary pyroclastic rocks from the Cretaceous to Eocene strata in the Central Myanmar Basin (CMB). The pore structure of these lithologic reservoirs is complex and rich in tuffaceous sandstone, which plays an adverse role in reservoir development in this region. To understand the development characteristics and genetic mechanism of the pyroclastic rocks within three sets of reservoirs in this area, a comprehensive analysis was conducted through borehole core observations, thin section identification, scanning electron microscope analysis, and mercury injection tests. The tuffaceous sandstone from the upper Cretaceous to the Eocene is dominated by intermediate-acid volcanic rock debris. The pyroclastic rocks exhibit evident chloritization and ironization, with residual intergranular pores being the principal type accompanied by a smaller amount of intergranular dissolved pores and intragranular dissolved pores. The highest porosity is observed in the Eocene tuffaceous sandstone, ranging from 8% to 12%. The Late Cretaceous to Paleocene sandstones exhibit lower porosity levels of only 4%–6%. These reservoirs are characterized by their low porosity and low-permeability. Despite the presence of a good source rock in this area, the volcanic debris particles filling the pores, as well as their subsequent devitrification, chloritization, and limonite mineralization, result in pore throat blockage and narrowing. The reservoirs in this area are small in size, exhibit poor reservoir connectivity and lateral continuity, and fail to meet the necessary conditions for commercial-scale hydrocarbon accumulation and migration.

Keyword

Neo-tethys evolution, Central Myanmar Basin, reservoir characteristics, volcanic debris

Segmented activity of the Shuntuoguole Low Uplift strike-slip fault zone and its impact on oil and gas charge events: Constraints from calcite veins containing hydrocarbon inclusions

Mengting HANG[1]*, School of Geosciences, China University of Petroleum (East China), Qingdao, China (S22010059@s.upc.edu.cn)
Jinqiang TIAN[2], School of Geosciences, China University of Petroleum (East China), Qingdao, China

Abstract

The strike-slip faults within the craton exhibit distinct segmented kinematic characteristics and oil and gas enrichment tendencies. Although research has been conducted on the overlapping segments of strike-slip faults and the distribution characteristics of reservoirs, there is still a dearth of detailed investigation into the spatiotemporal coupling relationship between fault segmentation characteristics and oil and gas charge events. The strike-slip fault zone serves as the primary oil and gas-bearing structure in the Tarim Basin, holding significant importance in controlling deep oil and gas accumulation. This study integrates calcite U-Pb dating with quantitative fluorescence spectroscopy to identify the fault activity and periods of oil and gas charging in structural segments of two strike-slip faults (SHB No. 4 and SHB No. 8). Research findings indicate that the SHB No. 4 and SHB No. 8 faults exhibited varying degrees of activity during the mid to late Caledonian and late Hercynian periods. Both SHB 805X well and SHB 45X well, situated in the extensional segment of the strike-slip fault, underwent four stages of oil and gas charge events. Among these stages, yellow fluorescence color oil inclusions (λmax [wavelength at maximal light absorbance] ranging from 540 nm to 490 nm) formed during the mid-Caledonian period, blue-green fluorescence color oil inclusions (λmax ranging from 490 nm to 460 nm) formed during the late Caledonian period, blue fluorescence color oil inclusions (λmax ranging from 460 nm to 440 nm) formed during the late Hercynian period, and methane inclusions formed during the Himalayan period. SHB 804X well, located in the contractional segment of the strike-slip fault, experienced only one phase of gas charging during the Himalayan period. This suggests that the extensional segment of the strike-slip fault is more conducive to oil and gas charging compared to the contractional segment.

Keyword

strike-slip faults, Tarim Basin, hydrocarbon inclusions, U-Pb dating

Multiple hydrocarbon accumulation model around Sangtamu fault zone in Lunnan area, Tarim Basin

GANG PENG[1]*, School of Geosciences, China University of Petroleum (East China), Qingdao,China (pg2714756005@gmail.com)
Jinqiang TIAN[2], School of Geosciences, China University of Petroleum (East China),Qingdao,China

Abstract

The Tarim Basin is located between the two orogenic belts of Tethys and Altay and the tectonic events in the orogenic belts around the basin have caused different tectonic deformations in the stratigraphic system within the basin from Cambrian to Quaternary. The Sangtamu fault zone is located in Lunnan area in east of Tabei uplift and the north of Tarim Basin. Through the petrological observation of core samples, fluid inclusion system analysis and testing, and crude oil fluorescence determination in the Sangtamu area, combined with the homogeneous temperature-burial history projection method, and the simulation of hydrocarbon production history of hydrocarbon source rocks, crude oil geochemical characteristics, and the history of fracture activities, the hydrocarbon complex formation model was established.The results show that the Ordovician in the Sangtamu area develops three phases of oil inclusions, which fluoresce in blue, yellowish green and yellowish brown. Carboniferous system develops two phases of oil inclusions, yellow-green and blue-white fluorescence. The Triassic system develops two phases of inclusions, respectively, blue-white and yellow. The filling time of Ordovician crude oil is the Late Caledonian-Early Hercynian, Late Hercynian, and Yanshanian. The Carboniferous System exists two phases of crude oil charging, which are the Late Yanshanian-Early Himalayan and Late Himalayan, and the oil and gas charging is mainly related to the Sangtamu Fault Basement Belt and the north-east-east oriented fracture. The Triassic system shows two phases of crude oil charging in the Himalayan period; the T3 layer has two phases of charging in the early Himalayan and late Himalayan periods, while the T1 layer only has the characteristic of charging in the late Himalayan period. The density of Ordovician average crude oil density is 0.84g/cm3; the density of Carboniferous average crude oil density is 0.87g/cm3; the density of Triassic average crude oil density is 0.88g/cm3.The Sangtamu fault zone and the NEE faults jointly control the crude oil properties and the hydrocarbon formation process. Inside the Sangtamu fault zone, the T1-T3 layer fracture is not completely through, and most of the crude oil along the injection point in the early Himalayan period only entered the T3 layer and produced lateral transportation; when reinjected in the late period, the crude oil in the T3 layer entered the T1 layer upward along the overflow point, resulting in the differential aggregation between the two layers. The low-mature oil charged into the Ordovician in the late Caledonian was adjusted upward into the Carboniferous along the NNE-directed fractures in the Yanshanian, leading to the high crude oil density in the present-day reservoir; the Triassic and Ordovician were charged with more late oil along the fractures. the temporal and spatial matching relationship between the fracture activity time and oil

and gas charging results in the existence of multiple periods of crude oil charging.

Keyword

Tarim basin, fluid inclusion, accumulation period, burial history

Hydrocarbon complex formation model around the periphery of the Lunnan fault zone in the Lunnan area of the Tarim Basin

Maogeng TIAN[1]*, School of Geosciences, China University of Petroleum (East China), Qingdao, China (tmg413529@163.com)
Jinqiang TIAN[2], School of Geosciences, China University of Petroleum (East China), Qingdao, China

Abstract

The Tarim Basin, as a typical superposition basin, is sandwiched between the tectonic domains of the Paleo-Asian Ocean in the north and the Tethys Ocean in the south. Lunnan area is located in the northwestern part of the Tarim Basin Tabei Rise, and the Lunnan Fault Zone is in the northern part of the Lunnan area, which is an important oil and gas exploration area. Under the effect of multi-phase tectonic evolution, many deep and large fractures have been developed, and the distribution of hydrocarbons is exceptionally complicated by the influence of fracture activities. Through petrological observation of core samples, fluid inclusion analysis, quantitative fluorescence spectral analysis of crude oil, simulation of hydrocarbon history of hydrocarbon source rocks, and the use of homogeneous temperature-burial history projection method as well as the geochemical characteristics of crude oil in the area of Lunnan Fault Belt, the accumulation period is determined, and the process of hydrocarbon formation is recovered by combining with the activity of fractures in different periods.

The results show that the Ordovician crude oil develops yellow and green colored oil inclusions, and the fluorescence wavelengths of the crude oil are 560-600 nm and 440-560 nm, respectively. Measurement of the homogenization temperature of the accompanying brine inclusions reveals that the homogenization temperature of the Ordovician is 90-110℃, and no accompanying brine inclusions were found in the yellow fluorescent oil inclusions; and the homogenization temperature of the Triassic System is in two phases: 70-85 ℃ and 100-110 ℃. Combined with the history of hydrocarbon generation and charging, Two phases of Ordovician crude oil charging existed, namely, the Late Caledonian and the Late Hercynian; the Triassic crude oil also has two phases of charging, namely, the Early Xishan and the Late Xishan phases. The geochemical characteristics indicates, Ordovician crude oil density 0.79-0.83 g/cm3, an average of 0.81 g/cm3, the wax content of 1.9-6.8%, an average of 3.69%; Triassic 0.83-0.88 g/cm3, an average of 0.85 g/cm 3, the wax content of 3.72-9.9%, an average of 6.06%.

Due to the fracture activity between different layers, it provides transportation channels for hydrocarbon migration and causes large differences in the nature of crude oil. After the generation of crude oil in the Late Caledonian, it was transported vertically to the Triassic along the Lunnan Fault Zone in the early Xishan, and mixed with the highly matured oil generated in the Late Hercynian, which had a high density and wax content; while the Ordovician mainly consisted of the highly matured oil generated in the Late Hercynian Period, which had a low density and wax

content. The fault activities in different periods provide transport channels for oil and gas, which eventually leads to the multi-stage charging of oil and gas in the Lunnan fault horst zone.

Keyword

Tarim Basin, Fluid inclusions, Hydrocarbon charging history, Accumulation period

In-Situ U-Pb Dating and Geochemical Characterization of Multi-Stage Calcite Cementation in the Upper Cretaceous Mishrif Formation, Mesopotamian Basin, Iraq: Constraints on Diagenetic, and Paleo-Oil Filling Events

HUAN WANG[1]*, Research Institute of Petroleum Exploration and Development, PetroChina (emma_wang@163.com)
Lirong Dou[2], Research Institute of Petroleum Exploration and Development, PetroChina
Xingyang Zhang[3], Research Institute of Petroleum Exploration and Development, PetroChina
Jiquan Yin[4], Research Institute of Petroleum Exploration and Development, PetroChina
Beiwei Luo[5], Research Institute of Petroleum Exploration and Development, PetroChina
Anjiang Shen[6], Research Institute of Petroleum Exploration and Development, PetroChina

Abstract

Paleo-fluid circulation plays a critical role in the geochemical and geodynamic evolution of sedimentary basins. Improved understanding of subsurface paleo-fluid evolution aids in reconstructing the associated diagenetic and petroleum evolution of carbonate reservoirs. Multi-stage calcite cements generated by basinal fluids over time were investigated using a combination of petrography, geochemistry, fluid-inclusion studies, and in situ U-Pb geochronology interpretation. This study aims to gain clues about diagenetic and paleo-oil filling events within the Mishrif Formation, Mesopotamian Basin, Iraq. Three main phases of calcite cementation were petrographically, geochemically, and geochronologically distinguished, which can be attributed to varied diagenetic phases and environments. The earliest calcites occurred as rim granular cement featured high Sr, Na content, and low Fe, Mn content, and adjacent drusy/blocky cement featured high Mn content and low Sr, Na content growing along the moldic pores, interpreted as pene-contemporaneous cements formed in a subsurface environment featured by a mixture of meteoric and marine waters with an in situ U-Pb age of 96.8–85.5 Ma. The second calcites presented as blocky cements filled in the center of the moldic pores, with high Fe, Mn, and low Sr content indicating brine fluid during the shallow burial stage with an in situ U-Pb age of 69.44–67.62 Ma. The last blocky calcite cement in the vugs or fractures is characterized by a high Fe, Mn, and low Sr content derived from brine fluid in the deep burial environment, with an in situ U-Pb age of 24.7–12.7 Ma. In addition, we constrained two oil migration processes under an absolute time frame by integrating oil-inclusion fluorescence and in situ calcite U-Pb dating in different calcite generations hosting primary oil inclusions. The U-Pb age of 67.62–69.44 Ma for the second blocky calcite related to yellow fluorescence oil inclusion constrained the early timing of the oil-filling event, coinciding with the closure of the Southern Neo-Tethys. This early-stage hydrocarbon accumulation was sourced from the Sulaiy Formation and its equivalent Chia Gara Formation of the Upper Jurassic, whose Ro reached 0.6~0.75%. The younger U-Pb age of 24.7–12.7 Ma for the last blocky calcite containing green fluorescence oil inclusion defined the time of the late oil-filling event, agreeing well with the timing of the closure of the Neo-Tethys and Zagros orogenies. This late-stage hydrocarbon accumulation was derived from the same source formation as the early-stage, with a Ro of 0.85~0.97%. This study contributes to (1)

comprehending the differential diagenetic process in the impact of various diagenetic stages and hydrocarbon emplacement and (2) linking diagenetic sequence to tectonic evolution and hydrocarbon accumulation in foreland basins evolved from Neo-Tethys tectonics.

Keyword

Paleo-fluid Flow, U-Pb Geochronology, Calcite Cement, Diagenesis, Paleo-oil Filling

Main Controlling Factors on Cambrian Dolomite from the Tarim basin, northwest China: implications for Ultra deep Reservoir

Xuelian YOU[1]*, China University of Geosciences, Beijing (youxuelian@cugb.edu.cn)
Kehui zhang[2], China University of Geosciences, Beijing

Abstract

The deep reservoirs in the Tarim Basin are characterised by their large burial depths and ancient stratigraphy, making it one of the largest deep-lying oil and gas rich areas in China. The genesis of deep-ultra-deep dolomite reservoirs is crucial for exploration and development. In the Tarim Basin, the Cambrian sub-salt dolomite reservoirs are widely distributed, with the discovery of numerous carbonate hydrocarbon fields indicating vast reserves, offering significant prospects for ultra-deep reservoir exploration. This study employs big data methodologies to focus on the exploration and development of deep hydrocarbon reservoirs in the Cambrian of the Tarim Basin. It conducts data collection and analysis of porosity and permeability within Cambrian carbonate reservoirs in the western Tarim Basin. Based on the sedimentary evolution and distribution of carbonate-evaporite sequences, factors such as sedimentary facies, sedimentary thickness, distribution of fault zones, and source-reservoir combinations are considered as primary reference parameters. The study delineates the macroscopic distribution patterns of porosity and permeability and establishes three categories of favorable oil and gas zones. Predictive modeling is utilized to forecast oil and gas favorable zones within the Series 2, Miaolingian, and Furongian systems. Furthermore, the study analyzes the controlling factors influencing the development of Cambrian carbonate reservoirs on the northwestern margin of the Tarim Basin from both sedimentary and diagenetic periods. Factors such as tectonism, sedimentary environment, microbiology, compaction and dissolution are analyzed to understand the main causes of differences in porosity and permeability distribution. Firstly, the arid climate of the ancient era favored the development of carbonate reservoirs, with concentrated seawater being the primary source of carbonate fluid. Secondly, the geological genesis model of different types of carbonate reservoirs is associated with the content and crystal characteristics of carbonate minerals, which are crucial for the formation of storage space. Lastly, specific marine environments, such as the gypsum-bearing dolomite flat intertidal-subtidal zone under the arid climate background of the Middle-Lower Cambrian in the Tarim Basin, serve as favorable reservoir development areas. The main controlling factors of reservoirs in the Tarim Basin include periodic sea-level changes, diagenesis, multiple periods of dissolution, and moderate dolomitization. These factors collectively influence the formation and development of reservoirs. In conclusion, the Series 2 of the Cambrian carbonate reservoirs exhibits higher porosity and permeability, with a large distribution area, indicating favorable exploration prospects in areas such as Bachu-Tazhong and Kalping. The Miaolingian is mainly affected by diagenesis, with high permeability but smaller porosity and distribution range. The Furongian primarily in Kalping and Bachu areas, exhibits higher porosity, permeability, and greater sedimentary thickness, possibly indicating higher

reserves.

Keyword

Cambrian Dolomite, Tarim basin, Ultra deep Reservoir

The hydrocarbon charging history and accumulation model of deep buried carbonate reservoirs in Yuqi area, Tarim Basin, Northwestern China

Zhiyi TIAN[1]*, School of Geosciences, China University of Petroleum (East China), Qingdao, China (z22010062@s.upc.edu.cn)
Jinqiang TIAN[2], School of Geosciences, China University of Petroleum (East China), Qingdao, China

Abstract

The Tarim Basin is located in the middle zone of the eastern section of the Tethys tectonic domain. It has experienced multi-cycle tectonic action and multi-stage oil and gas charging and adjustment transformation, and has the characteristics of large-area oil and gas. The crude oil properties of the Ordovician in the Yuqi area of the Tarim Basin exhibit a distinctive ring-like pattern of crude oil viscosity, becoming progressively denser from southeast to northwest. In certain localized areas, there are light oil reservoirs with abrupt changes in crude oil properties. The progress of hydrocarbon accumulation is complex and controversial, with limited previous research. In this study, we reconstruct the hydrocarbon charging history and establish the accumulation model by crude oil property analysis, fluid inclusion analysis, basin modelling, molecular geochemistry, in-situ calcite U-Pb dating and crude oil Re-Os dating. Molecular parameters indicate that the Ordovician crude oils have generally undergone biodegradation and the mixing of heavy oil and light oil is common. Quantitative fluorescence spectroscopy of hydrocarbon inclusions and fluid inclusion homogenization temperature (Th) combined burial history modelling, Re-Os dating and U-Pb dating indicate that there are three periods of oil charging in the Ordovician reservoir, which are the late Caledonian (463.2-420.5Ma), the late Hercynian (255-295Ma) and the Himalayan (10-20Ma). Since most of the oil and gas in the late Caledonian were destroyed, the current spatial distribution pattern of oil and gas properties and phases is mainly affected by the biodegradation intensity in the late Hercynian and the charging intensity of light hydrocarbon in the Himalayan. During the late Caledonian to Early Hercynian period, the source rocks of the Yuertusi Formation entered the oil generation window, and both the Luntai fault and the main strike-slip fault were active, creating dominant vertical migration pathways that facilitated the vertical migration of oil and gas. However, the reservoirs in this area are relatively shallow and lack effective cap layers, resulting the crude oil was destroyed. During the Late Hercynian period, the source rocks were in the high mature stage and experienced significant hydrocarbon generation. The shallowest burial depth of the Ordovician reservoirs was less than 2000m. The oil charged during this period commonly underwent biodegradation, resulting in the formation of present-day heavy to ultra-heavy oil reservoirs. During the Himalayan period, the source rocks in the study area still retained the hydrocarbon generation potential, and light oil and condensate hydrocarbon were continuously generated in the process of rapid subsidence and burial warming. Under the vertical transport of the late activated Luntai fault, they were charged into the reservoir and mixed with the early oil and gas. The local NNE-

and NEE-trending strike-slip faults around the Luntai fault are opened, resulting in high local light oil charging strength and forming the current YQX1 light oil reservoir.

Keyword

Tarim Basin, Fluid inclusions, Hydrocarbon charging history, Accumulation period, Luntai fault

The basic model and controlling factors of hydrocarbon enrichment in deep buried carbonate reservoirs: A case study of Tuoputai area in the Tarim Basin, Northwest China

Honglei XIE[1]*, China University of Petroleum (East China) (b20010021@s.upc.edu.cn)
Jinqiang Tian[2], China University of Petroleum (East China)

Abstract

With the increasing global levels of oil and gas consumption and the growing challenges in exploration, the target layers for hydrocarbon exploration are rapidly extending from shallow to deep and ultra-deep layers. Investigating the basic model and controlling factors of hydrocarbon enrichment in deep reservoirs is of great significance in improving exploration and development efficiency. The Tarim Basin is located in the central part of the eastern segment of the Tethys tectonic domain with complex tectonic evolution history. The Ordovician carbonate intervals are hot spots for exploration and are characterized by complex hydrocarbon properties and multistage accumulation. The crude oil properties exhibit a distinctive ring-like pattern, becoming progressively light from north to south. In this paper, we established the hydrocarbon enrichment model and analyzed its controlling factors in Tuoputai area by integrating the physical properties and molecular geochemical parameters of crude oils, fluid inclusion analysis, basin modeling and in-situ calcite U-Pb dating. The primary accumulation of Ordovician crude oils in the study area is mainly found in the strike-slip fault zones and their adjacent areas. Molecular parameters indicate that the crude oils have undergone biodegradation in the north of study area. Additionally, the maturity of the crude oils increases gradually from north to south. All the oils were derived from the same source rock, deposited in a reduced marine environment. The results of fluid inclusion analysis and basin modeling suggested the presence of three oil generation and charging events during the late Caledonian, late Hercynian and Himalayan. Calcite U-Pb ages provide constraints on the timing of the first and second charging episodes in the study area, at approximately 474–463 Ma, 450-426 Ma and ca. 278–267 Ma, respectively. Comparing the fluorescence spectra of reservoir oils and oil inclusions revealed that the late Hercynian is the major period of crude oils charging. The X-type conjugate strike-slip fractures developed in the study area have experienced multiple activity periods, which were conductive to hydrocarbon migration and accumulation. In the early Hercynian, tectonic uplift led to the destruction of late Caledonian-charged crude oils, and present-day crude oil properties are mainly controlled by biodegradation in the late Hercynian and light crude oils charging in the Himalayan. The deep Ordovician reservoirs exhibited a hydrocarbon enrichment model characterized by multiple charging events, vertical hydrocarbon supply, early uplift and erosion, followed by later recharging and deep burial preservation in Tuoputai area. The differential thermal evolution of source rocks and the multiple activations of strike-slip faults caused by tectonic movements are the main controlling factors for hydrocarbon enrichment. This study reveals the hydrocarbon enrichment mechanism in deep buried carbonate reservoirs, which is of great significance for oil and gas exploration and efficient

development.

Keyword

Deep buried carbonate reservoirs, Enrichment model, Controlling factors, Strike-slip faults, Basin modeling

Geochemical characteristics, genetic types and sources of gas accumulations in the northern Jizhong Subbasin, Bohai Bay Basin, eastern China

NIAN LIU[1]*, Beijing Research Institute of Uranium Geology (liuniancup@163.com)
Nansheng QIU[2], China University of Petroleum, Beijing
Man Lu[3], China University of Petroleum, Beijing

Abstract

Gas source and genetic type identification are important for gas system analysis and successful exploration. However, such crucial information is generally lacking or highly controversial in the northern Jizhong Subbasin, Bohai Bay Basin, hindering further gas exploration. The geochemical characteristics, genetic types and sources of gas accumulations are investigated based on a series of organic and inorganic geochemical analyses, including elemental and stable isotopic compositions, noble gases isotopic composition, and mercury content in gas in combination with molecular compositions of associated oils. Multiple genetic types of gases are identified in the northern Jizhong Subbasin, including biogenic gas, coal-derived gas and oil-associated gas. In particular, gases in the shallow Paleogene reservoirs are composed mainly of oil-associated gases derived from sapropelic organic matter in the Paleogene third member of the Shahejie Formation (Es3) and dark shales in the fourth member of the Shahejie and Kongdian formations (Es4+Ek). Gases in the deeply-buried Ordovician and Carboniferous–Permian reservoirs are mainly derived from coal with some contribution from oil-associated gases. The deep gases are mainly derived from the Carboniferous–Permian coal-bearing humic source rocks with contribution from mixed organic matter in the Es4+Ek source rocks.

Microbially generated gases, mainly distributed in the Paleogene Es3 and the first member of Shahejie Formation (Es1) reservoirs, are dominated by secondary microbially generated gas via carbon dioxide reduction. Microbially generated gases co-occur with biodegraded oils and are probably derived from sapropelic organic matter in the Es3 source rock. Based on the findings, it is concluded that shallow Paleogene rocks might be favorable reservoir zone for primary (kerogen) cracking gases generated from Type II1 kerogen. Dry gases derived from Type III kerogen and secondary cracking gases from Type II1 kerogen in the deep and ultra-deep Ordovician and Precambrian–Cambrian reservoirs can be other potential exploration targets in the northern Jizhong Subbasin.

Keyword

Gas, Genetic mechanism, Gas-source correlation, Jizhong Subbasin

Geological structure of the Cenozoic strata of the Fergana region in the light of oil and gas prospects

Radjabov SHUKHRAT[1]*, University of geological Sciences, National University of Uzbekistan (radjabovs@mail.ru)
Atabaev Dilshot[2], National University of Uzbekistan
Tukhtasinov Akhmadjon[3], National University of Uzbekistan
Amirqulov Jalil[4], National University of Uzbekistan
Majidova Shirinbonu[5], National University of Uzbekistan

Abstract

The Ferghana Basin is located in the Central Asia and is a part pf paleotethis. The Ferghana Basin is located in the Central Asia. The basin lies within three countries: Kyrgyzstan, Uzbekistan and Tajikistan. The basin is a topographical depression within the southern Tian Shan Fold Belt, corresponding to the valley of the Syr-Darya (Naryn) river, and is surrounded by mountain ridges. The northwestern boundary of the basin is formed by the Severo-Fergana (North Ferghana) fault, which is a thrust fault dipping to the northwest and separating the basin from the Kurama and Chatkal ridges. In the northernmost part of the basin, the Chatkalo-Atoynak thrust fault bifurcates from the Severo-Fergana fault. The deformed zone that lies along this margin of the basin is known as the Northern Underthrust Zone. A major continental strike-slip fault, the Talass Fergana fault, lies to the east of the basin and trends northwest-southeast. The southern margin of the basin is formed by the Yuzhno-Fergana (South Fergana) fault, a south-dipping thrust that separates the basin from the east-west trending Turkestan and Alay ridges. A series of troughs lie along the northern margin of this fault, including the Buzhum-Khaydarkan and Lyaylyak troughs. The Yuzhno-Fergana fault bifurcates south of Fergana, and the northern arm of the northeast trending thrust fault delineates the prospective part of the basin. To the southeast of this thrust, the hanging-wall comprises the Kurshabo-Uzgem trough, the Karavan-Kokdzhar trough and the Kara-Chatyr massif. A major northwest-southeast strike-slip fault, the Vostochno-Fergana (East Ferghana) fault, is thought to cut through the center-east of the basin, paralleling the Talas Fergana fault, separating the eastern structural highs (Mayli-Say and Achi-Su) from the deeper part of the basin. The Central Graben lies along the axis of the basin and is bounded on either side by reverse faults or thrust faults, beyond which lie the surrounding terraces: the Southern Terrace in the south and the Chust-Pap-Namangan and Khodzhent terraces to the northwest.

The Ferghana basin is a roughly east-west trending very deep graben which was formed as a reaction to the various continental movements which took place in particular since the late Paleogene–Neogene.

The study of the geological and tectonic evolution of the Fergana region is an important component in the study of the history of geological development, sedimentation, prospecting and exploration of mineral deposits, including oil and gas. Based on the analysis of the results of interpretation of geological and geophysical materials, including including seismic and borehole data a paleotectonic reconstruction of the sedimentary cover of the Fergana region along the line

extending from south to north was made, which characterizes the geological and tectonic evolution at a certain stage of sedimentation.

Keyword

Fergana Basin, Oil, Sedimentation, Seismic data, Borehole data

Reunderstanding Of Hydrocarbon Generation Evolution And Hydrocarbon Generation Potential Of Lower Cambrian Source Rocks In Tarim Basin

Shiyang ZHOU[1]*, 1173295078@qq.com (1173295078@qq.com)
Qi Wang[2], 376460511@qq.com

Abstract

The evaluation of hydrocarbon generation potential of deep ancient marine source rocks is one of the key objectives ultra-deep oil and gas exploration.As the main source rock of the Lower Cambrian, Yuertusi Formation in Tarim Basin is a typical representative of deep and mature ancient marine source rock with the characteristics of old age, deep burial and high thermal evolution.In this paper,TOC analysis was carried out on core and outcrop samples to clarify the differences in the abundance of spatial organic matter.Comprehensive seismic,logging,sedimentary facies and geochemical data were integrated to improve and compile the isocontour maps of source rock thickness,TOC and vitrinite reflectance in different zones.At the same time,low-maturity Inca shale samples with similar tectonic latitude,sedimentary environment and source composition to the Tarim Basin were selected for thermal simulation experiments,and the hydrocarbon generation evolution chart under the closed system was established.By simulating the evolution process of hydrocarbon generation in geological history, and calculating the maturity degree(Ro) corresponding to each experimental temperature based on the EasyRo model, the hydrocarbon production component plates under different maturity levels were established to calculate the hydrocarbon production rate of source rocks in the critical period.Finally,based on the basic map of macroscopic distribution of source rocks and hydrocarbon production rate, the area calculation function of Petrel software is used to quantitatively characterize the amount of oil generation and gas generation in geological history.The result show that the source rocks of the Yuertusi Formation have produced a large amount of oil in the Hercynian period,and the crude oil in the reservoir is mainly preserved in deep burial.The source rocks of Yuertusi Formation still have great gas potential in the hilltop period and belong to the effective gas source rocks.The evolution of hydrocarbon generating focus reveals that the ultra-deep Aman transition zone still has a good oil and gas exploration prospect.

Keyword

Yuertusi Formation, Tarim Basin, hydrocarbon-generating potential, thermal simulation experiment, source rock

Cretaceous prototype basins, lithofacies paleogeography of Tethys region and their controlling on oil and gas accumulation

Tongfei HUANG[1]*, Beijing, China (huangtfei@126.com)
Guangya ZHANG[2], Beijing, China
Beiwei LUO[3], Beijing,China
Zhiliang HE[4], BeijingChina
Guoping BAI[5], Beijing,China

Abstract

Studying the paleotectonic situation, prototype basins, and lithofacies paleogeographic characteristics of the Tethys domain during the Cretaceous plays an important role in deepening the understanding of the oil and gas enrichment laws in the Tethys domain. On the basis of global prototype basins and lithofacies paleogeography research in the Early Cretaceous (125 Ma) and Late Cretaceous (90 Ma), this article focuses on the prototype basins and lithofacies paleogeography development characteristics of the Tethys domain in the above two periods, and then focuses on the control of Cretaceous tectonics and sedimentary evolution on the oil and gas accumulation conditions and enrichment laws of the Tethys domain. Research has shown that the Early Cretaceous period was in the first stage of the breakup of the Pangaea Supercontinent (fromT to K1), with the Cimmerian Continent drifting in a northeast direction, the Neo-Tethys Ocean rapidly opening and reaching its maximum width in the early Cretaceous. In the North Africa-Europe segment, and Middle East-Central Asia segments of the Tethys domain, rift basins and backarc basins are mainly developed on the Laurasia side, while passive margin basins are widely developed on the Gondwana side of the Tethys domain. Late Cretaceous was in the second stage of the breakup of the Pangaea Supercontinent (from K2 to present), with the African plate, Indian plate, and Australian plate drifting in a nearly northeast direction. The passive continental margin basins on the northern margin of the Gondwana and the rift basins and backarc basins on the southern edge of the Laurasia were in successively developed. The northern margin of the Gondwana and the southern margin of the Laurasia extensively developed a thick combination of sandstone, mudstone, and carbonate rocks in the early and late Cretaceous. The relatively stable coastal shallow sea -semi deep sea environment is conducive to the formation and preservation of Cretaceous mudstone source rocks and multiple sets of sandstone and carbonate reservoirs. These multiple combinations in vertical are conducive to the accumulation of oil and gas, especially in the northern margin of the Gondwana in Africa, Arabia, India, and the northern part of the Australian plate, where the geological conditions for oil and gas generation, reservoir, and cap are more favorable. The Persian Gulf region benefited from the superior petroleum geology conditions of the Cretaceous Tethys domain. The Arabian Plate continued to be located in a low latitude environment, with a relatively stable passive continental margin background for coastal shallow sea and semi-deep-sea sediments, which were conducive to the formation and preservation of organic rich source rocks in the Cretaceous and multiple combinations, which were prerequisite for those huge oilfields.

Keyword

Cretaceous, Tethys domain, lithofacies paleogeography, prototype basin, hydrocarbon enrichment

Geochemical characteristics and accumulation model of natural gas in the Cenozoic Bohaibay basin

Bo Yang[1]*, China University of Petroleum(Beijing), CNOOC Hainan Branch Company
(2022315002@student.cup.edu.cn)
Fujie Jiang[2], China University of Petroleum(Beijing)
Di Chen[3], China University of Petroleum(Beijing)

Abstract

Natural gas, acknowledged as one of the most environmentally friendly energy sources worldwide, is poised to play an increasingly prominent role in the global energy landscape. The Nanpu Sag, situated within the Bohai Bay Basin of China, stands out as a significant reservoir of natural gas resources. Nevertheless, a comprehensive understanding of the overarching natural gas accumulation model in this region has been lacking. Leveraging the natural gas composition and carbon isotope composition data derived from 30 gas samples obtained from 30 wells within the Nanpu Sag, this study undertakes an examination of the causes and classifications of natural gas, delves into the sources of natural gas, explores the vertical migration patterns of natural gas, identifies the controlling factors governing its accumulation, and establishes the principal accumulation models specific to the study area. Our findings reveal that the dominant alkane component in natural gas within the Nanpu Sag is methane, with concentrations ranging from 52.98% to 90.94%. Ethane and propane exhibit average concentrations of 10.30% and 5.66%, respectively, signifying a low level of natural gas maturity. Methane carbon isotope values predominantly fall below -35‰, while ethane carbon isotope values primarily reside within the -25‰ to -30‰ range, averaging at -26.37‰. Propane and butane carbon isotope values span from -20‰ to -28‰. The genesis of this natural gas is primarily characterized as mature to highly mature thermal degradation gas, with transitional and humic gas components. By evaluating the relationship between the natural gas's Ro and the source rock Ro and comparing the natural gas type to the parent material type, we ascertain that the primary source of natural gas stems from the third member of the Shahejie Formation source rock. Variations in CO2 and N2 content indicate a vertical migration of natural gas from the Es3 layer to the western Ordovician zone, featuring notable transitions in Es3 to Es1, Ng, and Nm. Methane content and methane carbon isotope variations highlight the primary migration traits from Es3 and Es1 to adjacent strata. Ultimately, consolidating prior research outcomes and summarizing the overall structural geological evolution characteristics of the study area, we establish two accumulation models: source-proximate accumulation and far-source fault-induced accumulation.

Keyword

Nanpu Sag, Naural Gas Accumulation Model, Gas Composition, Carbon Isotope

Influence of tectonic activity on petroleum enrichmentTake organic-rich shale reservoirs for example

xiaoshi LI[1]*, Institute of GeomechanicsChinese academy of geological sciences
(lixiaoshi4656@126.com)
mingliang Liang[2], Institute of GeomechanicsChinese academy of geological sciences
yuxi Yu[3], Institute of GeomechanicsChinese academy of geological sciences
shengxin Liu[4], Institute of GeomechanicsChinese academy of geological sciences

Abstract

The Marine shale in the Middle and Upper Yangtze region of China has experienced complex tectonic movement, and is one of the best areas to study the enrichment effect of oil and gas resources in the complex structural zone. The exploration and development of shale gas in the Sichuan Basin has gradually shifted from the stable zone to the complex structural zone outside the basin, which has made great progress, revealing the complex multi-scale geological process of shale gas formation and preservation conditions. Clarifying the shale deformation caused by tectonic processes and its influence on the development of shale reservoirs and the enrichment of shale gas is also helpful for the study of Petroleum enrichment and Tethys geodynamic system. The study shows that, as a key parameter affecting shale gas accumulation, the physical characteristics of shale reservoir are greatly affected by tectonic stress transformation and deformation, which not only affects the occurrence state of shale gas, but also determines the evaluation and exploration prospect of shale gas resource potential by changing the migration and enrichment of shale gas. On the basis of field structural geological investigation and deformation analysis, combined with laboratory test and simulation experiment, a systematic study was carried out on the evolution characteristics of Marine shale reservoirs in complex structural areas in southern China, such as pore structure, permeability and adsorption properties. The study reveals the intrinsic connection and mechanism of shale pore-fracture and organic matter, inorganic mineral particle structure evolution and tectonic stress, and identifies the remodeling mechanism of the shale reservoir physical property change. The findings contribute to the theory of shale deformation and gas accumulation, as well as offer a scientific foundation for the exploration of marine shale gas in the complex tectonic zones.

Keyword

Organic-rich shale, Structural deformation, Shale gas, Middle and Upper Yangtze region

Ancient alkaline lacustrine formation mechanism and distribution characteristic of Fengcheng Formation in Junggar Basin, Northwestern China

Yunxian FENG[1]*, PetroChina Xinjiang Oilfield Company and School of Geosciences, China University of Petroleum (fengyunxian_198205@163.com)
Yong TANG[2], PetroChina Xinjiang Oilfield Company

Abstract

Alkaline lacustrine is considered as one of the most promising aquatic environments for source rock forming due to its high initial productivity and excellent organic matter preservation condition. Fengcheng Formation of Mahu Sag, the main oil-producing shale series in the northwest region of Junggar Basin, belongs to the Tethys structural domain surrounding Tianshan Mountain. It is the oldest alkaline lacustrine deposit in China. The mineral composition of Fengcheng Formation exhibits a wide diversity. Besides sedimentary pyroclastic rocks, it also includes dolomite, calcite and various types of alkaline minerals (such as trona, shortite, eitelite etc.).

According to the paleogeomorphy, Mahu Sag can be divided into three units: the edge fault zone, the slope transitional zone and the depression center. In the slope area, the formation consists mainly of calcareous siltstone, dolomitic mudstone and mixed rocks. In the depression center, mudstone deposits are accompanied by the alkaline minerals which are especially abundant in the second member of Fengcheng Formation.

In the slope area, the stratigraphic units of Fengcheng Formation contain a complete third-order sequences. From bottom to top, it develops andesite, fan delta conglomerate in the lowstand system tract, silty mudstone in the semi-deep lacustrine during transgression period, maximum flooding shale, and muddy siltstone of shallow water in highstand system tract. The geochemical data (such as trace element, isotopic geochemistry) indicate that the maximum flooding shale in the second member of Fengcheng Formation was formed in the reducing environment with the highest salinity in the deepest water body. And almost at the same time, the bulk alkaline minerals began to accumulate in the depression center.

Mahu sag is considered as a closed to semi-closed hydrological system due to the low leakeage rate of andesite subbottom of Fengcheng Formation. During the transgression stage, a large number of Na+, K+Ca2+ and Mg2+ formed by the weathering of pyroclastic rocks were injected into the lake with overland runoff. Meanwhile, the climbing CO2 concentration and strong evaporation caused by frequent volcanic activities also accelerated ion enrichment in the lacustrine water. Those solutes sank by gravity, which contributed to the vertical stratification of the water column. At the maximum flooding stage, low-solubility calcite was more easily formed in the shallow slope zone because of the lower salinity caused by the nearshore fresh water injection. On the other hand, as ion concentration continuously increased in the depression center, alkaline minerals were formed vastly at the bottom of lake center when the precipitation saturation was finally reached. After that, during the highstand tract development stage, the salinity in the sag

was diluted resulted from the frequent flood events, and the alkaline deposits were no longer formed in Mahu Sag. Such a complex suit of minerals within a formation are not only affected by volcanical activities and paleoclimate, but also influenced by paleogeomorphy and hydrological conditions.

Keyword

Alkaline lacustrine, Alkaline mineral, Hydrological condition, Fengcheng Formation, Mahu Sag

Two pulsed activities of the Emeishan large igneous province in southwestern China inferred from dolomite U-Pb geochronology and significance

Di XIAO[1]*, Southwest Petroleum University (super_xd_mm@126.com)
Tianhai Huang[2], Southwest Petroleum University
Qiang Xu[3], Southwest Petroleum University
Xiucheng Tan[4], Southwest Petroleum University
Jianfeng Zheng[5], China National Petroleum Corporation
Long Wen[6], PetroChina Southwest Oil and Gas Field Company
Jian Cao[7], Nanjing University

Abstract

As universally acknowledged, large igneous province (LIP) events are, in general, associated with tectonic activity, paleoclimatic change, paleoenvironmental disruption, and the generation of sedimentary mineral resources; therefore, LIPs have attracted considerable research attention in the field of Earth science.

The Emeishan large igneous province(ELIP) was a major geological event that took place around the Middle–Late Permian boundary. The major episode of the ELIP is generally considered to have occurred at 260–259 Ma, although an increasing number of geological data have suggested that multiple episodes of magmatic activity might have occurred. Here we report astudy of a Lower Permian dolomite whose formation was influenced by the ELIP in the Sichuan Basin of southwestern China.

Results show two new pulsed activities at 273.2 ± 9.7 Ma to 269.1 ± 12.0 Ma (ELIP-I) and 263.2 ± 10.3 Ma to 258.7 ± 8.1 Ma (ELIP-II). The two stages of the ELIP magmatism and thermal activity controlled theregional tectonic, sedimentary, and diagenetic evolution and exerted a profound influence on the oil and gas reservoirs, source rocks, and lithofacies paleogeography. This study is the first to interpret the timing of the ELIP from analysis of hydrothermal dolomite and provides new clues and data for improving our understanding of the dynamic formation mechanism and Earth system of the ELIP.

Keyword

Emeishan large igneous province, dolomite U-Pb dating, southwestern China, Permian, Oil-gas effect

Discovery, formation, and significance of the basement ancient uplift in the South Yellow Sea Basin

Dingyou LV[1], CNOOC China Limited, Tianjin Branch
Qingxun WU[2]*, CNOOC China Limited, Tianjin Branch, (wuqx@cnooc.com.cn)
Ying Guo[3], CNOOC China Limited, Tianjin Branch
Zhen Huang[4], CNOOC China Limited, Tianjin Branch
Zhiqiang Li[5], CNOOC China Limited, Tianjin Branch

Abstract

The ancient uplift plays an important role in marine oil and gas exploration, controlling large-scale marine oil and gas fields. No conventional model of ancient uplift has been found in the Lower Yangtze region. The latest research results indicate that there is a basement ancient uplift in the South Yellow Sea Basin, with Ordovician limestone directly covering granite and missing the Sinian and Cambrian systems.The zircon U-Pb dating results indicate that the cooling age of the granite is around 731-820 Ma. The overlying limestone of granite contains a large amount of biological fragments and a large amount of terrigenous debris, locally appearing red, and without thermal contact metamorphism. Comprehensive analysis suggests that the Ordovician limestone is in sedimentary cold contact with the underlying granite, confirming the existence of Pre-Ordovician ancient uplift in the South Yellow Sea Basin. The ancient uplift was characterized using seismic data, and the results showed that it is located in the middle of the central uplift, with an overall northwest distribution and an area of approximately 2100 square kilometers. Based on unconformity analysis and stratigraphic paleontological analysis, the formation and evolution process of ancient uplifts were clarified: after the intrusion of the Jinning period granite, the ancient uplifts dominated by granite were formed under the influence of the Tongwan movement, and the water bodies gradually deepened during the Ordovician period, and the ancient uplifts were gradually submerged.

The discovery of ancient uplifts has changed the traditional understanding of the "iron plate" within the Lower Yangtze Craton Basin during the Cambrian Ordovician, and requires a reconsideration of plate tectonics, tectonic evolution, and paleogeographic patterns. In addition, the existence of ancient uplifts indirectly confirms the existence of ancient depressions, and the edge high-energy facies zones of ancient uplifts have developed high-quality reservoirs, which are favorable oil and gas exploration zones.

Keyword

Ancient uplift, Granite, Cambrian period, Oil and gas, South Yellow Sea Basin

Discovery and Geological Significance of Ancient Crystalline Basement in the South Yellow Sea Basin, Eastern China

Jian REN[1]*, Bohai Oilfield Institute,CNOOC (renjian5@cnooc.com.cn)
Zijun Han[2], Bohai Oilfield Institute,CNOOC
Yongqiang Yao[3], Bohai Oilfield Institute,CNOOC
Shaowei Chen[4], Bohai Oilfield Institute,CNOOC
Xilong Gao[5], Bohai Oilfield Institute,CNOOC

Abstract

Late Archean to Early Proterozoic crystalline basement is widely present in the Upper and Middle Yangtze craton. However, the fundamental issues regarding the formation and evolution of the early Precambrian basement of the Yangtze craton remain unresolved. On one hand, the existence of ancient crystalline basement in the Lower Yangtze region has been controversial, and on the other hand, oil and gas exploration practices in the Upper Yangtze region have indicated that the presence of ancient crystalline basement is essential for ensuring weak deformation of shallow cover layers and favorable conditions for hydrocarbon preservation. The existence of ancient crystalline basement in the South Yellow Sea area is crucial for the prospects of oil and gas exploration in the region. Based on the latest drilling data from the South Yellow Sea area, Lu-Hf isotope and Sr-Nd isotope tracing analysis of the Neoproterozoic granite samples were conducted. The results indicate the presence of Late Archean to Early Proterozoic crystalline basement aged between 2.5 Ga and 2.9 Ga in the South Yellow Sea area, and the age of this basement can be directly compared with that of the Upper and Middle Yangtze basement. In addition, based on the calibration of this well and the combined inversion methods of gravity, magnetism and seismic, the range of ancient crystalline basement was delineated, suggesting that the main body of the Lower Yangtze crystalline basement should be located in the South Yellow Sea Basin. This study demonstrates that some areas of the South Yellow Sea Basin are structurally stable zones protected by the crystalline basement, providing direction for future oil and gas exploration in the region. In addition, further exploration is needed regarding the relationship between the crystalline basement of the South Yellow Sea and the basement of the Gyeonggi block, as well as the response of the crystalline basement during late compression movement.

Keyword

ancient crystalline basement, isotopic tracing, hydrocarbon preservation, the South Yellow Sea Basin, Lower Yangtze

Discovery of Early Paleozoic “Rifting Troughs” in the South Yellow Sea and Its Significance for Oil and Gas Exploration

Haifeng Yang[1], Bohai Oilfield InstituteCNOOC
Jian REN[2]*, Bohai Oilfield Institute,CNOOC (renjian5@cnooc.com.cn)
Bo Yang[3], Bohai Oilfield Institute,CNOOC
Xiaogang Pei[4], Bohai Oilfield Institute,CNOOC

Abstract

The ancient “rifting trough” is a low terrain area formed by extensional subsidence in marine facies basins, where sedimentation primarily consists of mudstone as source rocks, with high-quality reservoirs developed along the margins of carbonate platforms, thus possessing excellent source-reservoir configuration conditions. In the marine sedimentary strata of the Upper Yangtze Sichuan Basin in western China, both upper and lower ancient rifting troughs have been successively discovered, and Continuous exploration around these two ancient rifting troughs has led to the discovery of two trillion cubic meters gas field clusters. The South Yellow Sea Basin in eastern China, located in the Lower Yangtze region, shares very similar lithofacies and paleogeographic conditions with the Upper Yangtze. Whether ancient rifting troughs are developed in this area is crucial for its exploration prospects. Based on the latest drilling stratigraphic analysis, the lithogeochemistry of samples, as well as new obtained gravity-magnetic and seismic data in the South Yellow Sea Basin, it has been confirmed that ancient rifting trough developed during the Early Paleozoic: 1)The late Ordovician thick mudstone thrust nappe encountered directly during drilling is an ancient rifting trough sedimentary system, which underwent thrust napping in the late stage2) The ancient uplift revealed by drilling is a granite intrusion formed in conjunction with ancient rifts, and the geochemical analysis of granite shows that it is a rifting type granite associated with the extensional movement of ancient rifting troughs during the same period3) The aeromagnetic data of the South Yellow Sea Basin shows obvious low magnetic anomalies, while seismic data shows local abnormal subsidence. The discovery of the ancient rifting trough in the South Yellow Sea laid the foundation for the formation of oil and gas reservoirs in the area and provides direction for the follow-up exploration.

Keyword

rifting troughs, source rocks, granite, the South Yellow Sea Basin, Early Paleozoic

New evidence of post Indosinian tectonic evolution in the South Yellow Sea Basin in eastern China

Rucai Zhang[1], Bohai Oilfield Institute,CNOOC
Jun Ming[2], Bohai Oilfield Institute,CNOOC
Zhen Huang[3], Bohai Oilfield Institute,CNOOC
Xilong Gao[4], Bohai Oilfield Institute,CNOOC
Jian REN[5]*, Bohai Oilfield Institute,CNOOC (renjian5@cnooc.com.cn)

Abstract

The South Yellow Sea Basin in eastern China is a superimposed basin of the Paleozoic marine facies and Cenozoic continental facies that developed on the basement of the pre-Cambrian. Due to limited drilling and seismic data in this area, the unclear understanding of the tectonic evolution processes and mechanisms since the Mesozoic has hindered further oil and gas exploration. Based on the analysis of apatite fission track and carbonate U-Pb dating of the latest drilling sample, and newly obtained seismic and gravity-magnetic data, the tectonic evolution in this area is analyzed. The study identifies four key tectonic events since the Mesozoic Indosinian period: 1) During the Indosinian period, the collision between the North China and South China plates caused significant north-south compression and thrusting in the area, with prominent thrust nappe structure on the northern side of the South Yellow Sea Basin . 2) The latest data indicates that during the late Yanshanian period, the area experienced a significant east-west compression, forming large-scale north-south thrusting structures, orthogonal to the thrust structures of the Indosinian period. 3) From the end of the Yanshanian period to the beginning of the Eocene, influenced by the subduction of the Pacific Plate, the South Yellow Sea Basin experienced a transition from depression to rifting, with the deposition of source rocks in local depressions. 4) During the Oligocene, the South Yellow Sea Basin underwent the last phase of significant tectonic compression known as the "Sanduo Movement," developing numerous north-south thrust faults in the rift zone. The clear evolution process indicates that the exploration of oil and gas in the Paleozoic strata of the South Yellow Sea should focus on the tectonic disturbances effects during the Indosinian-Yanshanian period and search for favorable preservation areas for oil and gas, while exploration in the Mesozoic-Cenozoic strata should focus on the scale of rifting and the adjustment and distribution of hydrocarbons by the Sanduo Movement.

Keyword

tectonic evolution, post Indosinian, the South Yellow Sea Basin, Yanshanian period, favorable preservation

Characteristics and Petroleum Geological Significance of Neoproterozoic Granite in the South Yellow Sea Basin, China

Ying GUO[1]*, CNOOC China Limited,Tianjin Branch (350426124@qq.com)
Bo YANG[2], CNOOC China Limited,Tianjin Branch
Jun WANG[3], CNOOC China Limited,Tianjin Branch
Jian REN[4], CNOOC China Limited,Tianjin Branch
Xilong GAO[5], CNOOC China Limited,Tianjin Branch
Zhangjin CHEN[6], CNOOC China Limited,Tianjin Branch

Abstract

During drilling in the South Yellow Sea Basin, China, a thick layer of granite intrusion was encountered beneath the Ordovician limestone strata. The presence of this granite intrusion directly led to the absence of the Sinian-Cambrian strata in the study area, affecting oil and gas accumulation and posing a huge challenge for oil and gas exploration work in the area. In this study, lithological characteristics, age, and genesis of this granite intrusion were investigated using logging, logging, seismic, and analytical data, and its geological significance for oil and gas exploration was discussed. The study reveals: 1) The lithology of the granite intrusion in the study area mainly consists of light gray and gray granite, granodiorite, and quartz diorite, belonging to the high-potassium calc-alkaline series A-type granite. 2) Through U-Pb zircon dating and tectonic evolution analysis, it was determined that the granite intrusion formed during the late stage of the Neoproterozoic Jinning Movement when the Yangtze Plate transitioned from compression to extension, similar to the genesis background of Neoproterozoic granite in Sichuan Basin of the Upper Yangtze. The development of numerous asphalt-filled fractures confirms the presence of a structural environment conducive to the formation of large ancient rift basins in the study area. 3) The granite body exhibits characteristics of multi-stage pulsating intrusion, mainly divided into five stages, with different intrusive stages forming structural weak zones near the interface, promoting the concentrated development of intra-fracture reservoirs. 4) Based on fracture cutting and filling characteristics, the granite fractures are divided into four stages, formed during the Caledonian, Hercynian, Indosinian, and Yanshan-Xishan periods. The first and second stages of fractures are filled with asphalt, indicating the presence of ancient oil reservoirs, while the fourth stage represents effective open fractures critical for reservoir alteration and hydrocarbon accumulation. 5) Intense late-stage hydrothermal fluid activity in the granite development area promoted thermal evolution of Permian source rocks and the development of hydrothermal dolomite reservoirs in the Upper Paleozoic, suggesting the potential for the formation of large gas fields in the Upper Paleozoic. In summary, this suite of granite not only has the potential to form high-quality reservoirs, but also promotes thermal evolution of source rocks and the development of dolomite reservoirs in the Upper Paleozoic. The results of this study greatly deepen our understanding of the fundamental geological conditions of the South Yellow Sea Basin and are of great significance for the next step of oil and gas exploration.

Keyword

South Yellow Sea Basin, Neoproterozoic, Granite Characteristics, Petroleum Geological Significance

The relationship between Structural Fracture Development and Hydrocarbon Accumulation in the Foreland Basin under the Tethys Evolution: Examples from the Kuqa Foreland Basin

LI SHANMING[1]*, China University of Petroleum East China (409703155@qq.com)

Abstract

The Kuqa foreland basin, situated in the eastern segment of the Tethys orogenic belt, is rich in oil and gas owing to its distinctive plate interactions and intricate tectonic history. This research employs balanced profile technique to partition the study area into distinct tectonic evolution stages. It integrates core observations, imaging logging, and stress field numerical simulation to delineate the spatial and temporal distribution characteristics of fractures within the area. Consequently, the study investigates the interplay between key tectonic evolution stages, fracture development patterns, and the accumulation of oil and gas resources in the region.

The results indicate that the Kuqa Foreland Basin has undergone five different stages of tectonic evolution.By aligning faulting periods with hydrocarbon accumulation period, three key periods emerge: the Late Cretaceous-Paleocene, the Kangcun period of the Neogene, and the Kuqa period of the Neogene. Stress field simulation results, coupled with assessments of fracture filling degree, effective fracture parameters, and fracture distribution across various strata, suggest an overall trend of structural fracture development first increase and then decrease from south to north,. Particularly, the Bozi-Dabei area within the Kelasu structural belt exhibits the most pronounced fracture development.Moreover, fractures within the Lower Jurassic Ahe Formation and the Lower Cretaceous Bashkizeke Formation vertically display higher degrees of development. For individual faulted folds, substantial fractures with lower abundance predominantly occur in core of the fold, indicative of heightened overall fracture development. Conversely, medium to small fractures with greater occurrence are prevalent in the fold's wings, signaling a lesser degree of overall fracture development. The presence of a network of fractures in fault zones and adjacent strata underscores favorable conditions for fracture development.

The Kangcun and Kuqa periods of the Neogene emerge as critical phases for structural fracture formation in the Kelasu and Bozi-Dabei areas, correlating with the second and third periods of hydrocarbon charging in the Kuqa Foreland Basin. Concurrently, disparities in the distribution of dominant fracture development zones contribute to the overarching oil and gas distribution pattern in the Kuqa Foreland Basin, characterized by "north-south zoning, vertical layering, and fold-related accumulation".

Keyword

Tectonic evolution, Structural fractures, Numerical simulation of stress field, Hydrocarbon accumulation

Research on the genesis and characterization methods of non-horizontal fluid surface in oil and gas reservoirs in the Middle East

XIAO DU[1]*, Sinopec Research Institute of Science and Technology (duxiao.syky@sinopec.com)

Abstract

The Arabian Basin is the basin richest in petroleum resources in the world, with large-scale and diverse types of oil and gas reservoirs. Affected by reservoir characteristics and accumulation conditions, non-horizontal fluid surface exist in a large number of reservoirs, which have an important impact on the reserve evaluation and development technology strategies optimization. Based on core analysis data, test data, monitoring data and production dynamic data, this paper applies fluid potential analysis and numerical simulation methods to study the controlling factors, types and characterization methods of non-horizontal fluid interfaces in oil and gas reservoirs in the Middle East.

Studies have shown that reservoir properties, hydrodynamic conditions, fluid density, and tectonic movement are the main controlling factors of non-horizontal fluid surface in oil and gas reservoirs. According to the genesis, it can be divided into property genetic type, hydrodynamic genetic type, fluid density genetic type and trap adjustment genetic type. Among them, if it is only affected by the properties of the reservoir, it is classified as property genetic type. If there are other controls factors are classified into corresponding genetic types, which are manifested as the joint influence of corresponding control factors and reservoir physical properties. Affected by reservoir heterogeneity, non-horizontal fluid surfaces are difficult to accurately predict through a small number of evaluation wells. This paper proposes a method and process to characterize such fluid interfaces: 1) determine the free water level at the wells through pressure gradient data; 2) determine the free water surface trend based on the genetic type; 3) correct the trend surface through well data and conduct uncertainty evaluation.

Keyword

Middle East, genetic type, non-horizontal fluid surface

Bedding-parallel stylolites as a proxy for the sealing capacity of deep-burial carbonate cap rocks in the Tarim Basin, NW China

Jun WU[1]*, China University of Geosciences (Beijing) (junwu@cugb.edu.cn)
Tailiang FAN[2], China University of Geosciences (Beijing)

Abstract

The sealing capacity of carbonate cap rocks bearing different stylolite types is analyzed using a combination of petrographic, petrophysical, pore structure and sealing capacity characterization techniques. This study is based on examples of carbonate cap rocks that seal ultradeep hydrocarbon reservoirs of the Tarim Basin (China). Samples from both drill cores and their outcrop analogues are investigated to quantify how morphology does influence the sealing capacity of different types of stylolite-bearing rocks. The study cap rocks consist of mudstone, wackestone to packstone, grainstone and dolomitic limestone. Four stylolite types are identified: rectangular layer, seismogram pinning, suture & sharp peak and simple wave-like types. The difference in the sealing capacity of carbonate cap rocks is attributed to their pore structure connection and stylolite types. Samples bearing simple wave-like stylolites have the best sealing capacity, followed those with rectangular layer and suture & sharp peak types, whereas carbonates hosting seismogram pinning type have the lowest sealing capacity. The impact of stylolite segments on the rock sealing properties, however, differ from one segment to another. Rectangular layer type stylolites can be divided into three distinct segments (with good, moderate and poor sealing, respectively). Both the seismogram pining and suture & sharp peak stylolite types are divided in two parts, with the former one having moderate and poor sealing and the latter exhibiting good and moderate sealing. The simple wave-like type has a good sealing capacity all along the pressure-solution seam. The most effective sealing barriers for vertical fluid flow form when (1) calcite and siliceous cements are pervasively distributed in the vicinity of stylolites, forming highly cemented zones with lower porosity and permeability than their surrounding host rocks; (2) stylolites are enriched in insoluble residues; (3) rare microfractures and dissolution vugs are found along the stylolites. This work provides useful examples for the prediction of the sealing potential of stylolite-bearing carbonate rocks according to stylolite morphology in other geological settings.

Keyword

Carbonate cap rocks, Stylolite morphology, Pore structure, Sealing potential, Tarim Basin

The orogenic Mo deposit overprinted by gold mineralization

Nuo LI[1]*, Xinjiang Institute of Ecology and Geography, Chinese Academy of Sciences (linuo@ms.xjb.ac.cn)

Abstract

The Qinling Orogen in Central China underwent complex tectonic evolution and was finally formed through the continental collision between North China Craton and Yangtze Craton during Mesozoic. Here we report a case in the northern Qinling Orogen that was overprinted by metamorphic fluids. The Dahu deposit was initially explored as a gold deposit with salient features of orogenic-type mineralization. Recent underground exploiting has revealed the economic significance of Mo mineralization in the deeper part of auriferous quartz lodes. Such Au-Mo metal association made the Dahu deposit extremely unique, not only in the Qinling Orogen, but also worldwide, because no economically viable Mo has been reported for orogenic-type gold deposit. Gold and molybdenum mineralization are associated with a series of quartz lodes controlled by EW-trending and north-dipping faults. Geological, structural analysis and geochronological (including molybdenite Re-Os geochronology and hydrothermal monazite U-Pb dating) studies identify two mineralization episodes. The first episode is represented by Triassic (~216 Ma) Mo mineralization, with mineral association of quartz, K-feldspar, pyrite, minor sphalerite and monazite. A younger episode occurred in Cretaceous (~125 Ma), and resulted in gold mineralization and overprinted previous molybdenum mineralization. After that, quartz-calcite veins were formed, with limited contribution to mineralization. Detailed fluid inclusion studies indicate that the ore-forming fluids are featured by meso-to hypothermal, low-salinity and CO2-rich, which is identical to those responsible for orogenic-type deposits worldwide. Molybdenite was deposited at higher temperature and pressure (400−500 C, 138−331 MPa) in comparison to gold (215–464 C, 78−237). H-O isotope further revealed a metamorphic origin for the fluids and later mixing with meteoric water. Thus, the Dahu deposit represents a case that has overprinted orogenic Au mineralization on precursor Mo mineralization. The study also demonstrates the fate of ore deposits depending on subsequent tectonic evolution in complex orogenic belt.

Keyword

orogenic deposit, metamorphic fluid, Qinling, Triassic mineralization

Metamorphic fluids and orogenic-type gold mineralization

Richen Zhong[1]*, University of Science and Technology Beijing (zhongrichen@126.com)
Chang Yu[2], University of Science and Technology Beijing, Beijing, China
Yanjing Chen[3], Peking University, Beijing, China
Joël Brugger[4], Monash University, Clayton, Victoria, Australia
Wenbo Li[5], Peking University, Beijing, China
Andrew Tomkins[6], Monash University, Clayton, Victoria, Australia
Hao Cui[7], University of Science and Technology Beijing, Beijing, China

Abstract

The source(s) for ore-forming components of orogenic gold deposits has long been debated. The metamorphic devolatilization model (Phillips and Powell 2010), or supracrustal metamorphic model (Goldfarb et al. 2001) is widely accepted to explain the genesis of orogenic gold deposits. It emphasizes that gold and auriferous fluid are originated from metamorphic devolatilization of pelites or altered basaltic rocks when crossing the greenschist-amphibolite facies boundary (Tomkins 2010; Zhong et al. 2015). However, this model is challenged by models that infer non-metamorphic fluids, such as magmatic or mantle-derived fluids, because it can not explain the presence of hypozonal orogenic gold deposits hosted in high-grade (amphibolite facies) terranes in greenstone belts (Groves et al. 2020; Kolb et al. 2015).

To evaluate the feasibility of metamorphic rocks as the source for gold-forming fluids, thermodynamic modelings were conducted to simulated the devolatilization processes of gold- and sulfur-bearing metapelite and metabasite, which are broadly suggested sources for gold-forming components, as well as altered komatiite, which also contributes large propotions of metmorphic rocks in Precambrian greenstone belts.

The simulation results of metabasites show that auriferous metamorphic fluids are mainly liberated by decomposition of chlorite and epidote during the transition from greenschist to amphibolite facies (450−550 °C). Up to ~2 wt.% of free water and ~1 to 1.5 ppb of Au (relative to rock mass) can be released from the source rock across this transition. It implies that the majority of Au (50%−70%) in a basalt will have been striped when entering amphibolite facies, taken that Archean basaltic rocks contain ~2 ppb of Au in average. At temperatures higher than the wet solidus of basalts, the gold releasing process ceases because breakdown of hydrous minerals would result in partial melting. The gold liberation pattern of pelite is similar for metabasite. After the breakdown of chlorite during the greenschist-amphibolite transition, the majority of gold in average pelite will be liberated from the source rock by metamorphic fluids.

The situation is different for devolatilization of altered komatiite, which is characterized by two pulses of fluid and gold liberation. First, ~4 wt.% of water and ~1−1.4 ppb of Au (relative to rock mass) can be released when crossing the greenschist-amphibolite boundary at ~550 °C due to breakdown of antigorite. After entering amphibolite facies, a sharp rise in gold liberation occurs at ~700 °C as responses to dehydration of talc and chlorite, which liberates ~0.5 wt.% of water and ~2 to 5.5 ppb of Au. Although the second step of devolatilization releases less amount of water

than the first, more gold can be scavenged because of the higher solubility of gold at high-temperature metamorphic fluids. As ultramafic rocks, komatiites have higher temperatures of wet solidus (~1000 °C) than basalts and thus maintain in solid states during the second step of fluid and gold liberation at ~700 °C. The simulation resutls prove that metamorphic fluids can effectively mobilize gold from source rocks, and the metamorphic devolatilization model can account for gold mineralization in both greenschist terranes and higher grade rocks.

Keyword

Orogenic gold deposit, Metamorphic fluid, Thermodynamic modeling, hypozonal deposit, Komatiite

The lithium behavior of during prograde metamorphism: implications for optimal crustal sources for mineralization

Ming XIAO[1]*, The University of Hong Kong (xiao.ming.cn@hotmail.com)
Guochun Zhao[2], The University of Hong Kong
Yingde Jiang[3], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences
Chao Yuan[4], Guangzhou Institute of Geochemistry, Chinese Academy of Sciences

Abstract

A pre-enriched metasedimentary source is crucial for the generation of lithium (Li)-rich magma. However, the compositions and physical-chemical attributes of the source are poorly known due to its deep level in the crust. To reveal the key crustal source conditions such as the mineral assemblages, subsolidus metamorphic grades, and reworking degrees for the generation of Li-rich magma, whole-rock and in-situ mineral elemental analyses were conducted on a collection of Barrovian-type metamorphic rocks from the Chinese Altai, central Asia to investigate the host minerals and content variations of Li during the prograde metamorphism. These metamorphic rocks have similar greywacke-arkose sedimentary protoliths and encompass continuous biotite, garnet, staurolite, kyanite, and sillimanite metamorphic zones, corresponding to greenschist to upper amphibolite facies metamorphism. The in-situ LA-ICP-MS elemental results show that the staurolite mineral exhibits the highest Li-carrying capacity (Li contents up to 972 ppm) among other metamorphic minerals. It is noteworthy that staurolite, even in low volumetric proportions (e.g., around 10%), can dominate the whole-rock Li contents, which gives rise to the highest Li contents (94-105 ppm) in the staurolite zone and staurolite-bearing sillimanite zone in the studied metamorphic belt. A positive correlation was also observed between the Li contents in the studied and collected staurolites and their host metamorphic rocks, regardless of the lithologies of the host rocks and the metamorphic domains they are from. These observations suggest that staurolite-rich middle-high grade metamorphic rocks can emerge as a more fertile source for Li-rich magma, in comparison to rocks of other lithologies.

On the other hand, in-situ elemental results show that staurolites with the lowest MgO/(MgO+FeO) and/or Zn+Co values display the highest Li contents (619-972 ppm). This suggests that apart from inheritance from metamorphic reactions (e.g., muscovite + chlorite = staurolite + biotite + quartz + H2O), metamorphic fluids generated from local and regional metamorphic dehydration, especially, those that are rich in Li and poor in Mg-Fe-Zn-Co, can also elevate the Li contents in the staurolite. Based on these findings, a theoretical model that outlines the evolution of ordinary crustal sources into optimal sources for Li-rich magma can be proposed. The model shows that prograde metamorphism across the staurolite-in isograd accompanied by infiltration of Li-rich fluids/melts has the potential to generate Li-rich staurolites. Metamorphic rocks that contain high concentrations of Li-rich staurolites are likely to be the most suitable source for generating Li-rich magma.

In summary, this study has important implications for the budget and behavior of Li during crustal

reworking and evolution, which shed new light on the process of how a Li-enriched crustal source is formed.

Keyword

metasedimentary source, Li-rich magma, staurolite-rich metamorphic rocks, prograde metamorphism, metamorphic fluids

Metal origin and redistribution of cobalt in the ore-forming fluid of sediment-hosted stratiform Cu-Co deposits: Evidence from geochemistry of sulfides from the Shizishan deposit, SW China

Wenbo LI[1]*, Peking University (liwenbo@pku.edu.cn)
Tianyao Fu[2], Peking University

Abstract

Differentiation of Co and Cu is very common in sediment-hosted stratiform Cu-Co (SSC) deposits and its mechanism remains controversial. In this study, we discussed the metal origin and the process of metal redistribution during through a systematic petrographic and geochemical analysis at the Shizishan Cu-Co deposit, SW China. The ore body at Shizishan can be divided into three layers from the bottom upward. L1 mainly includes disseminated chalcopyrite and minor cobaltite and pyrite. L2 includes chalcopyrite, bornite and a large amount of cobaltite in both disseminated and vein structure. L3 mainly includes vein chalcopyrite and minor pyrite. A two-stage metallogenic process can be recognized at the Shizishan deposit. The first stage was a diagenetic stage forming disseminated chalcopyrite and cobaltite. The second stage was controlled by tectonic activities and formed vein and nodule bornite, cobaltite and chalcopyrite. Additionally, underlaying the ore-bearing dolostone is a “red bed” stratum enriched in strongly altered pyrite.

Pyrite from the red bed strata has high Co and As content, which shows its potential as the Co origin of the ore body. However, Cu content of the red bed pyrite is extremely low. Chalcopyrite and cobaltite show distinct groupings of different styles. Chalcopyrite in low-Co layers is enriched in Co, Ni, As, Se, Ag, Sb and Pb compared with those in high-Co layers. Ni, Se, Sb and Pb are enriched in disseminated and vein cobaltite coordinated with Co and As. Different Ga, Ge and In contents in different types of chalcopyrite suggest that the post-diagenetic fluid had higher initial temperature than the diagenetic fluid and experienced a cooling process during upward migration. Ni-Se-Cd ternary graph demonstrates that chalcopyrite of all types generally has a magmatic source, suggesting unknown deeper igneous rocks enriched in Cu. Ag and Bi are obviously enriched in bornite, which also indicates the alteration of chalcopyrite by the post-diagenetic fluid.

In the diagenetic stage, Co was preliminarily enriched and formed disseminated sulfide. In the post-diagenetic stage, elements in red bed and diagenetic sulfides were redistributed due to metamorphic fluid activities. The mobilization of fluid in the post-diagenetic stage was probably derived by tectonic activities and constrained by fault zones and porosity of the strata. More abundant space for fluid migration and stronger temperature changes may contribute to the higher grade of cobaltite in the post-diagenetic stage. Although Co and Cu have different sources, they were both extracted into the ore-forming fluid during fluid migration and precipitated in the same stratum. Differentiation of Co and Co is related to such element redistribution in the post-diagenetic ore-forming fluid. Furthermore, according to these geochemical results and considering distribution characteristics of ore bodies from some other typical large-scale sediment-hosted Co deposits, we state that secondary enrichment of Co in the post-diagenetic fluid may be the key

factor of high-grade Co mineralization.

Keyword

sediment-hosted deposit, cobalt, trace element geochemistry, metal source, enrichment mechanism

Saline fluids drive Cu mineralization in the Precambrian metasediments in the Trans-North China Orogen

Hong-Rui Fan[1]*, Professor (fanhr@mail.igcas.ac.cn)
Zheng-Jie Qiu[2], Dr.
Kui-Feng Yang[3], Dr.
Xiao-Chun Li[4], Dr.

Abstract

Epigenetic hydrothermal Cu-(Co) deposits are widely distributed in the Zhongtiao Mountains within the Paleoproterozoic Trans-North China Orogen in the North China Craton. The Henglingguan Cu-(Co) deposit in Zhongtiao is an epigenetic hydrothermal Cu deposit hosted within the meta-sedimentary rocks, consisting of the early disseminated mineralization and the late quartz vein mineralization. The parent ore fluids were likely subjected to the fluid immiscibility based as inferred from fluid inclusion petrography observations, microthermometry results, and fluid phase analysis of the H2O–NaCl-CO2 system. Pressure and temperature conditions of the fluid immiscibility were constrained at 320 to 340 °C and 3.5 to 4.0 kbar, respectively, according to the homogenization temperature-pressure conditions for the endmember of carbonic fluid inclusion. The combination of high salinity and high CO2 contents makes the ore fluids in the Henglingguan Cu deposits distinct from almost of the other major hydrothermal deposits. The parent ore fluids before fluid immiscibility had high salinity (XNaCl = 0.1 to 0.2) and significant CO2 contents (XCO2 = 0.1 to 0.15) based on the fluid phase analysis. In-situ composition analysis of individual fluid inclusions by LA-ICP-MS show that the ore fluids are rich in Na, Ca, Fe and Mn, and evolved towards Sr-Ba enrichment in the Ba-Rb-Sr ternary plot. This indicates that the ore fluids are metamorphic brine derived from the evaporitic sedimentary rocks. The negative sulfur isotope data (-10 to -11 ‰) further suggests a sedimentary rock source of sulfur for the hydrothermal Cu mineralization. The high salinity and high CO2 fluids are likely derived from the evaporative carbonate rocks developed on the basin margins or passive continental margins. This metamorphic brine served as effective medium in the transportation of Cu along its flow paths. The fluid cooling and decompression during the retrograde stage/post-collision exhumation were the key triggers for fluid immiscibility. The fluid unmixing is likely responsible for Cu mineralization in the quartz veins. Combining with the metamorphic P-T-t-m evolution path of the Henglingguan deposit proposed and a comprehensive understanding of the ore fluids evolution in this area, a saline metamorphic hydrothermal ore formation is proposed to explain the epigenetic hydrothermal Cu deposits hosted in the metasedimentary rocks. The source-transportation-precipitation of metallic elements was likely linked to the formation and closure of the Zhongtiao rift during ~2.2 to 1.85 Ga.

Keyword

Epigenetic hydrothermal Cu deposit, Fluid inclusion, Metamorphic brine, Trans-North China Orogen

Orogenic gold mineralization in the Huangling region and its intimate tectonic linkage to the Neoproterozoic orogeny of South China

Huimin WANG[1]*, China University of Geosciences(Wuhan) (1516561213@qq.com)
Qinlin Xia[2], China University of Geoscience(Wuhan)
Zhou Zhou[3], Seventh Geological Brigade, Hubei Geological Bureau

Abstract

Gold mineralization types were rarely exposed in the Neoproterozoic accretionary-to-collisional orogen, particularly in China, throughout Earth's history. The Huangling region in South China contains more than 70 gold deposits/occurrences hosted in Archean-Paleoproterozoic metamorphic rocks and Neoproterozoic granitic complexes. However, the absolute age of hydrothermal mineralization, genesis, and their relationship with regional-scale processes, such as tectonism, magmatism, and metamorphism, remains unclear. Therefore, in this study, we investigated three gold deposits (Shuiyuesi, Hongwucun, and Guaizigou) hosted in different lithological units from the northern, central, and southern regions of Huangling, respectively. We conducted detailed fieldwork and analyzed the hydrothermal apatite and monazite geochronology and Sr-Nd isotopic composition of these deposits. The gold mineralization is mainly hosted within sulfide-quartz veinlets, and it is structurally controlled by second-order NW- or NNW-striking faults of the first-order NW trending main fault zone. Gold is present in various forms, such as native gold, electrum, and petzite or in fine-grained pyrite as invisible gold co-precipitated with alteration mineral assemblages that include sericite, quartz, and hydrothermal apatite, and monazite. LA-ICP-MS U-Pb dating of the hydrothermal monazite and apatite for the Shuiyuesi deposit yielded two ages: 831±2 Ma and 830±23 Ma. These ages are consistent with the weighted mean 206Pb/238U age of 834±3 Ma for apatite, obtained from the southern Guaizigou deposit within margin of error. Monazite and apatite dating of the Hongwucun gold deposit yielded younger ages of 810±3 Ma and 800±10 Ma, respectively. The new dates suggest that the gold deposits in the Huangling region underwent two distinct metallogenic episodes of gold mineralization during the Neoproterozoic, coeval with the temporal post-collisional mafic dykes, which postdated the regional metamorphism by ~100 m.y, as indicated in the Huangling region after the peak period of collisional orogeny and in response to an extensional setting, possibly due to asthenosphere wedging. The Sr-Nd isotope of apatite and monazite ($^{87}Sr/^{86}Sr$: 0.69555–0.76244, $\varepsilon Nd(t)$: −22.1– −2.9) and collective geochemical data indicate that ore-forming fluids are mainly consistent with magmatic sources with significant contribution from mantle materials. The results of the study suggest that the Huangling gold mineralization province is genetically related to Neoproterozoic post-collisional magmatism. Additionally, the region shares many characteristics of large orogenic gold provinces around the world, including alteration types, element associations, occurrence states of gold, and the evolution of orogenic belts, offering valuable new insights into the gold metallogeny of the early Neoproterozoic period, which is generally not known for its abundance of Au deposits.

Keyword

Neoproterozoic gold mineralization, Apatite dating, Monazite dating, Sr-Nd isotope, Post-collisional setting

Protracted gold mineralization in the southern part of the Mozambique Belt: Evidence from the Nanlia and Makorongo prospects, northeastern Mozambique

Manuel Augusto Manuel NOPEIA[1]*, Center for Regional Revitalization in Research and Education, Akita University, Japan (manuelnopeia@yahoo.com)
Akira Imai[2], Department of Earth Resources Engineering, Kyushu University, Japan
Ryohei Takahashi[3], Department of Earth Resource Science, Akita University, Japan
Andrea Agangi[4], Department of Earth Resource Science, Akita University, Japan and Department of Geology, University of Johannesburg, South Africa
Kotaro Yonezu[5], Department of Earth Resources Engineering, Kyushu University, Japan
Daud Jamal[6], Department of Geology, Eduardo Mondlane University, Mozambique

Abstract

The Mozambique Belt (MB) strikes nearly N-S and extends southward from the Arabian-Nubian Shield to Mozambique. It resulted from a continent-continent collision between eastern Africa (Kenya-Tanzania) and a collage of continental blocks including Madagascar, Sri Lanka, Seychelles, India and East Antarctica during the Neoproterozoic Pan-African orogeny characterized by both metamorphism and magmatism which continued until ca. 500 Ma. The southern part of the MB underlies a vast area of Mozambique and Tanzania and hosts several types of mineralization, particularly orogenic gold deposits. The metallogeny of orogenic gold deposits in the region is still debated, which precludes sustainable gold exploration. The Nanlia and Makorongo gold prospects are hosted by the Xixano Complex and are about 15 km apart. The gold mineralization in the Nanlia and Makorongo prospects occurred as approximately E-W trending gold-bearing quartz veins hosted parallel to the foliation of orthogneiss. New Re-Os age data of sulfides associated with gold mineralization in these prospects suggest a prolonged gold mineralization time in the region, spanning from ca. 580 to 560 Ma. This mineralization age interval postdated the timing of peak metamorphism of the host-rocks established at ca. 631–607 Ma and was contemporaneous with the metamorphism of basement rocks between ca. 607 and ca. 564 Ma as well as the timing of magmatism in the area constrained at 573±17 Ma. The timing of the Nanlia and Makorongo prospects is similar to that of the Amani Gold Field associated with N-S quartz-carbonate veins hosted in the Ubendian Belt, along the southwestern margin of the Tanzania Craton in Tanzania, which was dated at 600–550 Ma. The gold mineralization in the Xixano Complex and the Amani Gold Field is interpreted to be related with the Pan-African orogeny. These gold occurrences were formed by H2O-CO2±CH4 fluids with low to moderate salinity, which have been interpreted to be derived by metamorphism of basement rocks. Although a metamorphic-devolatilization model for gold mineralization has been proposed for the individual gold occurrences, the protracted gold mineralization in the MB and Ubenduan Belt during the Pan-African orogeny is unlikely to be explained solely by crustal metamorphism. Therefore, a combination of crustal metamorphic and magmatic model should not be ruled out for the Pan-African orogeny-related gold mineralization.

Keyword

Orogenic gold, Mozambique Belt, Pan-African orogeny

Syn-metamorphic remobilization of stratabound Zn and Pb: a case study on the Jiashengpan deposit in northern China

Chang YU[1]*, University of science and technology Beijing (yuchangustb@126.com)
Richen Zhong[2], University of science and technology Beijing
Yuling Xie[3], University of science and technology Beijing
Wenbo Li[4], Peking University

Abstract

The Langshan-Zhaertai region in western Inner Mongolia is located along the Northern margin of the North China Craton (NCC). This area is a significant Cu-Zn-Pb polymetallic ore belt hosting several Zn-Pb-(Cu) deposits. The Jiashengpan deposit, developed in Mesoproterozoic rift sedimentary rocks, is the most important Zn-Pb polymetallic deposit in this area. The ore-forming genesis of Jiashengpan is under debate. It has traditionally been regarded as a syngenetic strata-bound or sedimentary exhalative deposit. However, some researchers noted that deformation, such as thrust faulting, of ore-hosting rift sequences had significant control on the formation of Zn-Pb orebodies.

To clarify the ore-forming process of Jiashengpan deposit, the systematic research of petrology, mineralogy, fluid inclusion, thermodynamic simulation and geochronology on Jiashengpan deposit have been carried out. The petrographic and mineralogical studies show that the early-stage sulfides are characterized by the widely developed massive pyrite with fine-grained textures or framboid structure, indicating a sedimentary genesis. Besides, syngenetic Zn-Pb-sulfides were observed as disseminated fine grains in dolomite, and in general of no economic interest. All the economically important Zn-Pb ores were formed during the late-stage remobilized mineralization, with hydrothermal pyrite and pyrrhotite and gangue minerals such as quartz, calcite and dolomite. The mineralization in remobilized stage shows characteristics of shear zone-controlled mineralization, such as mineral precipitation following mylonitic foliations of the host rocks.

The fluid inclusion studies reveal that the Zn-Pb remobilized fluid is mesothermal, low salinity and carbon-rich, which are consistent with the characteristics of metamorphic fluid. In addition, the remobilized fluid evolute from high-temperature oxidized fluid primarily composed of CO2 to low-temperature CH4-rich reduced fluid. Thermodynamic simulation results of remobilized fluid flowing through host rocks show that the syngenesis disseminated Zn and Pb in rocks can be dissolved and migrated by remobilized fluids, and Zn-Pb sulfides are efficiently precipitated from Zn-Pb bearing fluids during flowing into the carbonaceous strata, which is the roof rocks of the Zn-Pb ore bodies.

The 39Ar/40Ar dating study of syn-ore hydrothermal muscovite prove that the Zn–Pb mineralization took place in the Devonian (~380 Ma). This result agrees with zircon U–Pb ages of post-ore granite, which constrain the ore formation to be older than 277 ± 2 Ma. Ore formation was coeval with the emplacement of regional orogenic belts that formed as result of subduction associated with the closure of the eastern Paleo-Asian Ocean (~400 Ma).

Therefore, two-stage genesis of Jiashengpan deposit has been established: (i) syngenetic processes (during sedimentation or diagenesis of the host rocks) lead to pre-enrichment of Zn and Pb, forming Zn-Pb-bearing but sub-economic rift sedimentary rocks, and (ii) syngenetic sulfides were subsequently remobilized by metamorphic fluids, migrated, and concentrated along shear zones, resulting in high-grade Zn-Pb mineralization.

Keyword

Zn-Pb mineralization, Metamorphic fluid, Remobilization, Thermodynamic modelling, North China Craton

[Invited] A predictive exploration framework for primary and metamorphosed IOCG and affiliated critical and precious metal deposits in Metasomatic iron and alkali-calcic mineral systems

Jean-Francois MONTREUIL[1]*, Red Pine/MacDonald Mines Exploration
(montreuil.jean.francois@gmail.com)
Louise Corriveau[2], Natural Resources Canada, Geological Survey of Canada
Olivier Blein[3], Bureau de Recherches Géologiques et Minières

Abstract

Iron oxide-copper-gold (IOCG) deposits are one of a growing list of base (Fe), critical (Bi, Co, Cu, Mo, Ni, PGE, REE, W, U, Zn) and precious metal (Ag, Au) deposits that can form in Metasomatic iron alkali-calcic (MIAC) mineral systems. In each MIAC system, pervasive and intense infiltration metasomatism significantly changes the composition of host rocks through regional-scale fluid-rock reactions between a voluminous hypersaline fluid plume and the upper crust as its fluids evolve from high temperatures (HT; reaching ~900°C) to low temperatures (LT; cooling to ~150°C) conditions. In the process, zones of alkali-rich alteration (Na, K) form regionally while zones of Fe-rich alteration in which Fe is coupled with alkali (Na, K) and/or calcic (Ca, Mg, Ba) metals, and zones of alkali-calcic alteration with quartz or carbonates without important Fe addition form more locally. Iron-rich alteration occurs as oxides, silicates, sulfides and/or carbonates.

A sequence of mineralogical changes occurs in MIAC systems as metasomatism proceeds and can be described using a suite of alteration facies, each associated with distinct metal associations. LT to HT Na-(Ca) alteration routinely forms albitite, is associated with Fe-poor skarn alteration in carbonate rocks and represents the ground preparation and heating stage of a MIAC system. Albitite occurs preferentially along local to regional structural discontinuities and are frequently brecciated by superimposed deformation and alteration. As metasomatism proceeds, skarn alteration becomes increasingly Fe-rich and marks the onset of Fe-rich alteration and W mineralization. In silicate-rich rocks, HT Na-Ca-Fe alteration marks the onset of Fe-rich alteration. HT Ca-Fe alteration represents the thermal peak of MIAC systems and is associated with the formation of Fe skarn, iron oxide-apatite (IOA), and Fe-rich Ni deposits. Rare earths elements (REE) can be concentrated in the apatite of certain IOA deposits and constitute a by-product of IOA mining, alternatively REE are remobilized as ores and form primary REE resources in IOA deposits. HT Ca-K-Fe alteration is associated with the formation of Fe-rich Co deposits that can also contain significant Au, Bi and Cu. The formation of Cu-rich deposits like IOCG or iron sulfide-copper-gold (ISCG) deposits begins at the HT K-Fe alteration facies (magnetite) as the system has sufficiently cooled to decrease the solubility of Cu-chloride complexes and continues at the LT (K,Ba,Ca,Na)-(CO2,F,H+)-Fe alteration facies (hematite). These facies can also form primary U deposits typically hosted in albitite. The transition from aluminosilicate-rich LT (K,Ba,Ca,Na)-(CO2,F,H+)-Fe alteration to silica-rich LT (Ca,Mg)-

(K,Na)-Si-Fe alteration can generate primary Au or Ag deposits whereas Fe-poor alteration facies can form primary Au, Cu, U and Mo deposits.
Post-MIAC fluid circulation induced by orogeneses or renewed magmatism can remobilize any of the metals present in preexisting alteration zones and form zones of high-grade mineralization. Once formed, MIAC systems can become metamorphosed to amphibolite to granulite facies during orogenesis. In the process, each alteration facies develops new —metamorphic— assemblages but metamorphism leaves their atypical chemistry unchanged. This enables the use of geochemical indexes to identify metamorphosed alteration facies in support of field interpretation and facilitates mineral exploration of high-grade metamorphic terranes.

Keyword

IOCG, Metasomatism, MIAC, Alteration facies, IOA

The polyphase development of gold mineralization in the Kibali gold district: Insights derived from the analysis of pyrite.

Yann Waku Mpaka[1]*, Stellenbosch University (yannwaku1@gmail.com)
Bjorn von der Heyden[2], Department of Earth Sciences, Stellenbosch University, Private Bag X1, Matieland 7602, South Africa
Sarah Glynn[3], School of Geosciences, University of the Witwatersrand, Johannesburg, South Africa
Gary Hurst[4], Barrick Gold Corporation, Toronto, ON, Canada
David Lawrence[5], Barrick Gold Corporation, Toronto, ON, Canada
Trézène Bampata[6], Barrick Gold Corporation, Toronto, ON, Canada
Etienne Mwandale[7], Barrick Gold Corporation, Toronto, ON, Canada

Abstract

The Kibali gold district, situated on the Congo Craton, holds a substantial Neoarchean gold resource exceeding 28.7 Moz. Positioned within a fold-and-thrust belt shaped by compressional tectonics around 2.64 - 2.60 Ga, the gold deposits are primarily found in metamorphosed BIF and clastic sedimentary rocks within a major fault-thrust zone spanning 60 kilometers. The study encompasses eight gold deposits: KCD, Agbarabo, Rhino, Kombokolo, Gorumbwa, Pakaka, Tete Bakangwe, and Kalimva. Employing detailed pyrite textural analyses, in situ trace element analyses using Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA-ICP-MS), and S isotopic composition analyses using Secondary Ion Mass Spectrometry (SIMS), the investigation unravels the gold metallogeny in the district. Eight distinct pyrite types (py-0a, py-0b, py-1, py-2, py-3, py-4a, py-4b, and py-5) are identified, each associated with distinct mineral-forming processes across a polyphase evolution. The syn-diagenetic py-0a serves as the primary gold repository (15.6 ppm median with a near-zero δ34S value) in older basin sediments deposited before 2.64 Ga. Py-0b corresponds to late diagenetic or early metamorphic pyrite in younger basin sediments, while solid-state metamorphic recrystallization leads to py-1. The early ore stage involves metal precipitation through sulfidation and carbonation (py-2) with high Au concentrations (3.1 ppm) and various trace element enrichments (As, Bi, Cr, Cu, Gd, La, Mn, Pb, Sb, W, and Zn). The second ore stage features deposition of py-4a (Au barren) and py-4b (avg. 5.5 ppm Au) formed by an over-pressured fluid. In the latter auriferous pyrite class, Au is concentrated in oscillatory zoned As-rich bands and is associated with high δ34S value (6.4 ‰ mean). Py-5, formed after the main ore stage, is generally Au-barren. Subsequent deformation events result in the remobilization and concentration of invisible gold to gold grains, contributing to the understanding of the origin and evolution of gold mineralization in the Kibali gold district.

Keyword

Pyrite, trace elements, Sulfur isotopes, Congo Craton, Kibali gold district

Sulfur and iron isotope constraints on the source of ore-forming materials of the Xiajiadian sediment-hosted gold deposit, China

Xu-Yang LIU[1]*, China University of Geosciences (liuxuyang124@163.com)
Ya-Fei WU[2], China University of Geosciences

Abstract

Sediment-hosted gold deposits such as orogenic and Carlin-type gold deposits are one of the most important gold resources in the world. Although numerous investigations have been conducted to reveal the genesis of these deposits, the origin of metals and ore fluids remains debated. Here we present in-situ sulfur and iron isotopes analyzed by laser ablation–(multiple collector)–inductively coupled plasma–mass spectrometry [LA–(MC)–ICP–MS] for sulfides from the Xiajiadian sediment-hosted gold deposit (>50 t Au) in the South Qinling Orogen, China. The δ34S values of chalcopyrite in the adjacent Mesozoic dioritic porphyrite (−1.5‰ to 0.7‰, mean = 0.1‰) and underlying Proterozoic metavolcanic rocks (1.5‰ to 2.3‰, mean = 1.7‰) are lower than, but fall in the range of, those previously reported of pyrite in gold ores (−9.4‰ to 7.2‰, mean = 3.3‰). The variable δ34S values of pyrite in gold ores are comparable to those of pyrite from the host rocks of Cambrian black shales (−8.8‰ to 10.6‰, mean = 0.7‰). The δ56Fe values of pyrite in mineralized and hydrothermally altered host rocks (0.29‰ to 0.86‰, mean = 0.61‰) are similar to those of pyrite in the host black shales (0.10‰ to 0.72‰, mean = 0.49‰). However, the δ56Fe values of chalcopyrite in the metavolcanic rocks (−1.42‰ to −0.78‰, mean = −0.94‰) and pyrite in the dioritic porphyrite (−1.07‰ to 1.23‰, mean = 0.13‰) are lower than those of pyrite in the mineralized and unaltered host rocks. Additionally, rock geochemistry analysis shows that the contents of Au, As, Ni, Pb, Sb, Se, Tl, U, and Zn are positively correlated with that of carbonaceous matter in the host black shales. The Au content, however, shows a negative correlation with that of carbonaceous matter in altered rocks.

The comparable sulfur and iron isotopic compositions of pyrite in the ores and unaltered host black shales indicate the Cambrian black shales could have provided sulfur and iron for gold transport, sulfidation, and gold deposition. However, the contribution of magmatic sulfur from dioritic porphyrite and underlying Proterozoic metavolcanic rocks cannot be excluded. The iron isotopes show that the metavolcanic rocks are not likely to provide iron for gold mineralization. The high contents of gold and a series of trace elements in the host black shales and the positive correlation between these metals and carbonaceous matter indicate that gold can be partly derived from the host rocks. The negative correlation between the contents of gold and carbonaceous matter in hydrothermally altered rocks might indicate that fluid-rock interactions during gold mineralization could have remobilized the carbonaceous matter-related gold originally hosted in the black shales.

Keyword

Sediment-hosted gold deposits, Metal origin, Iron isotope, Sulfur isotope, Carbonaceous matter

[Keynote] Metamorphic fluids and varieties of orogenic-type gold mineralisation

Andrew TOMKINS[1]*, Monash University (andy.tomkins@monash.edu)

Abstract

Regional metamorphism during orogenesis produced fluids that transported gold from source regions to the sites of orogenic gold deposit formation in the upper crust in numerous metamorphic belts around the world. Archean cratons have greenstone belts containing hydrated mafic-ultramafic rocks, felsic volcaniclastics and clastic metasedimentary rocks, whereas Phanerozoic metamorphic belts are dominated by turbidite sequences. Metamorphic dehydration of chlorite, and in some cases muscovite, produces large volumes of the low salinity, moderately reduced, H2S- and CO2-bearing fluid needed to form the gold deposits. Typical orogenic gold deposits contain minimal base metal enrichment, likely because gold can be transported in low salinity fluids as hydrosulfide complexes, whereas base metals tend to be transported as chloride complexes. Most Archean and Phanerozoic orogenic belts with greenschist to amphibolite facies metamorphic rocks contain orogenic gold deposits. However, there are some metamorphic belts that contain large numbers of mineral deposits, including gold-bearing deposits, but little or no typical orogenic gold mineralisation. Instead, there are numerous Cu-Au occurrences (some are iron-oxide Cu-Au mineralization style, others are iron-sulfide Cu-Au; IOCG and ISCG). Fluid inclusion studies have demonstrated that these Cu-Au deposits formed from highly saline fluids. A defining feature of these distinctly different metamorphic belts is that they contain thick sequences of scapolitic calc-silicate metasedimentary rocks, which evolved from modestly evaporitic muddy carbonate sediments. We have found that the presence of widespread Cl- and variably SO4-rich scapolite creates a system where metamorphic fluids are continuously buffered to oxidised and highly saline conditions. High salinity increases the solubility of base metals and gold, as well as other metal-complexing ligands such as sulfur, fluorine and phosphorus, and thus dramatically expands the range of metals that can be carried in the fluid. In this way, metamorphic belts with large volumes of evaporitic material are ideal for generating a broad spectrum of syn-orogenic hydrothermal ore deposit types - including IOCG, ISCG, Mo-Re and U-REE, but lacking Au-only. Unlike regions hosting traditional orogenic gold deposits, belts containing evaporitic sequences retain Cl-rich minerals to high metamorphic grades, allowing them to remain active as ore forming systems for prolonged periods. Supercontinent breakup, notably in the Mesoproterozoic, may have resulted in the formation of large, intracontinental basins well suited to the development of widespread evaporitic sequences. This, in combination with overprinting orogenesis and high temperature magmatism, may have provided the ingredients for widespread ore deposit formation at a global scale.

Keyword

Metamorphism, Gold, Mineralisation, Orogenic

Base metal mineralisation at Agnigundala Sulphide Belt and deformation stages in Nallamalai Fold Belt, Cuddapah Basin, India

MOHD QAIM QAIM RAZA[1]*, Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai 400076 India (talk2qaimalig@gmail.com)
Anshul Sahu[2], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai 400076 India
Md Inzmamul Haque[3], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai 400076 India
Sakthi Saravanan Chinnasamy[4], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai 400076 India

Abstract

In comparison to McArthur-Mt. Isa basin system of northern Australia, the Proterozoic Cuddapah basin of India also host several base metal mineralisations, however the grades of ore bodies are comparatively very low. The mineralisation (Cu-Pb±Zn) is dominantly hosted in strongly deformed and low-grade metamorphosed sediments of Nallamalai Fold Belt (NFB), Cuddapah Basin. The intensity of deformation and metamorphism decreases from the east towards west of the NFB. The stages of deformation (D1-D2) in NFB is linked with stages of deformation in Nellore Schist Belt occurring on the East and post to syn-kinematic granitic intrusion in the vicinity. The base metal mineralisations of the basin mainly exist in two sulphide belts known as Agnigundala at the northeastern part and Varikunta-Zangamrajupalle at the central part of NFB that represents basin level metallogeny. Therefore, studying the genesis of mineralisation will reveal the basin evolution in relation to regional tectonics.

In the present study, the detailed field work, extensive petrography of rock and mineralised samples, and fluid inclusion (FI) studies on mineralised vein samples are performed. The samples are collected from three base metal deposits of Agnigundala Sulphide Belt (Nallakonda, Dhukonda and Bandalamottu). The host rocks belong to Cumbum Formation of Nallamalai Group, Cuddapah Basin. The formation is comprised of dominantly shale (slate/phyllite) interbedded with dolomite and sandstone (quartzite). The base metal mineralisation is dominantly hosted in the interbedded rocks (copper dominantly in quartzite and lead dominantly in recrystallised dolomite). Mineralisation is stratabound dominated by copper at Nallakonda, both stratabound and vein-type copper-lead at Dhukonda while vein-type and interbreccia space filling dominated by lead at Bandalamottu. The mineralogy of the ore minerals is comprised of chalcopyrite, galena with minor amount of sphalerite. Gangue minerals are quartz and dolomite while pyrite is observed from pre- and syn-ore generations.

Development of pyrite porphyroblast, formation of pressure shadows around the pyrite and crenulation cleavages indicate multiple stages of deformation which is also inferred by earlier workers for the NFB. The post-mineralisation deformation of ore and gangue minerals are also evident from polycrystalline nature and sutured boundaries of quartz and folding of chalcopyrite-quartz vein along crenulation cleavage.

The FI in mineralised quartz-carbonate or quartz veins are primary and secondary, biphase liquid+vapour (L+V) and varying in shape (regular to irregular), size (<5−>40μm) and degree of fill (0.8−0.6). The FI microthermometry results from all three deposits showed a total solidification between −33°C to −49°C on freezing by bubble bursting. It indicates that FI are aqueous in nature. But on heating, inclusions either showed metastable condition by final ice melting at around +5°C or decrepitated while homogenisation. This also supports post mineralisation deformation-metamorphism. For some inclusions a broad range of homogenisation (L+V=L) temperature (125−235°C) was observed. To constrain the stages of deformation and basin evolution in relation to regional tectonics further geochemical and isotopic studies are required. Considering the ages of the mineralisation (~1600Ma), the granitic intrusions (~1590Ma) and Krishna orogeny (~1.68−1.6Ga), the study of the ore genesis at NFB may be a reliable window for understanding the Columbia supercontinent cycle.

Keyword

Nallamalai Fold Belt, hydrothermal, base metal mineralisation, fluid inclusion, basin evolution

The origin of the pyrite-pyrrhotite veins at Rampura Agucha, India.

Don CHATTERJEE[1]*, Indian Institute of Technology, Kharagpur (donchatterjee634@gmail.com)
Kamal Lochan Pruseth[2], Indian Institute of Technology, Kharagpur

Abstract

The world's largest open pit Zinc (Zn) mine and world-class base metal deposit-Rampura Agucha is exposed in Mesoproterozoic metasedimentary rocks of Bhilwara supracrustal belts of Aravalli-Delhi orogen at Rajasthan, India. The peak metamorphic conditions of 780°C and 6.2 kbar i.e., at granulite facies of metamorphism at the Rampura Agucha Zn-Pb deposit, has resulted in sulfide anatexis (Mishra and Bernhardt, 2009). The remobilized sulfide partial melt is expected to be lead(Pb) and copper(Cu) enriched containing considerable concentrations of low-melting chalcophile elements (Frost et al., 2002; Pruseth et al., 2014). Interestingly, in the Rampura Agucha deposit veins of exclusively pyrite and pyrrhotite, with minor sphalerite are encountered, in which subhedral to euhedral pitted pyrite grains occur with pyrrhotite permeating the vein. While sulfide melts are unlikely to be preserved, these veins can be ascribed directly to melting of pyrite and be considered an indicator to sulfide partial melting. In the Fe-S system (Ehlers, 1972), pyrite incongruently melts at 742±1oC to pyrrhotite + sulfur(S)-rich melt. This melt is easily remobilized into veins and on cooling, probably pyrrhotite is the first to crystallize, leaving the residual melt further enriched in sulfur(S). On further cooling pyrite crystals with numerous sulfur(S)-vapor inclusions may have formed, which now persist as pitted pyrite crystals.

Keyword

Sulfide anatexis, Fe-S system, Low-melting chalcophile elements, pyrite, pyrrhotite

Evolution of the metamorphic fluid in the ca. 1.89 Ga augen orthogneiss from the East European Craton

Laurynas ŠILIAUSKAS[1]*, Nature Research Centre (laurynas.siliauskas@gamtc.lt)
Gražina Skridlaite[2], Nature Research Centre

Abstract

Augen orthogneiss (ca. 1.89 Ga) is underlying ore bodies of the Varėna Iron Ore Deposit (VIOD) in the East European Craton (EEC). The applied phase modelling results indicate that assemblages of Cpx+Amf+Pl+Kf+Ilm+Qtz+melt±Bt (sample D8/845) and Amf+Pl+Kf+Mag+Ilm+Qtz+melt (sample D9/1124) are stable at a peak temperature of ~750° C, the pressure of 2-4 kbars and oxidizing conditions (logfO2 -13.5 to -13 and -13 to -12, respectively) which were achieved at 1.75-1.79 Ga (dark CL zircon rim ages). Similar T and P values were obtained from the Ti and Altotal in amphibole thermometry and barometry. Cl-enriched mineral assemblages have developed during the retrogression. Cl-rich scapolite forms a meshwork in the felsic domains. The most Cl-rich scapolite (Cl 0.74-0.96 apfu, EqAn 0.28-.037) grew in the presence of a Cl-rich fluid or melt and was in disequilibrium with calcite, whereas the late-stage scapolite (Cl 0.5-0.53 apfu, EqAn 0.50-0.54) was in equilibrium with calcite (XfluidNaCl 0.52-0.59; Ellis, 1978) at the very low water activity of 0.15-0.19 (Aranovich and Newton, 1996). The positive slope of the neighbouring Cl-rich scapolite-plagioclase tie-lines indicates their equilibrium with fluid, whereas negative slopes of the late-stage scapolite-plagioclase tie-lines show plagioclase and fluid disequilibrium (Kullerud and Erambert, 1999). The sporadic, Fe-rich, potassic-chloro-hastingsite (Cl 0.50-1.20 apfu, Mg# 0.00-0.32) is situated at the grain boundaries and defects of the peak-T amphibole.

As water is retained in the partial melt, and Cl partitions into coexisting aqueous fluid (Webster, 1997), small pockets of Cl-brine could develop after the peak and stabilise the Cl-rich scapolite. The amount of CO2 in the fluid was negligible at the peak temperature and gradually increased during the cooling when H2O and Cl were incorporated into retrograde titanite, biotite and amphibole, while the CO2 content was retained in the fluid until the formation of late-stage scapolite. The plagioclase-fluid disequilibrium indicates the dropping temperature at this stage. The cooling of the system and increase in CO2 would cause the evolved fluid composition to plot in an immiscible fluid field in the ternary H2O-CO2-NaCl system, resulting in low-Cl, low-density H2O-CO2 fluid and Cl brine (Heinrich, 2007), responsible for the formation of potassic-chloro-hastingsite.

This model suggests that only a small amount of fluid was present during the peak conditions, and all the free water was partitioned into the melt. Although the origin of Cl in the fluid is unclear (external fluid or fluid produced during the partial melting), the low-pressure and relatively high-temperature metamorphism of the augen gneiss may provide a mechanism for the development of a Cl-brine, that might be responsible for mobilizing Fe from the country rocks and forming of the rich magnetite ores overlying the studied augen gneisses (Skridlaite et al., 2019).

Keyword

Cl brine, metamorphic fluids, Potassic-hloro-hastingiste, Scapolite, East European Craton

REE and Nb remobilization during post-ore metamorphism of the giant Bayan Obo deposit

Long HAUNG[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (huanglong22@mails.ucas.ac.cn)
Xiaochun Li[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Hongrui Fan[3], Institute of Geology and Geophysics, Chinese Academy of Sciences
Kuifeng Yang[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Haidong She[5], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The enrichment and mineralization of Rare Earth Elements (REE) and niobium (Nb) are hot issues in the economic geology field. The carbonatite related deposits have been the world's major sources of REE and Nb. It seems that carbonatites experienced multiple stages of hydrothermal activity tend to be more likely to form rich REE and Nb deposits. The most well known example is the largest REE deposit in the world, the Bayan Obo REE-Nb-Fe deposit in China. Isotopic dating indicate that the primary mineralization occurred at ~1300 Ma. After that, the deposit experienced two episodes of overprint at 450-400Ma and 280-260 Ma, respectively. The primary mineralization is characterized by accumulation of light REE, accompanied with enrichment of Nb. During the overprinting events, fluorine- and sulfate-rich fluids pervasively flow through the deposit. The post-ore overprinting events did not improve the ore tenor. However, it resulted in internal mobilization of elements within the deposit. For example, heavy REE is more mobile than light REE, leading to local enrichment of heavy REE. In addition, the post-ore hydrothermal overprint led to mobilization of Nb, during which small Nb minerals were transferred into larger minerals. In general, the element mobilization processes help to create beneficial resources and improve the exploitable level of the deposit.

Keyword

REE, Bayan Obo, Carbonatites, Hydrothermal overprint, Niobium

In situ major, rare earth elements and U-Pb ages of apaite from orogenic Dongkeng gold deposit, Yunkai Massif, South China: implications for mineralization

Guozheng ZHANG[1]*, School of Earth Sciences and Engineering, Sun Yat-sen University (zhanggzh9@mail2.sysu.edu.cn)
Yi Zheng[2], School of Earth Sciences and Engineering, Sun Yat-sen University
Xi Chen[3], School of Earth Sciences and Engineering, Sun Yat-sen University
Mengxuan Chen[4], School of Earth Sciences and Engineering, Sun Yat-sen University

Abstract

The Dongkeng gold deposit is situated in the central part of the Yunkai Massif, west of the Wuchuan-Sihui falut, with a controlled reserve of 12t and prospective reserve of 20t, averaging approximately 5.68g/t. The orebodies are positioned along the NW-trending brittle-ductile shear fault, considered a secondary fault of the NE-trending Wuchuan-Sihui fault. The Yunkai Group of Proterozoic shallow-deep metamorphic rock series is exposed in the deposit, divided into three layers from top to bottom: eyeball-shaped migmatite, mica quartz schist, and banded migmatite. The mineralized zone occurs within the mica quartz schist zone, with a gold abundance value of 35.86×10-9. Amphibolite, diopside veins and small pegmatite veins are recognized within or near the deposit. High greenschist- to amphibolite- facies metamorphism with sillimanite- and cordierite-bearing mineral assemblages dominates in the shear zone. Metal minerals include natural gold, pyrite, auriferous bismuth, bismuth antimony, chalcopyrite, pyrrhotite, ilmenite, sphalerite and galena. The gangue minerals are primarily quartz, biotite, muscovite, apatite, zircon and chlorite.

Two phases of apatite were identified in the host rocks and ores. The early apatite (Ap1) was found in muscovite quartz schist, while the late apatite (Ap2) is associated with biotite, coexisting with ilmenite and Au. We conducted a study on the major, rare earth element (REE), and U-Pb age of these two phases of apatite. Two phases of apatite have high F/Cl ratios and exhibit an M-shaped REE chondrite normalized pattern. Ap1 contains approximately 8593.41~24198.49 ppm REE with an average of 13056.84 ppm, and marked negative Eu anomalies with δEu being 0.39~0.61 (averagely 0.47), REE is relatively concentrated; Ap2 contains about 2719.20~11182.49 ppm REE with an average of 6949.27 ppm, and marked negative Eu anomalies withδEu being 0.35~0.85 (averagely 0.65), REE is relatively dispersed. The Ap1 yielded Discordia U-Pb ages of 235.80±4.5Ma (MSWD=1.3, n=106); the Ap2 and ilmenite associated with Ap2 yielded Discordia U-Pb ages of 209.40±2.6Ma (MSWD=1.2, n=68) and 219±32Ma (MSWD =1.2, n=48), respectively. Collectively, the age data suggest that the Dongkeng gold deposit may have formed from two mineralization events during the Triassic, with second event being the dominant one.

Keyword

Dongkeng, Orogenic gold deposit, apatite

Study on the Geochronology and Geochemistry of concealed granite in Tongmukeng Tin deposit in Yunshan, Jiangxi province

MENGQI JIN[1]*, University of Science and Technology of China (jmq9097@163.com)

Abstract

1. Introduction

The Tongmukeng deposit is located 30 km away in the northwest direction of Yongxiu county, near a small rock protrusion at the north-northeastern edge of the Yunshan granite. Based on detailed field geological investigations, combined with previous research results, this article explores the genesis and material source of the concealed granite of the Tongmukeng tin deposit through comprehensive research on the geochemical characteristics of the granite, zircon U-Pb dating, cassiterite U-Pb dating, and zircon Lu-Hf isotopes.

2. U-Pb Geochronology

Zircon U-Pb geochronology test results show that the weighted average age of zircon in the coarse-grained granite is 130.9 ± 1.3 Ma (MSWD = 0.48, 2σ, n=12), and the concordant age is 131.2 ± 1.6 Ma (MSWD = 0.47, 2σ, n = 12), which are consistent within the error range. The weighted average age of zircon in the fine-grained granite is 129.8 ± 3.1 Ma (MSWD = 2.7, 2σ, n = 9), and the concordant age is 128.6 ± 2.4 Ma (MSWD = 1.05, 2σ, n=9), which are also consistent within the error range. In both types of granite, zircon exhibits oscillatory zoning, and the Th/U ratio varies between 0.04 and 0.12, which is a typical igneous crystallization zircon. Therefore, combined with the results of other geochemical studies in the study area, it is believed that the concealed granite pluton was formed in the Late Yanshanian period, with the age of 128-131 Ma, which is consistent with the ore-forming age of the third stage of the Yanshanian metallogenic activity proposed by Hua et al. (2005) in the southern China, and it was formed in the tectonic environment of large-scale post-arc extension in the early Cretaceous.

Cassiterite U-Pb dating data show that the weighted average age of cassiterite is 131.4 ± 3.2 Ma (MSWD = 0.33, 2σ, n=12), and the concordant age is 132.7 ± 5.1 Ma (MSWD = 0.36, 2σ, n=12). It indicates that the tin mineralization age of the Tongmukeng mining area is 131-132 Ma, which is consistent with the concealed granite pluton-forming age in the area.

3. Whole rock geochemistry

The whole rock geochemistry of Tongmukeng granite shows a high SiO2 content and belongs to high-potassium calc-alkaline peraluminous granite. In the chondrite-normalized rare earth element diagram, Tongmukeng granite exhibits a right-dipping pattern, enriched in light rare earth elements and depleted in heavy rare earth elements. In this study, zircon samples that have undergone U-Pb isotope analysis were also analyzed for Lu-Hf isotopes in adjacent positions. The results show that the εHf (t) values of coarse-grained granite zircons range from -5.9 to -4.1, with an average of -4.95, and the two-stage Hf isotope model ages (TDM2) range from 1439 to 1554 Ma. The εHf(t) values of fine-grained granite zircons range from -8.0 to -4.0, with an average of -

5.03, and the TDM2 range from 1432 to 1687 Ma. It is considered that the source of the Tongmukeng granite is likely derived from the metamorphic sedimentary rocks of the Shuangqiaoshan Group.

Keyword

Tin deposit, Geochemistry, Geochronology, Tongmukeng

Deposit-scale controls of disseminated-type orogenic gold mineralization in high-grade metamorphic turbidites from the Damara belt, Namibia.

Josia Tulongeni Shilunga[1]*, Stellenbosch University (josiashilunga@gmail.com)
Alexander Kisters[2], Stellenbosch University

Abstract

The recently discovered Twin Hills deposit is a new resource in the Neoproterozoic Pan-African Damara Belt of central Namibia described by a finely dispersed, low-grade and high tonnage disseminated and vein-style gold mineralization. The deposit comprises distinct clusters of economic-grade gold mineralization, measuring several hundred meters along strike, separated by several kilometer-long intervals of only sporadic and sub-economic gold grades. The underlying assumption of the 3D implicit modelling followed in this study is that the integration of gold grades and ore shells with structural and lithological data from oriented core logging reflects the underlying controls of hydrothermal fluid flow and mineralization at Twin Hills. Thus, this study aims to contextualize the controls of mineralization on a deposit-scale and discriminate factors that distinguish zones of economic-grade mineralization from intervening sub-economic domains that may guide exploration. Mineralization is developed on the subvertical southern limb of a regional-scale syncline hosted in highly-strained compositionally heterogeneous, amphibolite facies metaturbidites. Additionally, the stretch of the main mineralization in the central parts of the ~12 km long east-northeast-trending mineralized Twin Hills corridor coincides with the change of the fold vergence direction. Individual higher-grade clusters are controlled by the combination and interplay of two main factors, namely lithological contacts and subtle deflections of bedding of the highly-strained, subvertical metaturbidites. The ENE-trending mineralized corridor of the Twin Hills deposit is largely confined to imbricated and/or tightly folded packages of interbedded psammites-pelites within the otherwise pelite-dominated sequence. It is these units that promoted fracturing, fluid flow and the development of fine-scale vein networks as a result of pronounced strain partitioning between schist units (ductile) and interbedded psammites (brittle) during regional deformation (flexural-slip folding). High grade ore shoots (>1.5 g/t Au) follow these main lithological contacts, but are laterally confined to subtle (5-15°) clockwise deflections of bedding (dilational jogs) from its regional ENE trends. Outside these deflections, gold mineralization is sporadic and only sub-economic. The structural and lithological controls of the mineralization at Twin Hills closely resemble those of orogenic gold deposits, but the fine-grained and dispersed textures of gold and associated sulfide mineralization are more reminiscent of those found in disseminated gold deposits. We suggest that the Twin Hills deposit is an example of a hypozonal orogenic gold deposit formed under peak metamorphic amphibolite conditions.

Keyword

orogenic, disseminated, Damara belt, 3D modelling

Geochronological and sulfide geochemical evidence for gold mineralization related to post-collisional magmatism in the Wulonggou goldfield of the East Kunlun Orogen, northern Tibet

Qilin WANG[1]*, School of Earth Resources, China University of Geosciences
(1499361670@qq.com)
Jinyang ZHANG[2], School of Earth Resources, China University of Geosciences

Abstract

The relationships among magmatism, orogeny, and gold mineralization in lode gold deposits have been controversial for a long time. The East Kunlun Orogen in northern Tibet has experienced a complex Paleo-Tethyan tectono-magmatic evolution and hosts the largest Wulonggou lode gold deposits (>110 t). The Shuizhadonggou-Huanglonggou (SZDG-HLG) gold deposit is the largest in the Wulonggou goldfield and is an excellent candidate for solving the controversy through detailed field observations, magmatic and hydrothermal mineral in-situ U-Pb dating, and gold-bearing sulfide in-situ trace elements and sulfur-lead isotopes. Gold mineralization in the SZDG-HLG deposit includes sulfide disseminations and minor amounts of small quartz-sulfide veins in hydrothermal alteration assemblages along a ductile shear zone. Gold mineralization can be divided into four stages based on crosscutting relationships and associated alteration assemblages. U-Pb ages from magmatic zircon, hydrothermal rutile, and hydrothermal monazite support field relationships that gold mineralization was later than the ductile deformation but synchronous with the post-collisional porphyries. Gold mineralization evolved from high to low temperatures (560 ℃ to less than 300 ℃), accompanied by markedly decreased sulfur fugacities (-6.3 to -12.5) and oxygen fugacities (-20.7 to -40.5). The gradual increase of sulfur isotopes (δ34S) from stage 1 (-0.9 to 1.8‰ in Py1a) to stage 3 (up to 8‰) is ascribed to sulfide precipitation from a finite fluid reservoir, while the sharp decrease of δ34S ratios in stage 4 (down to -24‰) is caused by the fluid oxidation. The negative covariations of δ34S and Se/S ratios, positive correlations between Au and chalcophile elements (As, Sb, Te, and Bi) in most sulfides, and overlapping lead isotopes of sulfides and Late Triassic granodiorite-diorite confirm a post-collisional magmatic gold and sulfur source. This study demonstrates that lode gold deposits in Phanerozoic orogens having similar characteristics to their counterparts in Archean metamorphic terranes can be genetically related to post-collisional magmatism.

Keyword

Lode gold deposits, Geochronological, Post-collisional, Wulonggou, Kunlun Orogen

Fluid Inclusion Characterization of the Quartz Vein in Mineralized Banded Iron Formation of Hiriyur Formation, Dharwar Craton

MANJU SATI[1]*, DEPARTMENT OF EARTH SCIENCES, IIT ROORKEE (msati@es.iitr.ac.in)
RAJAGOPAL KRISHNAMURTHI[2], DEPARTMENT OF EARTH SCIENCES, IIT ROORKEE
SAKTHI SARVANAN CHINNASAMY[3], DEPARTMENT OF EARTH SCIENCES, IIT MUMBAI

Abstract

Altered metabasalt and quartz veins in BIF are the hosts for gold mineralization at Paramanahalli in the Chitradurga Greenstone Belt of Western Dharwar Craton, Peninsular India. In this work, the information on the composition, origin, and implications of the fluids responsible for mineralization in the area has been addressed with the help of fluid inclusion studies. Fluid inclusion petrography, micro thermometry, and Raman spectroscopy were performed on mineralized quartz veins in BIF. Three primary inclusions are significant: Type Ia-aqueous inclusions, Type Ib-carbonic monophase inclusions, and Type Ic-aqueous carbonic inclusions. Type- Ia and Ib are more abundant and are commonly found to coexist in veins. The micro-thermometric analyses of different inclusions indicate homogenization temperature (Th) ranges from 220˚C to 362˚C. The calculated salinity values (wt% NaCl eq.) vary from 1.07 to 18.10.This temperture has been confirmned by Chlorite thermometry (260-372˚C). The abundance of CO2 and CO2-H2O inclusions indicates the metamorphic derivation of mineralizing fluids. The fluid has low-moderate salinity, a medium-high temperature of Th, and low density similar to other orogenic lodes gold deposits reported elsewhere in the world. The Th-salinity plot of inclusions confirms this during our study. The results indicate a complex geological past, including metamorphism and syn-post hydrothermal alterations.

Keyword

Fluid inclusions, Chlorite thermometry, Hydrothermal alteration, Metamorphic fluid, Gold mineralization

UNLOCKING HIDDEN RICHES: NEW METHODS FOR REPURPOSING MINING WASTE IN UZBEKISTAN

Shukhrat Rayimovich SHUKUROV[1]*, Institute of Geology and Geophysics named after Kh.M. Abdullaev (shuxrat2200@mail.ru)
Nosir SHUKUROV[2], Institute of Geology and Geophysics named after Kh.M. Abdullaev
Shohboz YOSHUZOKOV[3], Institute of Geology and Geophysics named after Kh.M. Abdullaev

Abstract

The Republic of Uzbekistan does have significant potential in the field of mining and production of non-ferrous, precious and rare elements, which are concentrated mainly in the Navoi and Almalyk mining regions. These resources extend beyond traditionally mined materials to "technogenic deposits" - waste materials from previous mining activities. This research focuses on repurposing these wastes, specifically from gold and gold-silver deposits managed by NMMC. A new methodology - "Landscape-Mineral-Geochemical System (LMGS)" was proposed. A large-scale geological and technological mapping of the watered area of dumps and off-balance ores of NMMC and AMMC were carried out according to this methodology. Were taken 272 samples, which were investigated by geochemical and mineralogical methods. The results uncover promising opportunities. The wastes contain abundant sulfide minerals (pyrite, arsenopyrite) undergoing active oxidation, generating various new minerals (goethite, hydrogetite, sulfites, etc.). Furthermore, the wastes harbor valuable chalcophilic elements (Cu, Zn, Pb, Sb, As, Bi, Se, Hg, Sn, W) in trace amounts within primary and secondary minerals like cuprite, zincite, scorodite, and lankarite. Additionally, elements like Ni, Co, Cu, Zn, and As are embedded within pyrite, arsenopyrite, and other sulfides. This research demonstrates the potential to extract valuable resources from mining waste, promoting sustainability and responsible resource management in Uzbekistan's mining sector.

Keyword

Mining, Technogenic, Waste, Geochemistry, Mineralogy

Synthesis of Kudremukh Iron Ore Mine Tailings based on Geopolymer Aggregates using Fly ash as Precursor in Construction Industry

Ramaraju H K[1]*, Visveswaraya Technological University (hkramaraju@gmail.com)

Abstract

The increasing trend of solid waste generation has made its ecological disposal an important issue due to concerns about its hazardous social and environmental impact. One of the methods to minimize these issues is recycling of industry wastes. The construction industry has a great potential to absorb various industrial residues provided the recycled materials are properly characterized before its application as a construction material. Iron is the world's most commonly used metal—steel, in which iron ore is the raw material, represents almost 95% of all metals used annually. A huge resource of 25.24 billion tons of Iron ore is blessed to India. India produces colossal volumes of Iron ore mine waste of around 130 million tons every year and the same are dumped at adjacent mining destinations. In state of Karnataka, India, Kudremukh Iron Ore Company Limited (KIOCL) had operated the most sophisticated mechanized Magnetite iron ore mine to produce 22.5 million tons of Run of Mine (ROM) per annum with the state of the art beneficiation technology to produce 7.5 million tons of concentrate. Mine being low grade ore in nature and nearly 12 million tons of Iron Ore Tailing (IOT) were generated annually during the process of beneficiation and stopped its operations at the end of 2005. During the process of beneficiation, about 200 million tons of Iron ore mine tailings were deposited in Lakya dam which spreads about 2 square kilometers with a depth of 85-90 meters. The present research includes characterization of raw materials for physical, chemical and mineralogical properties. Trial and error method was used to fix fly ash to iron ore tailing ratio. Totally 4 different ratios were considered with fly ash to iron ore tailing ratios as 80:20, 70:30, 60:40 and 50:50. Binding materials such as Sodium hydroxide (NaoH) and Sodium silicate (Na2SiO3) were being considered in manufacture of coarse aggregates as an alternative to natural aggregates. Aggregate tests were conducted for the obtained Geopolymer aggregates and compared with the natural aggregates. Mechanical properties such as Compressive strength, flexural strength and split tensile strength of hardened concrete was determined. Finally, Non-Destructive testing (NDT) of hardened concrete was determined using Ultrasonic Pulse Velocity (UPV) test. Based on the experimental tests conducted on fresh and hardened concrete, the results recommend to use of mining tailing waste and Geopolymer as a raw material in the construction industry, as is the need of hour due to scarcity of raw materials.

Keyword

Iron Ore Tailings, Fly ash, Geopolymer aggregate, Mechanical properties, Non-Destructive test

[Keynote] Pyrophyllite as substitute raw material for future Industrial Development in India

ASIM AMITABH PRADHAN[1]*, FAKIR MOHAN UNIVERSITY (asimgeology@gmail.com)
MADHUMITA DAS[2], UTKAL UNIVERSITY, BHUBANESWAR
BISWANATH SAHOO[3], FAKIR MOHAN UNIVERSITY
ROSALIN DAS[4], FAKIR MOHAN UNIVERSITY

Abstract

Minerals are indispensable part of our life, and these natural resources are finite. Minerals are increasingly being extracted due to rapid growth of population and for our modern lifestyle. Minerals should be conserved by reducing wastage in the process of mining, recycling of metals using scrap metals, using alternative renewable substitutes and by adoption of improved technologies to use the low-grade ores at low costs. Pyrophyllite, an industrial mineral, can be used as a substitute for kaolinite mineral group in many industrial applications, such as in the ceramic, and pottery, and filler industries, because kaolinite mineral group are rapidly depleting.

Pyrophyllite ($Al_2Si_4O_{10}(OH)_2$) is characterized by various chemical, physical, and thermal properties that make it suitable for several industrial applications. It is a phyllosilicate often associated with quartz, mica, kaolinite, epidote, and rutile minerals. In its pure state, pyrophyllite exhibits unique properties such as low thermal and electrical conductivity, high refractive behaviour, low expansion coefficient, chemical inertness, and high resistance to corrosion by molten metals and gases. Pyrophyllite is a chemically inert hydrous aluminosilicate $Al_2O_3 \cdot 4SiO_2 \cdot H_2O$ [$Al_2Si_4O_{10}(OH)_2$], composed of 67% SiO_2, 28% Al_2O_3 and 5% H_2O. It is an early stage metamorphic mineral. Pyrophyllite is largely an overlooked raw material available in huge quantities in nature. This is mainly due to the fact that other comparable aluminosilicate raw materials like china clay are available in much purer form. Pyrophyllite occurrences are mainly in Chhatarpur, Tikamgarh and Shivpuri districts of Madhya Pradesh, Mahoba and Lalitpur districts of Uttar Pradesh and Keonjhar district of Odisha. The total reserve of pyrophyllite in India is 59.61 million tonnes.

The uses of pyrophyllite in industry include its application as a refractory material in the refractory industry and as a raw material in the ceramic, fiberglass, and cosmetic industries. Moreover, pyrophyllite is used as filler in the paper, plastic, paint, and pharmaceutical industries, as a soil conditioner in fertilizer applications and as a dusting agent in the rubber & asphalt industries.

To increase its market value, pyrophyllite must have high alumina (Al_2O_3) content, without impurities, and possess as much whiteness as possible. This paper deals with industrial applications of pyrophyllite and the specifications required for its use in industry as a substitute to minerals like kaolinite, talc, and feldspar. It also presents the most effective and economical techniques for enriching low-grade pyrophyllite ores to make them suitable for various industrial applications.

Keyword

pyrophyllite, specification, enrichment of low grade

Assessing the Impacts of Coal Mining on water quality in the Talcher Region, Angul District, Orissa, India

ARUN KUMAR NAIK[1]*, FAKIR MOHAN UNIVERSITY,BALASORE
(naik.arunkumar70@gmail.com)
ASIM AMITABH PRADHAN[2], FAKIR MOHAN UNIVERSITY,BALASORE
MADHUMITA DAS[3], UTKAL UNIVERSITY, BHUBANESWAR
SUSANTA KUMAR DAS[4], FAKIR MOHAN UNIVERSITY,BALASORE

Abstract

Coal is an essential energy source that plays a critical role in thermal power plant for electricity generation and supporting various industrial operations. Coal mining operations involve the release of pollutants into nearby water bodies through erosion, leaching, and runoff. These pollutants include heavy metals, such as mercury, lead, and arsenic, which can severely degrade water quality. Talcher is known for its thriving coal mining industry, has experienced remarkable growth and progress in recent years. This abstract provides a thorough examination of the effects of coal mining on water quality of the study area. The contamination of groundwater sources in Talcher not only jeopardizes drinking water supplies for local communities but also exacerbates the degradation of aquatic ecosystems and agricultural productivity. The water in the Talcher coalfield area is severely polluted, containing excessive amounts of harmful contaminants like Cd, As, Ni, Pb, and Hg that surpass the acceptable limits for drinking water. Mine effluent discharge has a significant impact on the water quality, resulting in increased pollution levels in downstream areas. 28 samples were collected from different locations of Talcher area and nine parameters viz. Cl-, F-, pH, Ca, Mg, SO4-, NO3-, Alkalinity and Hardness, have been considered to determine the water quality index (WQI). The American Public Health Association has established standards for the sampling of groundwater (APHA, 2005). The Bureau of Indian Standard (BIS, 2012) was used for assessing the potability of groundwater and establishing the Water Quality Index (WQI). The fluoride concentration in the water samples is >57% which exceeds the permissible limit. There is a prevalent issue in this region where individuals are experiencing skeletal fluorosis and dental fluorosis. The research indicates that the water requires appropriate treatment prior to its utilization for drinking, household purposes, or release into the environment. In order to achieve a harmonious and enduring water quality, it is imperative for the region to enhance its treatment facilities and embrace environmentally friendly mining practices. Additional investigation into groundwater quality and the surrounding regions is necessary to enhance water resource management.

Keyword

FLUORIDE CONTAMINATION, Water quality index, COAL MINING, Talcher

Ultrasonic Leaching: A Green Leaching Technology of Clay-Type Lithium Resources in Salt Lakes

KAISHENG XIA[1]*, China University of Geosciences (xks_mail@126.com)
CHENGKAI LIU[2], China University of Geosciences
YI MENG[3], China University of Geosciences
ZHEN YANG[4], China University of Geosciences
CHENGLIN LIU[5], China University of Geosciences

Abstract

With the rapid development of the new energy car industry, lithium as an energy metal is increasingly important in recent years. Currently, the lithium carbonate used in industry mainly come from brine lithium and pegmatite lithium. Clay-type lithium as an new lithium resource widely distributed in unconsolidated mud sediments of modern salt lakes with level of 100*X ppm has not been developed and utilized on a large scaleTherefore, its development and utilization maybe alleviate the pressure on the supply shortage of current lithium resources. However, there are some problems in the current development and utilization for clay-type lithium resources in salt lakes, such as excessive acidity of the leaching solution and leaching residue, and environmental pollution etc. In order to overcome these problems, this study proposes a green leaching technology of clay-type lithium of some salt lakes in northwestern China. In this work, X-ray fluorescence spectroscopy, powder crystal X-ray diffraction, scanning electron microscopy and other analytical techniques were used to figure out main chemical composition, mineral composition, microscopic morphological of clay-type lithium resources. The results show that lithium mainly exist in kaolinite and montmorillonite as absorption occurrence. We have explored the optimal parameters of ultrasonic water immersion process, the experimental results showed that the leaching rate can reach to 64.34% when the leaching solvent temperature reaching 40℃, the leaching time is 2 hours, and the ratio of clay ore and pure water solid-liquid is 1:10. There is no significantly change of mineral composition after ultrasonic water immersion process. This green and economical leaching technology without roasting and acid leaching process shows great application prospects in the development and utilization for clay-type lithium resources.

Keyword

Clay-type lithium resources, Salt lake, Green-extraction, Ultrasonic leaching

The Role of Pyrophyllite in Advanced Materials: A Critical Review of Current Trends

BISWANATH SAHOO[1]*, FAKIR MOHAN UNIVERSITY (biswanathsahoo164@gmail.com)
ASIM AMITABH PRADHAN[2], FAKIR MOHAN UNIVERSITY

Abstract

Pyrophyllite, the naturally occurring aluminosilicate mineral has emerged as a noteworthy constituent in the realm of advanced materials, shaping current trends in the field of geology. This abstract provides a comprehensive overview of the role of pyrophyllite in advanced materials, encapsulating the current state of research, applications, and prospects. The lamellar structure of pyrophyllite, characterized by its aluminium-rich composition, used for various advanced materials. Its utilization spans diverse fields, from ceramics to polymers, composites, and environmental applications, and in the field of ceramics, pyrophyllite plays a pivotal role as an additive, influencing sintering behaviours, mechanicalstrength, and thermal conductivity. Pyrophyllite's incorporation into polymer composites has garnered attention for its ability to improve mechanical properties, thermal stability, and flame retardancy. The collaboration of pyrophyllite and polymers gives rise to materials endowed with improved properties, expanding their utility across diverse industries, including aerospace, automotive, and construction. The adsorption capabilities of pyrophyllite have been harnessed in future environmental remediation and water purification technologies and due to its high surface area and distinctive surface chemistry, pyrophyllite effectively adsorbs various pollutants, providing a sustainable solution for addressing environmental challenges. Integration of pyrophyllite into nanocomposites will offer opportunities for applications in electronics, energy storage devices, catalysis, and energy storage devices, such as batteries and capacitors, underscores its role in the pursuit of sustainable energy solutions. The current investigation is on the electrochemical properties of pyrophyllite-based materials to enhance energy storage capacity, cycling stability, and overall performance in next-generation energy storage systems. This work provides a panoramic view of the current trends in utilizing pyrophyllite in advanced materials. The ongoing research presented here emphasizes the dynamic role of pyrophyllite in shaping the landscape of advanced materials, providing insight into its potential impact on future technological advancements.

Keyword

Pyrophyllite, Thermal stability, Flame retardancy, Nanocomposites

Exploration of geothermal resources by using geophysical method in the north of Changbaishan Mountain

Yan Wu GUAN[1]*, Jinlin University (guanyw@jlu.edu.cn)
Xu Jin[2], Jilin University

Abstract

There are rich geothermal resources near Tianchi Volcano on Changbaishan Mountain. In the traditional concept, the direct expression of geothermal resources is geothermal water. It often exists in the fracture zone. Therefore, our work adopts gravity, magnetic method, and CSAMT methods to explore the research area in Songjianghe Town, Jilin Province, China. Several apparent resistivity models have been built based on optimization inversion technology using 4 CSAMT profiles. We can focus on the low resistivity zones, which is may full of water. Main faults can been infered based on edge detection (such as vertical second derivative, Euler deconvolution, etc. which can be processed with Geosoft's Oasis Montaj) using of gravity and magnetic anomaly data. Based on all the information (low resistivity zones, fracture zones and geological structure characteristics), we can infer a more likely location for the existence of geothermal water and design two 2500m deep drilling holes. The actual drilling results confirmed the accuracy of the speculation and obtained a geothermal water resource of 75℃ at 2000m deep hole. A geothermal structure concept model can been built based on the electrical structure, main faults and regional geological structure. The heat source is deep magma chamber from Changbaishan Tianchi volcano. The geothermal aisles are high-angle Water-bearing fault zones. Water is the best medium for heat storage. Quaternary strata such as shallow volcanic ash are the best caps which Stop heat loss.

Keyword

hot water, Changbaishan Mountain, gravity and magnetic mothed, CSAMT mothed, geothermal structure concept model

Hydrocarbon prospect in parts of the Nagapattinam sub-basin in the Cauvery Basin, deciphered from the biostratigraphy and source rock characterisation

Ashish SARKAR[1]*, Retired as Associate Professor from the Pandit Deendayal Petroleum University, Gandhinagar, India (ashish29s@yahoo.co.in)

Abstract

Among the category I petroliferous basins of India, Cauvery basin with nearly 25,000 sq. km on-shore and 30,000 sq km off-shore is a significant producing basin between 8°30' – 12°12' N; 78°30' – 80°30' E, where exploration began in 1964 by ONGC, and still witnesses the exploration activity in it. This basin involves a depression (Cauvery – Srilanka), consisting of horst and graben morphology with nine major tectonic elements having multiple sub-basins. Sedimentary fill in the basin is more than 6,000 m thick ranging between Permian – Recent, which overlies PreCambrian granites and Syenites. Cauvery basin developed during the break-up of Gondwana Land and underwent four phases of deformation, (i) Late Jurassic / Early Cretaceous syn-rift extension, (ii) Late Cretaceous late rift / early drift stage cooling contraction, (iii) Late Cretaceous – Paleogene drift stage strike slip reactivation, and (iv) Neogene passive margin subsidence.

The basin witnessed multiple transgressive and regressive events as is evident from the presence of five major unconformities. The oils, so far produced from the basin, are of paraffinic – naphthenic composition; light to very light (API gravity 41° – 49°) with 5.4% wax and 0.48% asphaltenes; more heavier (28° API) and lighter (56° API) oils are also present. Oil and gas have been generated from localized source rocks at different maturity (0.7 to 1.15% VRo). Isotopic signatures show, oils in various sub-basins are genetically different. In order to look for a new prospect in the basin, a hole was drilled in the Nagapattinum sub-basin. An account of the systematic study is presented in the present paper.

60 core samples, and 55 cutting samples have been studied between 6 and 3996.5 m drilled interval, which have yielded 28 species of benthic foraminifera, 20 species of planktonic foraminifera, and 12 species of ostracodes. Based on the fossil assemblages at different levels along with the FAD and LAD, biostratigraphy at the drilling location was established. While Andimadam Formation and Sattapadi Shale are the oldest in the studied sequence and belong to the pre Upper Cretaceous age, overlying Bhuvanagiri Formation to the youngest Tittacheri Formation range in age from Upper Cretaceous to Late Miocene, depicting the depositional environment from deltaic to outer neritic.

Source rock characterisation using rock-eval pyrolysis was attempted in the Sattapadi Shale and Andimadam Formation in the drilled hole to know the hydrocarbon prospect in the area. About 628 m thick Cretaceous sequence in the interval of 3231 – 3858 m, has fair to good amount of organic matter (TOC 0.62 – 1.33%, average being 0.9%), lower hydrogen index (HI 52 to 80 mg

HC/g TOC and oxygen index (OI) ranges between 46 and 133 mg HC/g TOC. The data suggests presence of type IV kerogen, and hence a poor hydrocarbon prospect in the area is interpreted based on source rock evaluation from Andimadam Formation and Sattapadi Shale.

Keyword

Petroliferous Basin, Sub-Basin, Biostratigraphy, Rock-eval pyrolysis, Hydrocarbon prospect

Geological and technogenic support of the combined exploitation and preservation of the environment during the development of ore deposits.

Marat BITIMBAYEV[1]*, National Engineering Academy of Republic of Kazakhstan
(mbitimbayev@mail.ru)
Mirgali Kunayev[2], Caspian Service Inc. JSC
Amanat Konakbayev[3], SSM-Oil

Abstract

A fundamental aspect in successful development of civilization is the production of marketable product from minerals contained in the bowels of the Earth.

Obtaining minerals both today and in the foreseeable future is a necessity, which in terms of its volumes and nomenclature is growing at a much faster pace than population growth.

These two factors, despite their lack of alternatives, face problems as a result of their impact on natural systems, which must be eliminated.

First of all, we are talking about the rapid depletion of mineral resources, primarily metals in the bowels, expected within 30-150 years, as of 2050 according to proven statistics, in the continental part of earth's crust. Secondly, natural ecosystems that provide conditions for the existence of living matter are degraded and irreversibly destroyed as a result of the development of mining industry.

Paradoxically, good aspirations of human society to improve the quality of life are being fulfilled paired with destruction of natural balance of the environment in which comfortable conditions have been created by nature for man and the world around him.

From the emerging negative situation the goal of our work was determined: creation of an industry in which interaction of natural geological environment and technogenic systems for the extraction of metals, would make it possible to meet the needs of humanity on a historical time scale without irreversible anthropogenic destruction of natural environment.

The goal can be achieved by analysis based on a systems approach, exploring artificial systems (arising with the participation of man) for the extraction and processing of ore and designing these systems with a positive impact on the results of changes in the geological environment.

Simultaneously, an analysis was made of all possible sources of metal production, which could not only be natural primary georesources, but also secondary ones created by man.

The development of the subsoil and its preservation should be solved by creating a new objective reality in the combined application of the discovered specific essential and natural geological patterns of ore formation and previously unidentified properties of man-made systems used for ore extraction and processing.

As a result, all existing and operating sources of metal production from primary and secondary georesources were identified, technological solutions and schemes were created for their practical application both in geological environment in new mining frontiers and on the surface from artificially created dumps, all in the format of circular economy.

The output of our work lead to conclusion that the research performed is the basis for a full-scale supply of metals to humanity in the mode of resource production, resource conservation and the preservation of quality of natural environment in all its aspects.
The result of theoretical basis of the created socially organized system should be practical provision of metals to humanity for an immeasurably long time in the format of cost-effective, technologically feasible and safe production, for humans and the environment. In the presented report, we propose real technological solutions to fulfill this format.

Keyword

Development of mineral resources, preservation of mineral resources, exhaustion of resources, destruction of ecosystems, patterns of ore formation

Push and Pull factors as predictors of entrepreneurial dynamics in artisanal and small-scale mining: a case study on industrial mineral exploitation in South Africa

Ndivhudzannyi n Rembuluwani[1]*, university of venda
(Ndivhudzannyi.rembuluwani@univen.ac.za)
makia Lawrence Diko[2], university of venda

Abstract

Artisanal and Small-Scale Mining (ASM) entrepreneurship plays a pivotal role in the global mining sector, contributing significantly to employment and local economies. This study explores the push and pull factors influencing ASM entrepreneurship dynamics in the industrial minerals sector in South Africa. Push factors include poverty, limited employment opportunities, job security, economic instability, and mineral rush. Conversely, pull factors comprise the allure of potential financial gains, cultural ties to mining traditions, personal development, achievement, entrepreneurial drive, and the desire for autonomy. While there is a consensus on the benefits of pull, over push factors, the extent to which this assertion holds true for the South African case study, remains elusive. To contribute towards this on-going debate, the current study investigates (i) the extent to which Push-Pull factors influence the typology of ASM in the industrial mineral sector (seasonal, permanent, Rush-type and Shock-push ASM), and (ii) the challenges and opportunities. The study employed a mixed-method approach, combining qualitative and quantitative surveys with administration of closed and open-ended questionnaires (n=200), The initial findings suggest a predominance of Shock-push ASM (70%) over Rush-type ASM (20%). This observation is due in part to preference of commodity (industrial mineral versus metallic minerals) and the associated level of risks. The major constraint is associated with formalization of the ASM initiative and access to support systems (human and financial resources for capacity development and value creation). These preliminary findings offer valuable insights for policymakers, development practitioners, and community leaders seeking to formulate sustainable strategies that balance economic growth with environmental and social considerations in the ASM sector.

Keyword

push and pull factors, artisanal small-scale mining, entrepreneurship

[Keynote] Geo-Resources in Sustainable Development

AFIA AKHTAR[1]*, AGID/GSB (afia@agni.com)

Abstract

Development and sustainable development are the most concerned terms widely discussed nowadays in the modern society and how to achieve these. But the problems like energy crisis, mineral & groundwater shortage; un-wise urbanization & industrialization, hazardous adverse impact, climate change, soil infertility, air-water-land pollution and consequently the imbalanced environmental ecosystem are major obstacles in achieving sustainability. To overcome these obstacles, proper application of geoscience knowledge along with the knowledge of multidisciplinary sciences is needed. The achievement of sustainable development largely depends on how much rich the country in her geo-resources, especially the hidden mineral resources and its capability to explore and exploit that resource for developing mineral based industries.

Geo-resources mineral-water-soil is the most vital commodities for developing industrialization, urbanization, and as a whole the civilization. These resources including fossil fuel which is a vehicle for rapid economic growth come from earth's components- atmosphere, lithosphere, hydrosphere and biosphere, the major four elements of earth system science. But any change or interaction in earth's components causes geo-hazards which have severe adverse impact on development and may even ruin the entire civilization.

Geoscience is an intuitive and day-to-day changing science. Therefore, in achieving sustainable development, regular updates and extensive research experiences are to be needed for understanding this science properly. So, for application of geoscience knowledge in development activities geoscientists must have to have good concept on earth, its components and to find out its hidden mineral resources, to utilize that resources in industrial development and to handle efficiently the negative impact of geo-hazards. Misuse of geo-resources, air-water-soil pollution, abuse of landscape, improper waste disposal, deforestation that enhance wildlife destruction and consequently the climatic change are the major causes for environmental deterioration and it is primarily due to lack of geoscience knowledge. By acquiring basic knowledge, even common people can contribute to nation-building development activities which will lead to sustainable development. But to get mass participation, people of a society must be aware about geo-resources and how it contributes in upgrading the living standard by achieving sustainable development. They also must be aware about how misuse & mismanagement of geo-resources and mishandling geo-hazardous adverse effect can deteriorate the environmental ecosystem which retards national economic growth with negative impact in achieving sustainable development.

My paper will illustrate the ways how to achieve sustainable development by proper utilization of geo-resources and also by avoiding misusing the resources as well as mishandling the adverse

impact of geo-hazards which causes huge destruction of properties and life. Good concept of geoscience knowledge and its right application in right time can help to deal with all of these in getting healthy development which will lead to reform the national economic infrastructure and then it will accelerate the high living standards of society, a sign of a sustainable development.

Keyword

Geo-resources, Geo-Hazards, Earth’s Components, Living Standards, Sustainable Development

Integrated and Multidisciplinary geoscientific mapping of the Limpopo Greenstone Belts, South Africa

Ndivhuwo Cecilia Cecilia Mukosi[1]*, Council for Geoscience (cmukosi@geoscience.org.za)
Tshilidzi Radzuma[2], Council for Geoscience
Jabulani Mathebula [3], Council for Geoscience
Taufeeq Dhansay[4], Council for Geoscience
David Ngobeni[5], Council for Geoscience
Mehdi Bensid[6], Council for Geoscience
Kefyalew Tegegn[7], Council for Geoscience
Lerato Mashiloane[8], Council for Geoscience
Godfrey Madzivire[9], Council for Geoscience
Sakia Lekoadu[10], Council for Geoscience
Tshinanne Ramukumba[11], Council for Geoscience
Khuthadzo Masindi[12], Council for Geoscience
Pamela Nolakana[13], Council for Geoscience
Phuti Masegela[14], Council for Geoscience
Gladness Mohale[15], Council for Geoscience
Melvin Sethobya[16], Council for Geoscience
Tshepo Motlakeng[17], Council for Geoscience
Zusakhe Nxantsiya[18], Council for Geoscience
Meso Ntsuku[19], Council for Geoscience

Abstract

In 2018, the Council for Geoscience embarked on an integrated and multidisciplinary geoscientific research in the Limpopo Province, South Africa, focusing on the Giyani Greenstone Belt (GGB) and surrounding areas. The objectives of the project were to support economic growth, address water security and promote environmental stewardship through an integrated approach that covers tasks across multi geoscience disciplines (i.e. detail geological mapping on a scale of 1:50 000, use of soil geochemistry datasets to assess the mineral potential, geophysical survey targeting deep crustal rocks to compensate for the poor outcrop in the area, geotechnical, groundwater and environmental studies to address socio challenges). Geologically, the GGB is situated along the boundary between the Kaapvaal Craton and the Southern Marginal Zone of the Limpopo Metamorphic Belt and comprises largely tonalite-trondhjemite-granodiorite rocks, metavolcanic and metasedimentary rocks, and various Archaean-Paleoproterozoic age granites. Integration of geological, soil geochemical and radiometric datasets delineated previously unmapped sequences in the region. These include delineation of mafic and ultramafic rocks of the GGB, as well as delineation of more evolved felsic rocks (i.e. Shamiriri Grantie body and syenite body in the surrounding area). Six 1:50 000 geological maps covering the entire GGB, and the surroundings were produced. A Magnetotelluric (MT) survey focusing on deep crustal features (>15km) was conducted in the central part of the GGB along a NW-SE oriented profile of about 30 km. This included the delineation of deep crustal shear zones and subsidiary structural zones. Integration of MT and geological datasets on deep geological structures confirmed that these subsurface

structures hold potential for structurally controlled gold mineralisation. This is corroborated by the results of the Induced Polarization geophysical surveys. Surface litho-samples in shear zone-hosted quartz lodes indicate that both the structural and lithological control are important. From a hydrological perspective the project area occurs in a semi-arid region with limited water sources. In order to address socio-economic challenges in the area, groundwater, environmental and geotechnical studies were conducted. These tasks were guided by stakeholder engagements which commenced in 2018. Hydrogeological results revealed that high-yielding groundwater occurrences are located along structural lineaments which control water flow. Groundwater analyses however, indicated high concentrations of arsenic close to historical mining areas, which present health risks to communities consuming groundwater in these areas. A geotechnical map of the region was produced and delineated areas suitable for urban and rural development. Environmental studies investigated the effects of historical and current mining activities in the region.

Keyword

Integrated mapping, Archaean, Geophyicaly survey, Groundwater, Geotechnical

Effects of foreign direct investment and Belt and Road Initiative on the mining industries in the ASEAN countries

JI WON MOON[1]*, U.S. Geological Survey (jmoon@usgs.gov)
Sean Y. Xun[2], U.S. Geological Survey
Steven D. Textoris[3], U.S. Geological Survey

Abstract

The annual gross domestic products (GDP) growth rate of Association of Southeast Asian Nations (ASEAN) countries between 2010 and 2017 was 5.5%, which was higher than the world average of 3.0%. Since the launch of China's Belt and Road Initiative (BRI) in 2013, Chinese foreign direct investment (FDI) to ASEAN region totaled $43 billion. In this study, economic factors to mining and quarrying sectors in ASEAN countries were considered before and after launch of BRI and the combined effect of FDI and BRI on the development in mining sector were evaluated. When compared the data from 2013-2017 with 2010-2012 after the global recession in 2009, average GDP growth rate increased in Philippines, Cambodia and Vietnam. During the same periods, the increasing rate of FDI to mining and quarrying sector were higher in Malaysia, Laos, and Burma. Chinese-sourced FDI also increased in Malaysia, Laos, and Vietnam. The GDP in mining and quarrying sector expanded faster in Laos, Cambodia, and Burma. Higher increase of cement consumption in Cambodia and Laos were likely due to extensive infrastructure projects that China supported, in terms of both hydro- and coal-power plants ($5.3 billion), Kunming-Vientiane railway ($7 billion), respectively. Coal production of Laos also increased by 2,600% to support power plant which was developed in cooperation with Thailand. The mining industry in Laos was an exemplary beneficiary derived from the integration of direct multi-sourced FDI to mining sectors and indirect facilitation by infrastructure projects through BRI.

Keyword

Association of Southeast Asian Nations (ASEAN), Mining Industry, Foreign Direct Investment (FDI), Belt and Road Initiative (BRI)

The distribution of platinum in ferromanganese crusts and nodules at different depth of the Suda Guyot, Western pacific

Yanhui DONG[1]*, Second Institute of Oceanography, MNR, China (dongyh@sio.org.cn)
Huan Zhang[2], Institut für Geologie, Centrum für Erdsystemforschung und Nachhaltigkeit, Universität Hamburg
Zhenggang Li[3], Second Institute of Oceanography, MNR, China
Jihao Zhu[4], Second Institute of Oceanography, MNR, China
Jie Li[5], State Key Laboratory of Isotope Geochemistry, Guangzhou Institute of Geochemistry, Chinese academic of science
Dengfeng Li[6], School of Marine Sciences, Sun Yat-sen University
Jinzhou Peng[7], School of Marine Sciences, Sun Yat-sen University
Huai li[8], Second Institute of Oceanography, MNR, China
Zhaocai Wu[9], Second Institute of Oceanography, MNR, China
Fengyou chu[10], Second Institute of Oceanography, MNR, China

Abstract

With the widespread adoption of hydrogen fuel cells, the demand for platinum, a key raw material, is expected to increase. Platinum is thought to be mainly adsorbed by iron and manganese oxide, and concentrated in cobalt-rich crusts and hydrogenetic nodules, which makes it of potential byproduct value. The control of water depth on ferromanganese crust and nodules composition has been reported for a long time, while the Pt contents variation of them with water depth is not well known, which is also the key to the understanding of the Pt enrichment mechanism.

In this study, ferromanganese nodules and crusts from the summit (~1400m) to the piedmont (~5400m) of the Suda Guyot in the western Pacific Ocean were collected and analyzed for Pt contents by LA-ICPMS and isotope dilution. Since only the top surfaces of nodules and crusts would be in chemical equilibrium with seawater, and their interior sections are more affected by the paleoenvironment, the top ~1mm layers of specimens were scraped for Pt isotope dilution analysis. The Pt contents of surface layers range from 0.1 to 0.3 ppm, which is irrelevant to water depth but consistent with the Pt distribution characteristics of the Western Pacific seawater. According to the LA-ICPMS mapping results of nodules, Pt mainly occurs in the Fe-Mn oxide phase, and particles with high Pt are rare. The samples of different water depths showed comparable Pt chemical stratigraphic characteristics, with the highest content in the inner layer (up to 2 ppm).

All the results obtained in this study clearly indicate water depth appears to have a limited effect on the Pt contents of nodules and crusts from seamounts, while the formation age is likely to be the most significant factor affecting their Pt contents. The larger the proportion of the old/interior layer in the crusts and nodules, the higher the Pt content of the bulk sample. Compared to the insoluble Ce (IV) and Co (III) oxidized by δ-MnO2, Pt (IV) was considered soluble, which makes the oxidation of Pt (II) to Pt (IV) might have minor attributes to the Pt enrichment in ferromanganese crust and nodules.

Keyword

Ferromanganese nodule, Co-rich crust, Platinum, Suda Guyot, Western Pacific

Microstratigraphic characterization of mineral diversity of hydrogenetic ferromanganese crusts in the Northwestern Pacific seamounts.

Akira USUI[1]*, MaCRI, Kochi University (a-usui@kochi-u.ac.jp)
Hikari Hino[2], Kochi University and JOGMEC

Abstract

We carried out acoustic bathymetry, on-site observations, and bottom sampling with dredge, ROV, submersible, as well as surface ships, and in-laboratory analyses of the structural growth patterns, chemical and mineral variations on the basis of microscopical and XRD analyses, dating with microfossils, radiochemical chemistry, paleomagnetism and basement rock data. Microstratigraphic characterization on small to regional scales suggested similar patters in various scales and water-depth dependency broadly among hyrdrogenetic ferromanganese crusts in the NW Pacific areas. The comprehensive joint studies indicated also characteristic temporal patterns of common growth patterns over the Pacific areas such as increasing supply of detrital silicate minerals in the younger layers and clear phosphatization vents in the older layers. These correlations were supported by the fairly constant continuous growth without any large breaks within the hydrogenetic ferromanganese crusts from the Cretaceous to Neogene environments, throughout the seamount areas. The microscopic correlations well indicate common growth history and common temporal variation patterns as well as similar and continuous resource potential of useful metal resources. We need further future collaboration programs in geochemical and mineralogical characterization of the ferromanganese deposits in the NW Pacific jointly with domestic and international organizations and among various fields of sciences and technology. This paper is a short summary of the recent progress in mostly geological sciences mostly based on microstratigraphic analyses and on-site field study.

Keyword

ferromanganese crust, Northwestern Pacific, seamount, manganese nodule

Seabed mining for a sustainable future

Fani SAKELLARIADOU[1]*, Dept of Maritime Studies, University of Piraeus, Piraeus, Greece & Dept of Mechanics and Maritime Sciences, Chalmers University of Technology, Gothenburg, Sweden (fsakelar@unipi.gr)
Francisco J. Gonzalez[2], Marine Geology Resources and Extreme Environments, Geological Survey of Spain, Madrid, Spain.
James R. Hein[3], Retired USGS, Soquel, CA, USA
Blanca Rincón-Tomás[4], Marine Geology Resources and Extreme Environments, Geological Survey of Spain, Madrid, Spain.
Nikolaos Arvanitidis[5], Dept of Mineral Resources, Geological Survey of Sweden, Uppsala, Sweden.
Thomas Kuhn[6], Federal Institute for Geosciences and Natural Resources, Hannover, Germany.

Abstract

A sustainable future requires a transition to a coherent, circular, and resource-efficient economy that combines technological, environmental, and social aspects and does not harm future generations. All available data indicate that we are on the verge of breaking the 1.5-degree Celsius threshold set out in the Paris Climate Agreement. Fossil fuels are by far the biggest cause of climate change, accounting for over 75% of global greenhouse gas emissions and almost 90% of carbon dioxide emissions. To reduce our dependence on fossil fuels, we need to invest in clean and sustainable alternative energy sources. Decarbonization will require large quantities of rare earth elements and other critical raw materials. Seabed resources are seen as a potential challenge for mineral exploration and extraction, as mineral deposits on land are becoming increasingly depleted. The major marine deposits include polymetallic sulfides, polymetallic nodules, cobalt-rich ferromanganese crusts, phosphorites, REY-rich muds, and placers [Sakellariadou et al., 2022].
In addition to climate change, the list of the most important environmental sustainability problems according to the UN 2030 Agenda includes the use of natural resources, waste production, water and air pollution, and declining biodiversity. Mining rare earth elements on land poses a significant threat to the environment, as large quantities of toxic chemicals are used during processing and refining, and uranium and thorium usually must be removed from the ores, even if not all ores are radioactive. It also causes significant impacts on non-living resources, i.e. the use and pollution of land, forests, water, and soil. The main obstacles to seabed mining are the impact on the entire seawater column, the habitats, and the communities. Given the high value of deep-sea communities and our limited knowledge, the scale of the potential impact is not easy to assess.

A major challenge will be to provide the large quantities of critical elements needed for the transition to green technology in a sustainable way. A key component of our mission will be the adoption of resource-efficient, ethical, and circular mineral value chains.
The DPSIR model framework can be used to support good natural resource management and policy as it combines socio-economic and environmental factors. The Driving forces (economic

growth, increase in world population) create Pressures (water pollution, habitat modification/removal, sediment disturbance, light and noise generation, air pollution) that change the State (exploitation of resources, including marine genetic resources, technological improvements, new job opportunities) and lead to Impacts (loss of biodiversity, metal prices on the world market, increase in wealth and well-being) that require Responses (regulations, ecological restoration, metal recycling, new technologies, knowledge accumulation, and transmission to future generations).

References

F. Sakellariadou, F.J. Gonzalez, J.R. Hein, B. Rincón-Tomás, N. Arvanitidis, and T. Kuhn. Pure and Applied Chemistry, (2022), https://doi.org/10.1515/pac-2021-0325

Acknowledgments: This work has been financially supported with funds from the IUPAC MaREE Project (2018-039-3-600) and the University of Piraeus Research Center.

Keyword

critical raw material, DPSIR model, environmental sustainability, marine deposits, REY

A first estimation of resource abundance in the Korea CFC contract area

Gyuha HWANG[1]*, Korea Institute of Ocean Science and Technology (ghhwang@kiost.ac.kr)
Wonnyon Kim[2], Korea Institute of Ocean Science and Technology
Youngtak Ko[3], Korea Institute of Ocean Science and Technology
Seung-Jin Yang[4], Korea Institute of Ocean Science and Technology

Abstract

Information on surface area and thickness is critical in estimating the resource abundance of cobalt-rich ferromanganese crusts (CFCs) covering the surface of seamounts. In this study, we obtained seafloor images and CFCs cores using ROV and a newly manufactured crust drill on the three Korean Contract seamounts (KC-7, KC-8, and KC-9) in the northwestern Pacific. Along the nine visual survey lines, a total of 66 CFCs drilling have been performed. The CFCs thickness was measured directly from the core sample, and seafloor conditions were manually classified into seven types from the seafloor image. Resultantly, we identify that 82.86% of the survey area (513,732 m^2 of 620,000 m^2) is covered by CFCs with a mean thickness of 11.49 cm across nine lines, indicating the abundance of 78,829 tons with a mean occurrence of 127.14 kg/m^2. As the visual survey could not cover the entire contract area, we consider that previously acquired backscatter intensities for the observed crust exposures were used to estimate the resource abundance for the CFCs exposure area. When the backscatter intensity for the CFCs exposure is applied in the three contract seamounts, the calculated resource abundance is highly variable ranging from 13,996,966 tons with 153.27 kg/m^2 to 22,684,912 tons with 155.38 kg/m^2, depending on selection criteria applied. Nevertheless, this study provides a reliable line-based resource estimation at this time.

Keyword

Cobalt-rich ferromanganese crusts, CFCs exposure, CFCs thickness, Resource abundance, Deep-sea survey

Contribution of Multiple Metal Sources to the Formation of Hydrothermal Chimney and Mound in the Mirae-2 Vent Field, Central Indian Ridge

Sun Ki CHOI[1]*, Korea Institute of Ocean Science and Technology (chlsunki@kiost.ac.kr)
Jonguk Kim[2], Korea Institute of Ocean Science and Technology
Sang Joon Pak[3], Korea Institute of Geoscience and Mineral Resources
Wonnyon Kim[4], Korea Institute of Ocean Science and Technology
Ryoung Gyun Kim[5], Korea Institute of Ocean Science and Technology

Abstract

The recent discovery of the Mirae-2 vent field (MVF-2) in the Central Indian Ridge provides new insights into the seafloor hydrothermal mineralization influenced by multiple origins of ore-forming elements in mid-ocean ridge settings. Mineralogical and geochemical characteristics of the MVF-2 chimney and mound exhibit the prevalence of reduced sulfide assemblages (pyrrhotite + isocubanite + Fe-rich sphalerite) and Sn enrichments (up to 1000 ppm), indicating an affinity with ultramafic-hosted hydrothermal mineralization, but the significant occurrence of barite and galena, along with enrichments in Ba (>100,000 ppm), Pb (up to 8.91 wt.%), and Si (31.9 wt.%), reflects the involvement of distinct metal sources other than the interaction of fluids with ultramafic substrates. This multi-origin hydrothermal mineralization is more evident in in-situ S (for pyrite and pyrrhotite) and Pb (for sphalerite) isotope analyses. The extremely positive $\delta^{34}S$ values (+5.46‰ to +17.24‰) and unusually radiogenic Pb isotope ratios ($^{206}Pb/^{204}Pb$ = 18.531–18.559; $^{207}Pb/^{204}Pb$ = 15.540–15.564; $^{208}Pb/^{204}Pb$ = 38.632–38.693) of the MVF-2 sulfides indicate that metals and S forming chimney and mound were leached mainly from serpentinized ultramafic rocks and enriched mid-ocean ridge basalts (i.e., the MVF-2 basalts) near the ridge axis (~ 5 km away). We propose that the initial seawater underwent multi-stage reactions, involving the leaching of Ba, Pb, and Si from the MVF-2 basalts in the recharge zone, followed by interaction with ultramafic rocks (i.e., serpentinization) underlying the MVF-2. This process ultimately resulted in the generation of hydrothermal fluids derived from multiple sources. Consequently, the MVF-2 exhibit mineralogical and geochemical features that differ from those of other ultramafic-hosted sulfide deposits, despite its location on an oceanic core complex. Our results highlight that multiple origins of seafloor hydrothermal mineralization may be common on slow-spreading mid-ocean ridges, given the more complex sub-surface lithological structure beneath sulfide deposits compared to that of fast-spreading mid-ocean ridges.

Keyword

Central Indian Ridge, Mirae-2 vent field, Multi-origin seafloor hydrothermal mineralization

Brothers volcano submarine hydrothermal system: upper parts of a porphyry Cu system

Cornel EJ DE RONDE[1]*, GNS Science (cornel.deronde@gns.cri.nz)

Abstract

High Cu-Au contents and strongly acidic vent fluids at Brothers volcano, Kermadec arc, are similar to those that formed the shallow parts of some porphyry copper and epithermal gold deposits. Two active, but distinct hydrothermal systems occur at Brothers volcano. One is magmatically-influenced and includes the Upper and Lower Cone vent sites that sit atop volcanic cones. The other is seawater-dominated and includes the Upper Caldera, NW Caldera and West Caldera vent sites, each perched on the caldera walls. The Upper Caldera vent field is host to numerous black smoker chimneys up to 20 m tall expelling fluids up to 320 °C. Hundreds of both active and inactive chimneys— reaching heights of ~15 m and discharging fluids up to 311 °C—are then perched on benches that cut across the caldera walls as part of the NW Caldera vent field.

Boundaries marking fluid flow can be defined by magnetic lows. For example, at the Upper Caldera site, an hour-glass shape (in plan view) denotes the magnetic low in the area, with a bulbous, open, top section ~1 km wide occurring near the Upper Caldera walls that extends ~800 m to the SE where it narrows to 400 m at the NW Caldera rim, occupying an area of ~0.68 km2 . This alteration zone then widens again to ~1 km and extends a further ~700 m towards the SE, encompassing an area of ~ 0.76 km2 that includes all of the NW Caldera site, and which extends onto the caldera floor.

The NW Caldera walls are characterized by normal faults that extend for up to 210 m (typically ~150 m) with throws up to 30 m. Extensive stockwork veining is exposed beneath the chimneys in the exposed faces of several of these faults, indicative of mobilization of metals that occurred prior to caldera collapse. Pyrite is the most dominant sulfide. These veins contain up to 10.1 wt.% Cu, 5320 ppm Zn, 3580 ppm As, 740 ppm Co, 467 ppm Mo, 296 ppm Pb, >90 ppm Se, >40 ppm Te, 40 ppm Bi, 37 ppm Sb, 16 ppm Ag, 12 ppm In, >11 ppm Tl and 1.9 ppm Au, consistent with a magmatic fluid contribution.

A series of boreholes were drilled into Brothers volcano by the International Ocean Discovery Program in 2018 and revealed hydrothermal alteration of the host dacitic volcaniclastics and lavas reflects primary lithological porosity and contrasting spatial and temporal contributions of magmatic fluid, hydrothermal fluid, and seawater. Initial hydrothermal activity, prior to caldera formation, is dominated by magmatic gases and hypersaline brines. The former mix with seawater as they ascend towards the seafloor, while the latter remain sequestered in the subsurface. Following caldera collapse, seawater ingress occurs by way of fault-controlled permeability, interacting with wall rock and the segregated brines, transporting associated metals towards the seafloor and forming present-day Cu-Au-rich chimneys.

Keyword

Brothers volcano, porphyry Cu, Cu-Au mineralization, Kermadec arc, New Zealand

Morphology-Driven Magnetic Properties in Coastal Ferromanganese Concretions

Joonas WASILJEFF[1]*, Geological Survey of Finland (GTK) (joonas.wasiljeff@gtk.fi)
Johanna M. Salminen[2], Department of Geosciences and Geography, University of Helsinki, Helsinki, Finland
Andrew P. Roberts[3], Research School of Earth Sciences, Australian National University, Canberra, Australia
Pengxiang Hu[4], Research School of Earth Sciences, Australian National University, Canberra, Australia
Maxwell Brown[5], Institute for Rock Magnetism, Department of Earth and Environmental Sciences, University of Minnesota, Minneapolis, MN, USA
Jukka Kuva[6], Geological Survey of Finland (GTK), Espoo, Finland
Sari Lukkari[7], Geological Survey of Finland (GTK), Espoo, Finland
Ester M. Jolis[8], Geological Survey of Finland (GTK), Espoo, Finland
Atko Heinsalu[9], Department of Geology, Tallinn University of Technology, Tallinn, Estonia
Wei-Li Hong[10], Department of Geological Sciences, Stockholm University, Stockholm, Sweden
Aivo Lepland[11], Department of Geology, Tallinn University of Technology, Tallinn, Estonia
Sten Suuroja[12], Geological Survey of Estonia, Rakvere, Estonia
Joni Parkkonen[13], Department of Physics and Nanoscience Center, University of Jyväskylä, Jyväskylä, Finland
Joonas J. Virtasalo[14], Geological Survey of Finland (GTK), Espoo, Finland

Abstract

Ferromanganese concretions, found both in deep ocean environments and shallow-water coastal regions globally, have gained renewed scientific attention due to their multifaceted significance as underwater habitats, critical raw material sources, and invaluable repositories of paleoceanographic information. The magnetic properties of ferrimagnetic minerals within these concretions, along with the origins of their natural remanent magnetization, are areas of exploration still in their early stages. Recent discoveries have revealed the involvement of biogenic magnetite in the development of biogeochemical remanent magnetization within deep ocean crusts and nodules, emphasizing the influence of microbial catalysis in their precipitation. While extensive research on the magnetic properties of deep ocean Fe-Mn deposits has been conducted, investigations into fast-growing shallow-water concretions have been notably absent. Additionally, the specific mechanisms governing the formation and (bio)mineralization of diverse concretion morphotypes (crust-like, discoidal, and spheroidal) in shallow-water settings remain enigmatic.

Our study focuses on ferromanganese concretions in shelf areas and seas, utilizing samples from the Baltic Sea. We present magnetic characteristics, microstructure, and the origin of Baltic Sea concretions, shedding light on their formation processes and environmental implications. Employing a comprehensive approach, we combined nano- and micro-computed tomography imaging, electron microscopy, micro-X-ray fluorescence spectroscopy, and detailed magnetic

property investigations. Spheroidal concretions, prevalent in various coastal Baltic Sea regions, contain a higher proportion of fine-grained magnetite, accompanied by evidence of bullet-shaped magnetofossils produced by magnetotactic bacteria. These magnetofossils are typically associated with eutrophic and less oxic environments, supported by the possible presence of rhodochrosite, indicating diagenetic Mn release from surrounding sediments, particularly in deeper water settings. In contrast, crust and discoidal concretions in shallower waters display pedogenic-like magnetic characteristics, reflecting an increased continental influence. Microstructural analysis reveals multiple growth stages in the concretions, with laminated, columnar, and dendritic structures indicating varying hydrodynamic and depositional conditions. Generally, spheroidal concretions appear to form in more tranquil settings compared to discoidal and crust concretions.

Our results provide insights into the intricate interplay of environmental conditions, biogenic processes, and mineralogical composition influencing ferromanganese concretion growth and magnetic properties in the Baltic Sea. We argue that biogenic magnetite globally contributes to the remanent magnetization of both shallow and deep-sea ferromanganese concretions.

This work was supported by the Research Council of Finland (Fermaid project, grant 332249).

Keyword

Baltic Sea, Biogenic magnetite, Fe-Mn, Nodule

Morphological Diversity and Its Influence on Geochemical Properties of Ferromanganese Concretions from the Baltic Sea

Joonas VIRTASALO[1]*, Geological Survey of Finland (GTK) (joonas.virtasalo@gtk.fi)
Joonas Wasiljeff[2], Geological Survey of Finland (GTK)
Yann Lahaye[3], Geological Survey of Finland (GTK)
Radoslaw Michallik[4], Geological Survey of Finland (GTK)

Abstract

Ferromanganese concretions, ubiquitously present in both deep ocean environments and shallow-water coastal regions worldwide, have rekindled scientific interest due to their significance as underwater habitats, repositories of paleoceanographic information, and resources of raw materials. In shallow-water settings, these concretions exhibit diverse morphotypes, such as crust-like, discoidal, and spheroidal. However, the processes driving the formation of these morphotypes and how the morphology influences their geochemical properties remain poorly understood.

We systematically examine element enrichment characteristics and conduct a comparative analysis of the geochemical and magnetic properties of shallow-water concretions from the Baltic Sea, focusing on the various morphotypes observed. The concretions generally exhibit similar or slightly enriched element contents when normalized to the composition of Earth's crust. Critical metal enrichments are somewhat lower compared to deep ocean diagenetic nodules and significantly lower compared to deep ocean hydrogenetic Fe-Mn crusts.

Although direct comparisons to deep ocean Fe-Mn precipitates are not straightforward due to the exceptionally rapid growth rates observed in the Baltic Sea compared to deep ocean settings, the trace element geochemical signature in these shallow-water concretions suggests a diagenetic origin. Additionally, the concretions exhibit morphotype and geochemistry-dependent magnetic properties.
A comprehensive understanding of the growth mechanisms and element enrichment processes of these concretions will contribute new insights into the spatial metal enrichment patterns and into paleoceanographic and environmental changes in the Baltic Sea and other shelf areas.

This research was funded by the Research Council of Finland (Fermaid project, grant 332249).

Keyword

ferromanganese concretions, geochemistry, morphology, Baltic Sea

Mapping and studying the European seabed minerals for sustainable development

Francisco Javier Gonzalez[1]*, Geological Survey of Spain (IGME-CSIC) (fj.gonzalez@igme.es)
Egidio Marino[2], Geological Survey of Spain (IGME-CSIC)
Harald Brekke[3], Norwegian Offshore Directorate (NOD)
Pedro Ferreira[4], National Laboratory of Energy and Geology (LNEG)
Ana Lobato[5], Geological Survey of Spain (IGME-CSIC)
Vitor Magalhães[6], Portuguese Institute for Sea and Atmosphere (IPMA)
Teresa Medialdea[7], Geological Survey of Spain (IGME-CSIC)
Xavier Monteys[8], Geological Survey of Ireland (GSI)
Henrik Schiellerup[9], Geological Survey of Norway (NGU)
Luis Somoza[10], Geological Survey of Spain (IGME-CSIC)
Irene Zananiri[11], Hellenic Survey of Geology & Mineral Exploration (HSGME)
GSEU Offshore Mineral Resources Team[12], EuroGeoSurveys

Abstract

Since 2018 EuroGeoSurveys (EGS) has developed GeoERA and GSEU programs drawing together the baseline data and knowledge needed to manage Europe's natural resources, including offshore mineral resources. Seabed minerals and their associated strategic and critical raw materials, in the Atlantic and Arctic oceans and the Baltic, Mediterranean and Black seas, are being analyzed based on extensive studies carried out previously. A complete database compilation includes 692 occurrences of volcanogenic massive sulfides and hydrothermal mineralizations, polymetallic nodules, cobalt-rich ferromanganese crusts, phosphorites and marine placers in pan-European seas. This standardized and harmonized database and the derived cartographic products contain the principal geological, metallogenic, environment and mining features of each occurrence. For the first time EGS is producing mineral occurrences, metallogeny, potential exploration areas, and predictive maps without limitations of national borders. More than 1190 individual samples collection provides information on the mineralogy and chemistry of the seabed resources, from shallow waters to deep-sea. The map on the CRM offshore occurrence of Europe is based on the 2023 CRM list of the European Commission, and enables the visualization and inspection of vast regions of the European seas. This study will contribute to increase the knowledge on the seabed environment and the associated geological resources, providing tools to policy makers for regulations and recommendations. Case studies and maps in progress will contribute to identify potential areas for environmental protection and responsible resource exploration and future extraction. Particular innovations of the studies in progress will include: first mapping of metallogenic provinces for offshore minerals pan-European setting; definition and mapping of strategic and critical raw materials associated with each deposit; identification of gaps defining underexplored marine areas; proposals for pilot zones with a high mineral potential for future research/ exploration with preservation or exploitation purposes; and the reinforcement of the European network of experts in seabed minerals.

Keyword

seabed minerals, critical raw materials, sustainability, European seas, deep-sea mining

New Developments of the Seabed Mineral Resources Research on the Norwegian Continental Shelf

Harald Brekke[1]*, Norwegian Offshore Directorate (harald.brekke@sodir.no)
Nils Rune Sandstå[2], Norwegian Offshore Directorate
Stig-Morten Knutsen[3], Norwegian Offshore Directorate
jan Arne Stenløkk[4], Norwegian Offshore Directorate
Sissel Henny Eriksen[5], Norwegian Offshore Directorate
Kristoffer Solvi[6], Norwegian Offshore Directorate
Andreas Bjørenstad[7], Norwegian Offshore Directorate

Abstract

The deep-sea mineral resources of the Norwegian continental shelf consist of deposits of polymetallic sulphides and polymetallic crusts; the area is not favourable for polymetallic nodules. For many years, the Norwegian Offshore Directorate (previously the Norwegian Petroleum Directorate) has collaborated on a scientific basis with academia in marine research on seabed minerals minerals in the deep-water areas of the Norwegian continental shelf in the Norwegian and Greenland seas. In particular, geological, geophysical and environmental data have been acquired during annual joint marine research cruises with the University of Bergen and the University of Tromsø since 2011 and 2019, respectively. Since 2018, the Directorate have carried out its own data acquisition cruises based on commercial tenders. During these activities, the Directorate has acquired high-resolution multibeam data, geophysical and electromagnetic data, together with drill cores, and samples by ROV. The data that had been acquired until 2022 have been released to the public and were the basis for the resource assessment report published by the Directorate last year.

For sulphide deposits, the stochastic estimates of total in place contained metal in sulphides are considerable, with copper at 38,100,000 tonnes, zinc at 45,000,000 tonnes, gold at 2,317 tonnes, silver at 85,200 tonnes, and cobalt at 1,000,000 tonnes. In addition, the prospective area for manganese crusts is estimated to cover more than 8,500 km^2, presenting a significant potential for various metals that may be of interest including manganese, cobalt, scandium, vanadium and possibly some of the REE elements. More details of the metal grades will be presented. Further marine data acquisition cruises have been carried out, two in 2023 and three in 2024. These cruises have been concentrating on the Knipovich Ridge and in the areas to the northwest of the Mohn Ridge outside of the axial valley. These recent data have confirmed hydrothermal vent deposits along the Knipovich Ridge, and also supports the potential for considerable sulphide and crust resources in northwest of the Mohn Ridge. This year's exploration have confirmed the major sulphide mound named Deep Insight that was discovered by the EMINENT Project under the lead of the University of Bergen in 2022. The Deep Insight deposit seems to be about 250 meters vide and 150 meters high, is in-active and located in the uplifted area adjacent to, but outside the spreading rift valley of the Mohn Ridge. It is the largest hydrothermal sulphide structure know today on the Norwegian Continental shelf. Furthermore, the recent data show the systematic

thickening of the crust deposits as one moves northwestwards away from the Mohn Ridge spreading valley. There is a gradual thickening from about 5 cm along the valley to more than 30-35 cm in the north west at about 150 km from the spreading axis. The saw blade was about 40 cm wide, but did not reach the substrate in the thickest parts. So far, it sems that the metal concentration does not change with thickness but stays more or less constant. More details in this will be presented.

Keyword

Sulphides, Manganese crusts, Seabed minerals, Resources, Norway

Towards the first licensing round for seabed minerals on the Norwgian continental shelf - a knowledge-based and stepwise approach

Harald Brekke[1]*, Norwegian Offshore Directorate (harald.brekke@sodir.no)
Espen Andreas Hauge[2], Norwegian Offshore Directorate
Nils Rune Sandstå[3], Norwegian Offshore Directorate
Hans Martin Veding[4], Norwegian Offshore Directorate
Kristoffer Solvi[5], Norwegian Offshore Directorate
Sissel Henny Eriksen[6], Norwegian Offshore Directorate
Stig-Morten Knutsen[7], Norwegian Offshore Directorate
Hilde Braut[8], Norwegian Offshore Directorate
Jan Anders Stenløkk[9], Norwegian Offshore Directorate
Andreas Bjørnestad[10], Norwegian Offshore Directorate

Abstract

In January 2024, the Norwegian Parliament reached the agreement to open an area for mineral activities on the seabed on the Norwegian continental shelf as proposed in the Government's white paper no. 25 (2022-2023). This decision followed from an opening process that was initiated by the Ministry of Petroleum and Energy (now the Ministry of Energy) in 2020. According to the decision, Norway will adopt a precautionary, knowledge-based approach in proceeding with a stepwise and responsible development of seabed mineral activities on the Norwegian continental shelf, in which environmental considerations will be upheld in all phases of the activity. The Government has now decided that it this year will start the process for announcing areas for the application and award of licenses for exclusive mineral activities.

The opening process consisted of two main parts: an impact assessment process and a minerals resource evaluation. As part of the impact assessment, government agencies and leading expert institutions prepared background reports and impact studies summarized in the document "Impact Assessment for Mineral Activities on the Norwegian Continental Shelf," included in the Government's white paper. The Norwegian Offshore Directorate (formerly the Norwegian Petroleum Directorate), the ministry's specialist directorate for seabed minerals, prepared a resource assessment study for the area under investigation. The assessment indicates significant potential mineral resources on the Norwegian continental shelf. Some of these resources may be extractable. The impact study, the resource assessment study and the results from the marine exploration and research available, including the data acquired during the three cruises this year (January to June) will be the basis for selecting areas to be announced in the first licensing round. These aspects will be dealt with in more detail in the presentation.

Applicants for licenses must present the details of their initial geological knowledge of the area in question, their technical competence, financial capability, and a work program designed to clarify whether the area holds resources that are feasible to develop for extraction, which is expected to include exploration activities in that respect. However, before extracting mineral resources, license holders must submit an extraction plan, including an environmental impact assessment for the

project, to the Ministry of Energy for its and the Parliament’s approval.

Keyword

Seabed minerals, Licensing round, Impact assessment

In-situ monitoring reveals the vertical stratification characteristics of sediment plume in deep-sea mining

zhihan Fan[1]*, Ocean University of China (fanzhihan@ouc.edu.cn)
yonggang JIA[2], Ocean University of China

Abstract

The spatial and temporal distribution of sediment plumes determines the environmental impact of deep-sea mining, and accurate modeling of the three-dimensional distribution of plumes depends on in-situ monitoring of plume concentration changes. However, existing studies lack in situ monitoring devices for continuous vertical changes in deep-sea sediment plumes. In this study, a plume in-situ monitoring device was developed, and a Self-Potential inversion model of suspended particle concentration was established through artificial neural network (ANN) training. In situ perturbation and monitoring have been carried out in the 5750m water depth of the polymetallic nodule area in the Western Pacific Ocean. The vertical concentration variation characteristics of the sediment plume within 0.74m from the bottom have been monitored in situ with a vertical resolution of 2 cm. The results show that the vertical plume concentration of sediments is stratified, with the upper plume concentration being low and the lower plume concentration being high in the 0.74m range. The mass of the lower plume accounted for more than 75% of the total particle mass, and the proportion of the lower plume gradually decreased with the increase of time. This study provides a new method for in-situ observation of vertical concentration of deep-sea mining plumes, increases the understanding of vertical concentration distribution characteristics of mining plumes, and provides data support for accurate simulation of temporal and spatial distribution of plumes.

Keyword

Sediment plumes, Deep-sea mining, Polymetallic nodules, In-situ monitoring, Self-potential prob

In-situ Geotechnical Properties of Abyssal Sediments and Implications for Polymetallic Nodule Mining

Zhenggang LI[1]*, Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310012, China (lizg@sio.org.cn)
Zhou Li[2], Changsha Research Institute of Mining and Metallurgy Co Ltd, Changsha 410012, China
James R Hein[3], U.S. Geological Survey Retired, Soquel, CA, USA
Yangrui Cheng[4], Changsha Research Institute of Mining and Metallurgy Co Ltd, Changsha 410012, China
Yuwei Liu[5], Changsha Research Institute of Mining and Metallurgy Co Ltd, Changsha 410012, China
Xibin Han[6], Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310012, China
Hao Wang[7], Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310012, China
Xiaohu Li[8], Second Institute of Oceanography, Ministry of Natural Resources, Hangzhou 310012, China

Abstract

Polymetallic nodules contain enormous amounts of critical metals, making them the top priority for future deep-ocean marine mining. Recent deep-ocean mining tests (2021-2022) of polymetallic nodules in the Clarion-Clipperton Contract Area by Global Sea Mineral Resources (GSR) and the Metals Company (TMC) suggest that environmental impacts caused by nodule mining operations are inevitable but manageable. How to mitigate those impacts is of critical importance and has become a core issue of concern by the international community. The most straightforward way of mitigation that the contractors and mining companies are seeking is to improve the design of the mining vehicle, which however has high industrial costs. Others propose to use flocculant to enhance particle settling to reduce the impact to benthic biology from the creation of a sediment plume. But to our knowledge, no one has proposed a mechanism for mitigation by optimizing the path of the mining vehicle.

In this contribution, we propose a geological measure for optimizing the mining path based on in-situ tests of geotechnical properties of abyssal sediments in the Clarion-Clipperton nodule field. We carried out 35 in-situ tests at 11 stations on the abyssal plain of the A-5 Block in the China Minmetals Contract Area, which covers a variable range of water depths (5150-5350 m) with rugged topography. By establishing a quantitative relationship between sediment penetration strength (a proxy for substrate hardness) and the BPI topography parameter, as well as the sediment grain size, we found that platforms have coarser sediments and harder substrate compared to basins. This was explained by a lateral sediment redistribution model where suspended sediments previously eroded from nearby platform by bottom currents is redeposited in the basins, which was exerted by periodically changing bottom currents. It is expected that a harder substrate would result in lower subsidence depth of the mining vehicle, thus disturbing less sediment, resulting in a decreased sediment plume. The proposed mining plan can mitigate the

environmental impacts of the unexploited basin areas, which will also contribute to the recovery of the ecosystem.

Keyword

polymetallic nodule mining, environmental impacts, sediment geotechnical properties, topography parameter BPI, Clarion-Clipperton Fracture zone

Quantifying the rare earth element enrichment process of bioapatite in deep-sea REY-rich sediments

Hao Wang[1]*, Second Institute of Oceanography, Ministry of Natural Resources (wanghao@sio.org.cn)
Xiaohu Li[2], Second Institute of Oceanography, Ministry of Natural Resources
Bin Fu[3], Institute of Geochemistry, Chinese Academy of Sciences
Zhenggang Li[4], Second Institute of Oceanography, Ministry of Natural Resources
Yanhui Dong[5], Second Institute of Oceanography, Ministry of Natural Resources
Jie Li[6], Second Institute of Oceanography, Ministry of Natural Resources

Abstract

The rare earth element and yttrium (REY) compositions of bioapatite (e.g., fish tooth and bone) in marine sediments are often used as a potential proxy for paleoenvironmental conditions, and its Nd isotopic signature has been widely used to reconstruct ocean circulation. Furthermore, deep-sea REY-rich sediments (total REY (ΣREY) ≥ 400 ppm) have received increasing economic interest after Kato et al. (2011) reported that it can be a new REY resource. As the dominant REY-host phase in deep-sea REY-rich sediments, bioapatite has also been used to study the REY mineralization process. However, the REY enrichment of bioapatite and REY transfer from Fe–Mn micronodule to bioapatite remain unclear owing to a lack of quantitative studies on these processes under variable redox conditions (oxic vs. suboxic). To address these uncertainties, we conducted in situ geochemical analyses of fish teeth and Fe–Mn micronodules from two REY-rich sediment cores (GC01 and GC02) collected from the Clarion–Clipperton fracture zone in the central equatorial Pacific. We found that the Ce/Ce* ratios of fish teeth from GC01 (sediments ΣREY = 723 ± 274 ppm) and GC02 (sediments ΣREY = 506 ± 65 ppm) gradually increased with depth under oxic conditions, with calculated oxic pore water-derived REY increasing from ~3% (surface layer) to ~30% (200cm layer). In deep sediment columns (>200 cmbsf), the suboxic pore water contributed a small amount of REY (~3% to ~14%) to fish teeth, as evidenced by sharp increases in Ce/Ce* ratios of fish teeth and decreases in Ce/Ce* ratios and increases in YN/HoN ratios of micronodules. Therefore, the Nd isotopic compositions of fish teeth in core-top samples of deep-sea REY-rich sediments could be used to construct ocean circulation, but the fish teeth in core-deep samples may be unreliable archives of ancient bottom seawater. In addition, the majority of REY in bioapatite was sourced from bottom seawater, and a small amount (~4.3%) of REY was sourced from micronodules. Additionally, micronodules accounted for only ~2.1% of the REY in bulk sediments. Therefore, the micronodules had limited effect on the formation of REY-rich sediments. Meanwhile, the low sedimentation rate enables the sediments to accumulate more bioapatite and allows sufficient time for the bioapatite to acquire REY from the bottom seawater at the sediment–water interface; thus, it is the key factor controlling the formation of deep-sea REY-rich sediments.

Keyword

rare earth elements, deep-sea REY-rich sediments, bioapatite, Fe–Mn micronodule, Clarion–Clipperton fracture zone

Hydrothermal activity within seafloor hydrothermal vent fields along the Southwest Indian Ridge

Weifang YANG[1]*, Second Institute of Oceanography, MNR (yangweifang@sio.org.cn)

Abstract

The modern seafloor hydrothermal system on ultraslow-spreading Southwest Indian Ridge (SWIR) exhibit diverse characteristics. The SWIR is characterized by an ultraslow-spreading rate (14 mm/yr), thin crust, ridge segmentation, deep axial valleys, a heterogeneous magma supply along the ridge axis, which is composed alternately of magmatic-enriched and magmatic-barren segments. The magmatic-barren segments often develop detachment faults and oceanic core complexes. From west to east along the SWIR, there are numerous hydrothermal fields, such as Sudi, Baidi, Chunxi, Yuhuang, Longqi, Suye, Duanqiao, Changbai, Junhui, Qiaoyue, Baishen, Tianzuo, Tiancheng, Mt. Jourdanne and Old city. Hydrothermal sulfides were developed among part of these hydrothermal fields. Sulfide chronology research can reveal multi-stage formation and superposition processes of ore bodies, as well as the formation and evolution history of sulfides, their growth and hydrothermal fluid activities more accurately. The 230Th/238U dating method was widely applied to determine the age of seafloor hydrothermal sulfides. Here, we collected 74 sulfide ages from Yuhuang, Longqi, Duanqiao, Tianzuo and Mt. Jourdanne hydrothermal fields that have been reported. The 74 nonzero chronological data from hydrothermal sulfide samples provide the first quantitative characterization of the spatial and temporal history along the SWIR. The SWIR sulfide dates indicate that hydrothermal events have been distributed unevenly through the time interval from 100 kyrs to 0.2 kyrs. Hydrothermal events in the SWIR demonstrate that over the past 20 kyrs, hydrothermal activity in the SWIR has been relatively active. In contrast, between 40 kyrs and 100 kyrs, hydrothermal activity was relatively infrequent and short in duration. The maximum activity occurred at 15–11 kyrs, 9–7 kyrs and 6–0.2 kyrs. Compared with fast-, intermediate-, and slow- spreading ridges, sulfide ages from the ultraslow spreading center are widely distributed. There is no age correlation between the hydrothermal events at different sites along the MAR, CIR and SWIR. Hydrothermal fields, such as Yuhuang, Duanqiao and Tianzuo, are large and have good resource potential whereas the Mt. Jourdanne HF is small in scale and resource.

Keyword

Southwest Indian Ridge, Hydrothermal sulfides, Hydrothermal activity

Potential Impact of Polymetallic Nodules Deep Sea Mining on the World Commodity Markets

Anna Mikhailovna LAPTEVA[1]*, Russian Mineral Resource Institute – VIMS
(annam.lapteva@gmail.com)
Alexandra Dmitrievna Chernova[2], Russian Mineral Resource Institute – VIMS

Abstract

Mining of deep-sea polymetallic nodules can bring significant amounts of Cu, Ni, Co and Mn to the market, whereas even relatively small additional supply at an unfavorable moment can unbalance the market or put pressure on prices. The consequences of falling price depends on actual reduction scale and economic condition of market participants.

If the market situation is unfavorable, the start of nodules mining can lead to global, regional or local consequences that are closely interconnected.

Global consequences are the disruption of the market supply/demand balance, which can cause an oversupply of one or more of the metals in question.

A decrease in prices of a metal or metals in question will provoke a cascade of diverse local and regional consequences, and all these cascades will develop simultaneously.

One of the cascade scenarios is:

Deteriorating shrinking revenues up to the point of companies losing profitability → reduction in production (limited capacity utilization) or suspension production → reduced wages or lay-offs → decrease in their purchasing power of families of employees of the affected companies → decrease in consumer demand from families of employees → decreased revenues in the service sector → closure of some service companies → lay-offs in the service sector → general decrease in the standard of living and employment in the communities of presence of the affected companies → reduced tax proceeds on regional and national levels → negative social consequences (social tension, population migration, etc).

Local and regional consequences will manifest itself on the global level. Reduced global production of the metals in question will shift the supply/demand balance towards shortages and cause respective change in price dynamics. The structure of the mining and metallurgical industries and the global value chain will also undergo changes.

The industry structure and the global value chain may be affected by the beneficiaries of nodules to be mined. Let's assume, that the “destination" of nodules are companies supplying metals to the countries-sponsors of the mining contractors. These countries are: China, Japan, France, Germany and Belgium. All these countries are major importers of mining and/or metallurgical products of the metals in question. A new source of these products will lead to a decrease in their imports from countries - traditional supplier. Thus, China imports manganese ore in large quantities (primarily from South Africa, Gabon, Ghana, Brazil), copper products (Chile, Peru, Mongolia, etc.), nickel (Philippines, Indonesia) and cobalt (DRC). These countries also main supply these metals to other countries. Nodules mining might lead to decreased import from traditional supplier

countries or cause such import to disappear altogether.

Keyword

deep-sea mining, polymetallic nodules, commodity markets

MARINE PLACER OCCURRENCES AND ASSOCIATED CRITICAL RAW MATERIALS IN RIAS BAIXAS (NW SPAIN)

Wai Long NG-CUTIPA[1], Geological Survey of Spain (IGME-CSIC)
Ana Lobato[2], Geological Survey of Spain (IGME-CSIC)
Francisco Javier González[3]*, Geological Survey of Spain (IGME-CSIC) (fj.gonzalez@igme.es)
Irene Zananiri[4], Hellenic Survey of Geology & Mineral Exploration (HSGME)
Georgios Georgalas[5], Hellenic Survey of Geology & Mineral Exploration (HSGME)
Ana Cláudia Teodoro[6], Faculty of Science, University of Porto
Jacob Støren[7], ECOTONE
Ingrid Myrnes[8], ECOTONE
S34i Shallow water team[9], Hellenic Survey of Geology & Mineral Exploration (HSGME)

Abstract

Rias Baixas, a funnel-shaped estuarine inflow system into the coastal drainage area located in NW Spain, is mainly surrounded by Variscan metamorphic and intrusive coastal outcrops. Heavy mineral placer occurrences and deposits were formed in coastal areas by weathering of these rocks. Balarés beach (Ponteceso, Coruña) is an example, 3,600 tonnes of ilmenite (Ti) and other by-products (garnet, zircon, rutile, monazite and cassiterite) were extracted from this deposit between 1941 and 1952. This work is part of the European HORIZON project S34i (https://s34i.eu/) and summarizes the first results to evaluate the critical raw materials (CRM) associated with placers in the coastal areas of the Ría de Vigo. Baluarte and Fontaiña (Vao Beach), Límens, Santa Marta, Alemans, Ratas and Canabal beaches were explored in March and September 2023, while potential placer occurrences were recognized according to IGME internal reports (1976 and 1979). Ten sandy-sediment samples were collected in the heavy minerals-enriched surface layer in March 2023. At each site, three different sampling points were taken from 1 cm depth within an area of 1 m2. Organic matter and carbonate were eliminated, and then the samples were graded by granulometry. Fine to medium sands (<0.250 - >0.125 mm) were selected for heavy mineral separation by liquid density using bromohoform. Geochemical analysis was carried out using ICP-MS. In the field trips were identified two main placer occurrences: Santa Marta and Vao Beach. Both areas are dominated by reddish accumulations of heavy minerals in multilayers to a depth of about 50 cm. Surface patches of black minerals (about 1 to 10 m2) characterise the other beaches and the western part of Santa Marta Beach. Granulometry shows medium to fine sands, and heavy mineral contents have been quantified up to 46%, in multilayer enriched. In addition, Vao and Santa Marta samples show high accumulation of Zr, Nb, Hf, Ta, Th, U, La, Ce, Nd, Sm and others (bulk sample). Further analysis is underway to quantify the percentage weight of each heavy mineral. The placer occurrences in the Rias Baixas show great potential for CRM accumulation, especially close to the sand and crystalline rock substrate contact at the beaches, and in depositional centres in shallow waters areas.

Keyword

Placers, CRM, heavy mineral, sand

Magnetite concentration in serpentinite from the Central Indian Ridge, a tracer of natural H2 formation

Wonnyon KIM[1]*, Korea Institute of Ocean Science & Technology (wkim@kiost.ac.kr)
Jihye OH[2], Korea Institute of Ocean Science & Technology
Jonguk KIM[3], Korea Institute of Ocean Science & Technology

Abstract

Natural hydrogen is attracting global interest as a potential future clean energy resource. While numerous studies have investigated its generation and potential terrestrial reservoirs, our understanding of hydrogen production in the ocean remains limited. Much of the existing research has focussed on the hydrogen ecosystem associated with the hydrothermal vents. It is well known that olivine and pyroxene in ultramafic rocks form serpentine minerals upon reaction with seawater or hydrothermal fluids, leading to the formation of magnetite and hydrogen as by-products. Consequently, the quantification of magnetite generated during this reaction can serve as an indicator of hydrogen production by employing relevant mineral chemical equations. In this study, we collected serpentinized rock samples using the ROV from the Cheoeum Vent Field and Onnuri Vent Field areas in the Central Indian Ridge. To identify the magnetic properties of serpentinite, we conducted various rock magnetic measurements on the prepared samples. The saturation magnetization (Ms) of stoichiometric magnetite is always 92.36 Am2kg-1. The magnetite concentration within a sample can be estimated by normalizing the sample's Ms with the Ms of magnetite. Notably, ferrous oxide (FeO) within olivine has no magnetic remanence, thereby allowing the Ms of serpentinite to reflect the concentration of newly formed magnetite. The calculated magnetite concentration ranges from 0.76 to 3.74 wt.%. Furthermore, there was a strong correlation (r2 = 0.87) observed between Ms values and easily measurable magnetic susceptibility. Analysis of magnetic hysteresis and first-order reverse curve revealed the presence of single-domain magnetite and its weathering trend towards coarsening grain-size and increasing coercivity. Under the microscope, the magnetite aggregates formed along micro-fractures of serpentinite, displaying distinct euhedral shapes. Comparison with serpentinization degree, as inferred from densities, indicated that significant magnetite formation occurred after reaching ~70% serpentinization.

Keyword

Magnetite, Serpentinite, Central Indian Ridge, Hydrogen

The comparative analysis of rare earth oxide amount in terrestrial ore deposits and deep-sea sediments

Hyosang KWON[1]*, Korea institute of Geoscience and mineral resources (khs9419@kigam.re.kr)
Yuri Kim[2], Korea institute of Geoscience and mineral resources
Yoon Mi Kim[3], Korea institute of Geoscience and mineral resources

Abstract

Rare earth elements and Yttrium (REY) are crucial strategic resources for highly advanced technologies. However, given the heavy reliance on China for most REY resources, there is growing interest in deep-sea REY to overcome the potential risk to the global supply chain. In this study, we conduct a comparative analysis of REY concentrations and enrichment mechanisms of the REY in the terrestrial ore deposits and deep-sea mud in the Pacific Ocean to understand the differences in REY distribution patterns between terrestrial and ocean. Comparing the Bayan Obo mine, which is classified as a carbonatite-related REY deposit, and the Hongcheon deposit with the Southwestern Pacific, the total contents of REY oxides are higher in the terrestrial deposits. However, a detailed comparison of the REY component shows that the HREE/LREE ratio in the Southwestern Pacific is found to be 56 times higher than the Bayan Obo Mine in China and 18 times higher compared to Hongcheon. In addition, seafloor sediments in the Southeast Pacific host 15-27 times higher La/Dy ratios and about 78-140 times enriched in Y concentrations than terrestrial deposits. While the content of rare earth oxides is much enriched in terrestrial deposits, the ratio of economically valuable HREE in deep-sea sediment is higher, suggesting the need for further consideration of the REY resource development in the ocean.

Keyword

REY, carbonatite, deep sea mud

Depth-dependent variations in paleoceanographic records of the ferromanganese nodules in the Arctic Ocean: High-resolution Raman spectroscopic study

Sangmi LEE[1]*, Department of Geology , Gyeongsang National University, Korea. (sangmi@gnu.ac.kr)
Hyo-Im Kim[2], Department of Geology and Research Institute of Molecular Alchemy, Gyeongsang National University
Hyen Goo Cho[3], Department of Geology, Gyeongsang National University
Hyo Jin Koo[4], Pusan National University

Abstract

Ferromanganese nodules, which are the aggregates of diverse metallic elements (e.g., Mn, Fe, Ni, and Co) formed by precipitation from the aqueous system, serve as critical archives for reconstructing paleoceanographic records. Determining the chemical compositions and the mineral species within concentrically growing structures in the ferromanganese nodules can provide invaluable insights into environmental factors such as the oxidation state of the aqueous system, temperature, and pH. Recently, it has been confirmed that the substantial amount of ferromanganese nodules in the shallow water regions of the Arctic Ocean, are notably sensitive to climate variations. These nodules have been observed in the East Siberian Sea at depths ranging from approximately 70 m to 250 m. Recent microscopic and XRD studies have reported that the external morphology, internal structure, and bulk mineral compositions vary with the water depths, suggesting that the geochemical conditions may differ depending on the water depths. We performed the high-resolution Raman spectroscopy, a powerful tool for examining the manganese oxide mineral species at several micrometer scales, on the natural manganese nodules collected from different depths from 73 to 240 m in the East Siberian Sea. To observe the internal textures and the distribution of chemical compositions, the scanning electron microscope (SEM) and electron microprobe (EPMA) were also performed. Note that the porous texture is more prevalent in the nodules from deeper depths. The Raman results show the distinct variations in the mineral species from central to the outer rim parts regardless of the water depths: notably, the todorokite (i.e., tunnel structure) is predominant in the central part, while the birnessite (i.e., layer structure) is prevalent in the outer rim part. However, the trend in the transition from todorokite to birnessite varies with the water depth. Combining the SEM and EPMA results, the detailed Raman profiles of mineralogical variation with varying samples are somewhat correlated with their internal structure. The observed variations in the mineralogical and textural characteristics in the ferromanganese nodules from the varying depths will be helpful for unraveling the paleoceanographic conditions in the Arctic Ocean.

Keyword

Ferromanganese nodule, Arctic Ocean, Raman spectroscopy, Todorokite, Birnessite

Baltic Sea ferromanganese concretion growth rates and conditions in laboratory experiment

Renata MAJAMÄKI[1]*, Geological Survey of Finland (renata.majamaki@gtk.fi)
Lotta Purkamo[2], Geological Survey of Finland
Jenni Hultman[3], Natural Resources Institute Finland
Joonas Wasiljeff[4], Geological Survey of Finland
Eero Asmala[5], Geological Survey of Finland
Pirjo Yli-Hemminki[6], Natural Resources Institute Finland
Kirsten Jorgensen[7], Finnish Environment Institute
Karoliina Koho[8], Geological Survey of Finland
Jukka Kuva[9], Geological Survey of Finland
Joonas Virtasalo[10], Geological Survey of Finland

Abstract

The transition to renewable energy and the acceleration of technology demand vast amounts of hi-tech metals that are critical in green energy technology. More than 10% of Finland's sea areas are covered by a layer of ferromanganese concretions, centimeter-scale accumulations of iron and manganese oxides. In addition to iron and manganese, concretions contain hi-tech metals, such as cobalt. Due to increasing demand for hi-tech metals near future, companies will likely start mining concretions from the Baltic Sea. The porous concretions host diverse microbial communities that regulate metal and nutrient cycling in the concretions. It is crucial that the seafloor ecosystem is not damaged while concretions are extracted. This study provides information on Baltic Sea Fe-Mn concretion growth rates and conditions in laboratory experiments. We collected the ferromanganese concretions from the Gulf of Finland in 2022 for a 12-week laboratory incubation and metal tracer experiments. Triplicate concretion and one abiotic control sample were collected into bottles containing artificial brackish seawater and incubated in the dark at +5 °C in an orbital shaker at 100 rpm to imitate seafloor conditions. Bottles were sampled at the beginning and the end of the 12-week incubation experiment. We measured the headspace methane concentrations and pH of the incubation solution. We analyzed the concretion growth with X-ray computed tomography and freshly formed concretion material with a scanning electron microscope. We measured total phosphorus and metal concentrations (Mn, Fe, Co, V, Ni, Zn, Mo) of the incubation solution with triple quadrupole ICP-MS. Our results showed that concretions grew in laboratory conditions, and new growth was close to 10 um within 12 weeks. Headspace methane concentrations decreased in all samples after an incubation but least in abiotic controls, where the microbial activity was eliminated. This indicates that microbes living on the surface of concretions utilized methane. Metal concentrations in the abiotic controls increased more than in the biotic triplicates after a 12-week incubation, indicating that metals dissolved from Fe-Mn concretions into the incubation solution faster without the activity of microbial communities. Here, we propose that microbes occupying the concretions have an important role in the concretions' growth and the factors affecting the accumulation and release processes of metals. This work was

supported by the Finnish Natural Resources Research Foundation and the Research Council of Finland (Fermaid project, grant 332249).

Keyword

concretions, nodules, marine, microbes, hi-tech metals

Cobalt-rich Ferromanganese Crusts from the Southwest Canary Islands Seamounts: Mineralogy and Geochemistry of Strategic and Critical Elements

Egidio Marino[1]*, Geological Survey of Spain (IGME-CSIC) (e.marino@igme.es)
Francisco Javier González[2], Geological Survey of Spain (IGME-CSIC)
Luis Somoza[3], Geological Survey of Spain (IGME-CSIC)
Thomas Kuhn[4], Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
Pedro Madureira[5], Portuguese Task Group for the Extension of the Continental Shelf (EMEPC)
Teresa Medialdea[6], Geological Survey of Spain (IGME-CSIC)
Anna Wegorzewski[7], Bundesanstalt für Geowissenschaften und Rohstoffe (BGR)
Rosario Lunar[8], Institute of Geosciences IGEO (UCM-CSIC)
Lorena Ortega[9], Faculty of Geology, Complutense University of Madrid (UCM)
Jose Mirao[10], HERCULES Laboratory, Évora University
Martin Oeser[11], Leibniz Universität Hannover Institut für Mineralogie
Catarina Miguel[12], HERCULES Laboratory, Évora University
Jesús Reyes[13], Geological Survey of Spain (IGME-CSIC)
Eva Bellido[14], Geological Survey of Spain (IGME-CSIC)
Mercedes Castillo-Carrión[15], Geological Survey of Spain (IGME-CSIC)

Abstract

The Canary Islands seamount province counts with hundreds of seamounts and submarine hills located in the area around the islands. The seamounts located in the south-west stand out for their Late Jurassic/Cretaceous age (146-72 Ma), great surface area and presence of mineralizations with potential economic importance.

For this research, forty-three cobalt rich Fe-Mn crusts have been selected as representative of the crust deposits on the slopes and summits of eight seamounts (Las Hijas, Bimbache, Amuley, Gaire, The Paps, Echo, Drago and Tropic) between 1600 and 5000 m water depth.

The analyses have shown that the crusts are dark brown to black, porous and fragile, formed by the accretion of thin laminae (<50 microns) that are packaged according to two main structures: sub-parallel and dendritic. Bulk mineralogy is dominated by Mn oxides (Fe-vernadite, birnessite, todorokite, buserite/asbolane), intergrown with Fe oxyhydroxides (goethite group). In addition, there is the presence of small amounts of accesory minerals represented essentially by silicates, carbonates and authigenic phosphates.

The geochemistry obtained reflects the main mineralogy, showing high average contents of Fe (25%) and Mn (17%) and lower amounts of the other major elements (in total <15%). Among the trace elements, crusts are rich in many critical and strategic elements with high average content of Co, Ni, Cu, V, Mo, Te, REYs and PGE (5000, 2300, 600, 1000, 450, 40, 3000 µg/g 240 ng/g respectively). Different discriminant diagrams given for almost all crust a hydrogenic origin. The calculation of growth rates and age using the "cobalt chronometer equation " in bulk samples supports this hydrogenetic origin for studied crusts, with very low growth rates (1-2 mm/Ma) and ages between 7 and 110 Ma, confirmed with EPMA transect analyses with ages reaching 90 Ma.

The high-resolution analyses allowed to know the Fe-Mn crusts in detail. Mineralogical analyses

have been obtained in solid samples micro mineralogical analyses (micro-XRD, Raman and FT-IR) resulted in the presence of intergrown vernadite, buserite, asbolane or todorokite. These minerals have been confirmed by transmission electron microscopy analysis, in which Mn oxides with interlaminar spacing between 9 and 10 Å have been recognized.
High-resolution geochemical analyses carried out directly on the Fe-Mn oxyhydroxide laminae using EPMA and LA-ICP-MS. In this way, laminae formed by buserite, asbolane or todorokite have a higher content of Mn, Ni and Cu (respectively more than 50, 6 and 2%) and lower content of Fe, Co, REYs and Te (respectively 2-3% and 1000, 160 and 1 μg/g on average). Vernadite laminae present similar contents of Fe and Mn (18 to 24 %) and high contents of Co, REYs and Te (up to 1, 0.5% and 200 μg/g).
The pilot hydrometallurgical experiments have shown high recovery rate of strategic elements Co, V and REY (between 60 and 80 %) resulting in a possible recover of 350, 60 and 200 T of these elements in one square kilometer of the summit the Tropic Seamount. compared to samples in which only ferric vernadite was found (81 and 70 %).

Keyword

Marine minerals, Fe-Mn crusts, Critical elements, Geochemistry, Economic potential

Bayesian linear regression with Gaussian mixture likelihood for outlier detection of metal grades

Yufu NIU[1]*, CSIRO Mineral Resources (yufu.niu@csiro.au)
Mark Lindsay[2], CSIRO Mineral Resources
Richard Scalzo[3], CSIRO Data61
Peter Coghill[4], CSIRO Mineral Resources
Lequn Zhang[5], CSIRO Mineral Resources
Kunning Tang[6], School of Minerals and Energy Resources Engineering, University of New South Wales

Abstract

High-grade porphyry Cu deposits are being exhausted. The falling head grade of ore aggravates the burden of mining industries because of the higher expenditure for dealing with waste. Ore sorting has the capacity to sort ores with high-grade Cu from barren rock, thus reduce the downstream operation cost, transport cost, and environmental footprint, thus improving the profitability and sustainability of mining operations.

Ore sorting can rapidly measure average key metal grade for pods of ores on a conveyor belt. However, the measurement of other metal grades are also critical for the optimisation of the subsequent mineral processing. Because of measurement error, latent geological features, and natural heterogeneity, data usually have outliers. When inferring related metal grades in mineral processing, outliers can produce significant bias and interfere related decisions such as chemical dosage and water/energy expense. Therefore, it is crucial to detect outliers for metal grade inference.

We present a Bayesian linear regression model with Gaussian mixture likelihood to identify outliers for the relationship of Cu and Fe grade in porphyry Cu deposit. Mine block model was used to split data for inferring local grade. Results show the proposed model can dramatically reduce mean square error, thus offer more accurate inferences than maximum likelihood estimation. Results also indicate that outliers may be crucial when planning mining operations. This method provides a reliable way to capture outliers in linear relationship of metal grades. This is particularly useful for mineral inference in ore sorting and decision-making in downstream mineral processing.

Keyword

Porphyry Cu deposit, Gaussian mixture likelihood, Outlier detection, Bayesian inference, MCMC

Multiscale variance prediction of metal grade for sortability assessment of bulk ore sorting in Cu deposit

Yufu NIU[1]*, CSIRO Mineral Resources (yufu.niu@csiro.au)
Lequn Zhang[2], CSIRO Mineral Resources
Peter Coghill[3], CSIRO Mineral Resources
Mark Lindsay[4], CSIRO Mineral Resources / Mineral Exploration Cooperative Research Centre, Centre for Exploration Targeting, School of Earth Science, The University of Western Australia / ARC centre for Data Analytics for Resources and Environments (DARE)
Kunning Tang[5], School of Minerals and Energy Resources Engineering, University of New South Wales

Abstract

Average Cu grades are decreasing as most Cu deposits have exhausted their high-grade ores leading to mining producing more waste. A solution is required to reduce waste levels while maintaining Cu production. Bulk ore sorting can rapidly estimate the grade of ore on a conveyor belt using a magnetic resonance technique that has been successfully used to detect chalcopyrite amongst the waste minerals at the scale of a few tonnes of ore. However, not all deposits are sortable due to the deposit type, heterogeneity of minerals, and spatial grade distribution. This raises a question: how do we determine the sortability of a deposit? Grade variability as a function of scale is the primary attribute to evaluate the sortability of a deposit. Bulk ore sorting falls between the intensively studied scales of variation at a block level of 1000s of tonnes and the sub-gram liberation scale. Where applicable all scales of variation can be used to improve ore processing efficiency.

In this study, we applied non-linear regression methods to estimate the relationship between tonnage scale and the variance of Cu grade by a sequence of geochemical data collected from bore core data characterising a sedimentary-hosted Cu deposit. The bore core data was used to calculate the variance of Cu grade at “small” (<1 Ton) and “large” scales (>10000 Ton). Then, the variance of Cu grade was predicted at a sortable scale (2 - 300 Ton) from model inference. The corresponding magnetic resonance data was utilised to validate model accuracy. Results show that our model can accurately predict grade variance at a sortable scale. The predicted grade variance at sortable scale can help stakeholders and engineers determine whether a deposit is sortable or not before installing bulk ore sorting sensors. Thus, the related decisions can be made from there. The methodology developed can be applied to other resources and may be used to estimate the potential returns of bulk sorting and hence whether it is likely to be economical. As more deposit and mining types have bulk ore sorting applications a comprehensive model can be developed for use in green field sites.

Keyword

Bulk ore sorting, Magnetic resonance, Variance, Sortability assessment, Cu deposit

Enhancing named entity recognition in geoscience by using a domain-specific schema

Sandra Paula VIILLACORTA CHAMBI[1]*, CSIRO (sandra.villacortachambi@csiro.au)
Mark Lindsay[2], CSIRO
Helen McFarlane[3], CSIRO
Klaus Gessner[4], Geological Survey of Western Australia
Erin Gray[5], Geological Survey of Western Australia

Abstract

Sparse or non-unique data, subjective or hyper-localised observations, and linguistic ambiguities have historically hindered communication or interrogation of geoscience-related concepts and models. In the context of mineral systems analysis, it is both scientifically and economically valuable to establish a coherent framework and vocabulary that precisely describes the geological phenomena and their relationships involved in ore deposit potential.

Accurate classification of geological entities is not only beneficial for enhancing human understanding of scientific research publications, but is pivotal for machine learning applications, such as summarising research papers in ways that enable swift and impartial analysis. Natural Language Processing (NLP) plays a critical role in this context, with Named Entity Recognition (NER) as a crucial NLP component. The efficacy of NER, however, is significantly influenced by the specific context of its application. In the geoscience domain, the successful implementation of NER requires additional support from tailored specialised ontologies and schemas. Moreover, the integration of advanced NER techniques, customised for the complex geoscience literature, is essential to optimise automated NER processes. Such optimisation is crucial for expediting the development of geoscience knowledge graphs, tools explored for enhancing the capability for rapid and objective analysis through visual representation.

This paper describes the development of a specialised geoscience schema aimed at improving the accuracy of geological entity classification. In this CSIRO Pilot project, we tested Flair, a proven effective algorithm in complex fields like medicine. The Flair NER accuracy was evaluated by analysing geoscience corpora obtained from Portable Document Format publications on iron deposits in Western Australia; using GeoIELite, a schema deployed to create geoscience knowledge graphs. This exercise provides insights into improving the precision of NER in geoscience and underscores the broader significance of standardised vocabularies in enhancing data management and analysis within geosciences.

Keyword

geological ontologies, named entity recognition, natural language processing, geoscience domain vocabulary

Identifying and Quantifying Indirect Trade Flows of Commodities

Jamie BRAINARD[1]*, US Geological Survey (jbrainard@usgs.gov)
Andrew Gulley[2], US Geological Survey
Nedal Nassar[3], US Geological Survey

Abstract

Tracking international mineral commodity trade is crucial for evaluating supply risk. Evaluations of mineral supply risk often consider import reliance on import partners as a measure of exposure to potential supply disruptions in those countries. However, inspection of United States (U.S.) import data reveals trade flows where reported import partners do not produce the relevant mineral commodity. These findings imply that these countries instead serve as intermediaries in an indirect trade network. The potential for trade to impact national policy necessitates identification of these discrepancies to more accurately capture the physical flow of goods. Here we develop a network analysis methodology to: 1) map indirect trade networks back to original producers, 2) quantify indirect trade, and 3) compare indirect trade with direct imports (as reported in the trade data). While this method could be applied to any mineral commodity (or other good), we apply it here to the supply chains for aluminum and antimony because of their inclusion on the 2022 U.S. Federal Critical Minerals list.

By using this method, in one instance we were able to increase the attribution of U.S. imports of antimony ores to mine producers by >77% over the reported direct imports in one study period. These results indicate that discrepancies between direct and indirect trade appear to correlate with the volume and value of commodities traded, with bulk commodities having less indirect trade. We also show how this methodology can be linked across multiple commodity forms moving downstream from mining. This approach enables us to better estimate the provenance of the initial mined material that has been later transformed via processing .

Keyword

Trade, Supply-chains, Critical Minerals

Leveraging Bayesian Hierarchical Models to Mitigate the Impact of Mineral Exploration Uncertainty on the Mineral Value Chain

Lequn ZHANG[1]*, CSIRO (lequn.zhang@csiro.au)
Mark Lindsay[2], CSIRO
Yufu Niu[3], CSIRO
Jingxu Jin[4], Macquarie University
Sandra Occhipinti[5], CSIRO

Abstract

The minerals value chain encompasses a broad spectrum of activities each contributing to the supply of metals sustaining global socioeconomic structures and supporting net-zero initiatives. These activities, such as mineral exploration, stockpiling, processing and selling in the end market, are subject to internal and external factors that affect the reliable and consistent supply of metals. The cumulative effect of these factors leads to significant uncertainty that impacts the final value of metal products.

Mineral exploration, the starting point of the minerals value chain, significantly influences subsequent stages by introducing uncertainty that affects decision-making and operational efficiency. This phase is crucial for developing resource models, which are essential for accurately capturing geological, mineralogical, and economic parameters of mineral deposits. These models are fundamental to mine planning and feasibility analysis, aiming to optimize extraction and enhance the economic value of mining projects. However, the complex nature of ore bodies, combined with the reliance on incomplete and often error-prone datasets, presents a substantial challenge, leading to increased uncertainty in resource estimation.

To address this challenges, this paper advocates the adoption of Bayesian Hierarchical Models (BHM) as a powerful tool for mitigating the uncertainties when model resource from mineral exploration data. Existing resource models often rely on grade and density estimates derived from a limited number of samples, which are seldom representative of the true geological heterogeneity of the mineral deposit. This lack of representativeness can lead to significant inaccuracies in tonnage estimates, potentially resulting in over- or underestimation of the available resources and directly impacting the economic evaluation and operational planning of the mining project. By using BHM model, the knowledge, such as lithology, alteration, block can be included in the models as the prior information, which provide a robust framework for the resource models.

A case study on a porphyry copper deposit illustrates the practical effectiveness of our proposed approach in a near-mine senarios. The results from this study demonstrate that the hierarchical model significantly reduces the resource model uncertainty, thereby enhancing the accuracy of resource estimation and improving the reliability of decision-making processes throughout the mineral value chain.

Keyword

Hierarchical Model, Uncertainty, Mineral Exploration, Mineral Value Chain

[Keynote] Fundamentals Enabling Integrated Mining Value Chains

Kerry TURNOCK[1]*, BHP (kerry.turnock@bhp.com)

Abstract

The mining value chain is a complex, multifaceted system that accounts for activities from resource identification through to closure. Whilst often represented simplistically, it spans a multitude of disciplines, behaves in a nonlinear fashion, and is required to support simultaneous decision making over different time horizons and spatial entities.

The integrity of the mining value chain is relative to its capability to predict, respond and react to a range of questions and requirements that support trade-off decisions between optimisation and execution. Maintenance of value chain integrity requires a high degree of integration which, in turn, is only successful when it is multidisciplinary and accounts for data, systems, processes, people, technology, and timescales.

Advancements in automation, simulation, artificial intelligence, robotics, and interoperable platforms in support of the mining value chain are continuing to define and redefine the way we do business. However, the aspiration to capture the benefits of these advancements can only be achieved when they are anchored to sound basics.

A common attribute of reliable, integrated mining value chains is that they are underpinned by robust fundamentals. These fundamentals include:
1. Timely, reliable and trusted data
2. Decision making capability that accounts for uncertainty and variability
3. Systems that are able to integrate and consume multidisciplinary inputs
4. Probabilistic planning and
5. Unbiased representation of the real world that has not been oversimplified.

Investing in the above fundamentals adds significant value for a mining operation. It enables design and planning optionality, improves our understanding of risk and supports rapid, confident and superior decision making across the entire value chain from exploration to closure.

Keyword

Integration, Mining, Value Chain

Overview of key Mineral requirements in the era of Intelligent vehicles: taking Software-defined vehicles as an example

Zizhan CHEN[1]*, CAGS (cdesignf1@hotmail.com)

Abstract

The rise of intelligent automotive technologies, particularly Software Defined Vehicles (SDVs), has prompted increasing demand for a range of critical minerals. These minerals—such as lithium, cobalt, copper, gallium, germanium and rare earth elements—are indispensable for manufacturing advanced automotive batteries, electric motors, and various electronic components integral to SDVs.

In the context of this surge in demand, this paper examines the relationship between the evolution of smart cars, specifically SDVs, and the consequent impact on global mineral resources. We start by mapping out the demand trends for crucial minerals necessitated by SDVs, dissecting the primary drivers behind this escalated need, including the proliferation of electric vehicles (EVs) and autonomous driving technologies.

These trends lead us to consider the implications for the mineral supply chain. Notable concerns in this sphere include potential supply risks, geopolitical tensions arising from the scramble for resources, and the environmental repercussions of increased mining activities. Additionally, we delve into sustainable strategies like the circular economy and mineral recycling, which have the potential to mitigate reliance on freshly mined resources and minimize environmental degradation.

The examination provided here aims to supply a comprehensive understanding of the key mineral demand landscape in the age of intelligent vehicles and proffers considerations for addressing the associated challenges. As technical advancements continue and policy landscapes evolve, strategies that focus on material efficiency, bolster recycling practices, and enhance supply chain transparency and resilience will be pivotal in ensuring sustainable supplies of these critical minerals.

Through this synthesis, we aspire to shed light on the pathways available for managing the demands of an industry at the forefront of technological innovation while considering the finite nature of the resources it relies on. With the continuous advancement of technology and the adoption of responsible resource management policies, a balance is achieved between the development of the intelligent automotive industry and the optimal utilization of critical minerals.

Keyword

software-defined vehicles (SDV), critical minerals, supply chain, electric vehicles (EVs)

Quantitative assessment of exploration criteria: A case study from the Yilgarn Craton in Western Australia

Mosayeb KHADEMI[1]*, Mineral Exploration Cooperative Research Centre (MinEx CRC) and University of South Australia (mosayeb.khademi_zahedi@mymail.unisa.edu.au)
David Giles[2], University of South Australia and Mineral Exploration Cooperative Research Centre (MinEx CRC)
Mark Lindsay[3], Mineral Exploration Cooperative Research Centre (MinEx CRC) and CSIRO - Mineral Resources
Caroline Tiddy[4], University of South Australia and Mineral Exploration Cooperative Research Centre (MinEx CRC)
Andrej Bona[5], Mineral Exploration Cooperative Research Centre (MinEx CRC)

Abstract

Mineral exploration requires a process to systematically reduce the exploration volume whilst maximizing the chance of success. Most exploration programs make volume reduction decisions in a qualitative way based on expert assessment of multiple, disparate datasets and geological concept. In this talk we present a quantitative method to assess the performance of key mineral exploration criteria using a case study from the Yilgarn Craton gold province in Western Australia.

We conducted Capture-efficiency and Receiver Operator Characteristic (ROC) analyses, seeking the exploration criteria which result in the maximum number of deposits per target volume. Capture-efficiency plots have axes of known deposits contained within the search criteria versus fractional volume (in this case simplified to area) of the search criteria. ROC plots have axes of "True Positive Rate" (known deposits contained within the search criteria) versus "False Positive Rate" (unsuccessful drill holes within the search criteria). We tested four regional-scale search criteria identified as the most useful by Witt et al. (2013), namely; i) within greenstone belts, ii) proximity to mafic granites, iii) increased fault density areas, and iv) proximity to fault bends. We also included proximity to maximum downhole Au grades >2 ppm for Witt et al. (2015), which is more appropriate to camp-scale exploration. The locations of known gold deposits were used as positive instances in the ROC analysis, while the locations of unsuccessful drill holes, outcropping and bedrock granites were set as negative instances.

In both the Capture-efficiency and ROC methods, the most effective search criteria (in scale order) were: inclusion within greenstone belts (30% area containing 94% known deposits), within 10 km of mafic granite (14% area, 58% deposits) and within 1 km of maximum downhole Au grades >2 ppm (15% area, 73% deposits).

Contrary to some popular exploration models, fault density and proximity to fault bends proved inefficient as search criteria. Maximum Capture-efficiency for these criteria occurred using buffer

distance of ~20 km, which is geologically unreasonable for faults. Given the well-established structural controls on gold mineralization in the Yilgarn, the poor performance of structural criteria in this study most likely reflects our inability to map faults and shear zones in an accurate and unbiased way.

The area under curve of the Capture-efficiency plots was consistently higher than for the ROC plots. This is a predictable outcome resulting from the assumption that any area outside the search criteria is a 'true negative' in the Capture-efficiency method, whereas only unsuccessful drill holes outside the search criteria are 'true negatives' in the ROC. Thus, the lack of drilling outside the known greenstone belts means that the large volume occupied by granite belts is 'untested' - as accurately illustrated in the ROC analyses. This highlights two challenges of 'data driven' mineral exploration techniques; 1) difficulties in areas of sparse or uneven data distribution and, 2) susceptibility to conceptual exploration models which result in sparse or uneven data acquisition, i.e., our conceptual models drive how we invest in surveys particularly in perceived lower exploration potential areas.

Keyword

Exploration Criteria, ROC Analysis, Area Selection, Model Validation, Yilgarn Craton

Phosphogypsum stacks from Năvodari (Romania) as secondary resource

Aurora Maruta IANCU[1]*, Geological Institute of Romania (iancu.maruta@yahoo.com)
Stefan MARINCEA[2], Geological Institute of Romania
Cristina SAVA GHINET[3], Geological Institute of Romania
Delia Georgeta DUMITRAS[4], Geological Institute of Romania

Abstract

The phosphogypsum (PG) stacks occupies significant areas in Romania: four important deposits, i.e., Turnu Măgurele, Bacău, Valea Călugărească and Năvodari (Romania), extends for more than 182 hectares. These deposits, in spite of their negative influence on the environment, constitute an important raw material resource, especially for road projects or plaster industry.

The phosphogypsum stacks from Năvodari are located westward from the homonymous town, on an area of 48 ha. They represent the by-product of a local phosphate fertilizer plant, now inactive.

The physical-chemical characteristics of the PG deposits depend on the composition and characteristics of the raw phosphate rock, and of the sulphuric acid used for attack. At Năvodari, the dihydrate process was used for PG production. The work temperature was of about 80oC, leading to the formation of H3PO4 acid with a P2O5 concentration between 28 - 32% and of phosphogypsum as by-product. The mineralogical composition of PG includes gypsum ($CaSO_4 \cdot 2H_2O$) and secondary brushite ($CaHPO_4 \cdot 2H_2O$) as main crystallized phases, with remnants of quartz and additional calcite issued by the lime added as acid compensator. The qualitative chemical composition of the main phase, resulted as average of 18 EDS point analyses, is (in wt.%): Ca = 45.33 – 66.20, (SO4)2- = 39.40 – 53.21, and (PO4)3- = 0.84 – 7.21. Chemical analyses by ICP-AES method mostly indicate siderophile elements such as V, Cr, Ni, Cu, Zn, Zr, Pb, Th. The presence of these elements can be correlated with the chemical composition of the raw phosphate rock, as well as with the presence of Fe and Al. These are derived at acid pH conditions from sesquioxides of initial phospathic mineral. Another series of elements such as Cd, Cr, Ba, Mg, Na and K can substitute Ca in gypsum structure.

ICP-AES chemical determinations of minor elements pointed out higher contents for Sr (800-1500 ppm), while the elements such as transitional metals have low contents: Cd: 1.0 – 2.2 ppm, Cr: 2.1 – 17 ppm, Ni: 1.8 – 7 ppm, Pb: 3.7 – 33 ppm, Zn: 12 -34 ppm. The REE+Y contents are relatively low: Er = 1.8 – 7.8 ppm, Y = 37 – 114 ppm and La = 15 – 140 ppm. Minor contents of Cu (43 – 142 ppm), Zr (46 – 160 ppm), Sc (0 – 12 ppm) and Co (3 – 32 ppm) were also detected. Taking into account that no harmful elements were detected and the radioactivity is low, we propose the use of the stack for road construction.

Keyword

phosphogypsum, chemical composition, Navodari, Romania, road construction

Geochemical fingerprinting of Cobalt and Nickel along the battery value chain: coupled information from trace elements and sulfur isotopes

Yuan Shang[1]*, Geological Survey of Finland (yuan.shang@gtk.fi)
Quentin Dehaine[2], Geological Survey of Finland
Xuan Liu[3], Geological Survey of Finland
Yann Lahaye[4], Geological Survey of Finland
Martina Bertelli[5], Geological Survey of Finland
Minna Myllyperkiö[6], Geological Survey of Finland
Sari Lukkari[7], Geological Survey of Finland

Abstract

Cobalt (Co) and nickel (Ni) are essential components in the cathode production of lithium-ion batteries. As the global electric vehicle market grows, the demand for Co and Ni in rechargeable batteries is rapidly rising. The Ni-Co supply chain is complex due to uneven geographic distribution of primary sources, the wide variability of deposit and ore types necessitating distinct refining processes and their manufacturing demands. The ability to identify the geographic origin of Ni and Co metals is critical to ensure a responsible value chain from ore to battery yet it is challenging due to complexity of the supply chain. Magmatic sulfide deposits are one of the primary sources for Ni and Co, and are mostly found in Canada, Australia, Russia as well as Finland. Finland also offers a close-loop value chain from mining and refining to recycling of batteries.

In this study, we analysed raw ores, mineral concentrates, as well as various metallurgical products sourced from a mine in northern Finland, which is a major Ni-Cu-PGE resource in the Central Lapland greenstone belt. We used a field emission scanning electron microscope (FESEM) to acquire high-resolution mineral feature maps and determine major to minor chemical compositions of the target minerals. Trace element contents and sulfur isotope ratios in sulfide grains, e.g., chalcopyrite, pyrite, pyrrhotite and pentlandite were then measured in-situ with laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Metallurgical processed samples such as solid residues and leachate solutions (evaporated to dry powders), iron-removed samples, and nickel sulphate powders, were prepared as pressed pellets and their trace elements and sulfur isotopic compositions were directly analysed in-situ by LA-ICP-MS. Finally, the trace element compositions and sulfur isotope ratios of these samples were compared by multivariate data analysis to extract robust fingerprints that possibly remained conservative along the value chain. The effect of extractive and refining metallurgy processes in altering geochemical signature of the original ore deposits are also evaluated. By a combined application of mineralogical and geochemical analytical techniques, we aim to develop a geochemical fingerprinting tool to trace Ni and Co from the original mining ores to the end products. The outcome of this research helps to improve transparency and sustainability of raw material supply along the battery value chain.

Keyword

Battery value chain, traceability, LA-ICP-MS, Co-Ni, critical raw material

Soil organic matter loss due to anthropogonic activities in settlement area in Forest steppe and Gobi region of Mongolia

Telmen TURMUNKH[1]*, Department of Earth and Environmental Sciences, Korea University (telmen808@gmail.com)
Ganzorig Ulgiichimeg[2], Institute of Geography and Geoecology, MAS
Seong-Taek Yun[3], Department of Earth and Environmental Sciences, Korea University

Abstract

Physical, chemical and biological properties of soil are closely related to soil organic matter (SOM) that considered one of the main indicators for soil health. Recent human activities contribute significantly to land degradation and soil erosion, particularly in urban areas due to the concentration of population, industry, and construction. Therefore, monitoring of SOM is needed as a simple and cost-effective way to assess land degradation and erosion. This study aimed to investigate the status of the SOM loss in settlement areas located within the climatically and topographically distinct, Forest Steppe and Gobi regions of Mongolia and compare the impact of urbanization on SOM across the contrasting Mongolian natural zones. To quantify SOM loss, surface soil samples were collected from seven settlement areas, alongside reference sites from fenced weather stations and near undisturbed areas. Our investigation revealed significant difference in SOM loss between natural zones. In the Gobi region, SOM loss ranged from 10% to 60% compared to reference sites, with an average decrease of 39% due to urbanization. The Forest Steppe showed a sharper decline, experiencing an average loss of 63%. While both regions have significant loss in SOM, the Gobi showed greater variation between settlements, with a coefficient of variation reaching 56%. This observation highlights more complex interactions of factors influencing SOM content in the Gobi region compared to the Forest Steppe. The inherently lower SOM content in the Gobi region (1.7%) compared to the Forest Steppe (3%) suggests a fundamental difference in ecosystem functioning between these regions. Soil organic matter loss provides general overview of land degradation in the two regions; however, it may not assess the full complexity of land degradation and soil erosion processes. To enhance understanding and achieve a more accurate assessment, this study suggests the integration of multiple soil properties and methodologies.
Acknowledgment: This study was supported by the Institute for Korea Spent Nuclear Fuel (SNF).

Keyword

Soil organic matter, soil erosion, land degradation, different natural zones, Mongolian settlement

Geometallurgy for the Energy Transition

Kathryn Goodenough[1]*, British Geological Survey (kmgo@bgs.ac.uk)
Richard Shaw[2], British Geological Survey
Eimear Deady[3], British Geological Survey

Abstract

In recent years, substantial focus has been placed on the critical raw materials, particularly those required for the transition to a decarbonised energy system. These include the battery raw materials, such as lithium, cobalt, graphite, nickel and manganese; the rare earth elements, used for high-strength magnets; and a variety of other metals required for electrification of energy systems. Although recycling approaches are developing rapidly, currently these raw materials are largely derived by mining of primary resources; and demand is expected to grow over the coming years, leading to investment in the opening of new mines. It is common for exploration companies to present ‘headline’ data on their resources in the form of grade and tonnage information, but for many of the critical raw materials, geometallurgical information is also essential. Energy transition technologies require high-purity mineral products, and processing routes to achieve this are variably developed for different ore minerals. Thus the details of ore mineralogy and texture are vital to the economics of critical raw material deposits, and description of mineral paragenesis is essential to the characterisation of any deposit. This talk will give an overview of some of the challenges in critical raw material supply chains, and will describe case studies that highlight the importance of geometallurgy.

Keyword

Critical raw materials, Energy Transition, Mineral paragenesis, Geometallurgy

The processing behaviour of the sphalerites from the Big Syncline deposit, South Africa

Gloria Boikanyo MOTLOBA[1]*, University of Johannesburg (beekay.motloba@gmail.com)
Albertus Johannes Smith[2], Department of Science and Innovation-National Research Foundation Centre of Excellence 5 in Mineral and Energy Resource Analysis, Department of Geology, University of Johannesburg
Karel Viljoen[3], Department of Geology, University of Johannesburg
Derek Rose[4], Mineralogy Division, MINTEK

Abstract

Big Syncline is the only one of the four Aggeneys-Gamsberg Ore District deposits of the Northern Cape Province of South Africa that remains unexploited. It comprises economic zinc > lead > copper mineralization. Future exploitation of this deposit requires a good understanding of the ore textures and mineralogy for beneficiation purposes. In accordance, two of the most commonly occurring mineralized units at Big Syncline, the mineralized pelitic schist and garnet-magnetite units, are investigated with regards to sphalerite petrography and mineralogy and its potential impact on zinc flotation recovery and grade.

Detailed optical petrographic analyses revealed three colour variations in the sphalerite: the opaque (i.e., black) and ruby-red varieties prevalent in the mineralized pelitic schist unit; and the honey-yellow variety more common in the garnet-magnetite unit. Scanning electron microscopy with energy-dispersive X-ray spectroscopy and electron microprobe analyses indicated increasing iron content from the honey-yellow to ruby-red to opaque sphalerite varieties. The latter two varieties were also observed to have elevated manganese contents. Overall, elevated manganese content was observed only in the mineralized pelitic schist unit, despite the minor occurrence of the ruby-red sphalerite variety in the garnet magnetite unit.

Laboratory-scale differential flotation was applied to the two mineralized units to determine their processing behaviour. Despite poor selectivity, the garnet-magnetite unit produced a bulk zinc concentrate of superior quality to the mineralized pelitic schist unit. However, the latter showed better selectivity with the bulk of the zinc reporting to the zinc concentrate. The reduced overall quality of the mineralized pelitic schist unit concentrate is attributed to the increased dilution associated with the high abundance of gangue sulphides in the flotation feeds as well as the higher contents of iron and manganese and lower zinc in the sphalerite. Furthermore, the higher manganese content in these sphalerites leads to higher manganese recovery in the zinc concentrates, which can lead to later processing problems during electrowinning. Compared to the mineralized pelitic schist, the garnet-magnetite unit has less gangue sulphides in the feed and higher zinc in sphalerite leading to better concentrate grade. Although the garnet-magnetite unit has higher manganese content in the feed, it is hosted in silicates, leading to substantial manganese rejection to the tailings.

Keyword

Sulphide ores, Differential flotation, Ore mineralogy, Grade and Recovery

Combination of geostatistical ore grade, RQD, and lithotype models for geometallurgical optimization of a tin deposit

Sylvie Rindraniaina RAHARISOLONJANAHARY[1]*, Kyoto University
(raharisolonjanahary.sylvie.66x@st.kyoto-u.ac.jp)
Katsuaki KOIKE[2], Kyoto University
Mohamad Nur Heriawan[3], Bandung Institute of Technology
Vitor Ribeiro de Sá [4], Kyoto University
Mochamad Slamet Sugiharto[5], PT Timah
Nur Rochman Nabawi[6], PT Timah
Anton Murtono[7], PT Timah

Abstract

Geometallurgic block models play a crucial role in optimizing mining operations, including metal production scheduling and cash flow management throughout the mine's lifespan. However, constructing accurate models for tin (Sn) mining operations faces challenges due to data scarcity and sparsity, leading to increased model uncertainty. This study proposes a methodology that integrates rock quality designation (RQD), lithologic, and geochemical information to address these challenges in Sn mining projects. By incorporating stochastic simulation methods such as sequential Gaussian simulation and indicator geostatistical techniques, we aim to improve the reliability of geometallurgic block models. RQD, a quantitative measure of rock quality, serves as a valuable indicator for detecting fracture zones, which are typically host to veins containing higher grades of Sn. Understanding the correlation between RQD and underlying geology is crucial for identifying areas of higher economic value and optimizing mineral exploitation. The study area, located in the Southeast Asia belt, is recognized for its potential Sn deposits. Utilizing data from 25 inclined boreholes, our research emphasizes the importance of integrating geostatistical methods with diverse data types to support informed decision-making in mining projects. This approach aims to minimize costs, maximize profitability, and enhance the sustainability of mining operations. In conclusion, the combination of geostatistical techniques and comprehensive data analysis holds significant promise for improving the efficiency and effectiveness of tin mining projects, ultimately contributing to the success and sustainability of the mining industry.

Keyword

Geometallurgy, tin mining, rock quality designation, stochastic simulation, Southeast Asia belt

A 2D predictive geometallurgical model of a tailings storage facility

Raimon TOLOSANA-DELGADO[1]*, Helmholtz Institute Freiberg/HZDR (r.tolosana@hzdr.de)
Lucas Pereira[2], Helmholtz Institute Freiberg/HZDR
Silum Teaghes Ghebreyesus[3], Helmholtz Institute Freiberg/HZDR
Max Frenzel[4], Helmholtz Institute Freiberg/HZDR
Duong Huu Hoang[5], Helmholtz Institute Freiberg/HZDR
Martin Rudolph[6], Helmholtz Institute Freiberg/HZDR
K. Gerald van den Boogaart[7], Helmholtz Institute Freiberg/HZDR
Jens Gutzmer[8], Helmholtz Institute Freiberg/HZDR

Abstract

Historical tailings storage facilities (TSFs) are being revisited everywhere in the World for their potential in commodities of recent interest, such as Indium, Lithium or REEs, as well as to mitigate their environmental risks. This interest has sparked the development of methods to quantify their value. In this contribution we present one such method for estimating both the grade and recoverability of target commodities, i.e. not just how much of the component is present in the tailings and where, but also how much is expected to be recovered with a specified minerals processing route.

The method exploits (i) particulate data from automated mineralogy systems (such as e.g. mineral liberation analysis, MLA) covering the TSF of interest, plus (ii) MLA analyses of the results of beneficiation tests on a handful of samples. A machine learning method (lasso regularised multinomial logistic regression) is trained on this second data set (ii) for predicting the chances of any particle to be recovered into the concentrate product as a function of its properties as measured by the MLA. This allows to calculate the expected proportion of mass of each component (both commodities and waste components) reporting to each output stream, not only for each MLA sample of the training set (ii) but also of the samples (i) from the TSF. These can then be interpolated with a geostatistical analysis.

We applied this framework to a TSF in the Ore Mountains, near Freiberg (Saxony, Germany). We applied an n-fold validation strategy, showing significant agreement between predictions and actually observed behaviour. This supports our claim that the proposed method has a strong predictive power.

Keyword

Tailings, Predictive Geometallurgy, Machine Learning, Geostatistics

Machine learning assisted geostatistical modelling of geometallurgical domains

Will Patton[1], BHP
Ute Anja MUELLER[2]*, Edith Cowan University (u.mueller@ecu.edu.au)
Emet Arya[3], Riotinto
Ilnur Minniakhmetov[4], BHP

Abstract

The spatial modelling of geometallurgical domains is important for the characterisation of an ore deposit allowing quantification of various rock types, their properties and the overall value of a project. To quantify uncertainty in the layout of various geometallurgical domains and ensure a proper representation of the heterogeneities in chemical and physical properties of the orebody, integrating machine learning techniques into geostatistical modelling workflows is becoming more common. Spatial machine learning techniques can be used to derive geometallurgical categories from multiscale, multiresolution and high dimensional measured rock properties. Here we show an application of the spatial random forest algorithm to define geometallurgical domains from geometallurgical test work data (oxide grades, mineral concentrations, and associated recoveries). The layout of geometallurgical domains and variabilities of associated rock properties are mapped with hierarchical truncated gaussian simulation. Geometallurgical properties in the form of size fraction recoveries can then be predicted using machine learning regression. Finally, uncertainties are quantified to assess risk following a confidence interval based framework. This approach can be used to identify zones of high uncertainty where collection of additional data might help mitigate or minimise risks and in turn improve forecast production performances.
The approach will be illustrated with an iron ore case study.

Keyword

Domaining, Uncertainty, Spatial data

Analyzing Refractory Gold and Deleterious Elements in Historical Witwatersrand Tailings: Implications for Gold Extraction Strategies

Steve Jason CHINGWARU[1]*, Stellenbosch University (stevejayce@gmail.com)
Bjorn von der Heyden[2], Stellenbosch University
Margreth Tadie[3], Stellenbosch University

Abstract

The Witwatersrand Basin, recognized as the world's largest gold province (containing 53,000 Au), has generated over 6 billion tons of mine tailings throughout its century-long mining history. As the basin has matured in gold production, these tailings are concurrently subjected to metallurgical processing alongside primary gold ores, utilizing traditional cyanidation techniques for gold extraction. Despite these efforts, the tailings persist as strongly refractory, with an estimated 1325-1855 tons of gold remaining in tertiary tailings. The complete mineralogical distribution of this remaining gold is not thoroughly understood. This research concentrates on extensively characterizing the refractory properties of gold-containing Witwatersrand tailings from various spatially diverse goldfields, employing physical separation coupled with mineralogical and chemical analyses. The findings indicate that the heavy mineral concentrate exhibits a higher gold concentration ranging from 0.71 to 10.12 ppm, whereas the light (< 2.95 g.cm-3) and slimes (< 10 μm) fractions show gold concentrations of 0.05-0.22 ppm and 0.17-0.76 ppm, respectively. Further in-depth in-situ analyses and leach tests of distinct mineral fractions suggest that the gold is enclosed within the tailings' mineralogy in the form of 'invisible' or 'solid-solution' gold, predominantly within pyrite and arsenian pyrites, with concentrations ranging from 0.01 to 2730 ppm, accounting for up to 420 tons of gold (approximately 31% of the total gold). Additionally, the tailings' sulphides harbor a significant concentration of detrimental and critical heavy metals (e.g., As, Ni, Co, etc.). The identification of invisible gold presents a potentially underutilized resource, constituting a substantial portion (50-70%) of the refractory nature of gold. The primary Witwatersrand ores are renowned for their native liberated gold, which elucidates the refractory nature of the residual re-dump gold during traditional extraction. The outcomes of this study carry implications for mining practices, economic considerations, environmental concerns, optimization of processing flowsheets, and insights into the origin of the Witwatersrand.

Keyword

Gemetallurgy, Witwatersrand, tailings, detrital pyrite, gold

ROLE OF IN-SITU TECHNIQUES IN IRON ORE MINERAL BENEFICIATION

Basanth Rath[1], NMDC Chattisgarh
P V SUNDER RAJU[2]*, CSIR-NGRI (perumala.raju@gmail.com)

Abstract

Banded iron formation (BIF) represents one of the most distinctive rock types that occurred widespread in space and time in the earlier part of the Precambrian in most of the shield areas of the world. India ranks 4th in terms of iron ore production with 246 million tons (MT) which is around 8% of the total iron ore production worldwide. High-grade ore consists of more than 62% Fe which mainly comes from Hematite (Fe-69.9%), Magnetite (Fe-72.4%), Goethite (Fe-62.9%), Limonite (Fe-60%) etc. As the demand for high-grade ore increases day by day, it can be estimated that the existing reserves may be exhausted in another 60-70 years. In Table 1 different minerals in varied ore types are shown and in such cases, the low and medium-grade ores (Fe-45%-62%) need to be utilized. To enhance the grade of any ore, the comminution process plays the main role in terms of creating an economically viable mineral beneficiation process. To achieve so, in-situ mineral characterization techniques such as light microscopy (LM), Scanning Electron Microscopy (EM), X-ray diffraction techniques, and Automated mineralogical techniques(Fig 1) help in getting sufficient and reliable data with accuracy and precisionin a very short time, the combination of various analytical techniques has been used and based on these data, suitable mineral beneficiation methods have been developed and adopted to a lab scale and pilot scale level and achieved the planned results which will be discussed during the presentation

Ore Types Mineral Presence

Eastern Iron Ore Deposit Central Iron Ore Deposit Southern Iron Ore Deposit South Western Iron Ore Deposit

Compact / Massive Ore Hematite, Goethite, Martite Hematite, Goethite, Martite Hematite, Goethite Hematite, Goethite

Hard Laminated Ore Hematite, Goethite, Martite, Gibbsite, Quartz Hematite, Goethite, Martite, Gibbsite, Quartz Hematite, Goethite Hematite, Goethite

Soft Laminated Ore Hematite, Goethite, Martite, Gibbsite, Quartz Hematite, Goethite, Martite, Microplaty Hematite, Gibbsite, Quartz Hematite, Goethite, Martite, Kaolinite Hematite, Goethite, Martite, Gibbsite, Kaolinite

Lateritic / Limonitic Ore Hematite, Goethite, Martite, Gibbsite, Siderite, Quartz Hematite, Goethite, Gibbsite, Kaolinite, Quartz Hematite, Goethite, Martite, Kaolinite Hematite, Goethite, Martite, Gibbsite, Kaolinite

Flaky Ore / Friable Ore/ Blue Dust Hematite, Martite, Quartz Hematite, Martite, Microplaty Hematite, Quartz Hematite, Martite, Microplaty Hematite, Quartz Hematite, Martite, Microplaty Hematite, Quartz

Banded Ore Banded Hematite Quartz (BHQ)-Hematite, Quartz and Banded Hematite Quartz

(BHJ)- Hematite, Jasper Banded Hematite Quartz (BHQ)-Hematite, Quartz Banded Hematite Quartz (BHJ)- Hematite, Jasper Banded Hematite Quartz (BHJ)- Hematite, Jasper
Shaleceous Ore Hematite, Goethite, Shale Hematite, Goethite, Shale Hematite, Goethite, Shale Hematite, Goethite, Shale

Keyword

Iron ore, Beneficiation, mineralogy, India, analytical

Forms of ore bodies in the Pirmirab mine

Anzor MAKHAMMATOV[1]*, Institut of Geology and Geophysics named after H.M.Abdullayev. (anzormb97@mail.ru)
Mirali Turapov[2], Institute of Mineral Resources
Gulnoza Karamatova[3], Institut of Geology and Geophysics named after H.M.Abdullayev
Mirkomil Kuyliev[4], Institute of Geology and Geophysics named after Kh. M. Abdullaev

Abstract

One of the main goals of Uzbekistan's geology is to expand its gold mineral base. Therefore, we have tried creating a multi-factor model of several gold mines, one of which is the Pirmirab mine. Scientists at the Central Research Geological Prospecting Institute of Non-ferrous and Noble Metals introduced the method of creation of a multi-factor model of deposits [1]. We used geological forecasting and prospecting methods combined with geophysical and geochemical databases. A new model based on the following materials was made: 1) Geological map of the Chadak mining area 1:25000; 2) Geological structure scheme of Chadak ore field. A geological structure model of the Pirmirab and a geological block diagram of southern Pirmirab were created. A geological scheme of the Pirmirab mine and a model of ore bodies (multifactorial)was designed [2]. The created model shows that ore bodies in the Pirmirab deposit are developed at about 2.5 km2 in the central part and 2 km2; in the south, they narrow to 1 km2 and less. Determining the ideal shape of ore bodies confirms their morphological models based on the ratio of length and thickness. They are divided into three classes: Class I - 0-150 m in length, 0-50 m in length and thickness ratio; Class II - 150-300 m in length, 50-100 m in length and thickness ratio; Class III - more than 300 m in length, more than 100 m in length and thickness ratio [1]. Ore bodies are morphologically different in Pirmirab. Plate-like, columnar, and apophysical bodies are standard. In terms of location, it is subparallel to the Chadakbashi fault. The analysis of the structural model of the ore bodies shows that the concentration of gold in closed bodies is higher than in others. In the Pirmirab deposit, the width of the formation of the ore bodies narrow from the top of the area to the depth. It can be concluded that - represents a connection of the ore body system with a standard root part. According to geochemical information, the strong correlation of gold and silver indicates the abundance of electrum minerals in the area.

References

1. M.K.Turapov, M.M.Pirnazarov, K.M.Valihojayev etc. “Creation of multifactor models of gold deposits in the Chatkal-Kurama region in order to optimize forecasting, prospecting and evaluation methods”. Tashkent, 1992.
2. R.X.Mirkamalov, I.M.Golovanov, V.V.Chirikin, L.P.Fadeicheva, G.X.Mirkamalova; I.B.Turamuradov etc. “Atlas of models of ore deposits in Uzbekistan”.State Committee of the Republic of Uzbekistan for Geology and Mineral Resources. State company “Scientific Research Institute of Mineral Resources”. “IMR”, 2010. -100 p

Keyword

forms of ore bodies, modeling gold mines, geologic maps, gold, electrum

Refractory gold ore characterization of the Bonanza-Sandy vein system, Maco Mine, Masara Gold District, Eastern Mindanao, Philippines

JILLIAN AIRA GABO-RATIO[1]*, University of the Philippines (jgratio@nigs.upd.edu.ph)
Hannagene Cleofe Dacillo[2], University of the Philippines
Kirk Justin Ramos[3], University of the Philippines
Paolo Aiman Ramirez[4], University of the Philippines
Zyrah Gwen Suaybaguio[5], Mapúa Malayan Colleges Mindanao
Juan Alex Vianne Amoroso[6], Apex Mining Co., Inc.
Gernelyn Logrosa[7], Mapúa Malayan Colleges Mindanao
Djoan Kate Tungpalan[8], University of the Philippines

Abstract

Gold mining plays a significant role in the Philippines minerals industry. One of the most productive gold deposits in recent years is the Bonanza-Sandy vein epithermal system in Maco Mine, Masara Gold District in Mindanao island. However, despite its long history of productive mineral extraction, more recent ores extracted in the area have been reported to become more complex, which presents metallurgical challenges. This study therefore focuses on examining the refractory gold ore characteristics of the Bonanza-Sandy vein by utilizing both conventional and automated mineralogical techniques.

The NW-trending Bonanza-Sandy Vein system has three main ore types: hydrothermal breccia, quartz sulfide and quartz-carbonate veins. The gangue minerals predominantly consist of quartz, calcite, rhodochrosite, white mica (muscovite-illite) and chlorite. Pyrite is the most dominant sulfide, and often occurs as fragmented grains or occasionally as pitted and elongated minerals. Associated with pyrite are sphalerite intergrowths, galena inclusions, and sparse chalcopyrite grains. The ore manifests either as gold-silver tellurides (typically hessite or petzite), as electrum minerals or more rarely as native gold grains. Mineral liberation analysis (MLA) data reveals that a significant proportion of gold ore (~90%) is binary-locked or ternary-locked within pyrite, sphalerite, and chalcopyrite. Only a small proportion of the gold grains are in a liberated state. The results also indicate that 80% of the gold grains are smaller than 12 microns in size. Further ore characterization from sequential extraction will provide additional insights into the nature of the refractory gold ores. These findings can hopefully provide significant input to enhance ore recovery and design more efficient extraction strategies.

Keyword

refractory gold, Masara Gold District, mineral liberation analysis

Controls on the formation of porphyry Mo, Cu and Au deposits in the Qinling Orogenic Belt, central China

Li TANG[1]*, China University of Geosciences Beijing (ltang@cugb.edu.cn)

Abstract

The Qinling Orogenic Belt (QOB) hosts one of the world-class porphyry Mo belts (proven Mo resource of 8.43 Mt), several porphyry-skarn Cu and Au deposits, and abundant barren granitoids. The Late Jurassic to Early Cretaceous mineralized and barren porphyry systems are broadly coeval and distributed in the eastern part of the QOB. The key factors controlling the porphyry fertility and diversity are not well understood, with magma source, magmatic water content, magma oxidation state, sulfur and halogen values, and nature of magma chamber, among other aspects. The fertile porphyries of Mo and Au deposits are characterized by enriched Sr-Nd-Hf isotopes, relatively low δ18O values of 4.58 to 8.65‰, abundant Neoarchean to Paleozoic inherited zircons and high apatite MnO contents, indicating a mixed magma sources from partial melting of the Neoarchean to Paleoproterozoic lower crust, subducted continental crust of the Yangtze Block and the metasomatized lithospheric mantle. The ore-forming porphyries of Cu (-Mo) deposits have depleted isotopic features and distinct magma source from partial melting of the Triassic juvenile lower crust with significant contribution of mantle derived mafic magma. We suggest that the lithospheric architecture and magma source are the primary controlling factors for the diverse Cu (-Mo), Mo (-W) and Au mineralization in Qinling. Chlorine and fluorine contents also show contrast between Cu-related and Mo-related porphyries, with the former being Cl-rich which is favorable for extraction and transportation of Cu, and the latter is F-rich which is crucial for porphyry Mo mineralization through lowering viscosity, promoting crystal fractionation and partitioning of Mo into fluid. The fertile porphyries in the Cu (-Mo) deposits have adakite-like Sr/Y ratios and high magmatic water content involving early amphibole fractionation and suppression of plagioclase fractionation. The less evolved porphyry Mo (-W) magma share similar geochemical features with the porphyry Cu (-Mo) and Au magmas, whereas the highly evolved porphyry Mo (-W) magma shows moderately high water content that cannot suppress plagioclase fractionation. The diverse porphyry Mo (-W) and Au mineralization with comparable magma source are controlled by the higher magmatic water content and oxidation state of the porphyry Au magma. The barren suites show overlapped Sr-Nd-Hf-O isotopes, whole rock Fe2O3/FeO ratios, zircon ΔFMQ and Ce4+/Ce3+ values, and apatite SO3 contents with the different types of fertile porphyries. The flat roof of the barren batholiths resulting in lack of fluid flow and focusing into a small volume could account for the barren porphyries, whereas the highly evolved late phase with favorable geometry would have higher potential for porphyry mineralization.

Keyword

Porphyry deposit, Magma source, Magmatic water content, Oxidation state, Qinling Orogenic Belt

GENETIC CLASSIFICATION OF SAUSAR GROUP, CENTRAL INDIA: A HOLISTIC APPROACH

SANJOY KUMAR SARKAR[1]*, MOIL Limited (sksarkar.moil@gmail.com)
M M Abdulla[2], MOIL LIMITED
A K Saxena[3], MOIL LIMITED

Abstract

Abstract: The manganese deposit located in Madhya Pradesh and Maharashtra, Central India is part of the Sausar Group and is well-known for its thick and bedded manganese deposit. Over the years, several attempts have been made to determine the origin of the Sausar Group. Different theories have been proposed to explain the genesis of the Sausar Group. Most researchers have suggested that the Sausar Group was formed through a metasedimentary process, while others believed that the manganese in the Sausar sequence originated from a volcanogenic source, followed by sedimentation and metamorphism. In this research paper, detailed studies were conducted on the manganese deposits of the Sausar Group, including Gumgaon, Kandri, Munsar, Tirodi, Chikla, Dongri Buzurg, Balaghat, and Ukwa, and various pieces of evidence were collected to shed light on the genesis of the Sausar Group.

To understand the genesis of the Sausar Group, several scientific studies were conducted, including field surveys, geological mapping, structural interpretation, sampling of ore mineral and associated rocks, and their petrological, mineralogical, and geochemical analysis. The study revealed that the manganese deposit of the Sausar Group is volcanogenic, involving both hydrothermal and volcano-sedimentary deposits in the formation of manganese ore, followed by sedimentation and metamorphism. The manganese ore of the Sausar Group is associated with jasper and is classified as a "Jasperiod Manganese Deposit" of volcano-sedimentary origin.

Keyword

volcanogene, Jasperiod, metasedimentary, volcano-sedimentary, gondite

Origin of fluids in the Lancangjiang tin belt, southwestern Yunnan, China: evidence from trace elements and boron isotopic compositions of tourmaline

Yiting ZHU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences
(yiting.z@foxmail.com)
Xiaofeng Li[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Yong Yu[3], Guilin University of Technology
David R Lentz[4], University of New Brunswick, Fredericton

Abstract

The Lancangjiang tin belt is located the eastern margin of the Tibetan Plateau, the northern segment of the Southeast Asia tin belt, which is known for its Sn, W, and base- metal deposits. Tourmaline alteration and high boron concentrations are typical features of the magmatic–hydrothermal systems of the Lancangjiang tin belt. Our new data for tourmaline intergrowth with cassiterite reveal complex geochemical features that provide valuable information on the origin of ore-forming fluids of this boron-rich tin belt. Most of tourmaline collected from the tin deposits and metamorphic rock all belong to the alkali-group dravite series, except some plot into X-vacant group. The composition of tourmaline differs among the ore districts, but all exhibit Fe-poor (0.61–1.08 apfu and Mg-rich (1.43–2.06 apfu) compositions, with Fe/(Mg+Fe) values in the range 0.18–0.46. Most trace elements in tourmalines exhibit lower concentrations <50 ppm, including large-ion lithophile elements (e.g., Cs and Ba), and high-field strength elements (e.g., Nb, Ta, Hf, Th). However, some trace elements [e.g., Zn (17–278 ppm), Sr (6–1240 ppm), V (7–1685 ppm), and Sn (2–1359 ppm)] exhibit high concentrationsof up to several hundreds or thousands of ppmin the tourmaline. The δ11B values of tourmaline from tin deposits range from −14.7 to −11.3‰, except for those tourmalines in the Man Makhsan tin deposit, which range from −12.0 to -8.1‰, but they are all largely overlap the δ11B values of the S-type granite and tourmalines from tin deposits worldwide (−18 to −7‰). The δ11B values (−14.7 to −8.1‰) and the positive correlation between Sn content and ratios of Nb/Ta, Al/Ga, and K/Cs in ore-related tourmaline indicate that the exsolved ore-forming fluids come from highly fractionated S-type granitic magma, which are mainly B-, Sn-, and Al-enriched fluids. We concluded that the lower ratio of Fe/(Mg+Fe), higher oxygen fugacity, and aluminum saturation of tourmaline are beneficial for cassiterite precipitation, as well as an indicator for the ore-forming potential of larger scale tin deposit systems.

Keyword

Tourmaline, Geochemical composition, δ11B value, Source of fluids, Lancangjiang tin belt

Investigating Chodarchay porphyry-epithermal deposit, NW Iran: Using EPMA and fire-assay minor/trace element data

Majid GHADERI[1]*, Tarbiat Modares University (mghaderi@modares.ac.ir)
Seyed Hedayatalah Mousavi Motlagh[2], Tarbiat Modares University
Narges Yasami[3], Tarbiat Modares University
Francisco Javier González[4], Geological Survey of Spain (IGME-CSIC)

Abstract

The principal purposes of this investigation are to determine sulfide and sulfosalt hosts for precious metals, and other valuable trace elements and to find the Ag partitioning trends among coexisting sulfosalts and between sulfosalts and sulfides at the Chodarchay deposit in the Alborz belt, NW Iran. The Chodarchay is the only porphyry-epithermal mineralization in the Alborz, so investigating the genetic model for the deposit using the chemistry of minor and trace elements is particularly important. Evaluating minor/trace element (not only Au and Ag but also other strategic and critical metals) distribution in sulfides and sulfosalts enables distinguishing among the elements present in a solid solution and the micro-scale inclusion of other minerals. Electron Probe Micro Analysis (EPMA) and fire-assay trace-element data are presented for base metal sulfides, accompanying sulfosalts, and other minerals at the Chodarchay. Discovered Bi–sulfosalts include cuprobismutite group minerals (cuprobismutite, hodrushite, and paderaite), aikinite–bismuthinite series (aikinite and friedrichite), emplectite, makovickyite, galenobismutite, gustavite, heyrovskyite, neyite, cupropavanite; and As-Sb-bearing Cu sulfosalts (watanabeite and colusite). The Au-Ag occurrence was reported from the neyite, emplectite, and gustavite. Sphalerite is the only Au host mineral among the sulfides as a nano-mineral phase. Silver hosted inside Cu-(Fe) sulfides as a solid solution, the significant part of them are chalcopyrite and Ag-rich Bi-sulfosalt micro-inclusions inside the chalcopyrite. The Ag-rich minerals crystallize from fractionated fluids that cooled during rising. The Ni concentrations in the pyrite imply that it was sourced from mantle mafic-ultramafic rocks. Bismuth assemblages precipitated at >350°C, and the cuprobismutite group at >300°C. The fluid temperature for the Ag and chalcopyrite precipitation is from 200 to 350°C and the sphalerite Fe/Zn ratios show that it was precipitated between 220 and 280°C. The supergene process and rare secondary enrichment of Ag and Au took place in the oxidation zone; this enrichment is dependent on the presence of manganese, so the concentration of gold is greater at shallower depths. The mentioned temperatures confirm porphyry-epithermal types and different stages of mineralization in the deposit, from the medium-high temperature hydrothermal (linked to mantle contribution) to an epithermal system with a surface supergene deposit.

Keyword

Bi-sulfosalts, Trace elements, EPMA, Porphyry-Epithermal, Iran

Magmatic-Hydrothermal Evolution at the Kuh-e Janja Porphyry Cu-Au Deposit, Southeastern Iran: Relative Timing of Hypogene Cu Mineralization from Vapor-Like, Near-Critical Density, Single-Phase Fluids

Majid SOLEYMANI[1]*, School of Geology, College of Science, University of Tehran, Tehran P94W+294, Iran (soleymani.majid12@gmail.com)
Shojaeddin Niroomand[2], School of Geology, College of Science, University of Tehran, Tehran P94W+294, Iran
Thomas Monecke[3], Center to Advance the Science of Exploration to Reclamation in Mining, Department of Geology and Geological Engineering, Colorado School of Mines, 1516 Illinois Street, Golden, Colorado 80401, USA
T. James Reynolds[4], FLUID INC., 1401 Wewatta Street #PH3, Denver, Colorado 80202, USA
Abdrorrahman Rajabi[5], School of Geology, College of Science, University of Tehran, Tehran P94W+294, Iran
Shahrokh Rajabpour[6], Instituto de Geología Económica Aplicada (GEA), Universidad de Concepción, Casilla 160–C, Concepción, Chile

Abstract

The Kuh-e Janja porphyry Cu-Au deposit is located 60 km southeast of Nehbandan in southern Iran, within the northern part of the Sistan Suture Zone. Several distinct stockwork vein types are recognized, differing in morphology, vein mineralogy, and associated alteration type. Early biotite (EB) veins containing biotite and minor amounts of quartz, magnetite, and anhydrite form the earliest veins. They are crosscut by A veins that are typically several millimeters in thickness and associated with potassic alteration envelopes. The abundant A veins at Kuh-e Janja consist of Q1 quartz that shows textural evidence for extensive recrystallization. Primary oscillatory growth zoning is rarely preserved in Q1 grains. Fluid inclusions in the quartz have been affected by post-entrapment modification. The A veins are interpreted to have formed at high (≳500°C) temperatures at lithostatic pressures. AB veins contain euhedral Q2 quartz crystals that have grown perpendicular to the vein walls within vugs. Molybdenite occurs as ribbons in recrystallized Q1 and Q2 quartz or as an infill in open spaces between the euhedral Q2 quartz crystals. The euhedral Q2 quartz crystals show well-developed sector and oscillatory growth zoning and are characterized by hypersaline liquid-rich and coexisting vapor-rich fluid inclusions that were entrapped at temperatures below ~500°C at the transition from lithostatic to hydrostatic pressure conditions. The AB veins formed at conditions of K-feldspar stability. Zones of high Cu grades at Kuh-e Janja are typified by the presence of abundant hairline fractures coated by chalcopyrite, pyrite, and minor molybdenite. These C veins are surrounded by minor chlorite alteration of the host rocks and crosscut all earlier vein types. The contacts between the early Q1 and Q2 quartz grains and chalcopyrite are irregular in shape. Chalcopyrite crosscuts the primary oscillatory zoning of the Q2 quartz grains suggesting that sulfide deposition occurred under conditions of retrograde quartz solubility. Wallrock or hydrothermal biotite in contact with chalcopyrite is frequently chloritized. Vapor-like single-phase fluid inclusions occur along healed microfractures hosted by euhedral Q2 crystals that are in contact with chalcopyrite in C vein. As many of the

fluid inclusions host small triangular opaque phases interpreted to be chalcopyrite, the vapor-like, near-critical density, single-phase fluid likely was the ore-forming fluid. Late D veins containing variable proportions of pyrite and quartz are surrounded by texturally destructive sericite alteration envelopes of the host rocks. Q3 quartz contains primary and secondary liquid-rich fluid inclusions entrapped at hydrostatic pressure conditions. Rare polymetallic E veins at Kuh-e Janja contain Q4 quartz, sphalerite, galena, and minor chalcopyrite. The study of the different vein types suggests that hypogene Cu mineralization at Kuh-e Janja occurred after potassic alteration of the host porphyry at temperatures close to the ductile-brittle transition. The mineralization formed from vapor-like, near-critical density, single-phase fluids along hairline fractures during their escape from lithostatic to hydrostatic conditions.

Keyword

Porphyry Cu-Au deposits, Timing of mineralization, Hydrothermal alteration, Kuh-e Janja, Iran

[Keynote] Rare metal deposits related to magmatic hydrothermal processes in China

Shao-Yong JIANG[1]*, China University of Geosciences (Wuhan) (shyjiang@cug.edu.cn)
Hui-Min Su[2], China University of Geosciences (Wuhan)
Zhenpeng Duan[3], China University of Geosciences (Wuhan)
Lu Zhang[4], China University of Geosciences (Wuhan)

Abstract

Rare metals including Lithium (Li), Beryllium (Be), Rubidium (Rb), Cesium (Cs), Zirconium (Zr), Hafnium (Hf), Niobium (Nb), Tantalum (Ta), Tungsten (W) and Tin (Sn) are important critical mineral resources. The distributions of rare metal deposits in China are mainly in several orogenic belts, namely, the Central Asian orogenic belt (the Altay and Southern Great Xingán Range regions); the Qilian–Qinling–Dabie orogenic belt (the Middle Qilian, South Qinling and East Qinling mountains regions); the Kunlun–Songpan–Garze orogenic belt (the Western Sichuan and Bailongshan–Dahongliutan regions), and also in the South China Block (the Northeastern Jiangxi, Northwestern Jiangxi, and Southern Hunan regions).

The major types of rare metal deposits in China include the highly fractionated granite type; pegmatite type; alkaline granite type; carbonatite and alkaline rock type; with minor amount of volcanic rock type and hydrothermal alteration or vein type. All of these types are genetically related to magmatic hydrothermal processes. The highly fractionated granite-related rare metal deposits (mostly Nb-Ta-Li-Be-Rb-Cs-W-Sn) are widespread in China, particularly in the South China, such as Jiangxi province (Yashan, Huangshan, Songshugang), Hunan province (Xianghualing, Jianfengling, Zhengchong, Renli) and Guangxi province (Shuiximiao, Jinzhuyuan), which were formed mostly during the Yanshanian 160–120 Ma, with a few in the Indosinian during 240–200 Ma. These deposits are mostly related to the high degree of fractional crystallization processes of the granitic magma and the formation of ore minerals are largely concentrated in the last magmatic stage (particularly the Nb-Ta-Li-Be-Rb-Cs) and transition to early hydrothermal stages (particularly the W-Sn). The important pegmatite-related rare metal deposits include the recently found Renli deposit in Hunan province, the Jiajika and Lijiagou deposits in Sichuan province, the Bailongshan and Dahongliutan deposits in Xinjiang. Most of these deposits have been considered as the highly evolved products of S-type granitic magmatic differentiation where the magma originate from marine sedimentary materials. However, direct anatexis origin for some of these rare metal pegmatites has also been proposed, such as the Keketuohai No 3 pegmatite in Xinjiang, western China. The most representative example of the alkaline granite type rare metal deposit in China is the super-large Baerzhe Zr–REE–Nb-Be deposit in the Southern Great Xingán Range region of Inner Mongolia, with the formation of ore minerals mostly during the magmatic stage but has a strong melt-fluid interaction during the ore-forming processes.

In addition, there are also new types of rare metal deposits recently found in China, including the Leptynite type and Breccia pipe type. The former is represented by the Yushishan Nb–Ta–(Zr–Hf–REE) deposit in Middle Qilian orogenic belt that was genetically related to magmatic and metamorphic hydrothermal activity, and the latter is represented by the Weilasituo Li–Rb–Sn–W–Zn–Pb deposit in the Southern Great Xingán Range region, which has a typical magmatic hydrothermal origin.

Keyword

Rare metal deposits, enrichment mechanism, geochemical characteristics, granite-pegmatite system, China

Iron-oxide apatite deposits formed by accumulation of magmatic hydrosaline liquids

Xin-Fu ZHAO[1]*, China University of Geosciences (Wuhan) (xfzhao@cug.edu.cn)
Li-Ping Zeng[2], China University of Geosciences (Wuhan)
Wang Liao[3], China University of Geosciences (Wuhan)
Yi-Zhe Fan[4], China University of Geosciences (Wuhan)

Abstract

Iron oxide-apatite (IOA or Kiruna-type) deposits typically consist of a magnetite-apatite-actinolite/diopside assemblage and are spatially associated with extensive Na-(Ca) alteration and breccia. The origin of these deposits is highly controversial and has been ascribed to the separation of iron-oxide/sulfate-(carbonate) melts, magnetite emulsions, or replacement of aqueous fluids from silicate magmas. Here, we propose a new model based on the findings from a cluster of IOA deposits located in the early Cretaceous Ningwu andesitic volcanic field, eastern China. The Ningwu volcanic field in the Middle-Lower Yangtze River Valley metallogenic belt, Eastern China, hosts tens of Mesozoic IOA deposits. These deposits have mineral assemblages typical of actinolite (diopside)-apatite-magnetite. They occur as coarse-grained veins, massive replacement, and fine-grained disseminations in the albitized, often brecciated, apical zones of diorite porphyry intrusions, the overlying andesites, and adjacent sedimentary rocks. The orebodies are mainly hosted within the apical zones of the shoshonitic dioritic intrusions and/or at the contacts between the intrusions and overlying country rocks. The intrusions commonly have porphyritic textures and are compositionally similar to the overlying andesitic volcanic rocks suggesting they were formed at a shallow subvolcanic setting.

Magnetite mineralization was closely associated with extensive hydrothermal alteration zone of several km in diameter. The inner alteration zone within the intrusion is characterized by extensive albitization of albite and scapolite. It was gradually transitioned to an intermediate zone dominated by diopside/actinolite, epidote, apatite, and chlorite. The outer zone has extensive carbonate veins with possible abundant pyrite. Precipitation of magnetite was slightly later than albitization and was likely coeval with apatite and actinolite suggesting they are formed by metasomatic replacement.

The primary magnetite grains from ores with various textures contain similar and variable trace element compositions with up to 5wt.% Ti + V, and show characteristics of high-temperature hydrothermal magnetite in magmatic-hydrothermal systems. Diopside and garnet as well as magnetite contain fluid inclusions with multiple daughter minerals (vapor+halite+sylvite±anhydrite± iron chloride±liquid±hematite), which show extremely high salinities up to ~90 wt.% NaClequiv and homogenization temperatures of ~800℃. In combination with oxygen isotopes of the magnetite-apatite assemblage and the association of shallow-seated ore-hosting porphyry, available evidence suggests that these deposits formed from hydrosaline liquid exsolved from subvolcanic diorite porphyry intrusions at magmatic temperatures. The

hydrosaline liquids were likely in equilibrium with silicate melts during the magmatic-hydrothermal transition. Fluid expansion and evolution of such unusual hydrosaline system is responsible for the extensive Na-Fe alteration and brecciation, which is characterized in IOA deposits.

Keyword

Iron-Oxide Apatite deposits, hydrosaline liquid, Ningwu volcanic field, Magmatic-hydrothermal system, magnetite composition

Lead-lead dating reveals Permian granite-induced high-grade niobium mineralization at Bayan Obo

Lan YANG[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (geoarya@outlook.com)
Yang Li[2], School of Earth and Space Sciences, Peking University
Yu Liu[3], Institute of Geology and Geophysics, Chinese Academy of Sciences
Xiao-Xiao Ling[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Li-Guang Wu[5], Institute of Geology and Geophysics, Chinese Academy of Sciences
Yan Yu[6], Institute of Geology and Geophysics, Chinese Academy of Sciences
Li Yang[7], Mining Research Institute, Baotou Iron and Steel (Group) Co., LTD
Wen-Xiang Meng[8], Mining Research Institute, Baotou Iron and Steel (Group) Co., LTD
Guo-Ying Yan[9], Mining Research Institute, Baotou Iron and Steel (Group) Co., LTD
Xian-Hua Li[10], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The Bayan Obo deposit hosted by the H8 dolomite is a world-class rare earth element (REE) deposit with considerable niobium (Nb) and iron (Fe). Permian granites are widely exposed in the mining area and have a close spatial association with Nb mineralization. Whether the granites contributed Nb, or only remobilized existing mineralization is important for understanding the controls of ore formation. Previous studies mostly focused on REE, whereas research on Nb has been limited. This is mainly due to the difficulty of accurately determining the age of the Nb mineralization, namely the fine-grained and texturally complex nature of Nb-bearing minerals with exceptionally low U. Although microbeam techniques show promise to tackle the aforementioned challenges, its application is hampered by matrix effects caused by the diverse composition of Nb-bearing minerals. Here we report the application of a high-precision secondary ion mass spectrometry (SIMS) Pb-Pb isochron approach that enables young samples (i.e., <500 Ma) to be dated without matrix-matched reference materials. A variety of Nb-bearing minerals from eastern Bayan Obo were analyzed, yielding Pb-Pb isochron ages of 276 ± 10 Ma (pyrochlore, 394–6864 ppm U in the rim and 6563–19858 ppm in the core), 277 ± 36 Ma (fersmite, 18–61 ppm U; fergusonite-Ce, 45–95 ppm U), and 257 ± 46 Ma (aeschynite, 342–1006 ppm U). In combination with the deposit geology and petrographic observations, these ages link the high-grade Nb mineralization to Permian granites (271 ± 1 Ma). Although these granites are not particularly rich in Nb, skarn formation during their emplacement could have remobilized the existing Nb mineralization, which would also have increased the grain size of the Nb-bearing minerals facilitating their extraction. Our study shows that high-precision SIMS Pb-Pb analysis holds promise for directly dating mineralization without matrix-matched reference materials, and the new results emphasize the need to consider the role of the metal re-enrichment for exploration and extraction at Bayan Obo and elsewhere.

Keyword

niobium mineralization, Pb-Pb dating, skarn deposit, Bayan Obo

Overlapping Alkalic Porphyry Cu-Au and Magnetite-Apatite mineralization in the Iron Mask Batholith, British Columbia, Canada

Andres Felipe GONZALEZ DURAN[1]*, University of Michigan (andresfg@umich.edu)
Adam Simon[2], University of Michigan
Robert Holder[3], University of Michigan
John Thompson[4], PetraScience Consultants
Devin Wade[5], New Gold Inc.
Catherine Ryan[6], New Gold Inc.

Abstract

The coexistence of porphyry-style mineralization and Iron Oxide Apatite (IOA) mineralization is a rare geological phenomenon documented sparingly worldwide. The Quesnel terrane, a mineral province in British Columbia, Canada, is recognized for hosting several late Triassic to early Jurassic alkalic intrusions genetically associated with porphyry deposits. These deposits exhibit significant Cu-Au-(PGE) mineralization, characterized by an elevated presence of magnetite. In particular, the Iron Mask Batholith hosts multiple Cu-Au deposits with abundant magnetite, particularly in massive lodes, as well as magnetite-rich orebodies, challenging conventional understanding of magnetite's role within the porphyry mineral system. This study explores the nature of magnetite mineralization in the Iron Mask Batholith, conducting a comparative analysis with similar deposits in British Columbia. Field observations and mineral chemistry reveal that magnetite lodes, containing apatite and actinolite, predate the Cu-Au mineralization stage, forming at higher temperatures. Notably, magnetite-apatite-actinolite lodes in several locations were not overprinted by Cu-Au-rich mineralization. This contrasts with areas such as New Afton, Ajax, and Copper King, where magnetite spatially coexists with Cu-Au mineralization. The massive magnetite lodes unaffected by Cu-Au mineralization exhibit distinctive features, including pegmatite-like zones, colloform magnetite, and symplectites with magnetite and Ti oxides, commonly associated with IOA deposits elsewhere. In contrast, the magnetite found in contact with porphyry Cu-Au mineralization exhibits extensive textural evidence of fluid-mediated re-equilibration. Additionally, the Cu-Au stage also formed coevally with some disseminated and veinlet-type magnetite, introducing complexity to the understanding of these systems. Unlike other alkalic porphyry deposits in British Columbia, with significant magnetite content, the Iron Mask Batholith's deposits are characterized by magnetite and apatite lodes partially superimposed by later Cu-Au-Fe-PGE-rich fluids. This unique feature, exclusively observed in the Iron Mask Batholith so far, prompts intriguing questions about the potential genetic link between the two mineralization styles during the magmatic-hydrothermal evolution of the Quesnel terrane.

Keyword

Porphyry, IOA, Magnetite, Canada

Recycled fluids in magmas of continental-collisional porphyry Cu deposits: Insights from mercury isotopes

Bo XU[1]*, China University of Geosciences (Beijing) (bo.xu@cugb.edu.cn)

Abstract

The sources of fluids and metals in ore systems in continental-collision settings are not well known. Mercury isotopes displaying unique mass-independent fractionation (expressed as Δ199Hg), may provide important constraints, given that Hg is a highly volatile metal and an important component of hydrothermal fluids. Here we report new Hg-isotope data on ore-forming porphyries, barren magmatic rocks, and mantle-derived mafic magmas from southern Tibet. The fertile porphyries and coeval mafic magmas display mainly positive Δ199Hg values (up to 0.25‰), while Δ199Hg values in barren magmatic rocks and mafic magmas are largely negative (Δ199Hg: −0.54 to 0.00‰). The positive Δ199Hg values observed here are consistent with previous results on seawater and marine sediments, suggesting that the fluids involved in the genesis of post-subduction porphyry copper deposits (PCDs) were derived from mantle lithosphere metasomatized by previous oceanic subduction. Recycled marine materials contain abundant volatiles (e.g., Cl, S and H2O), and we infer that the initial enrichment of these volatiles in magma sources, a key step in the formation of giant PCDs in continental collision zones, reflects refertilization of the subcontinental lithospheric mantle by slab-derived fluids. The Hg-isotope data record this mantle enrichment, and provide an alternative view to current enrichment models that focus on melting of the lower crust.

Keyword

mercury isotopes, southern Tibet, recycled marine sediments, porphyry copper deposits

FELSIC VOLCANIC HOSTED COPPER-GOLD MINERALIZATION AT MUNDIYAWAS-KHERA AREA, ALWAR BASIN, WESTERN INDIA: A PROSPECTIVE MODEL FOR EXPLORATION

ISRAIL KHAN[1]*, GEOLOGICAL SURVEY OF INDIA (israilkhan@rediffmail.com)
Prabodha Ranjan Sahoo[2], IIT (ISM), Dhanbad
Janmejaya Sahoo[3], Geological Survey of India
Shahina Siddiqui[4], Geological Survey of India
Manashree Mishra[5], Geological Survey of India
Pradeep Kumar Jena[6], Geological Survey of India

Abstract

The semi-concealed Mundiyawas-Khera copper-gold deposit in Alwar Basin, western India, is hosted by a sequence of volcanic and volcaniclastic rocks of the Proterozoic Delhi Supergroup. The litho types exposed in the study area are represented by felsic volcanic of rhyo-dacite composition interlayered with sedimentary sequences composed of quartzite, carbon phyllite and dolomitic marble intruded by numerous quartz and carbonate veins. Sporadic surface indications of copper mineralization have been identified in the form of malachite stains, Olivenite, Conichalcite and occasional fresh specks of chalcopyrite, arsenopyrite and pyrrhotite. The sulphide mineralization viz. chalcopyrite, arsenopyrite, pyrrhotite and minor pyrite mainly occurs in the form of disseminations, streaks, stringers, veinlets, fracture fillings and occasional as massive form. Both syngenetic mineralizations occur as fine disseminations within the felsic meta volcanic rocks and the epigenetic remobilized sulphide veins are preserved in the area. Petrographic studies of the host rocks show chalcopyrite as the principal copper ore mineral alongside pyrrhotite, arsenopyrite, pyrite and minor sphalerite. The rare mineral assemblages include cubanite, pentlandite, Bi, native gold (Au) to electrum, glaucodot, makovickyite and bravoite. EPMA studies of the ore sections reveal the presence of Au-Ag in the form of alloy (1:1 ratio), nugget gold, Ag-Au-Bi alloy and Ag-Au-Bi-Te alloy.

Sulfur isotopic studies of the core samples from the study area shows δ34SVCDT(‰) values for sulfide mineral samples from Mundiyawas-Khera show a range from -7.62 ‰ to + 7.10 ‰ with an average value of +3.42‰ with signatures of more or less similar to Precambrian VHMS (volcanic hosted massive sulfide) type deposits. The δ34SVCDT(‰) values closer to zero indicates magmatic/ igneous (volcanogenic) source / deep homogeneous source/ mantle source for the sulfide mineralization which is recorded in case of VHMS deposits. Hydrothermal alteration from the study area is well preserved in the form of the development of rich sulfides along with scapolite, tourmaline, tremolite, carbonate, sericite, epidote and chlorite. Hence, a strong hydrothermal activity is recorded at the Mundiyawas-Khera area supported by spaceborne mapping with well-defined hydrothermal alteration zones using SWIR bands of ASTER. Fluid inclusion micro thermometry results suggest a temperature range of 280°C to 320°C pointing towards an epithermal to mesothermal type deposit.

Exploration has established the presence of economically viable high tonnage low grade copper-gold-silver deposit at Mundiyawas-Khera deposit with a proven indicated ore resource of 40.49 Mt @ 0.37% Cu; 4.19 Mt@0.80 g/t Au and 2.71 Mt@ 7.07 g/t Ag respectively over a cumulative strike length of 1705 m. Host rock association, hydrothermal alteration, nature of mineralization augmented with mineralogical data predicts the mineralization to be VHMS type mineralization in the Mundiyawas-Khera area. Hence, the present understanding of the control of mineralization and metallogenesis of the copper-gold mineralization in the area will lead to new avenues for exploration strategies in a similar geological milieu.

Keyword

Hydrothermal ore, Rhyolite, Copper, Gold

Evolution of pyrite and Cu-Fe-sulphides in the Olympic Dam Cu-U-Au-Ag deposit, South Australia: Evidence from micron-scale EBSD study coupled with LA-ICP-MS analysis

Samuel Anthony King[1]*, University of Adelaide (samuel.king@adelaide.edu.au)
Nigel John Cook[2], University of Adelaide
Cristiana Liana Ciobanu[3], University of Adelaide
Kathy Ehrig[4], University of Adelaide, BHP Olympic Dam

Abstract

The world-class Olympic Dam iron-oxide copper gold (IOCG) deposit, South Australia, displays inwards and upwards zonation of Cu-Fe-sulphides from pyrite-chalcopyrite, bornite-chalcopyrite, to bornite-chalcocite assemblages, interpreted as a preserved primary feature. The deposit is hosted within the Olympic Dam Breccia Complex that formed dominantly in association to the ~1.6 Ga Roxby Downs Granite. Mineralisation is penecontemporaneous with the host intrusion and includes lower-grade disseminations throughout an area of brecciated and altered granite (outer shell) surrounding the resource.

This study aims at understanding the extent to which superimposed tectonothermal events have modified the mineralogy of the deposit since initial formation. Abundant evidence for fluid-assisted mobilization, recrystallization, and phase transformation, is identified in other mineral groups yet is generally believed to be obliterated in Cu-Fe-sulphides. To test this hypothesis, electron backscatter diffraction (EBSD) is employed to reveal microstructures alongside laser-ablation inductively-coupled-plasma mass spectrometry (LA-ICP-MS) element mapping on the same grains to relate microstructures to trace element (re)distribution. We compare pyrite, a refractory mineral that readily retains evidence of superimposed deformation, with chalcopyrite, a softer sulphide commonly associated with either pyrite or bornite.

Pyrite forming representative disseminated assemblages in the outer shell preserves evidence for two stages of ductile behaviour between intermittent fracturing. Pyrite displays compositional zoning with respect to As, Co, and Ni that has been disrupted by microstructures. Such microstructures correlate with domains enriched in Ag-Au-Pb-Bi-Te. Analysis was performed on chalcopyrite representative of the outer chalcopyrite-pyrite margin of the deposit, as well as the chalcopyrite-bornite zone. The first case shows chalcopyrite with inclusions of carrollite, whereas the second association is illustrated by progressive marginal replacement of chalcopyrite by bornite. EBSD shows chalcopyrite consists of fine aggregates, despite a single grain appearance, and displays {110} and {112} twinning. In contrast, bornite surrounding chalcopyrite has a mostly homogeneous single orientation. Silver, Bi, Pb and Sb can be traced along chalcopyrite grain boundaries and to a lesser extent along twin planes, even though bornite preferentially concentrates Ag-Bi-Sb-Pb relative to chalcopyrite.

In summary, the results show the first convincing evidence for ductile deformation in pyrite from a brecciated IOCG deposit. Furthermore, natural chalcopyrite is shown to be a rich source of

microstructural and -textural information, preserving (220) and (001) crystallographic preferred orientations, twinning, grain boundary migration recrystallization, and foam textures. Coupled EBSD-LA-ICP-MS analysis provides valuable new insights into ore genesis and superimposed events, with the novel use of chalcopyrite EBSD studies showing low- to medium-temperature evolution. This complements data from coexisting pyrite, a mineral that conventionally depicts higher-temperature deformation. Grain-scale elemental distributions also confirm the key role played by microstructures in Cu-Fe-sulphides as traps for value-add critical/precious metals (Ag, Bi, Sb, Au Te) and deleterious Pb.

This work will be complemented by nanoscale studies of bornite and chalcocite to assess micron-scale data in terms of Cu-Fe-sulphide speciation, intergrowths, and mineral inclusions; to better constrain their value for interpretation of ore genesis and especially in discriminating co-crystallisation from replacement.

Funding acknowledgement: ARC Grant LP200100156.

Keyword

Olympic Dam, Cu-(Fe)-sulphides, electron backscatter diffraction, trace elements, mineral characterization

Jurassic-Cretaceous W-Sn polymetallic ore formation and exhumation in South China: Tectonic-magmatic-metallogenic models

Huan LI[1]*, Central South University (lihuan@csu.edu.cn)

Abstract

South China contains the largest W-Sn province in the world, with the mineralization age dominantly at 160-150 Ma. Recently, A lots of mineralization-related A-type granites have been identified in the area. Was the tectonic setting a back-arc extension? Or a rifting?
For ore field structure: what tectonic stages, ancient stress fields, and ore-controlling structural systems controlled the formation of the world's largest W-Sn mineralization province? For ore deposit structure: what are the ore-controlling laws of various levels of structures? What are the combination types of structures at different depths? For regional exhumation and mineralization preservation: what are the differences in the degree of exhumation among different mineral deposits? How to evaluate the prospecting prospects and provide quantitative discrimination basis for deep ore exploration? This study conducts a systematic study on the tectonic-magmatic-metallogenic models of South China, aiming to reveal the Jurassic-Cretaceous W-Sn polymetallic ore formation and exhumation processes. This research found that the Mesozoic W-Sn mineralization in South China was controlled by normal faults in early rift graben system. South China experienced three important tectonic deformation events: Indosinian near EW compression, early and middle Yanshanian NW-SE compression, and late Yanshanian NW-SE extension. The Middle Jurassic to Early Cretaceous represented an important tectonic inversion period, and the transformation of tectonic stress from compression to extension led to large-scale W-Sn mineralization in South China. The degree of ore deposit exhumation gradually decreases from southeast epicontinental to northwest intracontinental in South China. Intracontinental South China possesses better prospects for ore exploration. Primary exhumation events of the South China resulted from changing subduction processes of the Paleo-Pacific Plate, which include slab break-off and foundering in the Late Jurassic, progressive slab retreat in the Early Cretaceous, and normal subduction in the Late Cretaceous, with minor exhumation events presumably triggered by the Paleogene opening of the South China Sea Basin. This research highlights the use of combined methods (including structural geology, low-temperature thermochronology and geochemistry) in studying the genesis of ore deposits and the exploration of critical metals.

Keyword

W-Sn deposits, orefield structure analysis, extension and rifting, Nanling Range, South China

Cl-rich hydrothermal fluid interaction for scapolite formation in copper deposits of Aravalli-Delhi Fold belt, western India

Prabodha Ranjan SAHOO[1]*, Indian Institute of Technology (Indian School of Mines) Dhanbad, India (prabodha@iitism.ac.in)
Janmejaya Sahoo[2], Indian Institute of Technology (Indian School of Mines) Dhanbad, India and Geological Survey of India
Israil Khan[3], Indian Institute of Technology (Indian School of Mines) Dhanbad, India and Geological Survey of India
Jyoti Priyam Sharma[4], Indian Institute of Technology (Indian School of Mines) Dhanbad, India
Venkatesh Satya Akella[5], Indian Institute of Technology (Indian School of Mines) Dhanbad, India

Abstract

Copper, lead and zinc deposits are located in the Proterozoic Aravalli Delhi Fold Belt of western India. As per the present understanding, these deposits have formed due to diversified origin and are classified as IOCG type for Khetri copper deposit, and SEDEX type mineralization for Pb-Zn mineralization in the Aravalli group of rocks. The mineralization in these deposits is hosted within the meta-sedimentary rocks of amphibolites to granulite facies condition. The ore minerals have also undergone different stages of deformation and metamorphism. Scapolite occurrences are observed in the metapelitic rocks hosting copper mineralization in the Nim ka Thana and Khetri copper deposit, whereas the scapolite is well developed in the copper-mineralized felsic volcanic rocks of the Alwar basin. Although these copper-bearing belts represent two different basins, the mineralization age is considered to be of similar age. Scapolite composition in both the copper mineralized areas is also marilaitic in nature despite their diverse host association. Since, scapolite is considered as a metasomatic product and often produced from halite-rich precursor sediments, the hydrothermal link of the scapolite is mainly ignored. However, the intricate relationship of the marialitic scapolite with the sulfide minerals suggests the interaction of the ore-bearing hydrothermal fluid with the country rocks for scapolite formation. Marialitic scapolite in felsic volcanic rock and sulfide inclusions in scapolite favours a strong criterion for chlorine rich hydrothermal fluid source for scapolite development and can be a guide for exploration targeting.

Keyword

Scapolite, hydrothermal fluid, felsic volcanic rock, copper mineralization

Oligocene magmato-tectonic events influential in the development of Pb-Zn, Ag and Au mineralization at the Plomosas deposit, southwestern Sierra Madre Occidental, Mexico

Paula Andrea MONTOYA LOPERA[1]*, CODES, UTAS (paula.montoyalopera@utas.edu.co)
Gilles Levresse[2], UNAM
Luca Ferrari[3], UNAM
Honza Catchpole[4], Metallerz Exploration
Luis Coto[5], GR Silver Mining
Felipe Mar[6], GR Silver Mining
Andres Cardenas[7], UNINORTE

Abstract

The Plomosas deposit is the product of a sequence of overlapping events of Pb–Zn, Ag and Au epithermal low sulfidation mineralization that occurred in Mexico's southwestern Sierra Madre Occidental (SMO). Field observations, detailed petrography, and U–Pb age dating of the entire stratigraphic sequence were used to characterize the magmatic evolution of the district and to obtain new insights into the evolution of the SMO. The stratigraphy at Plomosas is distinct from other areas to the north as it lacks Jurassic marine units, Cretaceous continental volcanic successions as well as Cretaceous and Paleocene batholiths. The local basement is composed of undeformed Late Jurassic volcaniclastic units and coeval felsic intrusions. Early to late Oligocene silicic ignimbrites, intermediate lava flows and occasional basaltic flows unconformably overlie the Jurassic basement. Several Oligocene intermediate to felsic porphyry bodies and rhyolitic domes crosscut the stratigraphy. The upper volcanic sequence is separated into two packages by an angular unconformity. Mineralization produced an early Pb–Zn-mineralized hydrothermal fault hydrothermal breccia, followed by Cu–Ag veins and late Au veins. The Pb–Zn mineralized breccia is hosted by ~30 Ma Oligocene volcanic units that form the basal sequence. The Cu–Ag and Au-rich veins overlap and crosscut the early hydrothermal features and cut the Late Oligocene volcanic cover that unconformably overlie the basal sequence. Our results highlight the importance of episodes of Oligocene magmatism to the genesis of mineralization in the southwestern SMO specifically through a genetic link between Pb–Zn veins and intermediate Oligocene intrusive bodies, and of Ag and Au veins with Late Oligocene volcanism.

Keyword

Oligocene magmatism, Oligocene extension, Low sulfidation epithermal system, Hydrothermal overprint events, Plomosas

Three-stage niobium mineralization at Bayan Obo, China

Yan YU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (geoyuyan@outlook.com)
Yang Li[2], School of Earth and Space Sciences, Peking University
Yu Liu[3], Institute of Geology and Geophysics, Chinese Academy of Sciences
Xiao-Xiao Ling[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Li-Guang Wu[5], Institute of Geology and Geophysics, Chinese Academy of Sciences
Li Yang[6], Mining Research Institute, Baotou Iron and Steel (Group) Co., LTD
Lan Yang[7], Institute of Geology and Geophysics, Chinese Academy of Sciences
Bo Yang[8], Mining Research Institute, Baotou Iron and Steel (Group) Co., LTD
Yong-Gang Zhao[9], Mining Research Institute, Baotou Iron and Steel (Group) Co., LTD
Xian-Hua Li[10], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The Chinese Bayan Obo deposit is a world-class rare earth element (REE) deposit with considerable niobium (Nb) and iron (Fe) resources. A complete genetic understanding on all metals is fundamental for establishing genetic models at Bayan Obo. With extensive research being focused on REE enrichment, the timing and controls of Nb enrichment remains unresolved at Bayan Obo, which is mainly due to the challenges in dating, i.e. multistage thermal events, fine-grained minerals with complex textures and the rare occurrence of uranium-enriched minerals with mature dating methods. Based on robust geological and petrographic frameworks, here we conducted ion probe uranium-lead (U-Pb) dating of ferrocolumbite to unravel the timing, hence the genesis of Nb mineralization. Three types of hydrothermal ferrocolumbites—key Nb-bearing minerals—are identified based on their textures and mineral assemblages. They yield U-Pb ages of 1312 ± 47 Ma (n = 99), 438 ± 7 Ma (n = 93), and 268 ± 5 Ma (n = 19), respectively. In line with deposit geology, we tentatively link the first, second and third stage Nb mineralization to Mesoproterozoic carbonatite magmatism, ubiquitous early Paleozoic hydrothermal activity, and Permian granitic magmatism, respectively. While quantifying the contribution of metal endowment from each stage requires further investigation, our new dates highlight that multi-stage mineralization is critical for Nb enrichment at Bayan Obo, which may also have implications for the enrichment mechanism of Nb in REE deposits in general.

Keyword

niobium mineralization, U-Pb dating, ferrocolumbite, Bayan Obo

Mineralization and remobilization of heavy rare earth elements in carbonatite rocks: insights from in situ elemental and Sr–S isotopic compositions of sulfate minerals

Si-Qi LIU[1]*, China University of Geosciences, Wuhan (1012850690@qq.com)
Shao-Yong Jiang[2], China University of Geosciences, Wuhan
Wei Chen[3], China University of Geosciences, Wuhan

Abstract

Currently, heavy rare earth elements (HREEs, Gd-Lu + Y) are critically important due to their high supply risk. Carbonatites and related rocks have long served as premier sources of light rare earth elements (LREEs, La-Eu), but there has been increasing concern regarding their potential for heavy rare earth element mineralization in recent years. The Huayangchuan deposit, located in the Qinling orogen of Central China, hosts supergiant uranium (> 20 kilotons) and 550 kilotons of rare earth element reserves, and most of the mineralization is hosted by carbonatite dykes. Heavy rare earth elements in the Huayangchuan deposit mostly occur as oxides (samarskite, euxenite, etc.) encased within rock-forming minerals (calcite and aegirine-augite) in carbonatites, suggesting early precipitation from the magma. Generally, these primary oxide minerals underwent later metasomatism along their rims and internal cracks.

Barite-celestine is widespread in the Huayangchuan deposit and can be divided into three types based on detailed textural observations. In this study, in situ elemental and Sr–S isotope analyses of three different types of sulfates are applied to decipher the mineralization sequence and constrain the nature of the fluids responsible for their formation. First, Brt-1 mainly occurs as veins cutting primary carbonatite minerals. It exhibits high total rare earth element contents (ΣREE = 1069 – 1809 ppm) and 87Sr/86Sr ratios matching those of fresh carbonatite (~0.70500), indicating its magmatic origin. Second, celestine in late zeolite-bearing veins (Brt-2) likely formed during the hydrothermal stage at lower temperatures. The much lower REE contents (ΣREE = 5.56 – 17.5 ppm) for Brt-2 reflect the substantial consumption of light rare earth elements before the transition from magmatic to hydrothermal stages, while the higher radiogenic 87Sr/86Sr ratios (~0.70600) suggest input from crustal materials. The third type of barite (Brt-3) is poorly crystallized and occurs as interstitials filling fractures and cavities in early-formed minerals (quartz, calcite, etc.). The high and variable 87Sr/86Sr ratios (0.70862 to 0.71077) of Brt-3 indicate contributions from the surrounding gneiss and can be elucidated through a binary mixing model between carbonatite-derived igneous species and an external fluid influx.

This study discusses the magmatic mineralization and hydrothermal reworking of HREEs in the Huayangchuan carbonatite rocks, providing a paradigm for the behavior of HREEs in carbonatite systems. The HREE mineralization potential of carbonatites is primarily controlled by their source budget. Then, the interactions between the carbonatitic magma and the wall rocks might have consumed the magma volume and ligands therein, potentially leading to the saturation of HREEs and triggering their early precipitation. Finally, HREEs are soluble in many geological fluids;

thus, late metasomatic fluids can assist in the formation of HREE minerals in hydrothermal veins and altered wall rocks but can also cause the destruction of primary ore minerals.

Keyword

Carbonatite, Sulfate, Sr-isotopes, Fluid evolution, Rare earth elements

Investigation of mineralogy, geochemistry, and fluid inclusions of the Ghalozendan iron deposit, Azerbaijan province, NW Iran

Soqra RASTI[1]*, PhD (azam.rasti@yahoo.com)
Ali Rostami[2], Payame Noor University
David R. Lentz[3], Department of Earth Sciences, University of New Brunswick, Fredericton, NB E3B 5A3, Canada

Abstract

The Ghalozendan iron deposit is situated in the Sanandaj-Sirjan Zone (SSZ) in NW Iran. The SSZ comprises Paleozoic to Cretaceous sedimentary and metamorphic rocks as part of the Hinterland Fold-Thrust Belt and the Zagros Thrust System. The dominant mineral host rock in this deposit includes granite, rhyolite, meta granite, meta rhyolite, genesis, and schist units related to the Late Precambrian. Iron mineralization is often parallel to the host rock and controls litho-structurally in the contact of schist rocks. The major ore mineral is magnetite and occurs as massive, lenticular, and disseminated ore. Hematite, goethite, pyrite, and chalcopyrite are minor phases. Geochemical investigations show that the Ni, Cr, Co, ΣREEs content of the Ghalozendan deposit is consistent with a typical hydrothermal origin. The iron ores are characterized by a negative positive correlation of Fe and LREE. The rhyolite and granite rocks in this area are regarded as the source of iron and heat in the mineralizing system. The fluid inclusion data from quartz suggest that the ore-bearing hydrothermal fluids with an average salinity of 5-15 wt% NaCl equivalent at a temperature of 130-400 ℃ are the source of iron mineralization. Microthermometric investigations suggest that Ghalozendan is a mesothermal type that formed due to cooling + mixing of the hydrothermal fluid with meteoric water which changed the chemical composition of the fluid and its temperature and pH drastically. The decrease in temperature and pressure, supplemented fluid neutralization due to the mixing of the hydrothermal fluid with meteoric water, controlled Fe precipitation in this deposit.

Keyword

Magnetite, Mineralogy, Geochemistry, Hydrothermal, Iran

[Keynote] Facts and myths about orthomagmatic ore deposits

Vadim Kamenetsky[1]*, Center of Deep Sea Research, Institute of Oceanology, Chinese Academy of Sciences (dima.kamenetsky@hotmail.com)

Abstract

The existence of metallogenic provinces is controlled by a number of interrelated factors that are responsible for a regional geochemical anomaly. The ultimate manifestation of such anomalies is one or several ore deposits reflecting energy-driven geological phenomena associated with paleogeography, structure, lithology, tectonic evolution, magmatism, sedimentation, fluid flow etc. The ore forming processes that are born out of the juxtaposition of five necessities, namely the source region, transport pathway, appropriate time, sufficient energy and depositional site, all have a definite control on the physical and chemical characteristics of any deposit.

Accumulations of metals (e.g., Cr, Ni, Cu, PGE) in mantle and crustal rocks are almost universally assigned to magmatic processes and lithologies. However, none of the above listed requirements for the formation of an ore deposit have been satisfactorily constrained for chromitites, Cu-Ni-PGE sulphide deposits, Cu-Au porphyries, and iron oxide – apatite +/- Cu-Au (IOA/IOCG) occurring in different geodynamic settings and allegedly related to different parental magmas.

Although discussions regarding formation of many types of deposits have been varied, current thinking still has an orthomagmatic “flavour”, where fertile (i.e. metal-rich) volatile-bearing magmas, liquid and fluid immiscibility, effects of mixing, mingling, contamination, prolonged fractionation, fluid boiling etc. are envisaged. In contrast to the mainstream research, my new approaches to understanding the origin of diverse metal deposits in high-temperature rocks are based on the laws of dialectics - the transformation of quantity into quality; the interpenetration of opposites; and the negation of the negation. When these laws are applied to grasping genetic aspects of the supergiant “orthomagmatic” deposits in my studies, such as Olympic Dam (U-Cu-Au-Ag, IOCG), Bushveld (Cr-Pt-Pd, chromitites in the layered complex), Noril’sk – Talnakh (Cu-Ni-Pd-Pt, sulphide ores in the layered complex) and a variety of Cu-porphyries, non-magmatic sources of metals and bona fide non-magmatic processes available and instrumental over significant time intervals become evident. These new data and non-orthodox thinking will be presented at the conference and, hopefully, stir further actions of separating facts from myths in the community of petrologists, geochemists and economic geologists.

Keyword

ore deposits, orthomagmatic, petrology, dialectics

Magmatic initial and saturated water thresholds determine copper endowments: insights from apatite F-Cl-OH compositions

Yingcai SUN[1]*, China university of geosciences (Beijing) (toknowsyc@163.com)
Qiushi Zhou[2], China university of geosciences (Beijing)
Rui Wang[3], China university of geosciences (Beijing)
Madeleine Humphreys[4], Durham University

Abstract

Magmatic volatiles (H2O, F, Cl), particularly water, are critical in the formation of porphyry copper deposit, for its significance as a carrier for metals. Magmatic water contents can be estimated using geochemical characteristics or directly measured using melt inclusions. However, accurately determining the water content, particularly the initial and saturation thresholds of deep ore-forming magma, remains challenging Further insights into these thresholds and the evolution path of volatiles are necessary to comprehend their impact on copper mineralization. To address this problem, we used apatite and forward modelling methods to reconstruct the evolution histories of magmatic water. Samples investigated include granitoid rocks and apatite from highly copper-mineralized and barren localities. Generally, our research suggested that both ore-related and ore-barren magma systems are hydrous, the modeled magmatic water contents vary significantly among systems whether mineralized or not, and the major difference lies in the threshold of water saturation (6.0 wt.% for barren systems, and up to 10.0 wt.% for highly mineralized systems). By integrating geochemistry data, phenocrysts assemblage and modeling, we infer that the ore-related magma are stored at deeper depth with higher water solubility. In conclusion, we propose that the degree of magmatic water saturation plays a crucial role in the formation of porphyry copper systems. Magmas with a high potential for mineralization not only exhibit increased water solubility but also experience significant water enrichment upon saturation. The deeper storage depth and injection of hydrous mafic magma are likely contributing factors to the elevated water solubility.

Keyword

porphyry copper deposit, magmatic water threshold, apatite, Gangdese belt

Paleoarchean volcanogenic massive sulfide (VMS) mineralization in the Nondweni Greenstone Belt, Kaapvaal craton: Direct links to submarine felsic eruptions, not to komatiites

Sebastian TAPPE[1]*, UiT The Arctic University of Norway (sebastian.tappe@uit.no)
Thendo Netshidzivhe[2], University of Johannesburg
Allan Wilson[3], University of the Witwatersrand
Harald Strauss[4], University of Münster
Fanus Viljoen[5], University of Johannesburg

Abstract

The Nondweni Greenstone Belt is located in the southeastern region of the Kaapvaal craton in South Africa and contains significant volumes of 3.53-3.45 Ga mafic-ultramafic lava flows (komatiitic and tholeiitic basalts). Minor felsic volcanic rock units, such as massive rhyolites and deformed quartz-feldspar-mica schists (felsic schists), also occur and are demonstrably linked to small base-metal sulfide ore bodies, interpreted here as VMS-type mineralization (e.g., sphalerite, pyrrhotite, chalcopyrite, pyrite, galena, acanthite). CA-ID-TIMS U-Pb zircon analysis yields a magma eruption age of 3531.91 ± 0.46 Ma for the felsic volcanic rock unit that hosts VMS-type mineralization at the abandoned St James mine, which renders this Zn-Cu-Pb-Ag mineralization among the oldest preserved of its kind, offering insights into ore-forming processes that took place on and below the Paleoarchean seafloor. Rare-earth element geochemical modeling suggests that the felsic volcanic rocks formed by moderate degrees of partial melting of hydrothermally altered basalts similar in composition to those from the Nondweni Greenstone Belt. Regarding ore formation, we envisage a scenario where basaltic ocean floor, near a back-arc spreading ridge, had been intensively altered and subjected to elevated temperatures, which facilitated localized melting at low pressures (<2 kbar) resulting in the production of rhyolitic magmas accompanied by hydrothermal sulfide deposition. This model is supported by evidence from multiple sulfur isotope data ($\delta^{34}S$ and $\Delta^{33}S$), which demonstrate that the basaltic rocks contain unfractionated magmatic sulfur and the rhyolitic rocks contain sulfur sourced from altered oceanic basalts. In contrast, the rhyolite-associated VMS-type mineralization records even more complex sulfur interactions, including contributions from surficial mass independent fractionated sulfur isotopic components; that is, these sulfide ores exhibit a negative S-MIF signature of -0.53‰ $\Delta^{33}S$.

Keyword

VMS deposit, MLA analysis, petrogenesis, TIMS U/Pb ages, komatiites

The role of magmatic sulfide floatation in the formation of seafloor massive sulfide deposits: Insights from the Fatu Kapa volcano in the NW Lau back-arc basin

Jung-Woo PARK[1]*, Seoul National University (jung-woo.park@snu.ac.kr)
Aurélien Jeanvoine[2], School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, South Korea
Ewan Pelleter[3], Unité Géosciences Marines, Ifremer, Plouzané, GM, F-29280, France
Antoine Bézos[4], Laboratoire de Planétologie et Géodynamique, LPG Nantes, CNRS UMR 6112, Université de Nantes, 2 rue de la Houssinière, 44322 Nantes, France
Gilles Chazot[5], Laboratoire Géosciences Océan, Institut Universitaire Européen de la Mer (IUEM), Université de Brest (UBO), UMR 6538, Place Copernic, Plouzané, 29280, France
Jiwon Hwang[6], School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, South Korea
Yves Fouquet[7], Unité Géosciences Marines, Ifremer, Plouzané, GM, F-29280, France

Abstract

Copper (Cu) and gold (Au)-enriched seafloor massive sulfide deposits found in intra-oceanic subduction settings are typically associated with hydrated and oxidized magmas. However, the processes driving their formation remain subject to debate. While it is recognized that S-undersaturated differentiation plays a role in enriching these metals in magmas, the specific mechanism by which Cu and Au are partitioned, whether into exsolved sulfides or aqueous fluids, remains uncertain. Recent studies have underscored the potential role of dense sulfides liquefied from magmas during their evolution, particularly when they become attached to bubbles of aqueous fluids and subsequently transported towards the surface. However, the rarity of such bubble-sulfide associations in natural settings hinders our understanding of whether sulfide flotation play a significant role in the transport of Cu and Au.

We introduce a distinctive case study of the sulfide-bubble associations within the volcanic suite of Fatu Kapa (ranging from basalts to trachy-dacites), which is associated with Cu- and Au-rich seafloor massive sulfide deposits. We measured Cu, Pb, and Zn contents of glasses and whole rocks using LA-ICPMS and ICP-MS, respectively, and analyzed Pd contents of glasses and whole rocks using nickel-sulfide fire assay combined with isotope dilution method. Through textural observations of magmatic sulfides and chalcophile element modeling within the Fatu Kapa magmas, our study elucidates that simultaneous sulfide and aqueous fluid formation lead to the formation of floating sulfide-bubble compound drops within the magmas. This phenomenon plays a pivotal role in the genesis of Cu-Au-rich hydrothermal ore deposits.

Keyword

Sulfide, Fatu Kapa, Chalcophile elements, Seafloor sulfide deposit, Lau basin

Open System Boiling of Saline Fluids form Salt-rich Ionic Melts: implications for formation of some IOA-IOCG systems

David R LENTZ[1]*, University of New Brunswick (dlentz@unb.ca)

Abstract

Various hypotheses have been proposed for Iron Ore-Apatite & Iron Ore-Copper-Gold deposits (IOA-IOCG) that are still very controversial, with many end-member models proposed for their origin. One end-member of those IOA-IOCG systems that is often described is the occurrence of magnetite-apatite (vein-dykes) with either diopside or actinolite within intermediate to mafic intrusive and extrusive igneous systems. These are obviously quite different from the Fe-Ti cumulates that are common to tholeiitic to alkalic mafic systems. Fe-oxide-silicate melt immiscibility has been proposed as has high-T hydrothermal systems linked to magmatic hydrothermal systems and circulating brines, extending to subsurface seawater reactions within boiling open systems. Shallowly emplaced tholeiitic to calc-alkalic magmatic systems forming within a submarine setting have the ability to generate convective hydrothermal systems that have been widely linked to formation of massive sulfide deposits, which form on or near the seafloor, but generally at considerable ocean depth to inhibit boiling in the system. Many volcanic islands and shallow marine rifts, rise to within the boiling zone though, so residual salinities of the boiling fluids can be driven up the salt saturation curve to values >> 50% salt, so can be described as hydrous molten salts (salt melts). Hydrothermal exchange of Na chlorides with Fe in the basalt-gabbro to ferroan andesites-diorites causes reduction during widespread alteration, and formation of Fe- & Ca-bearing chlorides within NaCl-rich salt melts with minor dissolved silica and mobilization of phosphoric acid. At T's > 450ºC, these Na-Fe-Ca exchange reactions in an open degassing system with abundant heat produces skarnoid-style alteration within spilitic metabasic to metadioritic rocks. The coalescence of hydrous ionic Fe-Ca-bearing salt melts and emplacement along structures will differentially evolved H2 from water with decreasing geostatic pressure, resulting in auto-oxidation of FeCl2 within the salt melt to form magnetite. Fe and P are typically coupled in both igneous and hydrothermal systems, so saturation of magnetite would lead to apatite saturation in the salt melt to saline brine. Ti and many other high field strength elements (HFSE), including REE, dissolves in hydrous ionic melts, so can be easily mobilized relative to near neutral brines at lower Ts. These brine to salt melt reactions will be S limited, as there is considerable Fe in these specific igneous systems to lower sulfur activity, thus stabilizing magnetite. Silica activity is also reduced due to calc-silicate saturation. Saturation of magnetite from Ti-bearing ionic melts (like ferroan carbonatites) can be quite Ti-rich; it is possible that titaniferous magnetite can saturate from high-T salt melts as well. Saturation of calc-silicates and apatite with Ti-bearing magnetite in the altered igneous groundmass, as veins, and vein-dykes and even exhalates (?) result from brine to hydrous ferroan Na-Cl salt melt reaction; these salt melts can extend to T's > 650oC. Chalcophile metals, like Cu and Au, probably represent hydrothermal endmembers of these processes with aH2S controlling saturation with decreasing T, forming the

CG in IOA systems (IOCG). IOA-IOCG systems form within the boiling zone, so within subvolcanic oceanic islands, shallow rift sequences, and primitive arc settings.

Keyword

boiling, molten salt, ionic melt, IOA-IOCG

Geological aspects of the Manto type copper deposits in the Sabzevar metallogenic zone, NE Iran

Susan EBRAHIMI[1]*, Department of Mineral Exploration, Faculty of Mining Engineering, Petroleum and Geophysics, Shahrood University of Technology, Shahrood, Iran (ebrahimisusan@gmail.com)

Abstract

The Manto type deposits are the second important copper deposits following porphyry reserves in Iran. These deposits occurred within Alborz magmatic assemblage (AMA), Urumieh-Dokhtar magmatic arc (UDMA), Sanandaj-Sirjan zone (SSZ), Lut block, and Sabzevar zone (SZ), which are hosted by Cretaceous to Eocene volcanic and volcano-sedimentary rocks. The UDMA and SZ are the most significant metallogenic provinces in Iran for Manto-type Cu-(Ag) exploration. The Sabzevar structural zone extends east-west for over 400km which is bounded to the south by the Doruneh fault and Atari and Mayamey faults in the north. The basement of the SZ consists of Precambrian metamorphic rocks covered by Paleozoic sedimentary rocks. The Sabzevar oceanic basin was created by rifting in the Late Triassic to the Mid-Cretaceous in the Central Iran microcontinent and began to close during the Late Cretaceous to the Early Paleocene due to the subduction of north-central Iran and eastern Alborz belt. The fragments of the oceanic Sabzevar crust remain as an Ophiolitic complex extending over 150 km length and 10-30 km wide. The post-ophiolitic sequences in the SZ covered by a thick sequence of Tertiary volcano-sedimentary rocks associated evaporate beds.

Based on the spatial distribution, different metal association, and geodynamic setting, ore deposits of the SZ can be separated into two groups. The Cretaceous mineralization consist VMS deposits are widespread of significant economic importance for Cu, Zn and Pb; and Mn ore deposits into the volcano-sedimentary sequences, and also chromite deposits associated with peridotites, gabbro and basalt. The Cenozoic mineralization includes Cu-Au porphyry, red-bed and Manto type Cu-(Ag) deposits.

Strataband copper deposits in the northeast of Iran are widely distributed along the Sabzevar to Semnan, forming an important cupriferous metallogenic zone in the SZ. Most of Manto-type deposits in NE Iran formed in the Eocene extension back-arc basin, which developed during the subduction of the NeoTethyan crust beneath the Iranian plate. These deposits are hosted within thick volcano-sedimentary sequences of Eocene age. Numerous geological and geophysical studies have been undertaken on these deposits over the years such as Dochileh, Abbasabad, Pirmardan, Asmanoo, Chah Moosa, Choghondar Sar, Kal Abri. Fluid inclusion data in these area indicate the primary copper mineralization are commonly generated in the range of 150 to 430 °C and less than 20% NaCl respectively. Sulfur isotope composition of the copper minerals (range between -25 to +24 ‰) imply the magmatic source/or leaching of the igneous rocks and marine sedimentary environments.

Keyword

Manto-type, Copper deposits, Sabzevar metallogenic, Iran

Practical assessment of ore-magmatic systems of Greater Altai

Oxana KUZMINA[1]*, D. Serikbaev East Kazakhstan Technical University (kik_kuzmins@mail.ru)
Tatyana Oitseva[2], D. Serikbaev East Kazakhstan Technical University
Marina Mizernaya[3], D. Serikbaev East Kazakhstan Technical University
Olga Ageyeva [4], D. Serikbaev East Kazakhstan Technical University

Abstract

Greater Altay was formed in the process of collision of the Kazakhstan and Siberian lithospheric plates. It combines four ore belts formed in different geodynamic conditions. In the Rudny Altai belt, large and unique pyrite deposits were formed in the rift-based ore-magmatic system, in the genetic connection of gold-copper-polymetallic mineralization with Devonian basalt-andesite-rhyolite volcanism. In the period of exploitation more than 500 ton of gold was mined at Ridder-Sokolnoye deposit. The collision ore-magmatic system (C1-C3) is productive for the formation of sulfide copper-nickel, copper-porphyritic and gold ore deposits. The ore-controlling systems include deep fault systems, thrust-melange structures, small intrusions and dikes of gabbro-diorite-granodiorite-plagiogranite series (C2-3-C3). Bakyrchik deposit is the largest gold-sulphide-carbon type deposits. Rare metal and rare earth deposits were formed in the post-collisional (orogenic) geodynamic setting in a genetic connection with the Permian granitic magmatism. In the Kalba-Narym belt, higher basicity granitoids are productive mainly for pegmatite mineralization (Ta, Nb, Be, Li, etc.), albitite-greisen metasomatites (Li, Ta, Sn) and quartz veins (Sn, W) are associated with normal granites, with leucogranite - hydrothermal (W) and crystal-bearing pegmatites, alkaline granites - Nb-Zr-TR. Ogonite dikes are indicators of hidden rare-metal mineralization. Large industrial rare metal objects are Yubileinoye, Bakenny, Belogorskoye, on the example of which a detailed study of potential rare metal ore occurrences is currently being carried out. The found metallogenic trend of geodynamic environments and different productivity of ore magmatic systems are the basis for starting prognostic-prospecting works.
This research has funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP23486908)

Keyword

Great Altai, tectonic, ore-magmatic system, geodynamic, geodynamic

Regularities of formation, prognostic criteria of gold-sulphide formation deposits in East Kazakhstan

Marina MIZERNAYA[1]*, East-Kazakhstan Technical University (mizernaya58@bk.ru)
Oxana Kuzmina[2], East-Kazakhstan Technical University
Tatyana Oitseva[3], East-Kazakhstan Technical University
Aruzhan Kudaibergeneva[4], East-Kazakhstan Technical University
Polina Tsymbal[5], East-Kazakhstan Technical University

Abstract

Regularities of formation, prognostic criteria of gold-sulphide formation deposits in East Kazakhstan

Mizernaya M. A., Kuzmina O.N., Oitseva T. A., Kudaibergeneva A., Tsymbal Polina

1 D. Serikbaev East Kazakhstan Technical University, Ust-Kamenogorsk, Republic of Kazakhstan, bdyachkov@mail.ru

The territory of East Kazakhstan is a part of Central Asian mobile belt. It is a unique polygon for its complex geological development and rich mineral deposits (Cu, Pb, Zn, Au etc.). Gold ore deposits are represented by different ore formation types. Proper gold ore deposits were formed in the process of Kazakhstani and Siberian lithosphere plates collision and localized in Zaisan suture zone of Great Altai. Basic gold ore zones (West Kalba, Zhanan-Boko-Zaisan) envelope Charsk-Gornostaevsk ophiolitic belt. Major deposits of gold-sulphide-carboniferous formation (Bakyrchik, Bolshevik and others) are compared with world deposits Suhoi Log and Muruntau in black-shale strata. Gold ore deposits of non-traditional apocarbonate type (Suzdalskoye) are controlled by the system of diagonal deep faults (West Kalba). Deposits of volcano-calciferous-terrigenous formation are ore-hosting (C1v2-3). Gold ore mineralization is associated with minor intrusions and dikes of collision type (C2-3-C3). Ore bodies are represented by zones of gold-sulphide mineralization with vein-impregnated ores. Gold is in free form and as an impurity in pyrite, arsenic pyrite. Basic typomorphic minerals are pyrite, goethite, magnetite, gold, as well as antimonite, galenite, cassiterite, scheelite and others. For the first time rare minerals were found in ores (ferrimagnetite, alamosite, gersdorffite, microlite). Ore-bearing zones are determined by magnetic anomalies of high intensity that is related to magnetite. Geochemical elements are indicators of ore formation: Fe, Mn, As, Sb, Ag, Cu, Pb, Zn. New perspective areas for discovering gold-sulphide deposits (including concealed and buried deposits) were defined on the basis of developed regional and local prognostic-prospecting criteria [1].

This research has been funded by the Science Committee of the Ministry of Science and Higher Education of the Republic of Kazakhstan (Grant No. AP19676805)

References:
1. [1] Dyachkov B., Mizernaya M., Kuzmina O., Zimanovskaya N., Oitseva T. Tectonic and Metallogeny of East Kazakhstan // Tectonics – Problems of regional settings. – 2018. – P. 67-84.

Keyword

gold-sulphide mineralization, prognostic-prospecting criteria, typomorphic minerals, East Kazakhstan, Central Asian mobile belt

New evidence for the intrusion-related gold deposit origin of Luanjiahe deposit in Jiaodong Peninsula, China

Xiaofeng Yao[1]*, Development and Research Centre, China Geological Survey
(yaoming212@qq.com)
Zezhong Du[2], Development and Research Centre, China Geological Survey

Abstract

1. BACKGROUND

The Jiaodong Peninsula, one of the most important Au ore provinces in China, more than 5000 t of Au reserves have been found in the northwest of Jiaodong Peninsula, in which most gold deposits lie along (N)NE–(S)SW-trending major faults. Two kind of mineralization and alteration were developed: altered rock- and quartz vein-types. The altered rock orebodies commonly have interstitial and cataclastic ore textures, and display symmetrical zones of alteration, from an inner zone of silicification, a middle zone of pyritization and sericitization, to an outer zone of K-feldspathization. The quartz vein orebodies are controlled by secondary normal faults or steep tension joints related to the major faults. The debate on the correlation between ore formation and magmatism is ongoing in the Jiaodong Peninsula because few intrusive rocks exhibit a clear association with ore deposits.

2. GEOLOGY OF LUANJIAHE DEPOSIT

The Luanjiahe gold deposit is located in the northern section of the Zhaoping fault, northwestern Jiaodong Peninsula. Alteration and mineralization are mainly restricted to the faults. The alteration, along the fault, includes K-feldspathization, silicification, sericitization, and carbonatization. The silicification and sericitization occur close to the inner zones of the fault, while K-feldspathization occurs in the outer zone. The orebodies are commonly located in the zone with silicification, sericitization, and pyritization. The main sulfide mineral is pyrite, with minor galena, sphalerite, and chalcopyrite. Native gold is closely associated with pyrite, chalcopyrite, and keatite.

3. EVIDENCE FOR THE IRGD ORIGIN

A mineralized and weakly altered biotite monzodiorite stock was found in the footwall of the Zhaoping fault, in a borehole within the deposit. Some special structure, micro texture, and isotopic chemistry characteristics achieved in the biotite monzodiorite, associated with the intrusion-related gold deposit origin, are described as follows:

(1) Miarolitic cavities, occasionally connected, are typically infilled by medium- to fine-grained quartz, calcite, disseminated pyrite, and biotite in some parts of the stock.

(2) Aplite veins and drops, characterized by fine-grained quartz and alkali feldspar, change gradually in grain size within the transition zone between the biotite monzodiorite and aplite.

(3) Skeletal and dendritic quartz, are always associated with plagioclase and biotite in the biotite monzodiorite.

(4) Explosion breccias, comprises clasts of biotite monzodiorite and aplite dike, and hydrothermal

quartz cement.
(5) S isotopic compositions of pyrite within the ores in the biotite monzodiorite ($\delta^{34}S$ = −1.7‰ to +7.3‰; mean = +3.5‰), are roughly consistent with those of magmatic sulfur.
Skeletal and dendritic quartz, late-stage aplite dikes and drops, reflect sudden undercooling during magma ascent. Explosion breccias and miarolitic cavities that are infilled by hydrothermal and ore minerals, were probably induced by saturation in volatiles, the upward transport of aqueous fluid, and subsequent hydrothermal fracturing. The S isotopic characteristics are indicative of a magmatic source. These findings, combined with the reported age of 123 Ma, show that the intrusion has close spatial, temporal, and geochemical relationships with Au mineralization in the area. Luanjiahe gold deposit can be regarded as an intrusion-related gold deposit.

Keyword

Jiaodong Peninsula, Gold deposit, Intrusion-related gold deposit

Caledonian Granites in the Longhua Ni-Co Deposit, South China : Tectonic Setting and Its Relationship with Mineralization

Hejun TANG[1]*, Chinese acadmy of geological science (03206125@163.com)
Jiayong Yan[2], Chinese acadmy of geological sciences
Zhen Deng[3], Chinese acadmy of geological sciences
Zhaolin Wang[4], Chinese acadmy of geological sciences
Ronghui Xue[5], Chinese acadmy of geological sciences
Guang Qi[6], Chinese acadmy of geological sciences
Kun Zhang[7], Chinese acadmy of geological sciences
Changxin Chen[8], Chinese acadmy of geological sciences

Abstract

The Longhua Ni-Co deposit is a newly discovered super-normal enrichment hydrothermal vein deposit in Dayaoshan, Guangxi, China. Exploration work preliminarily confirmed that it has a potential to be a medium to large Ni-Co deposit. In this study, new geochronology, petrogeochemistry and Sr-Nd-Hf isotope data for the granites related to mineralization were obtained, in order to discuss the granite genesis and tectonic setting. The LA-ICP-MS zircon U-Pb age of the Dajin granites is 448 Ma, which is within the time range of Caledonian magmatic activity in South China. Dajin granites are rich in Si, Al, Ca and Mg, as well as LILE (such as Rb, Th and U) In constrast significantly depletion is shown for Eu, Ba, Sr, P, Ti. All above features indicate that it is a typical high-differentiation A-type granite. The whole-rock εNd(t) values of Dajin granites are in the range of -1.99 to -4.26, zircon εHf(t) values are in the range of -9.4 to -4.2 and the peak age of TDM2 is between 1300 and 1400Ma. The granites are inferred to be formed by the partial melting of the lower crust mafic rocks during the Proterozoic period. Dajin granites were formed in the post-collision and extensional tectonic environment in an intracontinental orogen.

After the collision, Dayaoshan area was in a tension environment, and huge pressure was released along the fracture zone, which caused the upwelling of asthenosphere, baking and triggering the melting of Ni and Co-rich Neoproterozoic-Mesoproterozoic metamorphic mudstone and metamorphic greywacke to form Ni and Co-rich magma chamber. At the same time, a series of NE-NEE trending fracture zone were also formed during this period, along which Ni and Co-rich magma intruded upward into the upper Cambrian strata, forming ore source layer. During the process of magma upwelling, it mixes with magma produced by partial melting at different depths of the crust, undergoes a certain degree of crystallization differentiation, and finally emplaces, forming a highly differentiated magmatic rock with large progressions. At the same time, due to multiple stages of magma emplacement and post hydrothermal activity, the rich Ni and Co ore source layer is continuously activated and extracted. During the process, the fluid rich in volatile matter (F, Cl, etc.) participates in the enrichment of Ni and Co, and continues to migrate upwards along the near E-W structural fault, ultimately precipitating into quartz vein type Ni-Co deposits.

Keyword

Ni–Co deposit, high differentiation, Caledonian period, tectonic setting, South China

The critical mineral potential of the Kennedy Igneous Association: Petrogenesis, tectonic setting, and metallogeny

JONGHYUN LEE[1]*, James Cook University (jonghyun.lee@my.jcu.edu.au)
Ioan Sanislav[2], James Cook University

Abstract

Background
The Kennedy igneous association (KIA) is widespread intrusive and extrusive, which are dominantly felsic and silicic magmatism, throughout northeastern Queensland during the Carboniferous to the Permian. Geophysical data show that Permo-Carboniferous KIA belt forms a WNW-NNW trending.
Most of granites aged over 310 Ma are concentrated within the Kidston and Kangaroo Hills subprovinces. However, magmatism between 310-290 Ma occurred in the Herberton, Tate, and Burdekin Falls subprovinces closer to current coastline. After 290 Ma, the magmatism locations migrated north-eastwards into the Hodgkinson province, changing from mainly I-type to S- and A-type magmatism. These migration and transition have been interpreted as subduction zone retreat because of slab roll-back.

Mineralization
A variety of significant mineralization including Sn-W (±Mo, Bi), epithermal Au±Ag, and possibly porphyry/skarn Cu-Au mineralization associated with KIA are hosted in northeastern Queensland. For example, the Kidston, Red Dome, and Mount Leyshon are the representative of Au deposits, and there are Sn-W(±Mo) deposits such as the Bamford, Collingwood, and Wolfram camp deposits. However, Sn-W deposits related to KIA are dominantly located in the Herberton and Hodgkinson province, while Au deposits are concentrated in the Georgetown and Charters Towers provinces.

Geochemistry
Geochemical graphs are delineated to see transitions from the Kidston, Herberton and Tate to the Daintree subprovinces (from inland to coast). Igneous suites in the Herberton and Tate supbrovinces include the Almaden, Ootann, and O'Briens creek (OB) suites and S-type granitoids in the Daintree subprovince can be divided into Cooktown suite and other S-type suites.
OB is the most fractionated features among I-type granitoids, and Cooktown suite is more fractionated than other S-types. Some samples from the Kidston subprovince show higher Sr content trend from those from the Almaden and Ootann suites. Most of granitoids are basically sub-alkaline and high-K calc-alkaline series. I-type granitoids plot in I-type and boundary between meta- and peraluminous, but S-type granitoids are mostly peraluminous. The Yataga granodiorite and Almaden suite dominantly plot in VAG, while other I-type granitoids are boundary between VAG and WPG in tectonic setting discrimination graphs. S-type granitoids fall in VAG and syn-

COLG and especially Cooktown suite has more syn-COLG characteristics.
Samples from the Kidston subprovince and Yataga granodiorite has lower Rb/Sr ratio compared to other I-type suites, while OB and S-type granitoids associated with Sn and/or W mineralization show higher Rb/Sr ratio because they are more fractionated. Furthermore, some samples of the Kidston subprovince fall in adakite field associated with Au-Cu mineralization showing higher Sr/Y ratio. They are close to the affinities of Cu-Au mineralization plotting in TTG and Cu-Au ore-productive field unlike other samples.

Conclusions
As ages of granitoids become younger, the location of emplacement changed from inland toward current coastline. Young-aged S-type granitoids in the Daintree subprovince are more related to Sn-W(±Mo) mineralization. We will compare and analyse the geochemical and isotopic data after grouping by ages and subprovinces to understand changes of tectonic environment over time. Based on this research, we have a plan to interpret relationship between mineralization and magmatism derived from tectonic setting changes.

Keyword

Kennedy Igneous Association, W-Sn, Au-Cu, Hydrothermal, Northeastern Queensland

Sulfur and lead isotope geochemistry of granitoid rocks in the Taebaeksan Mineralized District, South Korea

Byeongyong YU[1]*, Kongju National University (yah0707@smail.kongju.ac.kr)
Dongbok SHIN[2], Kongju National University
Heonkyung IM[3], Korea Institute of Geoscience and Mineral Resource
Jaeguk JO[4], Kongju National University

Abstract

The role of granitoid and host rocks in the formation of metallic ore deposits is important, as their characterization is fundamental for understanding the genetic environment of ore deposits. The study area, the Taebaeksan mineralized district (TMD) in South Korea, encompasses the Precambrian metamorphic complex, the Paleozoic carbonate rocks, and granitoid intrusions of various ages. This study seeks to characterize the sulfur and lead isotopes of granitoid rocks prior to determining the relationship between the granitoid rocks, deposits, and host rocks. The Precambrian and Jurassic granitoid rocks exhibit average δ34S values of +5.8‰ (n=3), whereas the Cretaceous granitoid rocks show a lower value of average +3.5‰ (n=13). Regarding the lead isotope ratio, the Precambrian and Jurassic granitoids show a wide variation, ranging from 206Pb/204Pb=17.520 to 22.407 (avg. 20.314, n=3), while the Cretaceous granitoids exhibit a relatively narrow range of 206Pb/204Pb=18.329 to 19.259 (avg. 18.568, n=13). The sulfur and lead isotope results can be used to evaluate the influence of the country rocks. If the granitoid rocks had been influenced by carbonate rocks, they would exhibit relatively high δ34S values. However, they fall within the range typical of igneous rocks and display a positive correlation with SiO2 content, suggesting the effect of magma differentiation. Lead isotope analyses indicate that the influence of basement rock in the formation of granitoid rocks cannot be ignored. However, when compared with sulfur isotopes, no correlation was observed between them, suggesting that they did not mutually influence each other.

Keyword

Sulfur and lead isotope, granitoid rocks, Taebaeksan mineralized district

The Genesis of the San Francisco Manganese Deposits, Jalisco, Mexico: Geological Insights and Mineralogical Signatures

Genesis Arelly RAMOS GARCIA [1]*, Universidad Nacional Autónoma de México (arellyramos@geociencias.unam.mx)
Joseph Madondo[2], Centro de Geociencias, Universidad Nacional Autónoma de México (UNAM), Boulevard Juriquilla 3001, CP 76230 Querétaro, Querétaro., México.
Eduardo González[3], Centro de Geociencias, Universidad Nacional Autónoma de México (UNAM), Boulevard Juriquilla 3001, CP 76230 Querétaro, Querétaro., México.
Sanjeet Kumar Verma[4], División de Geociencias Aplicadas, Instituto Potosino de Investigación Científica y Tecnológica, A.C., San Luis Potosí, México.
Sumit Mishra[5], Centro de Geociencias, Universidad Nacional Autónoma de México (UNAM), Boulevard Juriquilla 3001, CP 76230 Querétaro, Querétaro., México.

Abstract

The San Francisco Manganese deposit is located in Jalisco, Mexico, within a continental volcanic province of the southwestern Sierra Madre Occidental. The regional geology is defined by a mosaic of volcanic and subvolcanic rhyolites, andesites, and their pyroclastic counterparts, and diorite plutons. Over a 10 x 10 km expanse encompassing the deposit, a coherent rock sequence unfolds, though its regional continuity remains elusive due to the complex volcanic terrain. The deposit is hosted by red tuffs with interbeds of green tuffaceous sandstone. Mineralization exist within two distinct zones: an iron-oxide-rich zone with modest manganese contents to the northwest and a manganese-oxide-rich zone to the southeast—where the deposit attains maximum thickness while exhibiting its lowest iron content. The manganese mineralization occurs as stratabound irregular orebodies and lenses hinting at a syngenetic sedimentary genesis. Manganese ore comprise predominantly of braunite with minor pyrolusite and traces of neltnerite and rhodochrosite which display a variety of textures such as laminated, disseminated, massive, replacement and open space filling. Iron oxides exist in the form of fine grained hematite and magnetite. Accessory minerals include quartz, calcite, barite, hematite, cryptocrystalline silica, and calcite. Electron microprobe analysis of braunite, the predominant mineral, gives average values of MnO2, SiO2 and Fe2O3 as 84.2, 9.6, and 0.9 percent, respectively, which is close to the ideal composition. The geological and geochemical characteristics of the San Francisco Manganese deposit provides important clues about the deposit's genesis, environment of formation and origin of manganese. The presence of volcanic and subvolcanic rocks, tuffs, and their pyroclastic counterparts and absence of epigenetic hydrothermal replacement, advocates for a syngenetic exhalative origin. The deposit is characterized by low trace element (Co, Cu and Ni) abundance and high Mn/Fe ratios (>500), typical of hydrothermal deposits. The Mn-Fe-(Ni + Cu + Co), MnO2-MgO-Fe2O3, and Na/Mg diagrams display signatures of a terrestrial environment. Geological and geochemical characteristics of the deposit point to deposition within a shallow water basin by subaerial volcanic activity during hiatus between two major eruptive cycles.

Keyword

Manganese oxides, stratabound, volcanogenic, subaerial, braunite

Cathodoluminescence, trace element and fluid inclusion studies of the ginguro-bearing crustiform veins in the Hokuryu Ag-Au deposit, Hokkaido, Japan

Omar Baculna SOBERANO[1]*, Akita University (obsoberano@gmail.com)
Ryohei TAKAHASHI[2], Akita University
Pearlyn Cabarubias MANALO[3], Akita University
Andrea AGANGI[4], Akita University

Abstract

The Hokuryu deposit was one of the largest producers of silver (Ag) and gold (Au) in Omu, Hokkaido, Japan. A type of ore in the deposit is ginguro-bearing crustiform veins that contain hundreds of ppm of Ag. Here, we investigate the detailed characteristics of these ginguro-bearing veins through the application of cathodoluminescence (CL), mineral chemistry and fluid inclusion techniques.

Petrographic observations show that the ginguro is mainly composed of a skeletal intergrowth of hessite and sulfides, such as sphalerite, pyrite, chalcopyrite, and galena. These ore minerals are mostly confined within a colloform band composed of microcrystalline quartz and adularia. The microcrystalline quartz exhibits microspherical texture that is made up of individual sphere having an apparent diameter of ~1-5 μm. Adularia located within the interstices of these quartz microspheres displays anhedral to rhombic habit with sizes ranging from ~1 to 10 μm. The quartz microspheres exhibit blue CL, with a peak at ~400 nm in the CL spectrum. Mineral chemistry analysis of these blue CL-emitting quartz microspheres shows Al and K concentrations of ave. 2940 ppm (n = 40) and ave. 1117 ppm (n = 40), respectively.

In addition, the ginguro-bearing microcrystalline colloform band is typically followed in the mineral deposition sequence by macrocrystalline comb quartz and tabular adularia, in which trace amounts of hessite and sulfides were also found. The comb quartz also generally exhibits blue CL with ~400 nm peak, but has significantly lower Al (ave. 2560 ppm, n = 14) and K (ave. 187 ppm, n = 14) concentrations. Moreover, primary two-phase liquid-rich inclusions were recognized along the cleavage planes of tabular adularia. Homogenization temperature and apparent salinity from three fluid inclusion assemblages are ave. 272°C and ave. 6 wt. % NaCl equivalent, respectively.

Keyword

low-sulfidation epithermal, ginguro, cathodoluminescence, quartz chemistry, adularia fluid inclusion

Hyper-enrichment of gold via quartz fracturing and growth of polymetallic melt droplets: example from the Xiaoqinling lode gold district, central China

Wei Jian[1]*, China University of Geosciences (Beijing) (weijian851@gmail.com)

Abstract

The precipitation of gold in hydrothermal ore deposits is generally attributed to the supersaturation of gold in aqueous or aqueous-carbonic fluids. However, it appears doubtful whether ore fluids can ever reach bulk saturation with respect to gold, because of the relatively low concentration of dissolved gold species compared to gold solubilities. This suggests there may be precipitation mechanisms that are not controlled by bulk gold solubilities, especially for the formation of ultrahigh-grade gold veins. This is because gold supersaturation triggered by processes such as boiling and fluid mixing will be accompanied by the precipitation of quartz, calcite, and other common vein minerals, which strongly dilute gold grade. This contrasts with the observation that gold minerals, e.g., native gold or Au-(Ag)-tellurides, are frequently a major or dominant component in micro-fractures of ultrahigh-grade gold quartz veins that can contain kilograms of gold per tonne or more.

Using a combination of scanning electron microscope (SEM) imaging and energy-dispersive X-ray spectrometry (EDS), heating-freezing experiments, and hydrothermal diamond anvil cell experiments, we present evidence for entrapment of polymetallic melt droplets in gold-bearing quartz veins from the Xiaoqinling gold district, central China. We propose a model of ultrahigh-grade gold enrichment through polymetallic droplet growth induced by quartz fracturing and generation of hydrogen and silanol groups during earthquake faulting. We propose that polymetallic melt droplets of Au-Ag-Te-Bi–rich composition form through adsorption-reduction of metal complexes on fractured quartz surfaces, where surface silanol groups and hydrogen serve as reductants. The melt droplets subsequently grow by catalyzing reduction of metal complexes and absorbing metals from fluids percolating in the fractured quartz network. The mobile and reactive polymetallic melt droplets can repeatedly react with the fluid on protracted quartz fracturing, and efficiently continue to scavenge gold from multiple pulses of gold-undersaturated ore fluids. Gold particles themselves are also known to act as catalysts during the reduction of positive gold ions. Repeated fracturing of quartz could then possibly also trigger self-catalyzed growth of metallic gold without the mediation of polymetallic melt droplets.

Keyword

polymetallic melt droplets, gold, quartz, earthquake faulting, central China

Fluid Evolution of the Wunugutushan Porphyry Copper-Molybdenum Deposit in Inner Mongolia: Insights from Quartz Fluid Inclusions and Muscovite Compositional Studies

Xiangkai CHU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (chuxiangkai20@mails.ucas.ac.cn)
Ping SHEN[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

The Wunugetushan porphyry copper-molybdenum deposit in Inner Mongolia, China, is a significant porphyry deposit with 2.5Mt copper and 0.2Mt molybdenum resources. However, complex fluid activity has resulted in the ore-forming fluid evolution process of the deposit remaining unclear. This study conducted microthermometry on quartz fluid inclusions at different stages, and investigated variations in muscovite compositions using electron probe microanalysis, laser ablation inductively coupled plasma mass spectrometry, and shortwave infrared spectroscopy. By integrating the analysis results, the process of mineralizing fluid evolution has been reconstructed.

Based on the cutting relationships of hydrothermal veins, mineral assemblages, and their sequence of formation, the fluid ore-forming process is divided into four stages: quartz-potassium feldspar stage, transitional stage, quartz-sericite stage, and carbonate-clay alteration stage. Fluid inclusions in quartz veins are abundant. It can mainly be divided into four types of inclusions: carbon dioxide inclusions, vapor-rich inclusions, liquid-rich inclusions, and daughter mineral-bearing inclusions. In the quartz-potassium feldspar stage, fluid inclusions mainly consist of vapor-rich inclusions and daughter mineral-bearing inclusions, with a minor presence of carbon dioxide inclusions, and homogeneous temperatures mostly exceeding 500°C. In the transitional stage, fluid inclusions are dominated by vapor-rich and liquid-rich inclusions, with homogeneous temperatures around 420°C. In the quartz-sericite stage, fluid inclusions are predominantly vapor-rich and liquid-rich inclusions, with homogeneous temperatures ranging from 480 to 280°C. In the carbonate-clay alteration stage, fluid inclusions are primarily liquid-rich inclusions, with homogeneous temperatures mostly below 300°C. Carbonate signals are detected in the liquid phase compositions of fluid inclusions in the quartz-potassium feldspar and transitional stage, while carbon dioxide signals are detected in the gas phase. In the later stage, both gas and liquid phases are dominated by H2O. Studies of fluid inclusions indicate that during the early stage, magmatic hydrothermal fluid predominate, with gradual input of meteoric water leading to a decrease in temperature, salinity, and metal content. This fluid formation resulted in a later stage alteration assemblage dominated by carbonate and clay minerals, overprinting the early alteration of the deposit, and precipitating small amounts of lead-zinc minerals. Boiling fluid inclusions assemblage developed in quartz surrounding sulfides suggest that, apart from cooling effects, fluid boiling also plays a significant role in mineralization.

The composition and spectral characteristics of different genetic muscovite in the Wunugutushan

porphyry deposit exhibit significant differences. Muscovite associated with molybdenite is richer in Al, K, Sr, and Ba, with an Al-OH characteristic wavelength ranging from 2197 to 2203 nm. Muscovite associated with chalcopyrite contains higher Si, Ti, Fe, Mn, Mg, Cu, Zn, Sn, and W, with an Al-OH characteristic wavelength ranging from 2200 to 2206 nm. The Al-OH wavelength of mica in Wunugetushan porphyry deposit is related to the distance from the mineralization center, while the wavelength < 2203nm indicates the molybdenum mineralization and closer the mineralization center.

In summary, the quartz fluid inclusions composition of muscovite are of significant scientific importance in understanding the evolution of fluid and exploration.

Keyword

Porphyry Copper-Molybdenum Deposit, Fluid Evolution, Mineralization process, Wunugetushan

New geochronological constraints on the giant Nurkazgan porphyry Cu-Au deposit, Central Kazakhstan

Haoxuan FENG[1]*, Key Laboratory of Mineral Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences (fenghaoxuan15@mails.ucas.ac.cn)
Reimar SELTMANN[2], Centre for Russian and Central EurAsian Mineral Studies, Department of Earth Sciences, Natural History Museum London
Ping SHEN[3], Key Laboratory of Mineral Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences
Xiangkai CHU[4], Key Laboratory of Mineral Resources, Institute of Geology and Geophysics, Chinese Academy of Sciences
Seitmuratova ELEONORA[5], Satpaev Institute of Geological Sciences

Abstract

The Nurkazgan Cu-Au deposit in the Central Kazakhstan, containing 3.93 Mt Cu and 293 t Au, is one of the giant porphyry copper deposits in the Central Asian Orogenic Belt. It is spatially associated with the Karaganda dioritic to granitic intrusive complex. Although some studies have been done on characteristics, and petrogenesison this intrusive complex, its magmatism history and genetic link to the porphyry mineralization are still poorly constrained. In this study, new zircon U-Pb geochronology analyses of various intrusions of the Karaganda complex have been performed. Furthermore, the timing of mineralization has been directly dated by the hydrothermal rutile SIMS U-Pb, and molybdenite Re-Os dating.

Firstly, our fieldworks and SHRIMP and LA-ICP-MS zircon U-Pb dating confirms five ore-bearing porphyry phases in the Karaganda: (1) early granodiorite porphyry, the oldest intrusion consisting of the main body of the Karaganda complex, have a 206Pb/238U weighted mean age of 440.8 ± 2.4 Ma; (2) early quartz diorite porphyry with a 206Pb/238U weighted mean age of 440.7 ±2.5 Ma; (3) the second pulse of quartz diorite porphyry emplaced at 429.7 ± 2.1 Ma; (4) the late granodiorite porphyry having a 206Pb/238U weighted mean age of 402.8 ± 3.7 Ma, and (5) the late quartz diorite porphyry emplaced at 402.0 ± 3.9 Ma. The later three porphyry phases are newly recognized. Collectively, the Karaganda intrusive complex has a punctuated magmatic history distributed over 35 m.y., and marked by three rather than a single episodic porphyry events: early (~440 Ma) and late (~430 Ma) Silurian, and early Devonian (~402 Ma).

Secondly, in-situ SIMS U-Pb dating of hydrothermal, Cu-rich (up to 13.2 ppm) rutile co-precipitated with chalcopyrite from the breccia-type ores indicates that the main-stage mineralization has been formed at 428.9 ± 6.9 Ma, which is coincident with the LA-ICP-MS zircon U-Pb age of the second pulse of quartz diorite porphyry (~430 Ma). Additionally, the rutile shows light REE-enriched chondrite-normalized REE patterns with moderate negative Eu anomaly similar to the ~430 Ma quartz diorite porphyry but in contrast to other dioritic intrusions. The similarity of U-Pb ages and REE patterns support that this porphyry acts as the causative intrusion responsible for the main-stage ore formation.

Finally, a molybdenite sample obtained from the main-ore stage stockwork vein near the contact

between the early Silurian quartz diorite and the late quartz diorite porphyry (402.0 ± 3.9 Ma) has a Re-Os age of 418.6 ± 1.8 Ma, which is slightly younger than the U-Pb age determinations of the rutile. This indicates that the Re-Os isotope system was disturbed by the second thermal and mineralizing event related to ~402 Ma quartz diorite porphyry.

Keyword

Zircon, Rutile, U-Pb and Re-Os ages, Porphyry copper deposit, Nurkazgan

Geology, alteration and mineralization of the Pemberton Hills porphyry system, Canada: anatomy of a lithocap

Pete HOLLINGS[1]*, Lakehead University (Peter.Hollings@lakeheadu.ca)
Patrick Hamilton[2], Lakehead University
Andrew Jedemann[3], Lakehead University
Lejun Zhang[4], University of Tasmania
David R Cooke[5], University of Tasmania
Ramon Taningco [6], Freeport-McMoRan
Ingemar Arellano[7], Freeport-McMoRan

Abstract

The Pemberton Hills porphyry system is located in northern Vancouver Island, British Columbia, Canada and forms part of a northwest trending belt of Jurassic porphyry and epithermal deposits and prospects within the Wrangellia Terrane. The porphyry environment at Pemberton Hills has been the target of limited exploration, despite the presence of a well-developed lithocap, and proximity to the Island Copper Mine (345 Mt @ 0.41% Cu, 0.17% Mo, 0.19 g/t Au), and the Hushamu (304 Mt @ 0.21% Cu, 0.1% Mo, 0.29 g/t Au, 0.55 g/t Re) and Red Dog prospects (23.6 Mt @ 0.32% Cu, 0.46 g/t Au).

The host rocks at Pemberton Hills include a wide range of volcanic units (andesites, basalts, flows, volcaniclastics, tuff, volcanic and hydrothermal breccias) and plutonic rocks (granodiorite, tonalite dyke, quartz diorite) with the lithocap hosted mainly in volcanic breccias and pyroclastic units, and local porphyritic intermediate volcanic rocks. Potassic and propylitic alteration mainly occurs within and proximal to plutonic rocks across the study site. Locally intense phyllic alteration, characterized by fine-grained quartz, white-mica, and pyrite, is generally constrained to samples located in the center of the study site to the northeast of the lithocap, and overprints previously formed mineral assemblages. The lithocap is characterized by the presence of pyrite, kaolinite, chlorite, and illite at the periphery and in minor faults in the propylitic alteration halo; quartz, alunite, dickite, pyrite increasing in abundance towards the centre; and a core of quartz, dickite, pyrophyllite, zunyite, topaz, and alunite, which has been interpreted as the upflow zone of the lithocap. Silicic alteration occurs on the shoulders of the upflow zone in the NE of the lithocap, generally cropping out as large ridges of resistant material. Texturally, these domains were typically massive but locally showed vuggy textures.

Intrusive units peripheral to the lithocap have been dated at 172.34 ± 0.11 Ma, 172.01 ± 0.17 Ma, 171.77 ± 0.13 Ma and 171.44 ± 0.25 Ma using U-Pb zircon methods. These ages overlap with a Re-Os age of 172.3 ± 0.8 Ma from molybdenite from the lithocap and U-Pb ages of an epidote vein and andraditic garnet-epidote-calcite-pyrite vein, both 170.1 ± 1.8 Ma. Three Ar-Ar ages of 166.2 ± 0.3 Ma, 167.1 ± 0.7 Ma, and 166.7 ± 0.3 Ma were generated using alunite from different locations within the lithocap. These ages broadly overlap with intrusions at the Island Copper mine as well as other Island Plutonic Suite intrusions in the area and suggest the lithocap formed late in the evolution of the Pemberton Hills system.

Keyword

Lithocaps, Porphyry, Geochemistry

Nature and Characteristics of Gold Deposit of Bhitar Dari Area of Gorumahisani-Badampahar Greenstone Belt of Iron Ore Group, East Singhbhum District, Jharkhand, India.

PANKAJ KUMAR[1]*, Geological Survey of India (pankaj.kumar1@gsi.gov.in)
Abhishek Das[2], Geological Survey of India
Nandu Khalkho[3], Geological Survey of India

Abstract

Worldwide, Archaean greenstone belts are mostly characterized by lode gold deposits with major deposits situated in cratonic areas of Australia, Brazil, Canada, India and South Africa (Foster,1984, Mcdonald, 1986, Ho and Groves, 1987). Archaean greenstone belts gold deposits/ occurrences are generally tectonically classified as orogenic gold deposits (Groves et.al 1998, Goldfarb et.al, 2001). The Palaeo-Meso Archaean volcano-sedimentary sequence of Gorumahisani-Badampahar greenstone belt occurs along the northeastern fringe of the Archaean Cratonic core region (ACCR). Volcano-sedimentary sequence along the fringes of ACCR in this eastern part of India are widely referred as Iron Ore Group of rocks.

The Bhitardari area belongs to Gorumahisani-Badampahar greenstone belt of Iron Ore Group and generally comprises inter-banded sequence of phyllite, tuffaceous phyllite, carbonaceous phyllite, quartzite, cherty quartzite, fuchsite, conglomerate, BIF, chlorite-schist and Ultramafics. Interfolial quartz and quartz-carbonate veins, which shows alteration in the form of silicification, ferruginisation & limonitisation at places, traverse along and across all the major lithunits of the area and acts as a host for gold mineralization in the area. Quartz/ quartz-carbonate veins of the area are mostly associated with syn-D2 shear zone. Predominance of the auriferous quartz veins, quartz-carbonate veins/ veinlets along S2 foliation in the area indicates major auriferous lode formation occurred during D2 event, which is otherwise most prominent deformation in the area. The main gold mineralizing event in the area is shear controlled and probably coeval with this regional deformation in the area.

Systematic sub-surface drilling has been carried out in the area to delineate the zone of gold mineralisation and to estimate the resource, first time in the northern limb of the fork shape structure in the IOG rocks in this part of the Singhbhum Craton. Sulphide minerals in the form of chalcopyrite, pyrite, pyrrhotite, sphalerite, galena, arsenopyrite and Millerite have been reported. Mineralization in the area occurs irrespective of lithology. Pyrite and arsenopyrite is the common sulphide mineral present in the area along with other sulphides, at low metamorphic grade. Gold occurs in the area in two distinct forms, as free milling (nugget) gold as well as invisible gold(refractory) within the pyrite. Gold values in the range of 60 ppb to 13.9 ppm occur in the area and resource has been established, on the basis of analytical result received by fire assay techniques. The auriferous lode of the area is defined as portion of the mineralized zone which was considered for resource estimation, have minimum Au value of 0.1 ppm over a minimum width of 1.5 m. The gold deposit established in the area is characterised as high sulphide,

epigenetic type Archaean lode gold deposit.

Keyword

IOG, Shear Controlled Mineralisation, Archean Lode Gold, Epigenetic

The formation of gold-rich goethite and hematite in an epithermal gold deposit

Feng-Xia HUANG[1]*, China University of Geosciences (6988350@cug.edu.cn)
Ya-Fei WU[2], China University of Geosciences

Abstract

Gold is closely associated with iron oxides such as hematite (α-Fe2O3) and magnetite (Fe3O4) in some hydrothermal gold deposits, indicating that gold and iron oxides are co-precipitated from oxidizing fluids. In addition, supergene hematite and goethite [α-FeO(OH)] are enriched in gold, which is released from hydrothermal auriferous sulfides under near-surface weathering conditions. Gold in these iron oxide-related deposits mainly occurs as visible gold grains as well as micron to nanoscale gold particles, forming easily extracted high-grade (tens to thousands of g/t) gold ores. However, processes that control the formation of iron oxide-related high-grade gold ores are largely unknown.

Here, we used scanning electron microscopy, laser ablation–(multiple collector)–inductively coupled plasma–mass spectrometry [LA–(MC)–ICP–MS], and transmission electron microscopy (TEM) to reveal the formation processes of gold-rich goethite and hematite in a high-grade ore (~36 g/t Au) from the Jinying epithermal gold deposit, China. Two types of iron oxide have been identified: (1) goethite that occurs within the fractures of pyrite or as overgrowths along the margins of pyrite; (2) aggregates of goethite and hematite within quartz of the mineralized sandstone. Type-1 goethite only contains rare gold particles, whereas a large number of fine-grained gold particles (<1 μm) occur within the type-2 aggregates of goethite and hematite. In-situ trace elemental and sulfur isotopic analyses show that the pyrite contains little gold (<0.68 ppm) and shows different sulfur isotopic compositions (mean = -2.1 ‰) with barite (mean = +16.4 ‰) that is intergrown with type-1 goethite. TEM analysis shows that type-2 goethite contains numerous spherical gold nanoparticles (5–300 nm), whereas gold nanoparticles in hematite are irregular and larger than those in goethite. Spherical gold nanoparticles tend to aggregate into irregular ones in hematite.

The different sulfur isotopic compositions between pyrite and barite indicate that type-1 goethite is not likely to form from the direct weathering of pre-existing pyrite. Instead, the two types of iron oxides might be precipitated from the oxidizing ore fluid that formed as a result of interactions between the original ore fluid with the wall rocks of Neoproterozoic hematite-bearing quartz sandstones. However, it is also possible that the addition of oxidizing meteoric water contributed to the formation of iron oxides at Jinying deposit. TEM results indicate that gold nanoparticles might be originally enriched into goethite and then aggregate into large ones in hematite. Our results provide new insights into the formation of high-grade iron oxide-related gold ores in hydrothermal gold deposits.

Keyword

Gold nanoparticles, Goethite and hematite, High-grade gold ores, Oxidizing ore fluid, Jinying gold deposit

Alunite and pyrite mineral chemistry vectoring to high-grade Au-Ag orebodies associated with the Martabe lithocap in Sumatra arc, Indonesia

Wei Hong[1]*, CODES, University of Tasmania (wei.hong@utas.edu.au)
Lejun Zhang[2], CODES, University of Tasmania
David Cooke[3], CODES, University of Tasmania
Nathan Fox[4], W.H. Bryan Mining & Geology Research Centre, The University of Queensland
Zhaoshan Chang[5], Department of Geology and Geological Engineering, Colorado School of Mines
Ivan Belousov[6], CODES, University of Tasmania

Abstract

The Martabe lithocap, located in western Sunda magmatic arc, Indonesia, has multiple gold-silver mineralisation centres. The lithocap hosts at least six high sulfidation epithermal deposits, including Purnama, Ramba Joring, Barani, Tor Uluala, Horas, and Uluala Hulu, in an area that is 7 km long × 3 km wide. This district is estimated to contain > 8 million ounces (Moz) Au and 75 Moz Ag, with a 0.5 g/t gold cutoff. The Martabe lithocap and Au-Ag orebodies are hosted mainly in Miocene basaltic andesite and Pliocene hornblende-phyric andesite and porphyritic dacite dome complexes that were overlain by a Quaternary rhyodacitic complex related to eruption of the Toba Supervolcano. Silica ridges dominated by vuggy quartz and quartz – kaolinite/dickite – pyrite assemblages are prominent at Purnama and Barani (central-south zone), whereas quartz – alunite – dickite – pyrite alteration assemblages are laterally restricted to the northern zone, including Ramba Joring, Tor Uluala, and Uluala Hulu. Extensive illite – montmorillonite – pyrite ± quartz alteration is widely developed in an approximately N-trending graben, and is flanked by chlorite ± epidote – calcite – pyrite alteration to the west. High-resolution microscale textural mapping shows that euhedrally tabular alunite has overgrown large quartz crystals and/or replaced primary aluminosilicate minerals, whereas abundant pyrite and minor barite infilled interstices between alunite and quartz. LA-ICP-MS trace element maps of pyrite reveal different zoned textures and compositional variations at Martabe. Pyrite from the central zone at Purnama has simple zoned texture and chemical compositions, characterised by As-Tl-Ti-rich cores and Au-Ag-Bi-Cu-Co-Ni-rich rims. Pyrite from the northern part of the district (e.g., Uluala Hulu) shows complex, multiple core-rim compositional characters, implying multiple mineralisation stages and high gold enrichment on the pyrite rims of each growth stage. The Martabe alunite has a narrow range in 1480 nm absorption feature, from 1477 to 1484 nm, with an increasing wavelength towards Purnama and Ramba Joring. In situ micro-analytical results demonstrate that the alunite is mostly K-rich, with minor Ca-rich huangite, whereas Na-rich natroalunite is notably absent. Several trace elements (e.g., Ba, Pb, and Sr) have high concentrations in alunite from both the northern (Uluala Hulu) and southern (Horas) areas, but are comparatively depleted in the central region. Sulfide micro-inclusions have been detected in the alunite that are characterised by anomalously high Cu (≤ 0.2 wt.%) and Au (≤ 40 ppm) values. These micro-inclusions occur in alunite proximal to mineralisation centres in the Martabe lithocap. This study suggests that alunite and pyrite textural and compositional characteristics may provide robust vectoring tools towards high-grade Au ores

and heat centres in the lithocap environment.

Keyword

Lithocap, High sulfidation mineralisation, Alunite, Pyrite, Indonesia

South African coal and coal by-products as potential alternative sources for rare earth elements: A case study of the Ermelo, Soutpansberg, Tuli, Utrecht and Waterberg coalfields

Christopher Baiyegunhi[1]*, University of Linpopo (christopher.baiyegunhi@ul.ac.za)

Abstract

Rare earth elements (REE) demand is rapidly increasing as new energy and energy storage technologies are developed, and conventional REE deposits are unable to meet the world's high REE demand. As the gap between global REE demand and supply widens, the search for alternative REE resources has become a global concern. Recent studies have shown that coal is a potential untapped resource for REE. South Africa is known to host large reserves of coal, estimated between 15 and 55 billion tons, and more reserves of coal are expected to be recovered. As a result of the need to diversify the source of REE, South Africa has significant opportunities to join the world's supply. Thus, there is growing interest in researching the occurrence, distribution and concentration of REE in South African coal and ash. In this study, laboratory-derived coal ash, power station coal fly ash and corresponding feed coals collected from different coalfields in South Africa were investigated for their chemical and mineralogical characteristics. The collected samples were analysed using x-ray diffraction (XRD), mineral liberation analyser (MLA), proximate analysis, ultimate analysis, scanning electron microscopy coupled with energy dispersive spectrometry (SEM+EDX) and inductively coupled plasma (ICP-MS). The XRD, SEM and MLA results revealed typical REE-bearing minerals (i.e., monazite, xenotime, parisite and allanite) in the samples. The back-scattered electron (BSE) detector images show a mix of locked, intermediate, and freed REE-hosted minerals. The REEs concentrations in the coal and ash samples ranged from 101 to 143 ppm and 389 to 587 ppm, respectively. In addition, the H– and M-type REE enrichment types were recorded in the samples. As expected, the REE concentrations in the ash samples are higher than the average upper crustal values, and higher than the global average hard coal ash values, but lower than the REE-rich coal ashes recorded for various deposits globally. In general, the results show that the REE occurrence, distribution and concentration differ between the different coalfields, which could be related to the sediment source in the peat swamp and subsequent mineralogical precipitation and alteration.

Keyword

Mineralogy, rare earth elements, coal, geochemistry, South Africa

The volcanic-hosted beryllium deposits in eastern China: Tectonic setting, Ages and Metallogenic potential

Xiaofeng LI[1]*, Institute of Geology and Geophysics, CAS (xiaofengli@mail.iggcas.ac.cn)
Zhu Yiting[2], Institute of Geology and Geophysics, CAS
Deng Xuanchi[3], Institute of Geology and Geophysics, CAS

Abstract

Volcanic-hosted Be deposits generally refer to epithermal low-temperature metasomatic and vein deposits occurring in volcanic-subvolcanic rocks, and related to high silica rhyolite and granite porphyry. Volcanic-hosted Be deposit is the major sources for beryllium production in the world. A large number of Mesozoic volcanic-subvolcanic rocks occurred in eastern China, but the metallogenic conditions, metallogenic potential and the prospecting prospect of volcanic-hosted Be is also unclear. This abstract clarifies the prospecting clues of volcanic-hosted Be deposits discovered recently in eastern Chin. The existing volcanic-hosted Be deposits (mineralization occurrences) in eastern China mainly hosted in the volcanic rocks of Zhangjiakou Formation, Nanyuan Formation and Jilongzhang Formation; The metallogenic chronology of volcanic-hosted Be deposits (mineralization occurrences) shows that they are mainly formed in the Late Jurassic, early Early-Cretaceous and early Late-Cretaceous. The early Early-Cretaceous is the main metallogenic period, which is basically consistent with the time of the extensional structure of Eurasia-Asia Continents in the Early Mesozoic, and the time limit of the tectonic regime transition in eastern China. It concludes that it preserves good metallogenic potential of volcanic-hosted Be deposits and a broad prospecting prospect in eastern China. The Great Xing'an Range and its adjacent areas, as well as the southeast coastal areas in China are the favorable for volcanic-hosted Be deposits (mineralization occurrences) prospecting in the future.

Keyword

Volcanic-hosted Be deposit, Early Early-Cretaceous, Tectonic Setting, Chronology, Eastern China

The chemical composition of helvine-group minerals and implications for the genesis of beryllium deposit: cases studies from Dawan, Qidushan and Taoxikeng deposits, southeast China

Yiting ZHU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (yiting.z@foxmail.com)
Xiaofeng Li[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Helvine-group minerals have characteristic chemical compositions and textures and occur in different environments within magmatic–hydrothermal deposits. However, their origin is still unclear. There are several quartz-vein beryllium deposits (Be-bearing minerals is mainly composed of helvine-group mineral) with different element assemblages existing in southeastern China, including the Dawan Be–Mo, Qidushan Be–Zn–Sn, and Taoxikeng Be–W deposits. We present the chemical composition of helvine-group minerals analyzed by electron probe micro-analysis EPMA and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). The EMPA data show that the helvine-group minerals from the three deposits is helvine and/or danalite. A wide variety of different trace elements display high concentrations in the different deposits (e.g., helvine-group minerals from the Dawan deposit are rich in Li, B, Sc, V, Ga, Y, Sn, Cs, Th, and U; those from the Qidushan deposit are rich in Sc, Cd, and Sn; whereas those from the Taoxikeng deposit are rich in Y, Cd, Sn, Ta, and total rare-earth elements ∑REE. The material analysed from the Dawan deposit have the highest concentrations of Li (28.03–134.96 ppm), Sn (126.01–709.24 ppm), Sc (108.10–287.64 ppm), Cs (0–37.24 ppm), Th (4.78–112.63 ppm), and U (0.79–4.13 ppm). The material analysed from the Taoxikeng deposit have the highest concentrations of Y (594.95–899.95 ppm), Cd (22.63–25.21 ppm), Ta (0.41–0.86 ppm), and ∑REE (281.69–451.79 ppm). However, those from the Qidushan deposit have the lowest concentrations of Y (10.21–37.70 ppm), Sn (0–26.88 ppm), U (0–19.06 ppm), Eu (0–0.14 ppm), and Cs being below the detection limit. All of them are rich in heavy REEs but poor in light REEs with distinctive REE patterns. Our results reveal that both crystallographic substitution and fluid composition control the enrichment of trace elements in helvine-group minerals. The textures and the trace element compositions of helvine-group minerals can represent various parageneses and ore-forming fluid compositions. We propose that the δ Eu values and La/YbN ratios can be used as markers to discriminate the genesis of helvine-group mineral precipitated from different environments, based on the chemical compositions and the origin of ore-forming fluids.

Keyword

Helvine-group minerals, chemical composition, trace elements concentration, ore genesis, beryllium deposits

Li-Rb-Cs mineraliztion of granite-pegmatite in the Gyirong-Nyalam region, Tibet and its significance

Fangyang HU[1]*, Institute of Geology and Geophysics, Chineses Academy of Sciences (hufangyang@mail.iggcas.ac.cn)
Xiao-Chi Liu[2], Institute of Geology and Geophysics, Chineses Academy of Sciences
Jia-Min Wang[3], Institute of Geology and Geophysics, Chineses Academy of Sciences
Shao-Xiong He[4], Institute of Geology and Geophysics, Chineses Academy of Sciences
Fu-Yuan Wu[5], Institute of Geology and Geophysics, Chineses Academy of Sciences

Abstract

In recent years, the research and prospecting of Himalayan rare metal mineralization have made significant breakthroughs, making Himalaya a potentially important rare metal mineralization belt. We recently discovered pollucite-lepidolite-albite granite and spodumene-bearing pegmatite in the Gyirong-Nyalam region. Among these, the pollucite in the Tsalung Valley is first discovered in the Himalayan belt in China. Additionally, the discovery of spodumene-bearing pegmatite at the Gangbu is another lithium ore occurrence after the discovery of spodumene-bearing pegmatite at the Qunggya Kang (Pusila), Gabo, Ra Chu, and Ku Chu regions in the Himalayas. The occurrence of pollucite indicates that the magma experienced an extremely high degree of fractionation, reflecting that the Gyirong-Nyalam region should have an excellent prospect for rare metal mineralization. The dating results of monazite, columbite-tantalite, and cassiterite from the tourmaline muscovite granite, spodumene-bearing pegmatites, and pollucite-lepidolite-albite granite showed that the age of the tourmaline muscovite granite and spodumene-bearing pegmatites are 25 Ma, and the pollucite-lepidolite-albite granite is formed at 19~18 Ma, confirming a two-stage of mineralization. In comparison to the spodumene pegmatite in the Himalayas, the pollucite-lepidolite-albite granite exhibits different whole-rock and mineral compositions, suggesting they may have different fractionation processes. Notably, the elevated fluorine (F) is proposed to greatly enhance the magmatic fractionation and the degree of rare-metal element enrichment. Importantly, most spodumene-bearing pegmatites from west to east in the Himalayas have a similar formation age and field occurrence, indicating that the lithium mineralization is temporally and spatially coherent along the strike of the Himalayan belt. Combined with the metamorphic and deformation characteristics of the strata, we propose that the Li-Rb-Cs mineralization is mainly controlled by the development of the South Tibetan Detachment System (STDS). It's also noteworthy that abundant Cs-bearing geyserite deposits are exposed along the Yarlung-Tsangpo River, indicating there is a potential link between the endogenic and exogenic rare-metal deposits, emphasizing how the Himalayan orogeny controls mineralization.

Keyword

Himalaya, rare metal, spodumene, pollucite, Gyirong-Nyalam

A preliminary study on the beryllium mineralization in the southern Great Xing'an Range, northeastern China

Yu-Sheng Zhu[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (zhuyusheng@mail.iggcas.ac.cn)
Hao Yang[2], College of Earth Sciences, Jilin University
Wen-Chun Ge[3], College of Earth Sciences, Jilin University
Jin-Hui Yang[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Zheng Ji[5], College of Geoexploration Science and Technology, Jilin University
Hao-Ran Wu[6], College of Earth Sciences, Jilin University
Zhi-Chao Zhang[7], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Beryllium, with its unique chemical properties, is dispensable and irreplaceable in many industries related to high-tech applications and products vital to national security, which makes maintaining stable supply of this metal for the economy and defense very essential. Bertrandite ore from the volcanic rocks and beryl ore from the pegmatite or granites are the major Be sources of the world and have been the focus of future exploration in many countries. The southern Great Xing'an Range (GXR) of the northeastern China is well-known for its widespread and large abundances of Mesozoic granites and volcanics, which was thought to have great potential for the Be metallogenies. However, the actual spatial-temporal distribution and metallogenetic condition of the Be deposits and occurrences in the southern GRX were rarely reported in the past. Our work in recent years confirmed twenty-one reported Be deposits or occurrences in the southern GXR and newly identified five Be occurrences that mainly associated with granite-pegmatite, quartz vein, and greisen. Beryl is the most common ore minerals in these new Be occurrences with secondary bertrandite and phenacite found in certain occurrences. Two metallogenetic episodes, including the middle to late Triassic (240~213 Ma) and the Early Cretaceous (144~125 Ma) were observed, corresponding to the post-collision extension after the closure of the Paleo Asian Ocean and the lithospheric extension caused by the roll-back of the subducted Paleo-Pacific oceanic plate, respectively. Systematic mineralogical, petrological and geochemical studies revealed that the Be deposits and occurrences from the southern GXR are genetically related to the coexisted highly-fractionated granites of the region and experienced strong fluid-melt interaction during the enrichment and mineralization of Be. In addition to the hydrous fluids released from the shallow granitic reservoir, deep magma reservoir-derived fluids were also involved and facilitated the depositing of Be minerals. Our results suggest that the granite-pegmatite hosted Be deposits and occurrences are widespread in the southern GRX and might be an important resource of the Be minerals.

Keyword

Be mineralization, Great Xing'an Range, Highly-fractionated granite, Beryl, Mesozoic

Rare Metals in Coals of Far East of Russian: Concentrations & Resources in Coal deposits

VLADIMIR ILICH VYALOV[1]*, Southern Federal University, Rostov-on-Don, Russia (vladimir_vyalov@vsegei.ru)
ALEKSEI V. NASTAVKIN[2], Southern Federal University, Rostov-on-Don, Russia
EVGENY P. SHISHOV[3], A.P. Karpinsky Russian Geological Research Institute, Saint-Petersburg, Russia

Abstract

Russian coal is of commercial interest not only as a fuel. Trace elements in 11 brown coals of the Far East and the Arctic coast of Russia were analyzed (more than 1000 samples) using the method of mass spectrometry with inductively coupled plasma. It was possible to determine the reliable concentrations of a number of chemical elements (Ge, Sb, W, Ag, etc.). Coals contain high contents of Ge, Be, Sc, Mo, W, REE, U, Ag, Pd, etc. Content of metals in brown coals of Kamchatka: the Korfskoe deposit (content in ash/in coal, ppm): Ge (70-500/-), Li (-/43), REE (445.5 (max 1314)/161.7), Sr (425.1/154.3, Zr (261 (max 1570)/94.7), Mo (32.4 (max 219)/11.7), V (442 (max 3010)/161), Sc (22.3 (max 60)/8.1), Cu (-/79.4), Ag (-/3.9), Pd+Pt (0.13/0.05). Echvayamskoe deposit: Ge (-/max 372), In (max 10/-), REE (max 514/-), Cu (-/max 140), V (max 1020/-). Coal deposits with metals of the Magadan Region: Lankovskoe, Viliginskoe deposits: REE (to 549.1 – 691.3); Viliginskoe: W (to 381), Mo (to 106), V (to 1160), Pd (to 0.048) in coal ash. Coal deposits of the Amur Region (to/average, ppm, in ash): Erkovetzkoe (East part): REE (3813.4/ 490.9), V (to 1180), Zn (to 676); Hurmulinskoe: REE (2037.3/1095.8), Ni (480/230.4); Lianskoe: REE (1914.8/521.3); W (458.0/57.5), Mo (48.8), Cu (289.0/141.6); Ushumunskoe: REE (to 913.5/380.7), W (to 359), Nb (to 156), etc. Coal deposits with rare metals of Primorski Krai (ppm): Pavlovskoe deposit. Mean: Be (29.4), Ge (580), Sb (192.1), Y + REE (91.0), Cs (5.2), W (254.2), Rb (13.3) (in coal substance). Shkotovskoe brown coal deposit. Mean: Be (38.8), Ge (1484), Sb (598), REE+Y (83.3), Mo (14.4), W (341.4), Rb (12.5) (in coal substance). Rakovskoe deposit: max. concentrations: Be (338), Ga (96.4), Ge (1100), Sb (610), REE+ Y (2853), Mo (230), In (1.63), U (3670) in ash.

Rare metal resource potential of coals of Far East Federal District (the non-licensed 11 deposits): this resource of metals in coals has been assessed according to categories of prognosticated resources («P3» and«P2» according to Russian classification). The amount of rare metals prognosticated resources of category P2 is as follows: Ge – 7.18 thousand tons, Sc – 11.98 thousand tons, Ga – 10.94 thousand tons, Rb2O – 40 thousand tons, SrO – 137 thousand tons, Cs2O – 3.6 thousand tons, ZrO2 – 36.3 thousand tons, REE+Y – 212.8 thousand tons. Category P3: Ge – 9.8 thousand tons Sc – 14.4 thousand tons, Ga – 16.4 thousand tons, Rb2O – 46.3 thousand tons, SrO – 125.7 thousand tons, Cs2O – 9.16 thousand tons, ZrO2 – 135.6 thousand tons, REE+Y – 266.18 thousand tons. PGM (Pd+ Pt) of category P2 amount to 15.1 tons and those of category P3, 24.4 tons. All this, in total, forms a new considerable mineral-raw base of rare

metals and other valuable metals in brawn coal deposits of Far East of Russia.
This study was supported by the Russian Science Foundation project № 23-27-00427, https://rscf.ru/project/23-27-00479/

Keyword

Rare metals, Concentrations, Coal deposit

Rare metal (REE, Nb, Ta) deposits hosted by carbonatite and alkaline complexes: A Canadian perspective

Anne-Aurélie Sappin[1]*, Geological Survey of Canada (anne-aurelie.sappin@nrcan-rncan.gc.ca)
Paul Bédard[2], Université du Québec à Chicoutimi
Marc Constantin[3], Université Laval

Abstract

Carbonatite and alkaline igneous rocks are relatively rare on the Earth's surface, accounting for less than 1% of all the Earth's igneous rocks. However, they are the main hosts of rare metal (rare earth elements (REE), Nb, Ta) deposits and most of the world's rare metal production is associated with these igneous rocks. Alkaline-carbonatitic magmatic systems emplaced into intracratonic anorogenic or post-orogenic extensional settings, spatially related to major crustal structures. They generally crystallize from volatile-enriched carbonatite and alkaline parental magmas generated by low degrees of partial melting of metasomatized or crustally contaminated lithospheric mantle sources. Canada hosts many of these unusual magmatic systems. They range in age from Neoarchean to Mesozoic, albeit many are Proterozoic in age, and mainly occurred within the Canadian Shield (central and eastern Canada) and the Canadian Cordillera (western Canada). The country also has numerous examples of alkaline-carbonatitic magmatic systems mineralized in REE, Nb, and Ta, some of which are currently in production (e.g., Niobec Nb mine – 1.8 Mt at 0.61% Nb2O5, total production in 2010) or at an advanced-stage of development (e.g., Strange Lake REE deposit – 278.0 Mt at 0.93% TREO and 1.92% ZrO2, indicated mineral resources; Kipawa REE deposit – 13.4 Mt at 0.36% TREO, indicated mineral resources). Based on their main host rock-association, these rare metal deposits can be subdivided into 1) carbonatite-related deposit, 2) peralkaline intrusion-related deposit, and 3) peralkaline volcanic rocks-related deposit. They were mainly formed by magmatic (e.g., fractional crystallization, magmatic immiscibility), hydrothermal, or metasomatic processes, or a combination of these. Overall, REE ores in these alkaline-carbonatitic magmatic systems contain a range of REE-bearing fluorocarbonates (e.g., bastnaesite–Ce, parisite–Ce, synchysite–Ce), phosphates (e.g., monazite–Ce, xenotime–Y), oxides (e.g., aeschynite–Y, fergusonite–Y), REE-bearing silicates (e.g., eudialyte, mosandrite–Ce) and halides (e.g., gagarinite–Ce, fluorite). In contrast, Nb and Ta ores consist mainly of oxides (e.g., pyrochlore–Nb, columbite–Nb-Ta, and rutile–Nb-Ta).

Canada has some of the largest known high-grade, high-tonnage rare metal geological resources associated with carbonatite (e.g., Niobec, Aley) and alkaline (e.g., Strange Lake, Nechalacho) magmatism worldwide. Although many geological features of these deposits have already been documented, the critical processes responsible for their formation need to be better constrained in many cases. Improving our knowledge of rare metal-bearing carbonatite and alkaline complexes in Canada will therefore help refine the global petrogenetic and metallogenic models for this type of deposit.

Keyword

Rare Earth Elements, Niobium, Tantalum, Carbonatite, Alkaline complex

Extreme low-T fractionation of felsic magmas and implications for rare-metal deposit genesis: analysis of regional thermal considerations and internal high heat production

David R LENTZ[1]*, University of New Brunswick (dlentz@unb.ca)

Abstract

The formation of very low temperature magmatic systems that are very highly enriched (extremely, i.e. > 1000 times) in key incompatible elements of interest are critical to both magmatic and magmatic hydrothermal deposits. A combination of selected partial melting and crystal fractionation are responsible for these levels of enrichment, although in many cases source protolith attributes are important as well. Like in most magmatic systems, the processes controlling fractionation to this degree are related to partitioning equilibria in the source and during ascent, emplacement, and locally even the eruption (tuff to flows) of these magmas. Other than the > 1000 times absolute enrichment values of metallogenic incompatible elements relative to the crust, key element ratios like Rb/Sr, Zr/Hf, Nb/Ta, Th/U etc. have long been applied to reflect degrees of differentiation to extreme fractionation levels, although some researchers have erroneously suggested that these indices can only reflect hydrothermal processes. However, the existence of virtually mineralized tuffs like the peraluminous Macusani (highly significant Li, U, Sn, Ta) and peralkaline Nb tuff (Brockman) (highly significant Nb, Ta, Zr, U) demonstrate these levels of differentiation can be entirely magmatic processes; numerous other examples are being realized worldwide. In addition, the saturation of ore minerals like spodumene, tantalite, cassiterite, uraninite, molybdenite, monazite, eudialyte etc. from extremely evolved magmas shows deep to shallow fractionation processes can occur, although are known to be extremely rare in nature. Published mineral solubility experiments show that these are reasonable saturation models as well. However, rheologic limitations coupled with limitations in crystal-melt separation mechanisms have cast doubt on extreme fractionation models. These specialized fractionation models have been termed boundary layer differentiation to solidification front fractionation, but none has solved the noted limitations to low-T crystal fractionation in felsic magmatic systems, even with high degrees of fluxing elements. Although typically neglected, the regional thermal environment of fractionating magmatic systems that can prolong selective partial melting through to extending fractional crystallization can extend these supra-solidus processes by up to 10 times. In addition, high U and Th (often > 10 times crustal values) in fractionating felsic magmatic systems, commonly termed high heat production (HHP), can also significantly extend the supra-solidus fractionation processes that will strongly affect very high degrees of fractionation. Although the absolute effects associated with significantly extending duration (t) of fractionation are not known, this is no doubt an important contributing factor in low-T fractionating magmatic systems. Also, metal endowment in these low-T fractionating felsic magmatic systems no doubt contributed to the relative fertility of these specialized felsic magmatic hydrothermal systems, although that remains quite controversial and vigorously debated.

Keyword

rare metal, extreme fractionation, fertility, high heat production, geothermal gradient

Volcanic-hosted hydrothermal rare earth element (REE) mineralisation, West Musgrave Province, Australia

Ben James Kimpton [1]*, Caspin Resources Ltd (benkimptongeo@gmail.com)
Garry A Dick[2], Caspin Resources Ltd
Greg J Miles[3], Caspin Resources Ltd

Abstract

A unique style of hydrothermally remobilised, volcanic-related Rare Earth Element (REE) mineralisation is described at the Duchess Prospect in the Proterozoic West Musgrave Province of Western Australia. Mantle derived, highly fractionated felsic volcanics of the Warakurna Large Igneous Province (LIP) with significant background enrichment in REEs serve as the likely source and observed host of mineralisation. REEs are precipitated and transported by hydrothermal fluids and deposited in high concentration predominantly at rheological boundaries, principally the structural-stratigraphic contact between volcanic units. SEM mineralogy demonstrates that the majority of REEs are hosted within monazite and lesser xenotime, which are secondary in nature replacing primary minerals including titanite. Mineralisation includes a substantial proportion of both light and heavy REEs including the economically significant Pr, Nd, Tb and Dy.

Approximately 2 km to the northwest at the Handpump Prosect, hydrothermal fluids with analogous structural-stratigraphic controls are observed to host significant gold mineralisation. Handpump has previously been interpreted as a low temperature, low sulfidation epithermal deposit with mineralisation being broadly coaeval to the Lower Mt Palgrave Group at 1075±8 Ma. Fine grained gold is primarily hosted in quartz veins and breccias with associated hydrothermal alteration at the contact between volcanoclastic and rhyolite units. Systematic surface geochemistry along a 7 km strike extension of this contact identified significant and widespread base and precious metal anomalism which instigated further exploration at the greater Duchess Prospect. The discovery of high-grade REE mineralisation along this contact was a serendipitous outcome of reconnaissance aircore drilling principally targeting Cu-Mo-Zn-Pb-Au-Ag+ anomalism in the area. While significant Au-Ag, Cu and Mo values were observed in drill and rock chip assays, REE mineralisation represents the standout exploration result from the prospect. Coincident base, precious and REE enrichment serves to highlight the prospectivity of the West Musgrave region and the felsic components of the Bentley Supergroup and Warakurna LIP.

Keyword

REE, West Musgrave, Hydrothermal, Volcanic, Rare Earths

In-situ U-Pb Dating of Apatite in Heima Pegmatite-hosted Lithium Deposit, West Yunnan

Yong YU[1]*, Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, College of Earth Sciences, Guilin University of Technology, Guilin,China (glyuyong@163.com)
Ji LIANG[2], Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, College of Earth Sciences, Guilin University of Technology, Guilin, China
Xiaofeng LI[3], Key Laboratory of Mineral Resources,Institute of Geology and Geophysics,Chinese Academy of Sciences
Zhentao JU[4], Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, College of Earth Sciences, Guilin University of Technology, Guilin, China
Yiting ZHU[5], Key Laboratory of Mineral Resources, Institute of Geology and Geophysics,Chinese Academy of Sciences

Abstract

Heima pegmatite-hosted lithium deposit is located in the Gaoligong Mountain area, close to the southern section of the Sanjiang region, Southwest China. There are more than 30 granite pegmatite veins developed in the ore district, most of which intrude into the metaquartzite hornblende schist of the Carboniferous system along the schistosity. The pegmatite veins are not well-zoned in the ore district, and the mother lode is mainly composed of quartz, zinnwaldite, albite, potassium feldspar, topaz, and apatite. The accessory minerals include niobium (tantalum) nigrine, garnet, tourmaline, beryl, cassiterite, zircon, and thorite. The rare metal ore-forming elements are mainly Li, as well as some Be, Nb, Ta, and Sn. Zinnwaldite is the main ore mineral in the ore district.

Apatite in the pegmatite of the Heima lithium deposit belongs to the fluorapatite and mainly occurs in zinnwaldite and mica fissuring, with a content of less than 5%. The apatite is colorless, transparent, and hypidiomorphic-xenomorphic granular, with a grain size of 0.2-2 mm, and some grains up to 10 mm. Commonly, it contains extremely small thorite inclusions. Under plane-polarized light, it is colorless and transparent, with a positive medium relief, while under cross-polarized light, the interference color appears as first-order gray, with parallel extinction.

The apatite in the pegmatite of the Heima lithium deposit exhibits uniform characteristics in both BSE and CL images and belongs to magmatic apatite. In this study, preliminary in-situ LA-ICP-MS U-Pb dating was analyzed on the 24 points of apatite. Results show that the 238U contents vary from 336.10 × 10-6 to 479.40 × 10-6, with an average of 386.40. The 238U/206Pb ratio ranges from 7.27 to 14.04, with an average of 11.41. The 207Pb/206 Pb ratio varies from 0.58 to 0.61, with an average of 0.59. The 238U/206Pb-207Pb/206 Pb age of apatite is 55 ± 4 Ma (MSWD=2.4), which could represent the diagenetic and ore-forming age of Heima pegmatite-hosted lithium deposit. Therefore, we can conclude that the rare metal mineralization was formed in the tectonic environment caused by the India-Eurasia collision which resulted in crustal thickening, which may be related to the crustal material remelting/deep melting caused by the India-Eurasia collision.

Keyword

In-situ U-Pb Dating, Apatite, Granitic pegmatite, Rare metal deposit, West Yunnan

Mineralogy of the REE-rich carbonatite complexes in Khotgor, South Mongolia

Bingbing GAO[1]*, Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of Technology (gao.bing.bing@163.com)
Meng FENG[2], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of Technology, Guangxi, China.
Wei FU[3], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of Technology, Guangxi, China.
Huahua TANG[4], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of Technology, Guangxi, China.

Abstract

Mongolia is divided into northern and southern domains by the main Mongolian lineament. The alkaline-carbonatite complexes are mainly distributed within the area of Southern Mongolia, which have a clear economic potential owing to their overall high content of rare-earth elements (REE). The Khotgor REE deposit located in the Gobi-Tien Shan fold belt in southern Mongolia and controlled by tectonic faults. Estimated resources in this deposit are 40Mt REO with an average content of 1.22 wt.% [1]. The alkaline-carbonatite complexes are mainly composed of nepheline syenite, carbonate breccia and carbonate dikes. Some of these dikes and breccia contain "apatite ore"[1]: magnetite-apatite or fluorite-celestine-magnetite-apatite associations. Previous studies have shown that the nepheline syenite age was 135 Ma[2].

At present, the study on mineralogy and geochemical of Khotgor carbonatite complexes are comparatively weak and not systematic. In our study, we analyzed the REE-rich carbonatite in Khotgor by SEM and TIMA. The carbonatites are, for the most part, medium-grained massive rocks composed of primary calcite, with different proportions of orthoclase, magnetite, dolomite, apatite, muscovite, biotite and barite. Accessory minerals are fluorite, quartz, zircon and chlorite. In some part of the carbonatite, calcite-dolomite-magnetite vein could be observed. Two REE minerals were identified: parisite and monazite. It is worth noting that the parisites are closely associated with calcite, orthoclase and other magmatic rock-forming minerals, with intact crystal form and mainly radially produced. Besides, most of the parisites are intergrown with or superimposed on barite (BaSO4), which also has a close relation with rock-forming mineral. All these mineralogical features show that the parisite and barite are mainly formed in the magmatic stage of carbonatite. The sulfate (SO42-) may be an important factor for rare-earth element migration and precipitation.

This work was supported by the National Natural Science Foundation of China (42272076) and Guangxi Natural Science Foundation Program(2022GXNSFBA035463).

Reference cited

[1] Muff R, Tamiraa A. Rare Earths of Mongolia: Evaluation of Market Opportunities for the Principal Deposits of Mongolia; Technical Report; Mineral Resources Authority of Mongolia[M]. Ulaanbaatar/Bundesanstalt für Geowissenschaften und Rohstoffe: Hannover, Germany, 2013: 63p.
[2] Nikiforov, A.V.; Yarmolyuk, V.V. Late Mesozoic carbonatite provinces in Central Asia: Their compositions, sources and genetic settings. Gondwana Res. 2019, 69, 56–72.

Keyword

REE, Mineralogy, Mineralization, Carbonatite, South Mongolia

Zircon and cassiterite U-Pb geochronology, Hf isotopes and geochemistry characteristics of Xianglushan rubidium-rich granite complex and its geological significance, northeast Guangxi , China

Yupeng HUO[1]*, Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of Technology, Guangxi, China (2387115247@qq.com)
Chuan ZHAO[2], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of TechnologyGuangxi, China.
Meng FENG[3], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of TechnologyGuangxi, China.
Wei FU[4], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of TechnologyGuangxi, China.
Zuohai FENG[5], Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources By the Province and Ministry,Guilin University of TechnologyGuangxi, China.

Abstract

Rubidium (Rb) is one of important rare metals and strategic emerging industry minerals, and it is anticipated to be of the focus of intrnational naturalresource competition in the future. South China is an important strategic mineral resource base in China, which has abundantly developed granites of multiple ages and gyres, and possesses large-scale mineralisation of rare and non-ferrous metals. The Miao'ershan-Yuechengling batholith (MYB) is one of the largest granitic batholiths in Guangxi Zhuang Autonomous Region, South China.

The Xianglushan rubidium-rich granite complex, which is mainly composed of alaskite and biotite monzonitic granite, is located at the northeastern part of the MYB. The content of Rb in granite body has exceeded the industrial grade. Alaskite has a concordant U-Pb age of 416.6±3.5 Ma (MSWD=0.15,N=12) of zircon and Tera-Wasserburg lower intercept ages of 415.9±2.4 Ma (MSWD=0.76,N=17) of cassiterite. All these new age data are indistinguishable within analytical uncertainty and, therefore, indicate the rubidium-rich granite complex formed in Caledonian. The εHf(t) values of zircon vary from -6.86 to -3.64 and calculated two-stage Hf model ages (TDM2) vary from 1.65 to 1.90Ga, indicating that the granites may have formed from partial melting of Paleoproterozoic basement rocks

The alaskite and biotite monzonitic granite have high SiO2 (74.58~80.71wt.%) and alkaline (K2O+Na2O=7.32~9.49wt.%), with a range of A/CNK ratios of 1.06~1.28. Both types of rock body have similar trace element characteristics, with relative enrichment in RbUThNb and Ta, and relative depletion in Sr and Ba. The mean value of the differentiation index (DI) is 93.93~98.03. All the geochemical features show that the Xianglushan rubidium-rich granite complex belongs to highly differentiated S-type granite.

This work was supported by the Guangxi Natural Science Foundation Program(2022GXNSFBA035463) and National Natural Science Foundation of China (42272076).

Keyword

Cassiterite, Zircon, LA-ICP-MS U-Pb age, Caledonian, South China

Allanite crystallization inhibits economic rare earth element mineralization in carbonatites.

SOURAV BHATTACHARJEE[1]*, Indian Institute of Science Education and Research, Tirupati (souravbhattacharjee@students.iisertirupati.ac.in)
Monojit Dey[2], Indian Institute of Science Education and Research, Tirupati
Aniket Chakrabarty[3], Indian Institute of Science Education and Research, Tirupati

Abstract

Carbonatites are magmatic rocks with more than 50% primary carbonate minerals. Carbonatites host economic-grade rare earth elements (REE), and their demand is anticipated to surge amid the global shift toward green technology. Carbonatite-forming magma-derived carbohydrothermal fluids are rich in REEs, alkalis (Na and K) and REE-complexing ligands (CO32-, OH-, F-, SO42-, and Cl-), leading to widespread REE mineralization. Despite the presence of REE-carbonates (e.g., ancylite), REE-fluorocarbonates (bastnäsite, parisite, synchysite), REE-phosphates (apatite, monazite, xenotime) and accessory REE-silicates (allanite, britholite) in carbonatites, economically viable REE extraction is currently feasible only from bastnasite and monazite (Chakhmouradian and Wall, 2012). In contrast to silica-rich country rocks, the insufficiency of silica and alumina in carbonatite-forming magmas often results in wall rock assimilation. The influx of Si into such magmas prompts the early incorporation of REEs within apatite during magmatic stages, decreasing the overall REE budget in carbohydrothermal fluids (Anenburg et al., 2020). The persistent contamination by Si and Al in post-magmatic or carbohydrothermal stages stabilizes the formation of allanite (Bhattacharjee et al., 2024). Carbonatite-related allanite occurrences can be generalized into two broad types: a. confined within the carbonatites with profuse wall rock xenoliths, and b. at the interphase between the carbonatite and the Si-Al-rich country rock. Wall rock xenoliths within carbonatite facilitate prolonged assimilation and contamination through magmatic and carbohydrothermal stages. This process may sequester a major portion of the REEs within apatite and allanite, hindering the economic concentration of monazite and bastnasite within carbonatites. On the contrary, minimal assimilation and contamination within carbonatites might facilitate the formation of monazite and bastnasite. Additionally, carbonatites with wall-rock xenoliths show proximal allanite-(Ce) and distal REE-rich epidote in the metasomatized country rocks, governed by the allanite-epidote ($REE^{3+} + Fe^{2+} = Ca + Fe^{3+}$) and allanite-clinozoisite ($REE^{3+} + Fe^{2+} = Ca + Al$) substitution mechanisms. Thus, the spatial variation in allanite compositions further supports the decreasing REE budget in carbohydrothermal fluids with high degrees of wall rock contamination within carbonatites.

References

Anenburg, M., Mavrogenes, J.A., Frigo, C. and Wall, F., 2020. Rare earth element mobility in and around carbonatites controlled by sodium, potassium, and silica. Science Advances, 6(41), p.eabb6570.

Bhattacharjee, S., Chakrabarty, A., Mitchell, R.H., Patel, S.C., Kozlov, E.N., Fomina, E.N., Dey, M. and Pal, S., 2024. The role of magmatic-to-carbohydrothermal processes in rare earth mineralization in Hogenakkal carbonatites, India. Lithos, 464, p.107431.
Chakhmouradian, A.R. and Wall, F., 2012. Rare earth elements: minerals, mines, magnets (and more). Elements, 8(5), pp.333-340.

Keyword

Allanite, Carbonatites, Rare earth elements, monazite, bastnäsite

Modification of magmatic-hydrothermal tin deposits by ductile shearing: Example of the Jiufeng and Nandaoao tin deposits of northern Guangxi, south China

ZuoHai FENG[1]*, Guilin University of Technology (fzh@glut.edu.cn)
Saisai Li[2], 1. Provincial and Ministry Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources, Guilin University of Technology, Guilin 541004, Guangxi, China. 2. Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, Guilin University of Technology, Guilin 541004, Guangxi, China.
Lei Liu[3], 1. Provincial and Ministry Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources, Guilin University of Technology, Guilin 541004, Guangxi, China. 2. Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, Guilin University of Technology, Guilin 541004, Guangxi, China.
Shehong Li[4], 1. Provincial and Ministry Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources, Guilin University of Technology, Guilin 541004, Guangxi, China. 2. Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, Guilin University of Technology, Guilin 541004, Guangxi, China.
Meng Feng[5], 1. Provincial and Ministry Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources, Guilin University of Technology, Guilin 541004, Guangxi, China. 2. Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, Guilin University of Technology, Guilin 541004, Guangxi, China.
Zengxia Zhao[6], 1. Provincial and Ministry Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources, Guilin University of Technology, Guilin 541004, Guangxi, China. 2. Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, Guilin University of Technology, Guilin 541004, Guangxi, China.
Jie Wu[7], 1. Provincial and Ministry Collaborative Innovation Center for Exploration of Nonferrous Metal Deposits and Efficient Utilization of Resources, Guilin University of Technology, Guilin 541004, Guangxi, China. 2. Guangxi Key Laboratory of Hidden Metallic Ore Deposits Exploration, Guilin University of Technology, Guilin 541004, Guangxi, China.
Chunzeng Wang[8], University of Maine at Presque Isle, Presque Isle, Maine, USA

Abstract

The Jiufeng and Nandaoao tin deposits occur in the Jiufeng ductile shear zone that is developed on the western outer contact zone of the Neoproterozoic Sanfang granitic pluton of northern Guangxi, south China. The deposits and the shear zone are hosted by the Neoproterozoic Sibu Group sedimentary rocks. Tin was mainly sourced from Sanfang granite. The tin deposits were products of magmatic hydrothermal activities associated with granitic emplacement and are dated ~830 Ma by zircon U-Pb method. The tin orebodies are present as tourmaline-bearing quartz veins, cassiterite-bearing quartz veins, and greisen. The Jiufeng ductile shear zone strikes in NNE, dips to SE, and shows left lateral-reverse motion. The ductile shear zone is dated 440 Ma, indicating that the ductile shear zone postdated the tin mineralization.

The ductile shear zone superimposed the tin deposits and caused the S-shape bending of the deposits although the continuity of the deposits is not broken. The sheared deposits are characterized by pervasive mylonitic foliation. Cassiterite crystals in the sheared orebodies show

brittle deformation. In the high strain domains, the cassiterite crystals are broken into very small fragments that occur along the mylonitic foliation with pronouncing shape-preferred orientation. In the weak strain domains, the cassiterite crystals are also broken but the broken fragments have high angularity, show only slight dislocation, and can still be restored to their original shape. The correlation coefficient between the degree of AMS (P) of the ductile shear zone and the tin mineralization intensity (content of tin) for both deposits is only 0.2, too low to be metallogenetically related to the ductile shearing event.

This research was funded by the Natural Science Foundation of Guangxi, China (Grant Nos. 2019GXNSFDA245009, 2022GXNSFBA035463) and National Natural Science Foundation of China, China (Grant Nos. 42072259, 42162018).

Keyword

tin deposits, ductile shear zone, Neoproterozoic, Early Paleozoic, South China

THE ZONE OF JUNCTION OF OIL AND GAS BEARING STRUCTURES AND URANIUM PROVINCES

Rakhimjan TURSUNMETOV[1]*, State Establishment "Institute of hydrogeology and engineering geology" (tursunmetov45@mail.ru)
Valentin TYO[2], State Establishment "Institute of hydrogeology and engineering geology"
Aziz Ibragimov[3], State Establishment "Institute of hydrogeology and engineering geology"
Salim Sobirov[4], MINISTRY OF MINING INDUSTRY AND GEOLOGY OF THE REPUBLIC OF UZBEKISTAN

Abstract

Recent studies indicate a consistent increase in the depth of detection of hydrogenic uranium mineralization annually. Exploration efforts are not only focused within traditional uranium ore regions but also extend into areas where oil and gas structures intersect. Notable intersections have been identified in the usa (specifically wyoming) and china, the republic of uzbekistan (ziatdin and bukhara oil and gas structures). Consequently, there is a keen interest in enhancing the mobile radiogeochemical method to detect deeply buried uranium ores. This method relies on soliton transfer from deep-seated ore zones, facilitating the migration of radioactive elements to the surface through energy channels adjacent to the electrically negative surface near the earth's crust, which possess an accumulating capacity.

Soliton transfer occurs due to tectonodynamic movements induced by lunar-solar tides, fostering deformation phenomena that facilitate the migration of radioactive and geochemical elements. Diffusion processes are pivotal in the mass transfer of energy over uranium mineralization, accompanied by ionization processes forming ion pairs with opposite charges. Significant uranium concentrations (20-25 mg/l) have been observed in oil and gas structures at considerable depths. Therefore, the task at hand is to pinpoint the deposition locations of ore-bearing flows emanating from magmatic bodies.

The search for uranium deposits necessitates studying magmatic bodies associated with uranium, with methodology based on the congruence of radiometric indicators, radioactive, and geochemical elements under specific geostructural conditions linked directly to ore deposition. Generally, uranium mineralization originates from igneous bodies of granite or granite-porphyry composition. Tectonodynamic activation facilitates the release of uranium components in ion form, migrating towards artesian basins. Magmatic bodies exhibit local gravitational anomalies and reduced magnetic anomalies. The direction of ore-bearing flows is characterized by a gradual decrease in the gravitational field and an increase in the geomagnetic field, with the mineralization location indicated by gradient changes in these fields. Special attention is given to identifying paleochannels in deep horizons, along which uranium components migrate.

Furthermore, transverse neotectonic structures adjacent to magmatic bodies are considered, hosting paleochannels that discharge into artesian basins, leading to the formation of localized ore structures. Horizontal stretching and compression deformations develop in these structures under tectonodynamic forces. Monitoring reveals anomalous daily dynamics of gamma radiation during

this process. Organic substances like humic and fulvic acids significantly impact the uranium deposition zone, drastically reducing the redox potential (rp). Due to their high migration ability, these substances play a vital role in uranium mineralization. A similar scenario is envisaged in the junction zone of oil and gas structures and uranium provinces.
The radiogeochemical method serves to identify and study the aforementioned structures for detecting uranium mineralization. This method has been practically applied near oil and gas structures, resulting in the identification of uranium mineralization at depths ranging from 500 to 800 meters.

Keyword

Uranium deposits, Radiogeochemic, Magmatic bodies, Soliton transfer, Junction zone

Beryl chemistry as a compositional framework for prospecting of rare-metal pegmatites in Nepal Himalaya

SUSHMITA BHANDARI[1]*, Department of Mines and Geology, Kathmandu, Nepal (sushgeo12@hotmail.com)
Kezhang Qin[2], Institute of Geology and Geophysics, University of Chinese Academy of Sciences, Beijing, China

Abstract

Beryl (Be3Al2Si6O18), being an important beryllium ore and valuable gemstone, is also an early rare-metal mineral crystallizing from fertile magma that potentially evolves to deposit Nb, Ta, Li, and Cs minerals. Although the highest concentration of aquamarines in South and Southeast Asia has been reported from Nepal, little is known about the geochemistry and mineralization characteristics of beryls from the Nepal Himalaya. This study presents major and trace element data for beryl from the recently discovered Yamrang pegmatite, aiming to elucidate characteristics of beryl and evaluate potential geochemical exploration tools for rare-metal pegmatites while also enhancing the prospects of other rare-metal commodities. Beryl mineralization was identified in zones 3, 4, and 5 out of the five mineralogical-textural zones within the Yamrang pegmatite. Two types of beryl, magmatic and hydrothermal, were distinguished based on their occurrences, mineral assemblage, texture, and geochemical properties. Magmatic beryls occur mainly in zones 3 and 4, mostly associated with blocky microcline and granular quartz. They are characterized by larger crystals (7-10 cm), prismatic to columnar habit, varying from opaque to translucent, and exhibiting green to bluish-white color. Their backscattered (BSE) images display homogeneous textures suggesting high Na and low alkali concentrations. In contrast, hydrothermal beryls are typically found in zone 5 miarolitic cavities, associated with smoky quartz crystals, albite (often cleavelandite variety), muscovite, and clay minerals. These beryls are smaller (1-3 cm), with tabular to acicular habit, ranging from colorless to deep blue, and exhibiting weak compositional zoning in BSE images, indicating alkali enrichment. Fe2+ is the main chromophore controlling the blue color of Yamrang aquamarines with up to 1.1 wt% of FeO. The octahedral Fe-Al substitution is the dominant element substitution mechanism in Yamrang beryls. The enriched Li + Cs + Rb and Fe, Mn, Rb concentration of beryl are the potential fractionation indicators. This study hopes to establish a fundamental compositional framework for future exploration of rare-metal pegmatites in the region.

Keyword

Beryl chemistry, rare-metal potential, Yamrang pegmatite, Nepal Himalaya

Cycling of Uranium (U)-polymetals in Earth System and its Effect on Mineral Resources and Environment

Deru XU[1]*, East China University of Technology, Nanchang, China (xuderu@gig.ac.cn)

Abstract

In recent years, more and more exploration and exploitation have revealed that in many different types of metallic deposits with
various ages in the world, uranium (U), present either as main metal resource or as by-product, is often symbiotic or concomitant with other metals, such as REE, W, Sn, Bi, Mo, Re, Au, PGEs (Pa, Pt), Ga, Ge, In, Co, Ni, V, Nb, Ta, Cu, Pb, Zn, Mn, etc. Such the typical ore deposit-types include: (1) hydrothermal IOCG Fe-Cu-Au-U-Ag-Ba-REE, Fe-Cu-Mo-Au-Co-REE-U and Fe-Cu-Au-Ag-PGE-U deposits, represented by the supergiant Olympic Dam deposit in Australia, (2) quartz pebble-related Au-U deposit, represented by South Africa's Witwatersrand Basin, (3) metasedimentary rocks-hosted Cu-Co-(Ni-U-Cr-Ag-Au-PGE-Mo) or Cu-Co-(Ag-Bi-W-Ni-REE-U) deposits, (4) sedimentary-metamorphic and/or magmatic hydrothermally reworked U-Cu-Au-Te-Mo-Ni-Co-Ga-V-REE and Co-Cu-U deposits, represented by that in India‘s Singhbhum shear zone, (5) unconformity-related U-Mo, U-Cu-Au, U-REE and U-Ni-Co-As-PGE-Zn deposits, represented by those in Athabasca Basin, Canada, (6) volcanics- or intrusion-related U-Ni-Co-As-Ag/Bi or Ag–Bi–Co–Ni–As±U, U-Pb-Zn-REE-Mo-Cu-Au-Ag, U-Mo-W-Sn-Cu-Pb-Zn-Ag-Au, U-Be-Mo-Cu-Pb-Ag-Au and Au-PGE±U deposits, (7) carbonatite-type U-Nb-REE-Pb-Sr-Se-In-Te-Ge deposit, and (8) U-rich coal-type U-Se-Mo-V-Re or U-Se-Mo-V-Cr-Re-REE deposits. All these instances indicate that there are intrinsically genetic link of U to other metals, especially those critical metals in metallogenetic process(es), and that U shares similar geochemical behavour to associated metals. This fact is of important significance not only for prospecting much more U-bearing mineral resources but also for seeking more effective methods to disposal of nuclear waste. However, to that what mechanism(s) caused coexistence of U and associated metals in U-bearing deposits, how about the cyclic characteristics of U and associated metals in the earth system, and what kind of Resource-Environment effect was caused by such the cycling, has not been pay attention and thus not been possible to be unambiguously understood, up to now, although these topics should have become a hot spot and frontier scientific issue in international geosciences.

The present study aims at hunting the cyclic characteristics of U and associated metals in the earth system and then attempting to unravelling the Resource-Environment effect caused by such the cycling. To give a compelling answer to these issues, the authors, from the global vision, propose that the future work maybe focus on the following six key scientific Issues on U and associated metals in different mineral systems, that is: (1) geochemical behaviors, characteristics and mechanisms of the U and associated metals in the circulation of the earth system, (2) origination, occurrence, migration, interaction and accumulation of the U and associated metals in atmosphere, hydrosphere, biosphere and lithosphere, (3) mineralogical characteristics and formation

mechanisms of the U and associated metals in the circulation of the earth system, (4) key factors controlling the genesis and evolution of the different types of U-bearing rock series and U-polymetal deposits, (5) dynamic-chemical processes of mineralization for the U and associated metals, and their prospecting breakthrough, and (6) constraint of the U and associated metals cycling on Environment and Climate change.

Keyword

uranium, circulation, earth system, associated metals, environment

Hydrodynamic relationships between shallow and deep parts of mineralization systems and implications for deep mineral exploration

Guoxiang Chi[1]*, University of Regina (guoxiang.chi@uregina.ca)
Yumeng Wang[2], University of Regina
Zenghua Li[3], East China University of Technology
Deru Xu[4], East China University of Technology
Teng Deng[5], East China University of Technology
Chunji Xue[6], China University of Geosciences
Patrick Ledru[7], Université Lorraine
Hao Song[8], Chengdu University of Technology

Abstract

Mineral deposits were formed at various depths in the upper crust, ranging from near surface to >10 km. The mineralization systems at different depths may be linked by a common hydrodynamic framework, even though the direct controlling factors and styles of mineralization are significantly different. This is particularly the case for mineralization systems in which structures exerted a major control. Understanding the genetic relationships between shallow and deep parts of the mineralization systems is critical for deep mineral exploration, which is increasingly important for finding new mineral resources. Since most mineral deposits formed from hydrothermal fluids, the hydrodynamic linkage between shallow and deep parts of a mineralization system, which controls the driving force, flow direction and velocity of the ore-forming fluids, plays a key role in determining whether or not, and where, mineralization is localized among the many seemingly similar structures.

The hydrodynamic relationships between shallow and deep parts of mineralization systems vary with the geologic setting, based on which the mineralization systems may be classified as magmatic-hydrothermal systems, structurally controlled hydrothermal systems with uncertain fluid sources, and hydrothermal systems associated with sedimentary basins. In the magmatic-hydrothermal systems, the difference in fluid pressure between the lithostatic or supralithostatic regime within the magmatic intrusions and hydrostatic or suprahydrostatic regime in the country rocks, is a major driving force for ore-forming fluid flow, in contrast to the shallow part of the system that is dominated by a hydrostatic regime. In structurally controlled hydrothermal systems, as typified by orogenic gold deposits, there is also a change from a lithostatic-dominated regime in the lower part to a hydrostatic-dominated regime in the shallow part. Similar fluid pressure profiles also occur in hydrothermal systems associated with sedimentary basins, although the lithostatic pressure regime may be developed in the basement far below the basin or within the basin, depending on the lithologies and sedimentation rate in the basin. In each of these systems, the structures that directly controlled the mineralization in the shallow part of the system may function as suction pumps during structural activity; however, such activities are likely linked to and regulated by those operating at depth by mechanisms such as described by the fault-valve model. Thus, the fluid flow related to structural activities at shallow depths actually resulted from

coupled suction pump (shallow) and fault-valve (deep) mechanisms. Whether or not a structure at shallow depth is linked to a deep-seated structure may be a determining factor for mineralization, not only for supply of ore-forming ingredients, but also for providing the driving force and pathways of ore-forming fluid flow. These hydrodynamic relationships between shallow and deep parts of mineralization systems and their implications for mineral exploration will be illustrated by several examples from South China and the Athabasca Basin in Canada.

Keyword

Hydrodynamics, mineralization, structural control, deep mineral exploration

Hydrodynamics of the Xiangshan volcanic-type uranium deposits in Jiangxi Province, South China

Zenghua LI[1]*, East China University of Technology (lizenghua@ecut.edu.cn)

Abstract

The Xiangshan volcanic Basin of the Jiangxi Province hosts the largest volcanic type uranium orefield in China. The formation of the uranium ore field was affected by many geological factors and/or processes. Firstly, uranium mineralization is almost consistent with the formation of the Cretaceous red beds in time and space. Previous studies suggest that the red beds might have played critical role in the ore-forming processes by providing oxidizing fluids. The meteoric water may have extracted Fe3+, Cl-, and other substances in the red beds and evolved into oxidizing brines, which are able to improve the activity of the uranium in the underlying uranium-rich rocks such as granites, volcanic and basement rocks. Many researchers have attempted to explain the genetic relationship between the red beds and U mineralization, but the dynamic flow pattern of the ore-forming fluids in the presence of the red beds and its significance for mineralization have not been specifically studied. In order to better understand the hydrodynamic mechanism of the ore-forming fluids and U mineralization processes in the Xiangshan U ore field, numerical models with different coupling mechanisms are established to simulate fluid flow patterns influenced by different factors on the basis of detailed field geological investigation and previous geological and geochemical data. Using the method of hydrodynamics and FLAC software, the modelling results are as follows: In the simulation results of the models that only have the topography-driven fluid flow, it is the slope gradient of the red beds that has a great influence on the fluid flow pattern in the Xiangshan Basin. Driven by topography, the fluid flows into the volcanic rocks or even into the basement at a high flow rate. The slope gradient of the red beds has a great influence on the velocity of the fluid in the shallow strata. In addition, the changes in the thickness and permeability of the red beds to a certain extent have little influence on the fluid flow pattern. In the results of the coupled hydro-thermal models, the fluid convection has formed in the model with a heat
source. It greatly changed the former fluid flow pattern and increased the flow velocity in the basement.
Meanwhile, it enhanced the temperature inside the volcanic rocks, which makes it easier to achieve for the
ore-forming temperature.This modelling is helpful to understand the effects of different geological factors on the fluid flow pattern in the shallow strata, and its implication for the Xiangshan ore-forming processes.

Keyword

numerical modelling, hydrothermal mineralization, hydrodynamics

Genetic association between carbonates and gold precipitation

Teng Deng[1]*, East China University of Technology (dengteng2015@126.com)
Qingxiang Wang[2], East China University of Technology
Deru Xu[3], East China University of Technology

Abstract

Carbonates have been traditionally regarded as post-ore minerals in hydrothermal deposits, but they can also occur in pre- and syn-ore stages. However, the genetic relationships between multi-stage carbonates and gold precipitation mechanisms remain unclear. The gold deposits in the Jiangnan Orogen (JO), is characterized with the occurrence of abundant hydrothermal carbonates. The nature of the carbonates, especially their association with gold precipitation, is examined in this study through petrographic and geochemical analyses as well as geochemical modeling. Field and petrographic work recognizes four paragenesis stages, i.e., 1) quartz (Q1)-carbonate, 2) pyrite-quartz (Q2), 3) gold-polysulfide-quartz (Q3)-carbonate and 4) chlorite-quartz(Q4)-carbonate. Carbonates associated with gold mineralization are mainly present in the first and third stages. Among them, the first-stage carbonates are pre-ore Fe-bearing carbonate (ankerite and siderite), which are generally crosscut by syn-ore sulfides. Such carbonates mostly occur in altered host rocks that are characterized with bleaching. Mineralogical and geochemical analyses reveal that chlorite is consumed while pre-ore ankerite or siderite produced, and Fe contents of the host rocks remain generally unchanged during alteration. Consequently, pre-ore Fe-bearing carbonate is interpreted to be generated by the interaction of CO2-bearing fluids and chlorite in the host rocks. Geochemical modeling reveals that both chlorite and Fe-bearing carbonate can lead to gold precipitation by triggering sulfidation, but Fe-bearing carbonate has higher chemical reactivity and therefore is kinetically favorable for more efficient gold deposition. Syn-ore carbonates are mainly formed in the third stage, primarily consisting of ankerite with minor calcite, and is co-precipitated with native gold, galena, sphalerite and chalcopyrite. Two stages of carbonates share similar δ13CV-PDB values, Pb, Zn and Cu contents but different Ca, Mg, Mn and Sr contents, indicating they are formed at different stages of the same hydrothermal event. Geochemical modeling demonstrates that pH increases as indicated by the formation of syn-ore carbonates, together with the consumption of S due to the precipitation of pyrite and arsenopyrite in the second stage, results in the decrease of Au, Pb, Zn and Cu solubility in aqueous fluids. This would lead to the co-precipitation of native gold with galena, sphalerite and chalcopyrite, forming the general small-scale but commonly occurred native gold-polysulfide veins in hydrothermal gold deposits. Consequently, both pre- and syn-ore carbonates in the gold deposits in JO are genetically associated with efficient Au-polymetal deposition through distinct mechanisms. Pre-ore carbonates could cause the large-scale bleaching of the host rocks, while syn-ore carbonates are closely related to native gold-polysulfides, and they can both be used as exploration indicator for hydrothermal gold deposits worldwide.

Keyword

gold precipitation, carbonates, geochemical modeling

Numerical modeling of the formation of ore shell by ore-forming materials enrichment in porphyry copper deposits

Changhua XIE[1]*, Sun Yat-sen University (xiechh23@mail2.sysu.edu.cn)
Fan XIAO[2], Sun Yat-sen University

Abstract

Porphyry deposits are the primary sources of copper and molybdenum globally, as well as significant sources of gold, silver, tin, tungsten, and other rare metals. In recent years, numerical simulation experiments have been extensively utilized to investigate the mechanisms of ore-forming dynamics, owing to their capability to effectively delineate crucial ore-forming processes through coupling physical-chemical processes and explore significant controlling factors. Furthermore, the study of porphyry deposits has been enduring, but there are still many scientific questions waiting to be answered, and one of the most important challenges is the unclear understanding of the dynamic mechanisms of ore metal enrichment and ore shell formation. Therefore, this study employs numerical simulation methods to quantitatively characterize the key process whereby ore-forming magma undergoes decompression boiling and crystallization differentiation boiling, resulting in "fluid exsolution" to form independent fluid phases, extracting ore-forming matels from the magma to create ore-forming fluids, transporting these matels to the shallow crust, and accumulating in a certain position to form ore shells. It elucidates the influence of key control factors such as magma temperature, intrusion periods of deep-seated magma, and deepth of upper crustal magma chambers on this process, yielding the following insights:(1) The magma temperature controls the interaction between the surrounding rocks temperature and fluid behavior by changing the permeability of the surrounding rocks, thereby causing ore-forming materials to accumulate to form a bell-shaped ore shell at about 1500 meters above the magma chamber, with most ore-forming materials accumulating at the bottom of the ore shell.(2) The most favorable temperature range of magma for the enrichment of ore-forming materials in magma is 850°C-900°C.(3) Deep-seated magma undergoing two upward intrusions is most favorable for the formation of the ore shell of porphyry copper deposits.(4) The temperature range for the formation of porphyry-copper ore shell (i.e., the mineralization temperature of porphyry copper deposits) is 450°C-200°C.This study effectively reveals the crucial factors and ore-forming response of porphyry copper deposits in terms of dynamic numerical simulation, providing new evidence for exploring the efficient enrichment mechanism of ore-forming materials in porphyry deposits through numerical simulation experiments. It supplements the theoretical model of porphyry copper mineralization and provides theoretical references for exploration of porphyry copper deposits.

Keyword

Porphyry copper, Numerical modeling, Ore-forming materials enrichment, Dynamic mechanisms

The influence of basin fluid activity on the mineralization process of sandstone-type uranium deposits

Taping He HE[1]*, 710233010@qq.com (b22010021@s.upc.edu.cn)
Yaoqi Zhou[2], 13608969182

Abstract

Sandstone-type uranium deposits are the most significant industrial uranium deposit type globally and in China, each accounting for over 40% of the total. Exploration and research have revealed a close relationship between uranium enrichment in sandstone and basin fluid activity. In the presence of uranium-rich oxidizing fluids in the basin and interactions with reducing substances, soluble U(VI) is reduced to insoluble U(IV) through processes involving debris, plant fragments, humates, hydrocarbons, and sulfides. Therefore, a comprehensive exploration and analysis of the types of basin fluids and their impact on uranium mineralization play a crucial guiding role in prospecting. This paper examines the influence of basin fluid activities on uranium reservoirs and mineralization from both macroscopic and microscopic perspectives. Drawing on basin examples, this paper explores the mechanisms behind uranium enrichment. By categorizing basin fluids into two types, namely surface oxidizing fluids and deep-seated thermal fluids, this analysis examines the properties and origins of different fluids. It clarifies the transformative role of deep-seated thermal fluid activity on uranium reservoirs. The paper classifies and discusses the spatiotemporal coupling relationships between different fluids and uranium ore bodies. It further elaborates on the impact of basin fluid activities on uranium minerals, co-associated minerals, and biological activities. The results indicate that fluid-rock reactions occurring between deep-seated thermal fluids and rock particles have a significant impact on reservoir porosity structures, thereby controlling the permeability heterogeneity of surface oxidizing fluids. Basin fluids primarily influence the formation of uranium deposits by controlling ore-forming minerals and the ore-forming environment. In particular, deep-seated hydrocarbon fluids have a significant impact on mineralization processes and can effectively compensate for the insufficient reducing capacity of reservoirs. The reaction interface between oxidizing fluids and reducing fluids serves as the deposition site for uranium minerals and associated minerals. It is a favorable zone for the enrichment and mineralization of uranium deposits.

Keyword

Basin fluid activity, Sandstone-type uranium deposits, Mineralization processes, Uranium enrichment mechanisms

The Characteristics and Origin of Barite in the Giant Mehdiabad Zn–Pb–Ba Deposit, Iran

Yingchao LIU[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(lychappy@126.com)

Abstract

Mehdiabad is the world's largest Mississippi Valley-Type (MVT) Zn–Pb deposit (394 Mt of metal ore at 4.2% Zn, 1.6% Pb) and contains significant barite resources (>40 Mt). Such large accumulations of barite are not common in carbonate-hosted Zn–Pb deposits. Therefore, the origin of the barite and its association with the Zn–Pb mineralization is of significant interest for further investigation.

Field work and petrographic studies indicate that the Zn–Pb–Ba ore bodies in the Mehdiabad are hosted by Lower Cretaceous carbonate units of the Taft and Abkuh Formations. Fine- to coarse-grained barite with lesser siderite formed in three stages (S1, S2, and S4), along with a quartz-sulfide stage (S3) with minor quartz, sphalerite, galena, chalcopyrite and pyrite, and the main Zn–Pb sulfide stage (S5) with massive sphalerite and galena.

The barites have δ34S values from 17.7 to 20.6‰, δ18O values from 13.2 to 16.8‰, △33SV–CDT values from –0.001 to 0.036‰, and initial 87Sr/86Sr ratios from 0.707327 ±0.000008 to 0.708593 ±0.000008. The siderites have δ13CV–PDB values from –3.8 to –2.7‰ and δ18OV–SMOW values from 18.2 to 20.9‰. These geochemical data and the barite morphology point to a diagenetic origin for all stages of barite. We suggest that S1 and S2 barite precipitated from pore fluids at the sulfate-methane transition zone (SMTZ) in a methane-diffusion-limited environment with increasing methane content. S4 barite precipitated when the methane and barium-bearing cold-seep fluid migrated to the shallow carbonate sediments and formed a methane-in-excess setting. For the three stages, the SO42– in barite came from the residual SO42– in pore fluids undergoing sulfate-driven anaerobic oxidation of methane, and the Ba2+ came from dissolved biogenic barite and terrigenous materials in the Taft and Sangestan Formations.

Primary fluid inclusions trapped in S3 quartz have salinities of 5.6 to 8.1 wt % NaCl equiv. and homogenization temperatures of 143.8° to 166.1°C. The quartz has δ18O values ranging from 9.8 to 22.5‰ and δ30Si values from –1.3 to –0.9‰. These data indicate hydrothermal fluid flow occurred between the diagenetic S2 and S4 events. Secondary fluid inclusions with salinities of 17.70 to 19.13 wt % NaCl equiv. and homogenization temperatures of 123.0° to 134.0°C are found in the S3 quartz, too. They might also represent the hydrothermal event formed by basinal brines in S5.

According to the ore textures and the comparison of the sulfur isotopes between S5 Zn–Pb sulfides and the digenetic barites, the barite provided a host and a sulfur source for the later Zn–Pb mineralization; the sulfate was reduced by bacterial sulfate reduction. The relationship between barite and the Zn–Pb mineralization indicates that significant accumulations of sulfates may be a

critical exploration target for this kind of giant deposit.

Keyword

Pb-Zn-Ba deposit, Barite, Mehdiabad

Low-crustal juvenility and continental-slab shallow subduction control the formation of post-collisional porphyry Cu systems in east Tibet

Zengqian HOU[1]*, Institute of Geology, Chinese Academy of Geological Sciences (houzengqian@126.com)

Abstract

Many large porphyry Cu deposits have been recently discovered in continental collision zones, yet it is unclear what controls their formation. Here, we aim to decipher the Sanjiang collisional orogenic belt (SCOB) formed by the Cenozoic Indo-Asian collision through better imaging of its lithosphere architecture by advanced seismic tomography methods and more detailed zircon Hf isotopic mapping. Seismic images show that the Indian continental slab is shallowly subducted northeastward beneath northern SCOB with many large Cenozoic porphyry Cu deposits and steeply subducted eastward beneath southern SCOB with few such deposits. This differential subduction resulted in the SCOB lithosphere with distinct thermal-stress states, i.e., cold upper mantle - thickened hot crust in the northern portion and hot upper mantle - thinned cold crust in the southern portion. The SCOB lithosphere shows significant heterogeneities, with its northern portion containing more juvenile mantle components in the lower crust, while the southern portion has limited crust juvenility. We argue that the collision-related ore-forming magmas were derived from partial melting of the juvenile mafic lower crust formed by underplating of previous arc mafic magmas. The Cu-Au refertilization within a low-crustal source and shallow subduction of a continental-slab during collision is critical for large porphyry Cu-(Au) deposits in a collisional zone.

Keyword

Low-crustal juvenility, continental-slab shallow subduction, post-collisional porphyry Cu systems, Tibet

W-Mo porphyry deposit Ochtiná-Rochovce (Western Carpathians, Slovakia) - lithological and mineralogical characterization

Peter Koděra[1]*, Department of Mineralogy, Petrology and Economic Geology, Faculty of Natural Sciences, Comenius University, Slovakia (peter.kodera@gmail.sk)
Diego Delgado Yáñez[2], Department of Mineralogy, Petrology and Economic Geology, Faculty of Natural Sciences, Comenius University, Slovakia
František Bakos[3], Green View, s.r.o., Bratislava, Slovakia

Abstract

The Ochtiná-Rochovce W-Mo deposit is located in the contact zone of Veporicum and Gemericum superunits in Western Carpathians. It is genetically linked to a Late Cretaceous monzodiorite to granodiorite intrusive complex (81.5 Ma) emplaced in the Lubeník-Margecany suture line in 3.7 to 7.5 km depth. The Gemeric Unit is represented here by Lower Carboniferous mylonitized schists with intercalated conglomerates and frequent metamorphosed basalts and basaltic pyroclastics (Ochtiná Fm). The Veporic Unit comprises Permian metasandstone (Rimava Fm) and underlying Carboniferous metamorphosed sandstone/graywacke and phyllite (Slatviná Fm). The deposit contains 50.9 Mt @ 0.097% Mo, 7.4 Mt @ 0.113% W, or 5.0 Mt @ 0.216% Mo, 2.4 Mt @ 0.22% W. Several small Pb-Zn, Au and Sb deposits and occurrences are present in the vicinity of the deposit. The deposit consists of two zones, which are partly overlapping. The lower Mo zone is ~400 m thick and occurs in 200 to 600 m depth, hosted partly by the endocontact of the granitoids, but mainly by the overlying Veporic unit. It is represented by molybdenite hosted by a stockwork of quartz veinlets. The upper W zone is ~100 m thick and reaches from surface to depths up to 300 m. It is represented by disseminated-stockwork and less frequent quartz veins in the Veporic and Gemeric units, while their contact zone is particularly W-enriched. Principal ore minerals are scheelite and less common wolframite in a quartz gangue. The intrusive complex generated a contact metamorphism aureole with cordierite, andalusite, biotite and chlorite zones, overprinting previous regional metamorphic assemblages.

Ore mineralization precipitated in four hydrothermal stages. The Mo-W stage is the earliest producing molybdenite, wolframite and pyrite. The W-Fe-Cu stage is developed above the Mo-zone, with scheelite replacing wolframite, abundant pyrite, minor chalcopyrite and rare arsenopyrite and tetrahedrite. The Bi-Pb-Sb stage is developed in external zones, represented by Pb-Bi-Sb sulphosalts and stibnite. The latest F-Pb-Zn stage minerals (galena, sphalerite, fluorite) occur close to the contact with the intrusion. Supergene zone reaches from 1 m to 20 m. It is enriched in W compared to primary ore and includes ferrimolybdite, tungstite and hydrotungstite. Hydrothermal alteration includes potassic alteration at the centre of the system (including intrusions), while the Mo-zone is accompanied be intense silicification, sericitization, pyritization and late carbonatization. In the upper part of the system (W-zone) alteration is restricted to narrow halos of veinlets, including biotite, K-feldspar, quartz, muscovite and pyrite. The earliest quartz veinlets parallel to the main foliation are related to regional metamorphism. Porphyry-related

veinlets are dominated by quartz gangue with variable proportions of ore minerals. Scheelite occurs in two generations: disseminated in rocks and veins as individual grains and replacing wolframite. Wolframite group minerals range from ferberite to rare huanzalaite. Tungsten is also variably enriched in rutile (up to 17.8 wt% WO3) but it represents a negligible fraction of W at the deposit. Veinlets also contain minor biotite, muscovite/illite, chlorite, calcite and fluorite.

Acknowledgement: This work was supported by the grant APVV-22-0134.

Keyword

tungsten, molybdenum, porphyry, mineralogy, alteration

Deep process and lithospheric architectural control of Cu-REE mineralization in the Gangdese and Sanjiang collisional belts

Rui WANG[1]*, CUGB (rw@cugb.edu.cn)

Abstract

Situated in an archetypal continental collision zone the Tibetan Plateau developed world-class porphyry Cu and carbonate REE metallogenetic belts, yet there is no scientific consensus about the mechanism of continental collision control of Cu-REE mineralization in the region. The outstanding issues include the exact trigger mechanism for melting of the thickened lithosphere, the relationship between the lithospheric framework and Cu-REE metallogenesis, and the source of Cu, REE and volatiles and their depositional processes. To better understand the deep process and lithospheric architectural control of Cu-REE metallogenesis, this paper summarizes the lithospheric architecture of the Gangdese forward and oblique collision zones had been imaged and analyzed using joint inversion of surface wave and satellite gravity data, combined with magnetotelluric (MT) array and geochemical data. During the India-Asia collision in the Cenozoic the subducting Indian lithosphere experienced significant tearing, allowing asthenospheric upwelling to rework the overlying Asian lithosphere and cause melting. The resulting ultrapotassic melt ascended and accumulated at the bottom of the crust, providing high heat flow and volatiles for the melting of the juvenile lower crust. In the hydrous melt, amphibole fractionation led to melt oxidation, promoting Cu recycling and enrichment. The above results revealed three key factors controlling the formation of collisional porphyry deposits: moderate-angle subduction, slab tearing, and reactivation of the sulfide-enriched juvenile lower crust. At the margin of the Yangtze craton, Sanjiang oblique collision zone, vertical upwelling and horizontal flow of asthenosphere, driven by subduction of the Indian plate or mantle convection, caused thermal erosion and partial melting of the cratonic continental lithosphere. The lithosphere beneath the craton margin was REE enriched due to prior metasomatism by REE/CO2-rich fluid from recycled oceanic sediment, and enriched REEs were carried by ascending carbonate melt along the lithosphere discontinuity (e.g., strike-slip fault, rift) to form large scale carbonate REE deposits. Without prior lithospheric metasomatism, carbonatic, ultrapotassic and mafic melts produced from the melting of the cratonic lithosphere had limited potential to form carbonate REE deposits.

Keyword

continental plate subduction, Tethyan belt, collision, juvenile crust, slab tearing

Porphyry Copper Deposits Main Characteristics in Iran

Maryam AHANKOUB[1]*, Department of geology, Payame Noor university, tehran, Iran
(m.ahankoub@pnu.ac.ir)
shohreh hassanpour[2], department ofgeology, Payame Noor University, Tehran, Iran

Abstract

Late Mesozoic-Cenozoic was a time of active magmatism in Iran, represented by three major magmatic belts: 1) East-north (Kerman), 2) West-central (Kerman-Yazd), and 3) Northwest (Arasbaran). The magmatism started in the late Cretaceous-Paleocene, peaked in the Eocene, and extended into the Miocene and Quaternary, with periodic subvolcanic intrusions into the existing rocks. The Cenozoic magmatism in Iran is associated with the successive stages of Tethyan ocean closure in the Kerman and Yazd areas, and Mesothetys in the Arasbaran region, including subduction events from the late Cretaceous to Miocene. These magmatic events are associated with a wide range of mineralization deposits, including epithermal precious metal deposits, skarn-type metal ores, porphyry-type Cu-Mo-Au deposits, and various industrial minerals.

The majority of known porphyry-type mineralization in Iran occurs in the Kerman and Kerman-Yazd belts, ranging in age from 13-9 million years (Ma). The Arasbaran belt also hosts porphyry-type mineralization with ages (Ar-Ar and U-Pb methods) ranging from 27-10 Ma. On the base of the Ar-Ar and U-Pb datings, age of intrusion bodies, caused to Cu mineralization in kerman belt, are 7.2-29.2 Ma.

Shallow-level porphyritic intrusions with dominantly adakite-like signatures are characteristic features of these deposits. Copper mineralization primarily occurs within the porphyritic intrusions and into hosted Paleocene-Eocene-Oligocene volcanic-sedimentary rocks.

Most copper mineralization in these deposits is associated with well-developed alterations, including potassic (K-feldspar and biotite), and phyllic, propylitic, and locally argillic dominant alterations. Stockworks, various types of quartz veinlets (A to E), and sulfide disseminations are observed within the intrusive bodies as well as in the surrounding rocks. The main hypogene copper mineral is chalcopyrite, occasionally associated with minor bornite and subordinate molybdenite and/or gold. Supergene alteration zone are observed in some of them especially in Kerman belt porphyries. Magnetite is a common mineral associated with potassic alteration, while pyrite is a common phase in the hypogene ores. Gypsum/anhydrite also are common in the more oxidized porphyry systems.

Keyword

Cu deposit, porphyritc, magmatism, mesozoic, iran

Geodynamic settings of formation and metallogeny of gold in the Altai-Sayan folded area (Southern Siberia)

Alexandr CHERNYKH[1]*, PJSC "Polyus" (chaigeo@yandex.ru)

Abstract

Altai-Sayan folded area (ASFA) in the Southern Siberia is a part of the Central-Asian orogenic belt. ASFA is one of the oldest mining districts known since the mid 17th century where coal, iron, copper, zinc, lead, silver and gold were mined. For the past 15 years new digital technologies, innovative mineral prospecting techniques, instrumentation and analytical equipment have appeared. This provides further opportunities for mineral prospecting in well-studied mining districts such as ASFA.

Our metallogenic analysis of the western part ASFA is based on the contemporary methods and new data. Since gold is one of the Altai-Sayan top commodities, studies have been focused on gold mineralization and granitoid rock associations, which are essential for its formation.

The western part of ASFA can be divided into the three large Caledonian metallogenic subprovinces: Altai-Salair, Alatau-Tuva and West-Sayan. In addition, the Kuznetsk Mesozoic metallogenic zone is distinguished, the gold mineralization which is superimposed on more ancient rocks. All these metallogenic units are defined as they have the unique geodynamic settings and metallogenic specialization. The characteristic features of gold mineralization of these subprovinces are associated with the peculiarities of ore-hosted volcanogenic-sedimentary rocks and granitoid complexes.

Gold mineralization in the Altai-Salair subprovince are formed on the tow metallogenic epoch. Gold-bearing polymetallic mineralization (VMS-type) formed in the early Cambrian in an island-arc geodynamic setting. The Devonian metallogenic epoch is characterized by the formation of gold mineralization in the conditions of an active Andean-type margin. At this time gold-skarn (with Cu), gold-sulfide-quartz mineralization (intrusions related) and epithermal gold-silver mineralization were formed.

In the Alatau-Tuva subprovince gold-skarn and gold-sulfide-quartz mineralization was formed in an island-arc setting in the Early Cambrian. The gold ore deposits of the Late Cambrian-Ordovician metallogenic epoch is the most widespread. At this time gold-quartz and gold-sulfide-quartz (RIRG) and gold-skarn (with Fe) mineralization is formed in an accretion-collision setting.

Gold mineralization of the West-Sayan subprovince is confined to its marginal parts, which are represented by deformed Vendian-Early Cambrian ophiolites, including large ultramafic massifs. Gold-quartz-sulfide mineralization in metasomatites (listvenites and berezites) are found here.

Gold mineralization of the Kuznetsk metallogenic zone was formed in the Permian-Triassic stage of intraplate plume activation of the region. Here, gold-sulfide-quartz mineralization (probably the Carlin-type) was identified in low-temperature metasomatites (jasperoids) among Devonian-Carboniferous terrigenous-carbonate strata.

Keyword

metallogeny, gold, Altai-Sayan, island arc, granites

Eruption Style, Mineralization and Geohazard of Mt Popa Volcano, central Myanmar

Khin ZAW[1]*, CODES CENTRE OF ORE DEPOSIT AND EARTH SCIENCES, UNIVERSITY OF TASMANIA (khin.zaw@utas.edu.au)

Abstract

Mt Popa is located in the Central Magmatic-Volcanic Belt (CMVB) of Myanmar, and it is a dormant volcano rising 1518 meters above sea. The primary feature of the volcano is an exploded crater on its northern side. The volcano occurred on Pliocene sandstones of the Ayerwaddy Formation. Its complex volcanic edifice is composed of lava flows and domes; the composition ranges from basalts to dacites of calc-alkaline affinities and represents Holocene volcanological evidence of the ongoing subduction in this part of the collision zone between India and Asia. Laser ablation 40Ar/39Ar age dating of two hornblende from Lava flow, basalt, volcanic bomb, and andesite yielded 0.0 Ma and U-Pb zircon age of Lava flow, basaltic andesite from Taung Kalat gave 0.68 ± 0.04 Ma, and K-Ar age of biotite from the volcanic bomb, trachybasalt provided 4.4 ± 0.5 Ma (Belousov et al., 2018, https://doi.org/10.1016/j.jvolgeores.2018.06.010).Sano et al. (2022, https://doi.org/10.1038/s41598-022-07097-4) also indicated that the older volcanic rocks were formed in the Miocene, as indicated by U–Pb ages of zircon 19.7–10.7 Ma and also recorded a new U-Pb age for the Taung Kalat plug (0.82 ± 0.07 Ma) that is close to the zircon U–Pb age constraints (0.68 ± 0.04 Ma) given by Belousov et al. (2018) and their K–Ar and 40Ar/39Ar ages indicate that the beginning of the Taung-Ma-Gyi stratovolcano eruption is ~ 0.33 Ma. A local legend reported that Mt. Popa could have had an eruption at 800 BP and 442 BCE. The timing and type of the most recent eruptions of the volcano include several mild explosive eruptions probably of Vulcanian Type ~ 12700-8500 BP, followed by large-scale edifice collapse~ 8000 BP, then followed (probably immediately) by strong magmatic eruption with deposition of the pyroclastic flow (Belousov et al., 2018). Probably the edifice of Mount Popa was destabilized by the intrusion of magma and the collapse triggered explosive eruption. Additional research is necessary to understand the occurrences of crater wall collapses, mudflows, and volcanic facies in the region. This is crucial due to the potential for future eruptions and geohazards, particularly in light of the landslides reported in October 2017. The heavy monsoonal rains caused the problems as the volcano is composed of soft and loose volcanic sandstones, ash, and lahar as well as deforestation making the soil erodible and more susceptible to landslides. High-sulphidation epithermal Au deposit in silicified rhyolite and tuffs is recorded at Taungni Hill in the Mt Popa area similar to the high-sulphidation epithermal Cu deposits at Monywa along the CMVB. In current times, mining is not a viable option in the Mt Popa area due to the recent establishment of a Geopark and the existence of numerous Geoheritage sites both in the vicinity of Mt Popa and near the historical landmarks and tourist attractions at Bagan where devastating earthquakes occurred as recently as in 1975 (Khin Zaw et al., 2017, https://doi.org/10.1144/M48.24). Further academic studies should be conducted to comprehensively understand the tectonic and metallogenic evolution of the entire

CMVB.

Keyword

Mt Popa, Eruption styles, Copper-gold, Geohazard, Tectonics

Geodynamics of Late Mesozoic giant decratonization-related gold mineralization in the North China Craton

Jin-Hui YANG[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (jinhui@mail.iggcas.ac.cn)
Lei Xu[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Jin-Feng Sun[3], College of Earth and Planetary Sciences, University of Chinese Academy of Sciences
Yu-Sheng Zhu[4], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Plenty of large and super-large gold deposits are widely distributed in the eastern North China Craton (NCC), which is suggested to be related to decratonization and termed as decratonic gold deposits. However, how the decratonization controls the formation and distribution of large-scale of gold and other metal deposits is not very clear. Late Mesozoic decratonization of the NCC triggered intensive magmatism, tectonism and hydrothermal activities. Here we systematically summarizes all of the data for the rock assemblages, chronology, geochemistry and petrogenesis of Mesozoic magmatic rocks, as well as for the mineralizing ages of gold and other metal deposits and the evolution of the Mesozoic basins in the eastern NCC to reveal the geodynamics of Late Mesozoic decratonization and related gold mineralization. After restoring the extensional rates of Mesozoic to Cenozoic basins and the strike-slip distance of the Tanlu Fault, the locations of the Paleo-Pacific plate subduction zone during the Mesozoic to Cenozoic is confirmed and the temporal and spatial distribution of Mesozoic gold and other metal deposits and magmatic rocks in the eastern NCC has been well reconstructed. The result shows that the magmatism and mineralization in the eastern NCC would westward migrate from east to west during the Early to Middle Jurassic, but they would eastward migrate from west to east during the Early Cretaceous. The mineralization of these deposits is genetically related to magmatism, and the magmas provided some ore-forming materials and fluids in the generation of metal deposits. Thus, the geodynamic mechanism of decratonization and related magmatism and mineralization can be proposed, i.e., the westward low-angle subduction of the Paleo-Pacific slab beneath the NCC formed continental magmatic arc with plenty of porphyry Cu-Mo-Au deposits in the Jurassic, similar to Andean continental arc in South America. The mantle wedge was metasomatized by the fluids/melts derived from the subducting slab, laying a material foundation for hydrothermal mineralization in the Early Cretaceous. While the rollback of the subducting slab with gradually increasing subduction angle and the retreat of the subduction zones during the Early Cretaceous induced strong destruction of the craton and the formation of extensive magmatic rocks and large-scale gold and other metal deposits.

Keyword

Geodynamics, Gold Mineralization, North China Craton, Decratonization, Magmatism

Copper skarn mineralization related to reduced monzodioritic magma at the Huanren deposit, northeastern China

Hegen Ouyang[1]*, Institute of Mineral Resources, Chinese Academy of Geological Sciences (oyhg1984@163.com)
John Caulfield[2], Queensland University of Technology
Guiqing Xie[3], Institute of Mineral Resources

Abstract

Most known Cu skarns are associated with oxidized intrusions. In this contribution, we report a Cu skarn associated with a reduced monzodioritic intrusion at Huanren, northeastern China, which contains 0.41 Mt of Cu accompanied by economic concentrations of Zn, Pb, Fe, Mo, and Ag. Copper-polymetallic mineralization in the Huanren deposit is concentrated in skarns located between the contacts of the monzodiorite (SiO_2 = 52 - 55 wt. %) and the Cambrian carbonate rocks, with minor molybdenite-bearing veinlets/veins and dissimilated chalcopyrite mineralization hosted within the monzodiorite. Laser ablation inductively coupled plasma-mass spectrometer (LA-ICP-MS) U-Pb zircon geochronology indicates the monzodiorite crystallized at 125.4 ± 0.6 Ma (2σ). Isotope dilution inductively coupled plasma mass spectrometry (ID-ICP-MS) Re-Os molybdenite geochronology indicates mineralization at Huanren occurred at 125.3 ± 0.8 Ma (2σ). Whole-rock major and trace elements and zircon Hf isotopic compositions suggest enriched (subduction metasomatised) lithospheric mantle-derived sources for the parental magma of the monzodiorite without significant crustal assimilation. Zircon trace element and magmatic apatite major element compositions indicate the reduced nature of the monzodiorite, as evidenced by low magmatic oxygen fugacity (FMQ-1.09 ± 0.19) and negligible apatite SO_3 contents (< 0.05 wt. %). A reduced magmatic-hydrothermal system at Huanren is also supported by the predominance of magmatic ilmenite over magnetite in the monzodiorite, and the presence of pyrrhotite and the absence of anhydrite and hematite in the ore. Chalcopyrite from the Huanren deposit has an average $\delta^{34}S$ value of 4.34 ± 0.88 ‰ (1σ), which is clearly higher than those from most porphyry-skarn Cu±Mo±Au deposits. Accordingly, we suggest that interaction of (1) external oxidized fluids equilibrated with evaporite with (2) reduced Cl-bearing magmas and related exsolved fluids may have played a critical role in the formation of the Huanren Cu skarn by increasing the ability of fluids to scavenge Cu from the reduced magma and subsequently precipitate Cu in the carbonate rocks. This study defines a new type of Cu skarn and thereby opens new potential for Cu skarn exploration proximal to intrusives previously deemed too reduced to be Cu fertile, especially in non-arc settings. Moreover, we conclude that the availability of Cl and S in magmatic-hydrothermal systems may be as critical as fO_2 in facilitating the actual ore-forming event in Cu skarn systems.

Keyword

Northeastern China, Skarn Cu deposit, Reduced intrusion, Huanren

Multiple mineralization and geodynamics of the Nanyangtian tungsten deposit, SW China: Constraints from structural deformation and geochronology

Da ZHANG[1]*, China University of Geosciences Beijing (zhangda@cugb.edu.cn)
Xinming Zhang[2], China University of Geosciences Beijing
Mingjian Yang[3], China University of Geosciences Beijing
Jincheng Song[4], China University of Geosciences Beijing

Abstract

Southeastern (SE) Yunnan contains one of the most economically important Mesozoic tungsten–tin metallogenic belts in East Asia. Several world-class tungsten–tin deposits (such as Gejiu tin, Dulong tin, and Nanyangtian tungsten deposits) have been identified in association with Late Cretaceous granites in these areas, although the geodynamics of the tungsten mineralization remain elusive and a subject of debate. On the other hand, more and more new metallogenic events have been revealed, and the overprinting of the multiple tungsten mineralization is especially prominent in the Nanyangtian tungsten deposit. The Nanyangtian tungsten deposit, which is located in the central of the Nanwenhe metamorphic core complex, consists of widespread subhorizontal skarn and overprinted localized steeply scheelite–mica–quartz (SMQ) vein mineralization. Structural analysis of the tungsten deposit and metamorphic core complex allows four stages of deformation that control multiple tungsten mineralization to be identified. Oriented quartz–orthoclase–microcline–plagioclase–amphibole–muscovite–biotite in the gneissic granites define the mylonitic foliations S1 and north-plunging mineral lineations L1 during D1. Asymmetric lenses, porphyroclasts, and intra-folial folds indicate a north-directed detachment (D1) under upper-greenschist- to low-amphibolite-facies conditions. Subsequently, the foliations S1 were asymmetric folded and overprinted by NE-striking subhorizontal foliations S2, indicating the northwest-directed thrusting (D2). Magmatic–hydrothermal fluid was channeled by these NE-striking foliations, and forming subhorizontal skarn mineralization after the peak of crustal thickening (D2). SMQ vein mineralization was occurred with the dextral transtensional faulting (D3). The final sinistral strike-slip faulting (D4) offset the pre-existing deformation and tungsten mineralization. Metamorphic zircon U–Pb and amphibole–mica 40Ar–39Ar ages (237–180 Ma) constrained the north-directed detachment (D1). In addition, the crystallization age of 162.5 Ma of zircons from undeformed skarn-related granitic dikes suggests the end of thrust deformation (D2) and the Late Jurassic skarn tungsten mineralization in the Nanyangtian deposit. 40Ar–39Ar isotope dating of biotite from the SMQ vein represent the Cretaceous vein mineralization and D3 in the deposit. By combining our new results with other research findings from SE Yunnan and East Asia, the inferred sequence suggests that the multiple stages of deformation and tungsten mineralization were influenced by geodynamic processes involving the Indochina and Paleo-Pacific blocks with the South China Block.

Keyword

Nanwenhe metamorphic dome, Nanyangtian tungsten deposit, structural analysis, geodynamics, geochronology

Gold Deposits of the Jiaodong Peninsula, Eastern China

Kunfeng QIU[1]*, China University of Geosciences (Beijing) (kunfengqiu@qq.com)
Haocheng Yu[2], China University of Geosciences (Beijing)
Shanshan Li[3], China University of Geosciences (Beijing)
Zhengyu Long[4], China University of Geosciences (Beijing)
Jingyuan Zhang[5], China University of Geosciences (Beijing)
Richard Goldfarb[6], China University of Geosciences (Beijing)
Jun Deng[7], China University of Geosciences (Beijing)

Abstract

The Jiaodong gold province, the third largest gold province globally, hosts gold resources of more than 5000 tonnes, with a present cumulative annual production estimated at 60 t Au. More than 90% of the Jiaodong gold resource is hosted by batholiths and related bodies of the Linglong (ca. 160–145 Ma) and, to a lesser degree, Guojialing (ca. 130–122 Ma) suites. The intrusions were emplaced into high-grade metamorphic basement rocks of the Precambrian Jiaobei (North China block) and Sulu (South China block) terranes during a 70-m.y.-period of lithospheric delamination, extensional core complex formation, and exhumation. The deposits are located about 20 to 200 km to the east of the continental-scale NNE-striking Tancheng-Lujiang (Tan-Lu) strike-slip fault system. They occur along a series of more regional NNE- to NE-striking brittle and ductile-brittle faults, which appear to intersect the Tan-Lu main structure to the southwest. This system of early to middle Mesozoic regional thrust faults, reactivated during Cretaceous normal motion and ore formation, tends to occur along the margins of the main Linglong batholiths or between intrusions of the two suites of granitoids. Orebodies are mainly present as quartz-pyrite veins and as stockwork veinlets and disseminated mineralization. The two mineralization styles are transitional and may be present within the same gold deposit. High-precision U-Pb dating on monazite yielded mineralization ages of ca. 120 Ma in the Jiaobei terrane and slightly younger age of 115 Ma in the Sulu terrane, which postdates the Paleoproterozoic high-grade metamorphism depriving the crustal basement of metal and volatiles. The comprehensive investigation of Ba-Li-Hg-S isotopes of mafic rocks and ores indicates that gold was released from continent-derived sediment and recycled into the subcontinental lithospheric mantle (SCLM) beneath Jiaodong during the Jurassic subduction of paleo-Pacific plate. Subsequently, the subducted carbonate-rich sediments oxidize SCLM, allowing the later mobilization of metal into magmas and/or fluids. Finally, the 120 Ma rollback of the paleo-Pacific plate induced upwelling of the asthenosphere and changes in the stress regime, triggering the release of metal from the SCLM in an extensional setting to form the giant Jiaodong gold deposits.

Keyword

Jiaodong, structural control, paleo-Pacific plate, sediment, gold recycling

Exploration Potential of Antimony Deposits in Myanmar: Insights from Fluid and Stable Isotope Geochemistry of the Lyhamyar Sb Deposit, Eastern Myanmar

Aung Min OO[1]*, Department of Geology, Kyaing Tong University (granite.aungmin@gmail.com)
Lv Xinbiao[2], Institute of Geological Survey, China University of Geosciences, Wuhan 430074, China
Khin Zaw[3], Centre for Ore Deposit and Earth Science, University of Tasmania, Private Bag 126, Hobart, Tasmania 7001, Australia
Sakthi Saravanan Chinnasamy[4], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai 400076, India

Abstract

Antimony is a critical metal in global markets (Kanellopoulos et al., 2024) with Myanmar emerging as a significant source, contributing 9000 metric tons of antimony ore (Gunn, 2014; Toe Aung Kyaw, 2017) in 2014, primarily exported to China. The country is a major metallogenic belt with various mineral deposits, including Pb, Zn, Ag, Fe, Sb, Au, and Mo. Most of the antimony ore is found in quartz-stibnite veins and breccias that form along fault zones in limestones and shales. Experts estimate that Myanmar has a total antimony resource of one million tons, with the possibility of additional deposits in areas near specific fault zones. In this study, we focus on the significant Lyhamyar Sb deposit, situated in the Southern Shan Plateau of Eastern Myanmar within the Early Silurian Linwe Formation, characterized by syntectonic quartz-stibnite veins. Based on the mineral assemblages and cross-cutting relationships, the deposit shows two mineralization stages: (1) the pre-ore sedimentary and diagenetic stage, and (2) the main-ore hydrothermal ore-forming stage (including stages I, II, and III), i.e., (i) early-ore stage (stage I) quartz-stibnite, (ii) late-ore stage (stage II) quartz-calcite-stibnite ± pyrite, and (iii) post-ore stage (stage III) carbonate. The study of primary fluid inclusions in quartz and calcite indicates that the ore-forming fluid had low temperatures (ranging from 144 to 260 °C) and moderate to high salinity (ranging from 2.9 to 20.9 wt. % NaCl equivalent). Hydrogen and oxygen isotopes suggest that the ore-forming fluids of the Lyhamyar deposit were derived from circulating meteoric water mixed with magmatic fluids that underwent isotopic exchange with the surrounding rocks. Sulfur in Lyhamyar was dominated by thermochemical sulfate reduction (TSR) with dominant magmatic source sulfur. The lead isotope compositions of the stibnite suggest that the ore-forming metals were a mixed source of the Late Proterozoic metasedimentary basement and the sedimentary host rocks. On the basis of the integrated geological setting, ore geology, fluid inclusions, (H-O-S-Pb) isotope data, and previous literature, we propose a new ore deposit model for the Lyhamyar Sb deposit: It was involved in an early deposition of pyrite in sedimentary and diagenetic stages and later Sb mineralization by mixing of circulating meteoric water with ascending magmatic fluids during the hydrothermal mineralization stage. The study highlights the need for further investigation into Myanmar's antimony deposits, suggesting future targets include geochronology, analysis of fluid characteristics and metal sources, and identifying exploration orientations. It also

recommends analyzing fluid inclusions, stable isotope analysis, LA-ICPMS analysis, and international research collaboration.

Keyword

Antimony deposits, Lyhamyar Sb deposit, Eastern Myanmar, fluid and stable isotope geochemistry, research collaboration

Mineralogy, Geochemistry, and Origin of Green Jasper in Northeastern Region of Cambodia

Seang Sirisokha[1]*, Institute of Technology of Cambodia (ssirisokha@yahoo.com)
Kret Kakda[2], 4Energy Technology and Management Unit, Research and Innovation Center, Institute of Technology of Cambodia
Khin Zaw[3], 3CODES Centre of Ore Deposit and Earth Sciences, University of Tasmania, Hobart, Tasmania, Australia
Kotaro Yonezu[4], Department of Earth Resources Engineering, Faculty of Engineering, Kyushu University
Koichiro Watanabe[5], Department of Earth Resources Engineering, Kyushu University, Fukuoka, Japan

Abstract

Green jasper can be used for jewelry, ornamental, carvings, cabochons, and home decoration. Green Jasper is a type of chalcedony that consists of a variety of micro-quartz crystals. Green jasper is found in the northeastern region of Cambodia. This research presents a new discovery of green jasper in Cambodia, and we investigated the formation environment based on the mineralogical and geochemical characteristics. Petrography, SEM-EDX, XRD, XRF, and LA-ICP-MS were used in this study. Based on the petrography and XRD, microcrystalline of quartz, k-feldspar, celadonite, chlorite, epidote, and magnetite were observed. Quartz is the main component of green jasper, occurs mainly as anhedral crystals ranging in size from cryptocrystalline to microcrystalline (<0.2mm). Silica and iron contents ranged from 78.7 wt.% to 90.8 wt.% as SiO2, and 4.63 wt.% to 7.87 wt.% as Fe2O3, respectively. This green jasper displays enrichment in concentrations of Rb, and K generally derived from hydrothermal fluid. In addition, the Al-Fe-Mn diagrams also confirm a hydrothermal origin. Total REE (ΣREE) contents are low in general up to 10.26 ppm, suggesting the possibility of the hydrothermal products due to its low REE contents. In addition, the chondrite-normalized rare earth element (REE) patterns of green jasper exhibit enrichment in LREE compared to HREE with values ranging from 1.30 to 7.17 for (La/Yb) N. Negative Ce anomalies are observed ranging from 0.49 to 3.10 negative Eu anomalies are also recognized ranging from 0.68 to 0.82. Various Ce anomalies suggest that green jasper is associated with hydrothermal alteration and the presence of oxidizing fluid or magmas. Negative Eu anomaly suggests that green jasper has undergone plagioclase feldspar fractionation. These mineralogical and geochemical results of this study provide significant potential for advancing the understanding formation and geological history of green jasper in Cambodia.

Keyword

hydrothermal, silicification, silicification, geochemistry

Characteristics and Timing of Migmatite Structures Exposed along the Kyaikkhami Beach area, Thanbyuzayat Township, Mon State, southern Myanmar

Zin Mar OO[1]*, Mawlamyine University, Mon State, Myanmar (zmo1984.geol@gmail.com)
Khin Zaw[2], Centre for Ore Deposit and Earth Science, University of Tasmania, Private Bag 126, Hobart, Tasmania 7001, Australia
Prinya Putthapiban[3], Geoscience, Mahidol University, Kanchanaburi, Thailand

Abstract

The Kyaikkhami area lies at the southwestern part of Thanbyuzayat Township, Mon State, southern Myanmar. The Three Padoda Fault is a major, large-scale, NW-SE strike-slip fault occurring in the Kyaikkhami area. The existing geological structures in the area are generally reflected in the shearing of the Three Pagoda Fault. The major structure of the Kyaikkhami area is the eastern limb of an overturned fold. This area is mainly composed of magmatic and metasedimentary rocks and forms a part of the Central Granitoid Belt of Myanmar (Khin Zaw, 1990). The metasedimentary rocks cover approximately 75% of the Kyaikkhami area. The dip angle of the quartzite unit (S0) which is greater than the phyllite unit (S1). Flow sturctures and many small-scale minor folds occur in migmatite units. Migmatites are well exposed at Kyaikkhami Pagoda, Sinpone Cave and Kayinthaung Daminseik. There is a sharp contact between biotite granite and migmatites. The structure of migmatite is stromatic migmatite which is one kind of metatexite migmatite. Biotite granite is a dome up intrusion that surrounds the migmatites and schists. Seven varieties of migmatite structures are classified by Mehnert classification (1968). In the Kyaikkhami Pagoda, migmatite structures such as phlebitic (vein) structure, stromatic (layered) structure, surreitic (dilation) structure, folded structure, ptygmatic structure, ophthalmitic (augen) structure and schlieren structure were recorded. In the Sinpone Cave, phlebitic (vein) structure, stromatic (layered) structure, surreitic (dilation) structure, folded structure, ptygmatic structure, and ophthalmitic (augen) structure were found. In the Kayinthaung Daminseik, stromatic (layered) structure, surreitic (dilation) structure, folded structure, and ptygmatic structure were also observed. Paleosome is mostly biotite schists, muscovite-biotite schists and biotite gneiss. Leucosome is aplite, leucogranite, biotite granite, granodiorite microgranite and other granitic materials. Melanosome is biotite gneiss, granite gneiss and contaminated granite. The age of granodiorite is 133±3.1 Ma and biotite granite is 123.4±52.1 Ma (CODES SE Asia database). In migmatites, one of the leucosome samples gives an Early Cretaceous by U-Pb zircon age determination indicating that the timing of migmatite formation is similar to the time of emplacement of the granitoid intrusion.

Keyword

migmatites, paleosome, melanosome, leucosome, Early Cretaceous

Origin of pegmatite-related gem deposits, northwestern part of Pyetkaywe Batholith, Myittha Townships, Mandalay Division, Myanmar

Yin Yin MYINT[1]*, Penta-Ocean Construction Co.Ltd (yym.geo@gmail.com)
khin Zaw[2], CODES Centre of Ore Deposit and Earth Sciences, University of Tasmania, Hobart, Tasmania, Australia 7001

Abstract

The studied area lies in the Central Granitoid belt which has a high endowment of Li and battery metals in Myanmar in addition to the presence of major W-Sn deposits, gem deposits, and other critical metals and REE mineral deposits. The Central belt granitoid are Late Cretaceous to Tertiary (Eocene and younger) in age and were emplaced during the eastward subduction of the Indian Plate (Khin Zaw, 1990, 1998, 2017). The area covers two peaks, East Pyetkaywe hill (1069m) and West Pyetkaywe hill (1031m). Two-thirds of the area is covered by igneous rocks of granitic composition with minor ultramafic intrusion. The rocks lie along the Jurassic to Miocene Mogok Metamorphic Belt (MMB) consisting of hornblende biotite gneiss, banded biotite gneiss, sillimanite schist, epidote quartzite, grossularite diopside marble and calc–silicate rocks as roof pendant. The exposed igneous rocks in the study area are porphyritic hornblende biotite granite, porphyritic biotite granite, biotite granite, diorite, meladiorite, and hornblendite. Meladiorite might have been formed by the magmatic differentiation of the dioritic magma and hornblendite as a segregated product. LA ICP-MS U-Pb zircon age of diorite exposed at the peak of west Pyetkaywe hill (Lat 21º13′ 15.2″, Long E 96º 12′ 17.5″) yielded 121±1.8 Ma (Early Cretaceous). The field evidence, together with petrological and geochemical analyses, indicate that the granite and diorite, of the northern Pyetkaywe area are calc-alkaline and are strongly peraluminous. Most granitoid rocks show S-type affinity and some fall in the I-type field. The granitic rocks are more akin to S-type due to the presence of tin and tungsten mineralization in the southern part. All the rocks, including the metamorphic rocks in the area, are transected by nearly N-S trending pegmatite dykes containing beryl and tourmaline crystals (Yin Yin Myint, Yin Yin Myint and Khin Zaw, 2014; MUIGC, Mahidol University, Thailand). The area is known for gem-bearing pegmatite deposits. The gems are beryl (aquamarine, goshenite, and yellow beryl), colourless topaz, schorl, and quartz (rock crystal and smoky quartz) are found along the streams of east Pyetkaywe Pagoda which attracted the locals for extraction. Aquamarine from the study area is locally known as Kume beryl which has much attention in the jewellery trade.

Keyword

Pyetkaywe batholith, granitic rocks, Mogok Metamorphic Belt, calc-alkaline, pegmatitic gem deposits

Magmatic history in the Suyoc prospect: Implications to hydrothermal mineralization in the Mankayan Mineral District, north Luzon, Philippines

JILLIAN AIRA GABO-RATIO[1]*, University of the Philippines (jgratio@nigs.upd.edu.ph)
Karl Jabagat[2], National Chung Cheng University
Yuan Hsi Lee[3], National Chung Cheng University
Kotaro Yonezu[4], Kyushu University
Carla Dimalanta[5], University of the Philippines
Eric Andal[6], Apex Mining Co., Inc.
Graciano Jr. Yumul[7], Cordillera Exploration Co., Inc.

Abstract

The Mankayan Mineral District in Northern Luzon, Philippines is known for the world class Cu-Au mineralization of the Far Southeast porphyry copper deposit, Lepanto high sulfidation deposit and the Victoria-Teresa intermediate sulfidation deposits. South of this cluster of deposits is the lesser-known Suyoc epithermal prospect. Recent studies identified potential porphyry mineralization at depth, in addition to surface porphyry copper prospects in the vicinity. This study focuses on the igneous rocks in Suyoc to understand the magmatic evolution and related hydrothermal mineralization in the Mankayan Mineral District.

New U-Pb zircon ages, bulk geochemistry, and mineral chemistry results from igneous rocks in the area reveal three magmatic episodes. The Late Eocene (36.93–37.20 Ma) tholeiitic tonalite-granodiorite of the Bagon Intrusive Complex represents magmatism from a thin, nascent Luzon arc, which is barren of mineralization. In contrast, the Middle Pliocene (2.87–3.4 Ma) calc-alkaline hornblende quartz diorite of the Suyoc Diorite is closely associated with hydrothermal mineralization due to fertile melts associated with ridge subduction in the Manila Trench. The youngest magmatic episode is represented by the Bato Dacite Porphyry, dated Early Pleistocene (1.73 Ma). The calc-alkaline dacitic magmas reveal more fertile signatures and higher water content compared to the Pliocene magmas. The results of the study reflect the complex subduction dynamics in northern Luzon, which led to the shift from barren to fertile magmatism that caused the formation of porphyry-epithermal deposits in the district.

Keyword

Suyoc epithermal prospect, fertile magma, Mankayan Mineral Disrict, Philippines

Bimodal volcanism and massive sulfide deposition in the mid-Miocene Hokuroku Rift of NE Japan

Andrea Agangi[1]*, Akita University (andrea_agangi@gipc.akita-u.ac.jp)

Abstract

Northeast Japan hosts important volcanic-hosted massive sulfide deposits that were deposited in the mid-Miocene during the final opening stages of the Japan Sea. These deposits formed in a similar tectonic setting and similar deep-sea environment to other massive sulfide deposits across the world, and serve as the type-locality of the Kuroko-type (1). The host-rocks of the deposits are composed of a bimodal, felsic-dominated deep-sea volcanic succession formed in a continental rift over stretched continental crust in a back-arc basin. A link between the composition of volcanic rocks, namely rare-earth element ratios, and the occurrence of massive sulfide deposits has long been proposed, implying large-scale effects of tectonic setting on magma composition and on ore deposition. However, the intensive parameters (magma temperature, pressure and depth of stalling and crystallization, water content, etc.) of host-rocks of the Kuroko of NE Japan are largely unknown, hindering attempts to link volcanism and hydrothermal activity (2).

This study focusses on a microtextural and microchemical approach to estimate some of the key magmatic parameters of the host volcanic rocks hosting Kuroko deposits of the well-studied Hokuroku District, historically one of the most important mining districts in Japan. Plagioclase-melt geothermometry in felsic tuff and lava samples collected from the foot-wall and hanging-wall of the Kuroko indicates temperatures of 880 – 940°C, and Fe-Ti oxide equilibrium indicates oxygen fugacity of ca. FMQ + 1.5. The melt inclusions have high-silica rhyolite compositions, suggesting low pressures of magma stalling and crystallisation (<1 kbar). Melt-plagioclase equilibrium indicates low water contents, mostly 1.0 – 3.3 wt% H2O and textural considerations suggest water-saturated conditions at the moment of melt entrapment. These water contents are compatible with pressures of 10 – 80 MPa, assuming solubility of pure water in rhyolitic melt (3). Because of these very shallow magma stalling pressures, the hydrostatic pressure imposed by the bathyal conditions (10 MPa/1000 m water depth) would have caused significant shallowing of the solidus, allowing magmas to migrate towards the sea-floor before freezing and caused efficient heat migration.

These results indicate that shallowly emplaced, hot (average temperature >900°C) felsic magmas provided heat necessary for vigorous sea-floor hydrothermal circulation, a pre-condition for ore deposition. Sea-floor depth may have played a key role in triggering ore-formation.

References

1 Ohmoto, H. (1996) Formation of volcanogenic massive sulfide deposits: The Kuroko perspective. Ore Geology Reviews 10(3–6):135-177

2 Hart, T.R., Gibson, H.L., Lesher, C.M. (2004) Trace element geochemistry and petrogenesis of felsic volcanic rocks associated with volcanogenic massive Cu-Zn-Pb sulfide deposits. Economic Geology 99, 1003-1013.

3 Newman, S., Lowenstern, J.B. (2002) VolatileCalc: a silicate melt–H2O–CO2 solution model written in Visual Basic for excel. Computers & Geosciences, 28, 597-604.

Keyword

Kuroko, Tohoku, Japan Sea, massive sulfide

Magma fertility of the Wuntho–Popa arc belt: implication for porphyry Cu mineralization in Myanmar

Jing-Jing Zhu[1]*, Institute of Geochemistry, Chinese Academy of Sciences
(zhujingjing@vip.gyig.ac.cn)
Ruizhong HU[2], Institute of Geochemistry, Chinese Academy of Sciences
Xianwu BI[3], Institute of Geochemistry, Chinese Academy of Sciences

Abstract

Myanmar, situated within the significant Mesozoic-Cenozoic Neotethyan orogenic belt spanning from the Alps to Indochina, harbors an abundance of porphyry Cu deposits (PCDs). However, Myanmar has relatively fewer PCD occurrences, with the exception of the notable Monywa high-sulfidation Cu deposit. The Wuntho-Popa arc, a magmatic belt trending north-south and extending approximately 500 kilometers from Mount Popa to Wuntho in the West Burma terrane, represents a promising region for porphyry Cu mineralization.

To assess the magma fertility across the entire Wuntho-Popa arc belt, we employed a comprehensive geochemical analysis of whole-rock, zircon, and apatite samples. Our data reveals a systematic and continuous increase in La/Yb, Eu/Eu*, Dy/Yb, and Sr/Y ratios in the magmas from 100 Ma to the present. This trend indicates a transition from plagioclase-dominated to amphibole-dominated fractionation assemblages, suggesting higher pressure crystallization and/or an increase in hydrous water content during the late stages of arc evolution. This interpretation is further supported by zircon compositions, exhibiting rising Eu/Eu* and Ce/Nd ratios over time.

Moreover, our calculations of magma oxygen fugacity, based on zircon Ce, Ti, and U contents, reveal a progressive increase from FMQ-1 at ~100 Ma, to FMQ + 1 at ~40 Ma, and ultimately FMQ + 2 at ~18 Ma, coincident with the formation of the Monywa Cu deposit. This trend aligns well with variations in apatite sulfur content.

Collectively, our findings indicate that magmas younger than 40 Ma are more conducive to PCD formation, serving as potential indicators for future PCD exploration in Myanmar. Our study underscores the significance of high-pressure, water-rich, and moderately oxidized magma conditions in the generation of PCDs.

Keyword

Porphyry Cu deposit, Myanmar, magma fertility

Role of chalcophile element fertility in the formation of post-collisional porphyry Cu deposits in the eastern Tethyan domain

Hongda Hao[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(hongda.hao@hotmail.com)
Jung-Woo PARK[2], Seoul National University

Abstract

Porphyry deposits, the world's most significant source of Cu and an important source of Au, are generally associated with continental or oceanic arc magmas. Recently, many porphyry deposits have been found in post-collisional settings and they have become an increasingly important exploration target. The post-collisional ore-forming magmas, generated by partial melting of subduction-modified sulfide-bearing lithosphere, are suggested to be enriched in chalcophile elements. However, the chalcophile element contents in the post-collisional magmas and its role in controlling the porphyry ore formation remain unclear. We analyzed the platinum-group element (PGE) concentrations of representative post-collisional ore-associated and barren suites in the eastern Tethyan metallogenic domain. The ore-associated suites have moderate Pd and Pt contents ranging from ~0.05 to 0.5 ppb, which are systematically higher than the most of the barren suites that have Pd and Pt concentrations below ~0.1 and 0.05 ppb, respectively. Numerical models show that the ore-forming magmas have experienced early sulfide saturaiton and precipitated a small amount of sulfides during magmatic evolution, resulting in the moderate Pd and Pt contents in the ore-associated suites. Early sulfide segregation may have substantially depleted Au contents in the ore-forming magmas, remaining sufficient Cu to form porphyry Cu deposits. In contrast, the barren suites contain systematically lower Pd, Pt and Cu contents, unfavorable for porphyry Cu ore formation. We suggest that moderate chalcophile element content in the ore-associated magmas is sufficient to form post-collisional porphyry deposits in the eastern Tethyan domain and it plays an important role in controlling the ore-forming potential.

Keyword

Post-collisional porphyry Cu deposits, Platinum-group element, Sulfide saturation

U–Pb and Hf-isotope analysis of zircons and Molybdenite Re-Os Dating in Gao'aobei Tungsten-molybdenum Ore, Southern Hunan Province , South China

Yanbin WANG[1]*, Institute of GeologyChinese Academy of Geological Sciences
(yanbinw@yeah.net)

Abstract

Gao'aobei tungsten-molybdenum mineral deposits , which are related genetically to granites , have been formed in the southern Hunan Province. , South China. However , the ages of W-Mo mineralization and granite crystallization are poorly understand at present. This study provides the first highly precise dating of the mineralization and rock-forming in the Gaoaobei W-Mo ore. The dating of zircon from Gaoaobei biotite granite determined by SHRIMP yield ages of 222.1±2.0 Ma. Hafnium isotope data was also acquired through laser-ablation multicollector ICP-MS analysis of zircon, with the aim of gaining insight into the age and nature of the source region of the pluton. The yield age (222±2 Ma) confirm that this biotite granite intrusion belongs to late Trassic. Hafnium analysis shows the biotite granite to have negative and variable epsilon Hf(t) values (-4.7 to -10.9) and Palaeo-Mesoproterozoic (1.6 to 2.0 Ga) depleted-mantle model ages, which is interpreted to reflect derivation from old crust source. The source region for these magmas may be tentatively correlated with Palaeo-Mesoproterozoic material of the South China Block, Which has been suggested to underlie the Hunan; however, further work is necessary to demonstrate this suggestion. Rhenium and osmium isotopic dating of molybdenite from the Gaoaobei tungsten-molybdenum ore by ICP-MS yields isochron ages of 157.3 ±6.6 Ma on the 187 Re versus 187Os correlation diagram. The result s suggest that the timing of W-Mo mineralization and granite crystallization are different period, W-Mo mineralization period is corresponding to the time of the largescale mineralization regionally in the Mesozoic. In addition , there exists an apparent time difference between W-Mo mineralization and granite crystallization.

Keyword

Tungsten-molybdenum deposits, zircon SHRIMP dating, molybdenite Re-Os isotopic dating, Hunan Province, South China

U-Pb geochronology, trace elements and Sr-Nd isotope geochemistry of the gold deposit in the Rangnim Massif, North Korea: a model for hydrothermal ore genesis

LEI XU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China (leixu@mail.iggcas.ac.cn)
JIN-HUI YANG[2], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
HAO WANG[3], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
YU-SHENG ZHU[4], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China
BAO-QUAN ZHOU[5], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing 100029, China

Abstract

The lack of geochronological constraints on hydrothermal Au deposits results from their relatively simplified mineralogy (e.g., pyrite, pyrrhotite, arsenopyrite, sphalerite, and galena) and a general paucity of mineral phases suitable for geochronology. Fortunately, apatite has been recognized as a minor, very fine grained phase associated with ore-forming stage sulfide, e.g., pyrite and arsenopyrite in four Au ores collected from an IOCG deposit in the Rangnim Massif, North Korea. REE contents of apatites from Au ores are highly variable but lower than magmatic apatites from the intrusive rocks, suggesting that apatites from Au ores underwent hydrothermal evolution and are typical of hydrothermal apatite. That means, these hydrothermal apatites are clearly associated and provide information of hydrothermal gold mineralization. Apatite has been widely used as a geochronometer because it can preferentially incorporate U relative to Pb, which is requisite for successful U-Pb dating. Directly LA-SF-ICP-MS U-Pb dating of hydrothermal-apatite from four Au ores indicate ages of 113.1 ± 1.3 Ma, 111.6 ± 1.8 Ma, 109.1 ± 1.1 Ma and 110.8 ± 1.7 Ma, which can represent the gold mineralization age. Moreover, these ages are coincide with the 111-112 Ma zircon ages of the high-MgO diorites to granodiorites and porphyric granites that partially host mineralization. Innitial 87Sr/86Sr ratios and εNd(t) values of hydrothermal apatites ranging from 0.70893 to 0.71296 and -6.0 to -19.5, similar to whole rock Sr-Nd isotope of Ealy Cretaceous high-MgO diorites to granodiorites and granites (0.70876 to 0.71152; -14.5 to -16.9). Combined with U-Pb geochronology, trace elements and Sr-Nd isotope geochemistry, gold mineralization in the Rangnim Massif, North Korea is closely related to the Early Cretaceous magmatis which is generated by AFC of enriched lithospheric mantle-derived magmas. The magmatism and gold mineralization are the result of lithospheric delamination in North Korea during Early Cretaceous.

Keyword

Au deposit, apatite, U-Pb dating, Sr-Nd isotope, North Korea

Biogenic mediated pyrite formation in the Shinyemi Skarn Fe polymetallic deposit, South Korea

Naing Aung KHANT[1]*, Department of Geology, Kangwon National University, Chuncheon, South Korea (khant_8@kangwon.ac.kr)
Chungwan Lim[2], Department of Geology, Kongju National University, Gongju, South Korea
Heejung KIM[3], Department of Geology, Kangwon National University, Chuncheon, South Korea

Abstract

Pyrite (FeS2) formations are occasionally mediated by sulphate-reducing bacteria (SRB) in the ore deposits. The origin of the Shinyemi Iron polymetallic ore field is related to the mineralization of skarn-type deposits. Shinyemi mine is one of the biggest polymetallic skarn-type Fe deposits in South Korea and contains Fe, Fe-Mo skarn, and Fe-Zn-Pb replacement skarn. Here, we investigated the SRB presence in these ores and reported the use of Raman spectrum features to distinguish the compositional characteristics of different types of pyrite (FeS2) from the deposit. The major types of pyrite can be identified by using transmission electron microscopy (TEM), and the major presence of organic carbon can be observed by using the Raman spectral pattern and peak positions. Pyrite sometimes occurs within the pyrrhotite, and two types of chalcopyrite occur: in stage 1 with a large proportion and in stage 2 with a small amount within either sphalerite or pyrite. Usually, pyrrhotite and pyrite are primarily observed in the range of 100–800 cm-1 peaks. The D1 peak and the G peak, which occur at 1301.04 cm-1 and 1608.43 cm-1, respectively, are the prominent peaks of pyrite that are associated with the presence of organic carbon. Only the D1 peak with the highest intensity was observed mostly, and the D1 and G peaks occurred together occasionally. Pyrite with no organic carbon peaks also occurred, which points out that there are two types of pyrite formation, biogenic and abiogenic, in the Shinyemi skarn deposit. The obtained results show that the use of Raman spectroscopy is an influential tool for the identification of all the minerals and biogenic trace which are usually found in pyrite. The optical absorption spectra of pyrrhotite exhibit low-frequency carbon-carbon (C-C) vibrations at approximately 800 cm-1. These C-C could result from the remnants of the organic carbon occurrence in the pyrite within the deposit. The secondary pyrite mineralization in the Shinyemi skarn deposit was probably precipitated with the help of sulphate-reducing bacteria.

Acknowledgement
This research was funded by the Basic Science Research Program through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (grant numbers 2019R1I1A2A01057002 and 2019R1A6A1A03033167).

Keyword

Pyrite, Skarn deposit, Sulphate reducing bacteria, Shinyemi, Organic carbon

Geochemical characteristics of antimony and tungsten mineralization of the Doi Ngom deposit, northern Thailand

Karn Phountong[1]*, Akita University (karn.p@outlook.co.th)
Ryohei Takahashi[2], Akita University
Punya Charusiri[3], Department of Mineral Resources
Andrea Agangi[4], Akita University
Pearlyn Manalo[5], Akita University
Ladda Tangwattananukul[6], Kasetsart University
Hinako Sato[7], Akita University

Abstract

The Doi Ngom W-Sb deposit is located in the Sukhothai Fold Belt, a N-S trending volcanic arc extending from Yunnan, southern China to Myanmar, Laos, Thailand and peninsular Malaysia. This research aims to elucidate geochemical characteristics of the Doi Ngom deposit based on the mode of occurrence of ores and host rocks. On the basis of the field observation, wolframite (i.e., ferberite-hubnerite solid solution) occurs in the breccia, whereas stibnite occurs as dissemination in mudstone. We employed petrography, whole-rock geochemical analysis, and sulfur isotope analysis. The petrography showed that wolframite and fine-grained quartz with 10–20 μm in size occur as cementing materials of the breccia consisting of very angular to moderately rounded pebble-sized clasts. Subhedral to euhedral stibnite with 1–5 mm in size and euhedral fluorite with 10–50 μm in size are disseminated in the mudstone. The wolframite-bearing breccia contains 0.01 – more than 10 wt% W, up to 0.69 wt% Sb, 0.06–0.13 ppm Au, 0.17–0.93 ppm Ag, 54.4–145 ppm Cu, 7.87–564 ppm Pb, and 15.2–858 ppm Zn. The stibnite-bearing mudstone contains 0.07–1.42 wt% Sb, 0.07–0.54 ppm Au, 0.15–0.23 ppm Ag, 12.7–53.7 ppm Cu, 0.18–23.9 ppm Pb, and 0.20–80.6 ppm Zn. There are positive correlations ($r > 0.8$) of Au against Cr; Ag against Bi, V, Zn, Ge, In, and Pb; W against Ti, Cu, Nd, Sm, Eu, Tb, Dy, Ho, Er, Tm, Yb, and Lu. These correlations suggest a possible relationship of Ti, Cu, Nd, and REEs with wolframite. The $\delta 34S$¬CDT values of stibnite have a narrow variation, ranging from -10.6 ‰ to -8.8 ‰, suggesting possible sedimentary and metamorphic sources of sulfur for stibnite. There is no evidence of co-occurrence of stibnite and wolframite.

Keyword

antimony, tungsten, Doi Ngom, Sukhothai, Thailand

Linking two types of breccia bodies to sedimentary rock-hosted stratiform copper (SSC) and iron oxide-copper-gold (IOCG) deposits in the Kangdian metallogenic belt, SW China

Xue-Qing YIN[1]*, China University of Geosciences (xueqingyin@cug.edu.cn)
Xin-Fu ZHAO[2], China University of Geosciences

Abstract

Breccia bodies have been known to be spatially associated with diverse base metal hydrothermal deposits worldwide. Voluminous breccia bodies, regionally known as the Yinmin Breccia, are widely distributed in the late Paleoproterozoic Dongchuan Group in the Kangdian Fe-Cu metallogenic belt, Southwest China. However, the origin of these breccia bodies and their relationship to the SSC and IOCG deposits in the region remains highly controversial. The Yinmin ore district contains the Yinmin SSC deposit and Xikuangshan IOCG deposit, both of which display close spatial association with breccia bodies, providing an excellent opportunity to address such critical issues.

Detailed field mapping and petrologic observations suggest that the Yinmin Breccia contains two types of breccia bodies, namely monomict and polymict breccia. The monomict breccia is characterized by the clasts mostly from the fragments of the Yinmin Formation that cemented by hydrothermal mineral assemblages of quartz and carbonates, with locally pyrite and chalcopyrite, which are similar to the alteration phases of the SSC mineralization. In contrast, the compositions of polymict breccia are much more complicated and contain the fragments of the Yinmin Formation, monomict breccia, and minor other country rocks, all of which have been extensively albitized and transitioned to Ca-Fe, K-Fe, and Ca-Mg alteration. Such alteration phases share many similarities to the hydrothermal alteration of the Xikuangshan IOCG deposit.

Field evidence shows that the IOCG-type alteration was overprinted on the precursor SSC mineralization and monomict breccia. A dolerite intrusion crosscutting the SSC orebodies and monomict breccia yields a zircon U-Pb age of 1698±29 Ma, providing a low limit on the timing of the monomict brecciation and SSC mineralization. Combined with B-C-O-S isotope compositions, we propose that the monomict breccia was the product of salt halokinesis due to the dissolution of evaporites, whereas the polymict breccia formed in response to fluid overpressures by continuous influx of deeper magmatic-hydrothermal fluids during the IOCG mineralization. Although there are close spatial association between SSC and IOCG deposits in the Kangdian region, they are products of two separate mineralization events which are overprinted in a coincident location. This work also provides an excellent example for linking ore genesis to regional breccia bodies.

Keyword

Yinmin Breccia, Breccia bodies, SSC deposit, IOCG deposit, Kangdian metallogenic belt

Robust age constraints on the Carlin-type gold and Skarn-type W deposits in the Youjiang basin of China: Implications for their genetic linkage and future exploration

WEI GAO[1]*, State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences (gaowei@mail.gyig.ac.cn)
SHANLING FU[2], State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences
RUIZHONG HU[3], State Key Laboratory of Ore Deposit Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences

Abstract

The Youjiang basin, located on the southwestern margin of the Yangtze block in southwestern China, represents the world's second-largest Carlin-type gold province after Nevada, USA. The limit availability of robust age determinations on gold deposits in this province has hindered understanding of their genesis and relation to the geodynamic setting. Hydrothermal apatite, rutile, and monazite that are coeval with gold mineralization have been identified in representative Carlin-type gold deposits. These hydrothermal minerals are characterized by intimate intergrowth with ore-stage gold-bearing sulfides, presence of primary two-phase fluid inclusions, composition affinities of hydrothermal origin, and highly variable concentrations of lattice-bound U and Th. In situ secondary ion mass spectrometry (SIMS) U-Th-Pb dating on these hydrothermal minerals yielded precise and reproducible U-Th-Pb ages of 150–140 Ma, representing the timing of Carlin-type gold deposits in the Youjiang basin, which are contemporary with the widespread felsic magmatism and associated high-temperature W-Sn mineralization to the east of the Youjiang basin. High-resolution nanoscale secondary ion mass spectrometry (Nano-SIMS) sulfur isotope analysis of gold-bearing pyrite and laser ablation inductively coupled plasma-mass spectrometry (LA-ICP-MS) composition analysis of individual fluid inclusion revealed that the Carlin-type gold deposits share similar geochemical fingerprints to the W-Sn deposits, indicating a common origin for the initial gold-bearing ore-forming fluids from deep magmatic-hydrothermal systems. Interestingly, in situ scheelite U-Pb dating conducted on the large Nanyangtian skarn-type W deposit in the southern margins of the basin has yielded robust mineralization ages of 155–145 Ma, confirming the scenario that there is indeed contemporaneous W mineralization occurring alongside with the Carlin-type gold deposits in the Youjiang basin. A vertical binary model has been established, characterized by lower high-temperature W mineralization and upper low-temperature Au mineralization. It can be predicted that there may exist high-temperature W deposits beneath the Carlin-type gold province in the Youjiang basin.

Keyword

Carlin-type Au deposits, Skarn-type W deposit, The Youjiang basin, U-Th-Pb dating, Vertical binary model

Metal sources of sediment-hosted antimony deposits: Evidence from antimony isotopes

Shanling FU[1]*, State Key Laboratory of Ore Deposit Geochemistry,Institute of Geochemistry, Chinese Academy of Sciences (fushanling@mail.gyig.ac.cn)
Wei GAO[2], Institute of Geochemistry, Chinese Academy of Sciences
Ruizhong HU[3], Institute of Geochemistry, Chinese Academy of Sciences

Abstract

Sediment-hosted antimony deposits are a major source of Sb, accounting for over 50% of global reserves and production. Although economically important, the genesis of sediment-hosted Sb deposits remains controversial due to the highly debated sources of metals in these deposits. The discovery by Rouxel et al. (2003) of significant Sb isotope fractionation in natural samples has led to numerous studies confirming the reliability of Sb isotopes as a geochemical tracer. However, the utilization of Sb isotopes as a tracer for source identification in Sb deposits remains limited due to ongoing debates surrounding Sb isotope fractionation models. The world's largest sediment-hosted Sb deposit, Xikuangshan, was studied to investigate the use of Sb isotopes as a tracer for identifying the metal source of such deposits. Investigation of Sb isotopic ratios of stibnite in the Xikuangshan deposit, altered and fresh host rocks, and metasedimentary rocks in Precambrian basement revealed that the Ediacaran and Banxi Group in the Precambrian basement may have served as the primary sources of Sb for the Xikuangshan deposit. The significant overlap of ε123Sb values in early-stage and late-stage stibnite suggest that the large variation of ε123Sb values from the early to late stages can be attributed to the episodic precipitation of multiple fluid batches that extracted Sb from the same source.

Keyword

Sediment-hosted Sb deposits, Antimony isotopes, Metal sources, Xikuangshan

Trapping of uranium by organic matter within sandstones during mineralization process: A case study from the Shuanglong uranium deposit, China

Fan Fan Zhang[1]*, China University of Geosciences (1027728636@qq.com)

Abstract

Carbonaceous debris (i.e., CD), dispersed organic matter (i.e., DOM) within sandstones, has been studied in the Shuanglong uranium deposit of the southern Ordos Basin, northern China. Relations of uranium enrichment and organic matter (i.e., OM) were investigated through maceral analyses, proximate analysis, vitrinite reflectance measurements, and morphology analyses of uranium minerals. The results show that CD widely distributed in sandstones, is associated with pyrite and uranium minerals. Macerals are mostly composed of telinite, collotelinite, collodetrinite, semifusinite, and inertodetrinite, including that collotelinite is dominant (contents more than 60%). The CD is at the stage of medium coalification, and is of low moisture, high ash, high volatile matter, medium fixed carbon, and high sulfur. Uranium occurs in uranium minerals (i.e., pitchblende and coffinite) and amorphous uranium. Moreover, uranium minerals partly or completely replace macerals. Statistical analyses show that porous inertinite and higher organic matter maturity is more advantageous to uranium enrichment. Additionally, uranium is unevenly distributed in macerals along certain directions, which is related to the physicochemical properties of macerals. Porous inertinite could provide channel for uranium-bearing fluid migration and space for uranium preconcentration. The CD at the stage of gas coal is of reducibility to be favorable for the forming of uranium minerals. Moreover, the relative atomic content of uranium (IV) increases with the increasing organic matter maturity. Uranium-bearing fluid could permeate into macerals under certain physical and chemical conditions, and react, i.e., adsorption followed by reduction. It is beneficial to comprehend the mechanism of uranium mineralization, providing certain guides for prospection.

Keyword

Uranium minerals, Macerals, Organic matter, Sandstone-type uranium deposit, Ordos Basin

[Keynote] Unusual multi-metallic uranium deposits in India: Their potentialities.

DEEPAK KUMAR SINHA[1]*, AMD & GMDC (dksjai@gmail.com)

Abstract

Indian Plate provides varied litho-structural domains for hosting classical multi-metallic deposits. It contains Archaean to Recent geological environments established for minerallogenic provinces. Deep exploration carried out recently has resulted in the identification of multi-metallic uranium deposits in a few unusual host rocks. The recent additions like altered serpentinised peridotite in the Singhbhum copper-uranium province of Singhbhum Supergroup and uranium-REE in magmatic albitite in the Khertri-copper province of Delhi Supergroup have been established for opening new mining centres. The well-known strata-bound uranium deposit of Tumalapalli in the Vempalli Limestone Formation of Cuddapah Supergroup has reached the status of the highest tonnage discovered so far in India (Single largest uranium deposit -2,41,309t U3O8). It is classified under the low-grade category and proved up to a depth of 1km. The serpentinised peridotite and magnetic albitite at Geratiyon-ki-Dhani ranging from low to medium grade are emerging potentialities with 2000 tonnes U3O8 and 1000 tonnes U3O8 respectively. The continued exploration has paved the way to add 3000 tonnes in each deposit for the higher life expectancy of mine's life. The present paper discusses recently investigated geological and genetic aspects of these unusual multi-metallic uranium deposits for the identification of similar resources in other geological domains of the country and beyond the Indian Plate as well.

Keyword

Uranium, Multi-metallic, india

Sandstone-type uranium deposits hosted in the aeolian sandstone: Taking an example of the Pengyang-Jingchuan deposit in the Ordos Basin, China

YIN CHEN[1]*, Tianjin Center, China Geological Survey (chenyinchain@sina.com)
HUALEI ZHAO[2], Tianjin Center, China Geological Survey
LULU CHEN[3], Tianjin Center, China Geological Survey
QINGHONG SI[4], Tianjin Center, China Geological Survey
JIANGUO LI[5], Zhengzhou Institute of Multipurpose Utilization of Mineral Resources, Chinese Academy of Geological Sciences

Abstract

Sandstone-type uranium deposits have been regarded as the most significant uranium resources in the world, which has covered the uranium production to be up to 63.3 % and 72.0% in the global and Chinese market. Uranium deposits hosted in the aeolian sandstone were newly discovered in the Ordos Basin, China. Especially, petrology, mineralogy, geochemistry, geochronology, etc. have been invested in the Pengyang-Jingchuan uranium deposit located in the southwestern Ordos Basin. Uranium bodies are hosted in the Lower Cretaceous successions which are characteristic of the aeolian and shallow lacustrine sedimentary systems. Features of aeolian sedimentation (e.g., grain flow, wind ripple, and wind fall) were widely observed in the outcrops, drill cores or by the microscope. As there are less reduced materials in the red aeolian sandstone, hydrocarbon fluids uplifting along faults from the oil/gas preserves, act as the reducing agent for uranium mineralization, and alter the red sandstone to be gray. This has been proved by the fluid inclusions, ring-coating reduced alteration zone along the fissures, oil content tests and altered minerals. Anatase, pyrite, apatite, and clay minerals commonly spread in the uriniferous sandstone and played significant roles in the mineralization process. In-situ S isotope of the colloidal pyrites from the ore-bearing layers shows that the biological process is of great significance to the enrichment and precipitation of colloidal pyrite and uranium. Whole rock geochemistry analyses of samples from the ore-bearing layers also state a positive correlation between U and S. Furthermore, the uranium minerals are mainly pitchblende, with a small amount of coffinite. In-situ U-Pb dating of uranium minerals have recorded a mineralization stage during the Pleistocene. Tectonic events surrounding the southwestern Ordos Basin were analyzed based on the zircon and apatite fission trick, and five stages of tectono-thermal events since the Late Mesozoic were revealed: (i) the Late Jurassic–Early Cretaceous, (ii) the late Early Cretaceous, (iii) the Late Cretaceous, (iv) the Late Paleogene–Early Neogene, and (v) the Late Miocene–present. Combined with the former dating results of uranium mineralization in the western Ordos Basin, the latest activity since the Late Miocene is confirmed to drive the reactivation and re-enrichment of the uranium mineralization. Besides, most uranium mineralized drillcores were found to be located beside the faults spatially. In the end, the tectonic-driving and reducing-fluids-altering uranium mineralization model is set up, which has promoted the prospecting breakthroughs in the southwestern Ordos Basin and gave some key information for the uranium mineralization in the red beds.

Keyword

Sandstone-type uranium deposit, Aeolian sandstone, Cretaceous, Ordos Basin in China, fluid inclusion

A new exudation metallogenic model for uranium deposit in the red-mottled sedimentary sandstone system in northern basins of China

Ziying LI[1]*, Beijing Research Institute of Uranium Geology (zyli9818@126.com)
Mingkuan QIN[2], Beijing Research Institute of Uranium Geology
Wusheng LIU[3], Beijing Research Institute of Uranium Geology
Feng HE[4], Beijing Research Institute of Uranium Geology
Weitao LI[5], Beijing Research Institute of Uranium Geology
Linfei QIU[6], Beijing Research Institute of Uranium Geology
Yuqi CAI[7], Beijing Research Institute of Uranium Geology
Mingming TIAN[8], Beijing Research Institute of Uranium Geology
Hongwei JI[9], Beijing Research Institute of Uranium Geology
Jian GUO[10], Beijing Research Institute of Uranium Geology

Abstract

The recently discovered uranium deposits occur in the red-mottled sedimentary sandstone system in northern basins of China, such as Hadatu deposit in Erlian basin and Hailijin deposit in south part of Songliao basin etc.. Unlike traditional sandstone-type uranium deposits, the uranium orebodies of these deposits exhibit multiple stratiform and tabular morphologies, which occur in grey-greenish sandstone layers within the red-mottled sandstone units, but do not appear to be controlled by a redox zone. The ore-bear grey-greenish sandstone layers display islet-, bead-like shapes in the bedding plane, and lens- and trumpet-like shapes in profile. These ore-bearing layers are associated with faults. The color of ores can be reddish to dark, which are geochemically rich in uranium, cobalt, nickel and zinc etc, showing similar element association of the source rocks rich in organic material below the ore beds. Uranium is closely related with organic material which is mostly determined to be bitumen. Multiple ages of the deposit have been determined to be Paleogene or Neogene, much younger than the hosted rocks. These signatures of these uranium deposits can not be explained in terms of the traditional infiltration (phreatic and interlayer oxidization-reduction) metallogenic theory.

based on the comprehensive studies on these deposits, a new exudation uranium metallogenic model for the formation of these deposits has been proposed. The ore-hosting red-mottled formation is evidenced to be syngenetic in origin, resulting from oxidization during primary sediment deposition. By contrast, the ore-controlling grey-greenish sandstone layers in the uranium-bearing formation are epigenetic in origin, resulting from secondary reduction by deep-seated reducing fluids that were mainly controlled by fault structures that connect the lower and upper parts of the sedimentary system. The uranium is believed to be from deep-seated dark sediments rich in various metals and organic materials. Uranium and other metals were transported by fluids originating from the same deep-seated source rocks, moving through faults and expelled during the sedimentary-tectonic evolution of the basin. The fluids were reducing in character, rich in organic acids, especially acetic acid and organic functional groups, and high in both temperature and pressure. These acids can leach and transport not only uranium, but also

zinc, cobalt, nickel, copper, and other metals. Furthermore, the functional groups can easily complex or combine with uranium and associated metals, which are soluble in those reducing fluids, and thus can migrate upwards into the overlying red-mottled sedimentary units. When the ore-bearing reducing fluids enter the red-mottled sedimentary units, the uranium complexes or compounds dissociate due to decreases in temperature and pressure, changes in pH and Eh values, oxidation, and other factors, resulting in precipitation of uranium and formation of the uranium deposit.

The new model has been applied to identify new prospective areas and a number of new discoveries on this new type of uranium deposit have been made in the red-mottled sedimentary formations of Meso- and Cenozoic basins in China for recent years.

Keyword

Sandstone-hosted uranium deposit, Exudation metallogeny, Red-mottled sedimentary formation, Ore-controlling grey sandstone body

Analysis on Uranium Metallogenic Conditions and Prospect Review of the Langka-Daladi Aera in Eastern Part of Southern Margin of Yili Basin, North China

SONG JI Jiye[1]*, Beijing Research Institute of Uranium Geology,CNNC (jessica_0@163.com)
QIN MING KUAN[2], BRIUG,CNNC

Abstract

Yili basin is an important uranium deposit base in China. So for, a series of large and medium-sized in-situ leachable interlayer oxidation zone sandstone type uranium deposits have been found in the middle and western part of the southern Yili Basin. However, there is no great breakthrough in the eastern part (Langka-Daladi area)of the basin south margin. Whether the area has the uranium metallogenic potential or not and how is the prospect is to be solved. In this paper, the uranium metallogenic condiontions (such as the metallogenic structure, sedimentry and palohydrodynamic conditions)and prospects in Langka-Daladi area have been studied detaily, through summarizing and analyzing the previous research results, making full use of drilling, geophysical exploration, field investigation and data collection, as well as indoor mapping study. The results show: the known uranium deposits area (Mengqiguer) and its eastern extention(Langka-Daladi area) are the favorable areas for the existing key exploration areas and the peripheral resources to increase and expand the deep prospecting space. The metallogenic scale of Kulusitai-Daladi compound syncline belt and its north area is limited compared with that of Meqiguer and its east extension, but it still has certain metallogenic prospect in the Almalai syncline and the area to the north of Almalai-Suaau.

Keyword

Metallogenic tectonic conditions, Metallogenic sedimentry conditions, Palohydrodynamic characteristics, Comprehensive evaluation of prospect, Langka-Daladi area in eastern segment of Yili basin southern margin

Genesis of high-grade uranium deposits in Motianling Neoproterozoic granites from northern Guangxi Province, South China: Constraints from in situ micro-chronology, sulfur isotope and trace elements analysis

Yongjian WANG[1]*, Beijing Research Institute of Uranium Geology, China National Nuclear Corporation, Beijing, 100029, China (wangyongjian9818@foxmail.com)
Yaqing PANG[2], Beijing Research Institute of Uranium Geology, China National Nuclear Corporation, Beijing, 100029, China
Honghai FAN[3], Beijing Research Institute of Uranium Geology, China National Nuclear Corporation, Beijing, 100029, China

Abstract

The Neoproterozoic Motianling granite complex in northern Guangxi, South China, hosts a number of uranium deposits and occurrences. This region stands out from other hydrothermal uranium deposits in South China due to several distinct geological characteristics. The host rocks are notably ancient (730–828 *Ma*), *and there is a considerable temporal gap* (>400 *Ma*) *between the formation of ore-hosting granites and uranium mineralization. Additionally, the deposits exhibit high uranium grades* (>0.3%) *and a variety of mineralization types. Limited research and exploration in this area have led to considerable debate and discrepancies regarding the uranium mineralization age and the ore genesis.*

The Daliang deposit, a primary focus of this study, predominantly features uraninite-chlorite (pyrite) mineralization type. In these ores, uranium primarily occurs as pitchblende, and brannerite. Additionally, a small amount of uranium is found in the form of isomorphism or adsorption in hematite, illite, apatite, and xenotime. In contrast, the Xincun deposit primarily involves uranium-silicification and uranium-fluorite mineralization types, with a simpler uranium occurrence mainly in the form of uraninite and minor coffinite. Temperature estimations based on chlorite geothermometers suggest that the mineralization temperature of the Daliang deposit was between 218–243℃, *which aligns with previous findings derived from fluid inclusion homogenization temperatures, indicating a medium to low-temperature condition. In contrast, the pre-mineralization formation temperature of chlorite in the Xincun deposit was estimated to be* 219–243℃, *notably higher than the fluid inclusion homogenization temperature in the syn-ore stage. LA-ICP-MS uraninite U-Pb analysis indicates that the uraninite-chlorite mineralization type at the Daliang deposit formed around* 800-750 *Ma. The primary mineralization stage of uranium-silicification type at Xincun occurred at* 57 *Ma, followed by a later uranium-*

fluorite mineralization type at 50 *Ma. Microelemental analysis of pitchblende, along with H-O isotopic studies of quartz and chlorite and in-situ S isotope characteristics of pyrite in both deposits, indicate that the mineralizing fluids were primarily a mixture of deep-sourced fluids and meteoric water. The mineralizing components were predominantly derived from the granite body itself.*

Based on this research, a multi-stage and complex genetic model for uranium mineralization involving both deep-sourced fluids and meteoric water has been developed for the Motianling area. This model highlights the intricate interplay of geological processes in forming these unique and valuable uranium deposits.

Keyword

Motianling in Guangxi Province, Neoproterozoic granite, Uranium mineralization age, In situ trace elements and S isotope of pyrite, South China

Uranium mineralization age constraint by indirect dating of syn-ore gangue minerals: a case study from a Na-metasomatite uranium deposit in Northwest China

Jun ZHONG[1]*, Beijing Research Institute of Uranium Geology (zhongjun9818@163.com)

Abstract

Constraining the mineralization age of any mineral deposit is fundamental for understanding ore genesis and determining prospecting strategies. For uranium deposits, the commonly applied dating method used in recent two decades is uraninite (pitchblende) SIMS and/or LA-ICP-MS U–Pb dating. However, the determination of mineralization age for some low-grade uranium deposits (e.g. Na-metasomatite type and sandstone-type) with fine-grained uranium minerals remains difficult because these fine-grained minerals are difficult to date. Moreover, the dating results of some uranium deposits may be inconclusive and even confusing due to the easily reset characteristics of uraninite/pitchblende by post-mineralization tectonothermal events and/or fluids. Effective alternatives, therefore, are necessary for the mineralization timing constraint for the uranium mineralization systems. In this study, we present for the first time a case study of a Na-metasomatite uranium deposit in northwestern China (the Xinshuijing deposit), using the syn-ore hydrothermal zircon U-Pb and albite Ar-Ar dating methods to bracket the mineralization age. The syn-ore hydrothermal zircon U–Pb and albite Ar–Ar ages are consistent with each other (378–366 Ma; given analytic uncertainties), but also within the range of uraninite chemical U–Pb ages (approximately 370 Ma). The coupled application of hydrothermal zircon U–Pb and albite Ar–Ar age dating is thus regarded as a robust approach for constraining the age of mineralization for Na-metasomatite uranium deposits. An age gap of approximately 70 m.y. between uranium mineralization (~ 370 Ma) and host granitoid emplacement (about 440 Ma) suggests no direct genetic linkage between the two, and further exploration in the surrounding sedimentary and metamorphic units, rather than only focusing on the host granitoids, should therefore be considered, especially where intensive wallrock alteration and structural features are pervasive. Our study highlights the importance of selecting appropriate isotopic dating methods for the uranium deposits, which is informed by detailed paragenetic and geochemical analysis of dateable minerals formed before or coeval to the main-stage uranium mineralization.

Keyword

Na-metasomatite uranium deposit, mineralization age, hydrothermal zircon U-Pb, albite Ar-Ar, Longshoushan metallogenic belt

Uranium mineral systems in Brazil

Hugo Jose de Oliveira POLO[1]*, Geological Survey of Brazil (hugo.polo@sgb.gov.br)
Anderson Dourado Rodrigues da Silva[2], Geological Survey of Brazil
Iago Sousa Lima Costa[3], Geological Survey of Brazil
Isabelle C.C.O. Serafim[4], Geological Survey of Brazil
Felipe Mattos Tavares[5], Geological Survey of Brazil
Lys Matos Cunha[6], Geological Survey of Brazil
Raul Eigenheer Meloni[7], Geological Survey of Brazil

Abstract

Brazil currently has one of the most extensive uranium resources in the world, with about 245 thousand tons of contained uranium. Besides, the country has the potential to be among the five largest resources globally due to its territorial extension, geological diversity, resumption of geological surveys, and prognosticated and speculative resources from a recently released IAEA report. Brazil has 36 uranium deposits in 9 different types, according to IAEA: 4 intrusive; 5 IOCG; 1 metamorphic; 15 metasomatic; 3 Paleo conglomerate with quartz pebble; 2 granite related; 3 sandstones; 2 phosphates; 1 superficial. In this work, we synthesize the current knowledge of Brazilian uranium deposits to obtain a macro-regional analysis. The deposit types are simplified into six sets of mineral systems: i) igneous, ii) metamorphic/metasomatic, iii) Proterozoic unconformity, iv) paleo conglomerate, v) sedimentary, and vi) superficial. There are 11 known igneous uranium deposits that account for between 38% and 48% of national reserves, the main ones are Salobo, Sossego and Pitinga, all located in Amazon Craton. Sedimentary deposits represent between 23% and 29% of reserves, with a total of 4 deposits, the most important being Amorinopolis and Figueira. There are 16 metasomatic/metamorphic deposits that represent between 27% and 31%, including Lagoa Real and Itataia/Santa Quiteria. The first is an active mine and the second is a project under development that should start production in 2026. Finally, paleoconglomerate and superficial deposits represent less than 2% of the total reserves, represented by Jacobina and Gandarela. We highlight that there are no Proterozoic unconformity uranium deposits described in Brazil, despite the high potential, due to the giant proterozoic basins that cover about 9% of crystalline terrain in Brazil. We also highlight that some of these deposits may represent the overlap of more than one mineral system. The sedimentary, metamorphic/metasomatic and igneous systems present best potential for new discovers based in the knowledge-driven analyses, and the airborne radiometric data, processed using artificial intelligence, are correlated to results for metamorphic/metasomatic and igneous systems. Due to the recent changes in the legal frameworks for uranium exploration in Brazil, it is necessary to publicise the Brazilian mineral potential widely. The mineral systems approach represents an important structure for the construction of prospectivity maps and other spatial data modeling products, which in turn assist in decision-making by public authorities and in the promotion of the mineral industry, by indicating priority areas for development of mineral exploration, thus reducing the risk and cost of exploration and consequently expanding national resources.

Keyword

Mineral system, Uranium, potential

Late Cretaceous-Cenozoic tectonic-sedimentary evolution and U-enrichment in the southern Songliao Basin

Shaoyi WANG[1]*, Tianjin Center, China Geological Survey (1032668801@qq.com)

Abstract

Late Cretaceous-Cenozoic tectonic-sedimentary evolution is fundamental to U (Uranium) migration and U-enrichment in the southern Songliao Basin, northeast China. To establish the genetic connection between tectonic-sedimentary evolution and U-enrichment, this paper presents a mineralogical study, apatite fission-track (AFT) analysis, and SEM-CL analysis of quartz grains. Two stages of mineralization were proposed, including the U pre-enrichment stage during the Late Cretaceous, and the ore-forming stage during the Cenozoic. Based on the density plots of the AFT ages, paleoclimate studies, and SEM-CL analysis of quartz grains, it is inferred that the U pre-enrichment was closely related to the rapid uplift of the Great Xing'an Range and the Zhangguangcai Range, and the O2-rich atmosphere during 97–90 Ma in the southern Songliao Basin. The O2-rich atmosphere increased U mobility and led to the formation of red beds during the Late Cretaceous, which widely developed U pre-enrichment in the basins of Northeast China. The mineralogical study reveals that the Qianjiadian uranium deposit developed in two stages. The diagenetic process experienced the transition from early alkaline to late acidic conditions, to promote the Stage I mineralization (U pre-enrichment). The dominant occurrence spaces for U were the dissolution pores of quartz, tightly packed with calcite cement. U-enrichment during alkaline ambient conditions was mainly via adsorption. With the increase of the buried depth, the early alkaline diagenesis returned to acidic conditions due to the abundant organic material. U(VI) was reduced to pitchblende due to the reducing capacity of the organic matter (OM). Stage II (ore-forming stage) mineralization was strictly related to the hydrocarbon re-concentration. According to the thermal history study of the CC1 and Q2 boreholes, the southern Songliao Basin experienced four episodes of rapid uplift during the Cenozoic at 83–80 Ma, 68–52 Ma, 33–23 Ma, and −8 Ma, respectively. The Cenozoic uplifts led to hydrocarbon migration at 65 Ma, 23 Ma, and present. The re-concentration of hydrocarbon prompted the U mineralization in the Qianjiadian uranium deposit in the southern Songliao Basin during the stable period of tectonic movements. The reducing conditions caused by hydrocarbons promoted U mineralization. The dominant spaces of coffinite were intergranular dissolved pores, formed during the transformation from the feldspar to the kaolinite under acidic conditions. The post-rift phase and structural inversion phase directly controlled the U pre-enrichment stage and the ore-forming stage, respectively. Overall, the tectonic-sedimentary evolution played an important role in controlling the U leaching from granites, the dominant occurrence spaces, and U recycling.

Keyword

Songliao Basin, U enrichment, Tectonic-sedimentary evolution, Fission track (FT) analysis

Trans-strata mineralization of sandstone-hosted uranium deposits triggered by neotectonics

Yinhang CHENG[1]*, Tianjin Center, China Geological Survey (weicheng1858@163.com)

Abstract

Sandstone-hosted uranium deposits (SUDs) are hosted in different strata from Proterozoic to Cenozoic concentrated, with dominant ore-bearing of Mesozoic and Cenozoic. Traditionally, it is believed that uranium precipitation of SUDs is multi-staged. However, whether there is a dominant stage during the mineralization process still remains unclear. Here we show that the neotectonics could play a larger role than previously thought in generating SUDs in Ordos Basin, China, even in the world. Two main uranium-bearing strata, including the Middle Jurassic Zhiluo Formation (ZF) and the Lower Cretaceous Luohe Formation (LF) have been detected, and most of the uranium is present in pitchblende and coffinite. Relevant in-situ pitchblende U-Pb dating (1514 spots) and their chemical ages (145 spots) for ZF and LF ore deposits yielded ages range from 100 Ma to 0.1 Ma, while ca. 95% of their worldwide occurrences are concentrated in the 25-0.1 Ma. In addition, there are three mineralized stages with ages of 91-80 Ma, 70-68Ma and 37-30 Ma before the main stage. These early three staged residual uranium minerals have been increased exponentially as the younger age developed. The early three staged uranium ores even earlier have been almost redistributed by the latest regional oxidizing uraniferous fluids flow triggered by neotectonic events and rarely preserved. Though, the SUDs have been found to be hosted in different strata, it is considered that they have been formed in a same mineralized ages triggered by global neotectonics and climatic variations, and it could be defined as trans-strata isochronous mineralization.

Keyword

trans-strata mineralization, sandstone-related uranium deposits, neotectonics, in-situ uranium mineral dating, North China

Determination of radon exhalation rate of uranium ore samples from sandstone-hosted uranium deposits

Nanping WANG[1]*, China University of Geosciences (Beijing (npwang@cugb.edu.cn)
Ying JIANG[2], China University of Geosciences (Beijing

Abstract

Radon exhalation rate is the flux of radon produced by radium decay in solid media and released into the air. It is an important parameter for the study of underground radon transport, and is related to the radium content of the sample and its physical properties such as humidity, porosity and particle size. There are few data on radon exhalation rates of rocks and ores with different uranium and radium specific activity levels. In order to understand the law of radon transport in deep uranium deposits, the method of determining radon exhalation rate of uranium ore samples was studied.

A cylindrical closed chamber was used to collect radon released from core samplesand an AlphaGUARD radon detector and gas circulation system were used to measure the radon concentration released from the samples in the sealed chamber with different accumulation time, and then the radon exhalation rate of samples was calculated. The measurement results of radon exhalation rate of uranium core samples in Erlian Basin of Inner Mongolia show that the method effectively excludes the interference of radon-220, and the fitting R2 value, radon concentration growth curve at different accumulation time, is higher than 0.90. The average radon exhalation rate of uranium ore core samples is 380 times that of surface soil samples. The repeated measurement results of radon exhalation rate are stable and reliable. This method is suitable for the measurement of radon exhalation rate of uranium ore and rock.

This research was supported by the National Natural Science Foundation of China (U2067204).

Keyword

Radon exhalation rate, uranium, closed chamber

Analysis and prediction of supply guarantee for the development of world nuclear power

SONG JI Jiye[1]*, Beijing Research Institute of Uranium Geology,CNNC (jessica_0@163.com)
QIN MING KUAN[2], Beijing Research Institute of Uranium Geology,CNNC

Abstract

The energy transformation by climate issues, coupled with the energy supply crisis, has led to the development of nuclear power being valued and re examined by many countries. It is expected that the demand for natural uranium will increase. The question of whether the development of world nuclear power can be guaranteed by 2050 urgently needs to be studied and analyzed.Based on the historical and latest data of nuclear power, uranium resources, mines, etc., this article comprehensively analyzes the new situation and historical changes in the demand and supply sides of nuclear power development, and quantitatively predicts the degree of guarantee of uranium resources and natural uranium supply for nuclear power development.The research results indicate that: a) On the demand side, the world's demand for nuclear power and natural uranium in nuclear power shows a concentrated pattern, while on the supply side, the total distribution of uranium resources in the world is uneven and highly concentrated, with a large overall economic gap. b) By 2035, low-cost identified (recyclable) uranium resources can basically guarantee the development of world nuclear power. From 2036 to 2050, 80% will be guaranteed by 55% of identified (recyclable) resources at medium to high costs, while medium to low cost resources can also meet nearly 20% of the world's nuclear power demand for natural uranium during this period. c) By 2035, the amount of natural uranium resources needed for nuclear power development can be guaranteed by 96% in terms of mining resources. However, from 2036 to 2050, on the basis of fully consuming the remaining resources in mining, all planned mines and nearly 90% of potential mine resources will be needed to supplement the needs. The overall resource guarantee situation is tense. d) By 2035, primary supply can only meet 78% -82% of the required natural uranium production under different production capacity scenarios, and the remaining shortfall cannot be fully satisfied by secondary supply. This will promote the increase of mine production capacity or the adjustment and supplementation of new planned mine operations. From 2036 to 2050, there is pressure to ensure the natural uranium production required for the development of nuclear power, and there is little secondary supply (which can be ignored). It is necessary to fully exploit and produce all resources in the production mines, and it is imperative to initiate plans and potential mine operations.

Keyword

uranium demand, uranium resources, uranium supply, supply guarantee analysis and prediction, world

Thorium and Uranium ore occurrences of Georgia (The Caucasus): A comparative analysis and Prospects

Avtandil OKROSTSVARIDZE[1]*, Doctor of Geological Sciences (okrostsvari@gmail.com)
Avtandil Okrostsvaridze[2], 1 Institute of Earth Sciences, Ilia State University, 0177 Tbilisi, Georgia
David Bluashvili[3], 2 Faculty of Geology and Mining, Georgian Technical University, 0171 Tbilisi, Georgia
Franziska Wilke[4], 3 German GeoResearch Center, 14473 Potsdam, Germany
Rabi Gabrielashvili[5], 1 Institute of Earth Sciences, Ilia State University, 0177 Tbilisi, Georgia

Abstract

The Caucasus represents a Phanerozoic collisional orogen that extends for over 1000 km from the Caspian to the Black Sea. Georgia is located in the central part of the orogen and covers the southern part of the Greater Caucasus, the Transcaucasus and northern part of the Lesser Caucasus. Several ore occurrences of uranium and thorium have been identified on the Georgian territory: Shkhara U-Th, Stori Th-Bi, Vakijvari Th-Fe and Merisi Th-U.

Among them, the recently discovered Shkhara U-Th mineralization deserves significant attention [1]. It has been identified along the Main Thrust of the Greater Caucasus, in the Paleozoic Shkhara crystalline massif. The parent rocks of the mineralization are represented by biotite plagiogranites, zircon 206Pb/238U dating of which indicates 310.2±7.5 Ma. According to ICP-MS-ES analyses, in these rocks the Th content varies from ~25 ppm to ~90 ppm, and the U varies between ~20 ppm to ~390 ppm. The mineralization is represented ore veins and nests of the hydrothermal generation Their investigation on the JXA-8230 electron probe microanalyzer has shown that the mineralization is present by Th-bearing Uraninite, the overall chemical U-Pb ages of which corresponds to 291±14 Ma.

The analysis of the obtained data indicated that the Shkhara uranium mineralization was formed in the pos-orogenic extension regime of this Greater Caucasus crystalline basement (Late Carboniferous-Early Permian). This date is in full correlation with the vein-type uranium deposits similar to different regions of the world, including central and Western Europe. This mineralization has a special similarity to the uranium deposits of the Armorican Massif (France) and of the Iberian Massif (Spain)].

Unlike uranium, there are more thorium ore occurrences in Georgia. Among them, we can mention Merisi Th-U mineralization. It was formed in the active contact area of Late Eocene Merisi syenitic pluton, in the hydrothermally altered intermediate volcanic rocks. The thorium content ranges from 52.3 g/t to 147.7 ppm, and uranium from 6.2 ppm to 17.5 ppm in these rocks.

Among From thorium mineralization, it should also be noted the Stori Th-Bi ore occurrences. It is exposed within the Middle Jurassic Stori hydrothermal ore field, which is formed on the Southern Slope of the Greater Caucasus. In this zone, carbonate quartz-plagioclase veins of 30-40 cm thick, intersect the Plinsbachian clay-shales. In these veins, thorium content reaches 3880 ppm, and bismuth - 4800 ppm. Although generally in these rocks Th content varies within the range of 50-200 ppm, and Bi within the range of 55-880 ppm. Thus, as a result of our investigation we can

conclude that several prospective ore occurrence of thorium and uranium were revealed in Georgia, which require further detailed study

References

1. Okrostsvaridze, A., Bluashvili, D., Gogoladze, S., Gabrielashvili, R., 2022. The discovery of U mineralization in the late Variscan plagiogranite veins of the Shkhara crystalline massif (Greater Caucasus, Georgia). Geologica Balcanica 51 (1): 3–14.

2. Okrostsvaridze, A., Gogoladze, S., 2017. Thorium Resources and their Energy Potential in Georgian Republic, the Caucasus. Energy Procedia 125: 291–299.

Keyword

Thorium, Uranium, Georgia, Caucasus

Occurrence and geochemical characteristics of uraniferous soil in Maninsan area, South Korea

Jinah Lim[1]*, Kongju National University (jinah@smail.kongju.ac.kr)
Dongbok Shin[2], Kongju National University
Jaeguk Jo[3], Kongju National University
Byeongyong Yu[4], Kongju National University
Jihun Ryu[5], Korea Atomic Energy Research Institute
Sanghoon Lee[6], Korea Atomic Energy Research Institute

Abstract

The uraniferous black and coaly slates are developed in the Ogcheon metamorphic belt, South Korea. In Maninsan area, weathered soil fills along the fracture zone of the uraniferous hornfels, and fragments of coaly slate are found around the soil. This study compares the mineralogical and geochemical characteristics of these rock types to discuss potential processes leading to uranium enrichment in the soil. Uranium minerals predominantly occur as Th-V-Ca mineral and uranothorite for the hornfels, brannerite and coffinite for the coaly slate, and francevillite and uraninite for the soil. Their grain sizes are 7 μm in the hornfels on average, 23 μm in the coaly slate, and 29 μm in the soil. The uranium concentrations in these rocks vary from 5 to 14 ppm (av. 10 ppm) in the hornfels, 88 to 477 ppm (av. 277 ppm) in the coaly slates, and 290 to 832 ppm (av. 613 ppm) in the soils. In addition, the coaly slate and soils exhibit negative Eu and Ce anomalies and enriched V, Mo, and U, with depleted Mn concentrations. Carbon isotopic compositions and total carbon contents of the hornfels, coaly slates, and soils display a range of -24.7 to -24.1‰ (av. -24.5‰), -29.2 to -28.4‰ (av. -28.7‰), and -28.6 to -27.4‰ (av. -28.4) and of 1.8 to 5.2% (av. 3.6%), 9.7 to 28.4% (av. 16.5%), and 7.4 to 23.9% (av. 17.5%), respectively. Soil and coaly slates have similar characteristics, indicating that the soils are the weathered product of the coaly slate. The coaly slates were hydrothermally altered from hornfels and formed uranium-rich soils through weathering and secondary reconcentration processes.

Keyword

Uraniferous coaly slate, Weathering, Uranium enrichment, Ogcheon Metamorphic Belt

Mineralogy of residual and redeposited uranium in the boreholes of in-situ leaching uranium mining

Anna Vladimirovna SASHCHENKO[1]*, Russian Mineral Resource Institute – VIMS (sashchenko@vims-geo.ru)
Gennady Ivanovich Avdonin[2], Russian Mineral Resource Institute – VIMS
Galina Alexsandrovna Tarkhanova[3], Tarkhanova

Abstract

Comparison was made between the natural composition of ore-bearing rocks and waters, contained in the ores, before ISL (in-situ leaching mining) and altered composition after ISL. The deposit studied belongs to sandstone type and is localized in Middle-Upper Jurassic paleo-alluvial deposits at depths of 480-600 meters. The mineralization is of infiltration-epigenetic genesis and is controlled by a wedging out oxidation zone.

The ore-bearing rocks are represented by gray-colored arenitic-argillitic formations with a significant admixture of vegetable detritus and iron sulfides, causing the reduction properties of the deposits. The arenitic part is composed of quartz and feldspar, the cement is of argillite – kaolinite composition. Pyrite of various morphologies is widespread in the ores. Pyrite content reaches 10%. Uranium mineralization is mainly in oxide form and is often associated with pyrite.

The uranium content in the ore-bearing horizon after 30 years after extraction ranges from 0.002 to 1%. The intervals with the maximum uranium content shows values of radioactive equilibrium ratio (RER) less than 1, which is typical for the conditions of its technogenic redeposition. In the same intervals, the content of pyrite reaches 16%. Two types of uranium mineralization of similar composition is associated with large nodules of pyrite.

The first type of uranium mineralization is confined to the central part of the nodules. According to laboratory studies, such mineralization is not leachable and represents a residual form. The second type is represented by films of multicomponent uranium-containing gels developed in the form of a thin rim in the marginal part of the nodule. Uranium mineralization of the second type often occurs together with small columnar gypsum aggregates, which are absent in natural ores. The indicated uranium mineralization is present in the form of a thin film with well-diagnosed shrinkage cracks, which indicates their fast formation. Given the absence of gypsum in natural ores, the morphology of uranium minerals, and its prevalence in ranges with RER values less than 1, it can be concluded that the mineralization is the result of redeposition during uranium extraction by the ISL method.

After 30 years since the completion of mining, the composition of waters has practically restored, along with the increase in the pH. the concentration of sulfate ions, sodium ions, uranium, as well as total mineralization decreased. The restoration of the initial composition of reservoir waters is associated with the neutralization ability of ore-bearing rocks.

Conclusion. Residual and redeposited uranium concentrations have been identified.

Keyword

uranium, In situ leaching, redeposition, exploration

New frontiers of multi-scale uranium exploration in Brazil. Case studies: Rio Cristalino and Itataia regions.

Isabelle Cavalcanti Corrêa de Oliveira Serafim[1]*, Geological Survey of Brazil (isabelle.serafim@sgb.gov.br)
Iago Sousa Lima Costa[2], Geological Survey of Brazil
Hugo José de Oliveira Polo[3], Geological Survey of Brazil
Anderson Dourado da Silva Rodrigues[4], Geological Survey of Brazil
Felipe Mattos Tavares[5], Geological Survey of Brazil

Abstract

Brazil has the seventh-largest uranium resource in the world. However, the country appears to be outside the ranking of relevant producers of this commodity. The reason is the need for systematic mapping and the Brazilian laws related to uranium exploration in force until 2022. The changing of Brazilian Nuclear Policy aims to promote research, prospecting, and national production of uranium resources. Therefore, in line with its institutional mission to generate and disseminate geoscientific knowledge nationwide, the Geological Survey of Brazil (SGB) initiated a uranium potential assessment program in the national territory. Due to Brazil's vast dimensions, the resumption of systematic exploration poses a significant challenge. To address this challenge, technological advances in multi-scale uranium anomaly detection can significantly increase the number of discoveries and, consequently, the contribution of Brazil to the global nuclear sector. The uranium concentration in rocks varies due to primary and secondary factors. These primary variations are associated with pedogenesis, geomorphology, geochemistry, and lithological variations. In contrast, secondary variations may be related to processes responsible for forming ores, such as fluid migration or hydrothermal alteration. The most relevant uranium anomalies are related to the secondary variations; however, as primary variations are the most expressive, they must be suppressed before analyzing the effects caused by secondary processes. In this work, we use Artificial Intelligence (AI) to decompose the airborne radiometric data into a Uranium Expected map (Ui) and Uranium Deviation map (Ud). The first map corresponds to the contribution of primary variations and is predicted through other radiometric channels, such as eTh and the ratios eTh/K and eU/K. The Ud map is associated with secondary variations and is calculated by the deviation between the acquired airborne radiometric data and the Ui values The Ud interpretation of the Rio Cristalino and Itataia regions correlates the positive and negative values to uranium enrichment and depletion areas, respectively. The highest Ud values were well-correlated with the known uranium occurrences, with several other potential anomalies to follow up. However, we noted some positive anomalies without geological correspondence. These irrelevant positive anomalies were generated because the methodology calculates the relative uranium enrichment, and consequently, the interpretation of this map is not straightforward. For example, in regions where the background value of radioelements is meager, a slight change in content could generate a relative anomaly without relevance. To improve our interpretation, we also evaluated the map of uranium concentration before selecting areas to field

check. Finally, this work shows a possible workflow to interpret the Ud data for uranium assessment in brownfield and greenfield areas.

Keyword

Uranium, Brazil, Itataia mine, Artificial Intelligence, airborne geophysics

Research on the verification method of weak information of airborne gamma spectrometry for sandstone-type uranium exploration

LIANCHENG SHI[1]*, 1)China University of Geosciences (Beijing), Beijing 100083, China;2)Airborne Survey and Remote Sensing Center of Nuclear Industry,Shijiazhuang, Hebei,050002 (slchejy@163.com)
HUAIYUAN LI[2], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei,050002
WEICHONG NI[3], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei,050002
XIANG ZHANG[4], Hebei Key Laboratory of Airborne Survey and Remote Sensing Technology, Shijiazhuang, Hebei,050002
NANPING WANG[5], China University of Geosciences (Beijing), Beijing 100083, China
CONG YU[6], China University of Geosciences (Beijing), Beijing 100083, China
PENGHUI HAN[7], Hebei Key Laboratory of Airborne Survey and Remote Sensing Technology, Shijiazhuang, Hebei,050002
ZHENGXIN SHEN[8], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei,050002

Abstract

With the continuous improvement of uranium exploration, the opportunities to find new outcrops and shallow deposits are gradually decreasing. As the main type of concealed uranium deposits, sandstone-type uranium deposits are mostly developed with thicker cover layers, and the surface anomaly information is weak, so the direct ore-hunting marks are not obvious. In recent years, studies on the theory and application of radon migration, geogas migration, and deep penetration geochemistry have shown that deep uranium mineralization can have weak anomaly information on the surface. However, how to identify and extract the weak airborne gamma spectrometry information on the surface of sandstone-type uranium deposits, and clarify their distribution characteristics, causes, and relationships with deep uranium ore bodies have become one of the key issues restricting the improvement of sandstone-type uranium exploration effects based on airborne gamma ray radiation data.

This study carried out profile measurements of five methods including geological observation, ground gamma spectrometry, soil radon concentration, geoelectrochemical and metal mobile state on known sandstone-type uranium deposits, typical aerial gamma spectrometry anomalies, and weak information of aerial gamma spectrometry in Erlian Basin of northern China. The point distance was 40m-80m, and the line distance was 100m-200 m. Based on the comprehensive study of the plan and profile maps of field geological observation, measured data and laboratory chemical analysis data, it was believed that the soil radon concentration above the sandstone-type uranium ore body or mineralization is mainly low, and the edge of the ore body often shows zonal or peak anomalies. The geoelectrochemical plane characteristics were high U and low Mo, and the profile characteristics were sawtooth U peak anomalies. Vertically along the ore body trend, the ground gamma spectrometry U content showed the characteristics of high on both sides and low in

the middle. The U extracted by metal mobile state presented irregular surface high values or anomalies and peak profile anomalies above the uranium ore body.

Therefore, aiming at the verification of the weak information of airborne radiation survey for the exploration of sandstone-type uranium deposits in the covered area, two kinds of effective combined methods and interpretation models have been established, including ground gamma spectrometry, soil radon concentration measurement, geoelectrochemical measurement or metal activity measurement. They can identify the spatial relationships between airborne radiation anomalies or weak information and deep uranium-rich geological bodies. In addition, in the future verification of airborne radiation anomalies and weak information in the covered area, as well as the exploration of concealed sandstone-type uranium deposits, priority should be given to analyzing the weak increase areas of surface gamma spectroscopy U content and the low-value areas near soil radon concentration anomalies. Attention should still be paid to the abnormal areas of airborne or surface gamma spectroscopy U content.

This research was supported by the National Natural Science Foundation of China (U2067204).

Keyword

Airborne gamma spectrometry, weak information, Sandstone-type uranium deposit, verification method

A Study on the Uranium-Radium Equilibrium Coefficient of Barun Sandstone-Hosted Uranium Deposit, Inner Mongolia

Aimin PENG[1]*, China University of Geosciences, Beijing (pengaimin126@126.com)
Nanping WANG[2], China University of Geosciences, Beijing
Mengke HAN[3], China University of Geosciences, Beijing

Abstract

The uranium-radium equilibrium coefficient reflects the post-formation migration and enrichment status of uranium in deposits and is a critical corrective parameter for estimating uranium reserves. However, it is susceptible to numerous factors, including the content of sample uranium and radium, as well as lithology. To investigate the characteristics of the uranium-radium equilibrium coefficient in sandstone-hosted uranium deposits, this study analyzed and researched the core samples from a drill hole in the Barun sandstone-hosted uranium deposit. The samples were divided into ore layer samples and non-ore layer samples. Uranium and radium contents in the samples were measured using an HPGe gamma-ray spectrometer, and their uranium-radium equilibrium coefficients were calculated. After using robust statistics to exclude outlier data, the average uranium-radium equilibrium coefficient was found to be 0.996 with a standard deviation of 0.293, indicating near equilibrium between uranium and radium in the samples. Further analysis on the distribution pattern of the uranium-radium equilibrium coefficient, considering influencing factors such as sample uranium content and lithology, showed that the coefficient negatively correlates with uranium content when categorized by uranium content. Except for conglomerates and medium sandstones, uranium and radium are essentially in equilibrium in other rock types. This research was supported by the National Natural Science Foundation of China(U2067204)

Keyword

sandstone-hosted uranium deposit, uranium-radium equilibrium coefficient, distribution characteristics

Types and spatiotemporal distribution characteristics of uranium deposits in China

Yuqi CAI[1]*, Beijing Research Institute of Uranium Geology, CNNC (caiyq1883@126.com)

Abstract

The Chinese Mainland is formed by many geobodies of different scales, with complex metallogenic geological background and various types of uranium deposits. According to the genesis of the deposit and the host rock, it can be divided into 4 major categories, 9 categories, and 21 subclasses. More than 350 uranium deposits have been discovered in China, with sandstone, granite, volcanic, and carbonaceous-siliceous-pelitic being the main types.Sandstone type uranium deposits are mainly distributed in northern terrestrial basins, with 7 major basins including Ordos Basin, Ili Basin, Tuha Basin, Erlian Basin, Songliao Basin, and Badain Jilin Bayingobi Basin accounting for over 85% of the total resources of this type. Uranium deposits have the characteristics of multiple periods and stages of mineralization, with mineralization ages ranging from 156 Ma to 2 Ma. The main mineralization periods are 85 ± 6 Ma, 65 ± 7 Ma, 49 ± 4 Ma, 8 ± 4 Ma, 21 ± 2 Ma, and 10 ± 2 Ma.Granite type uranium deposits are mainly distributed in uranium metallogenic belt of Taoshan-Zhuguan, Mount Wuyi and Chenzhou-Qinzhou in the south east China uranium metallogenic province. This type uranium mineralization period spans greatly from 1900-10 Ma, with the main mineralization periods being 82 ± 5 Ma, 74 ± 4 Ma, 64 ± 5 Ma, and 50 ± 4 Ma.Volcanic type uranium deposits are mainly distributed in Ganhang, Mount Wuyi, the middle and lower reaches of the Yangtze River, Guyuan-Hongshanzi, Xingcheng-Qinglong and Xuemishan uranium metallogenic belts. The uranium mineralization mainly occurred at 164 ± 12 Ma, 133 ± 9 Ma, 114 ± 3 Ma, 101 ± 2 Ma, and 85 ± 6 Ma.Carbonaceous-siliceous-pelitic type uranium deposits are mainly distributed in uranium mineralization zones such as the South Qinling, Xiushui-Ningguo, Central Hunan-Northwest Guizhou, Daming Mountains, the southern edge of the North China Block, and the northern edge of the Tarim Basin. The uranium mineralization period was later than the main rock formation period, concentrated in the Yanshan Himalayan period, with the main periods being 68 ± 16Ma and 31 ± 3Ma.

Keyword

Uranium deposit types, Uranium mineralization period, Uranium deposit distribution, China

The complex origin of the Proterozoic Varena Iron Ore deposit in the SW East European Craton, southern Lithuania: implications from microstructures, mineral chemistry and isotope study

Grazina SKRIDLAITE[1]*, Nature Research Centre (grazina.skridlaite@gamtc.lt)
Laurynas Siliauskas[2], Nature Research Centre
Boguslaw Baginski[3], Faculty of Geology of the University of Warsaw
Olga Demina[4], Nature Research Centre

Abstract

The Precambrian Varena Iron Ore deposit (VIOD) is covered with 300-500 m thick sediments and is estimated to yield ca. 220 million tons of iron ore. The ores are assumed to be of metasomatic and hydrothermal origin, however, several other hypotheses of the VIOD origin, e.g. as a layered mafic, ultramafic or carbonatite intrusion have been suggested by different investigators.

The major iron ore bodies of the VIOD are hosted by former impure dolostones and are underlaid by ca. 1.90 Ga metamorphosed magmatic rocks of felsic and intermediate composition. In places, the ores are overlaid by mica schists and gneisses.

The SEM, EMPA, LA-ICP-MS as well as the phase diagram application allowed to distinguish high-grade skarns (forsterite, enstatite, spinel and diopside) produced during metamorphism of the dolostones and neighboring silicate rocks at 600-710o C. Only a small amount of magnetite has originated from metamorphic reactions at that stage. No reliable time constraints are available for the peak metamorphism so far. It was recently established that after the drop in pressure, an iron-rich, oxidised, Cl-bearing, water fluid influx has resulted in the formation of an abundant magnetite at T of 300-500o C together with intense secondary dolomitization, chloritization and serpentinization. Even though the part of iron might have been mobilised from the host rocks, some other sources, richer in iron, should be involved. It is likely that the neighbouring 1.79-1.76 Ga mafic magmatism was responsible for the metamorphism and Fe, Cl etc enrichment. Monazite, baddeleyite, and zircon have precipitated from the water-rich fluid together with the magnetite at an age of 1.71 Ga, which can be considered as the approximate age of major iron, phosphorus, and rare earth element mineralization.

Numerous veins cross-cutting the iron bodies were dated at ca. 1.50 Ga. A similar age of ca. 1.54 Ga was recorded by small homogeneous monazite grains in the studied calciphyre. coinciding with the emplacement of voluminous AMCG suites such as the Mazury complex and the Kabeliai intrusions further west and south. This second, younger magmatic and hydrothermal overprint has affected the VIOD rocks and remobilized Fe, P, RE elements.

Taking into account the temporary and spatial relationship between various mineralizations in the VIOD and the sulphide, iron oxide and REE enrichments in the neighbouring Mazury complex and Kabeliai granite intrusions, the potential of mineral resources in the region would increase considerably.

Keyword

Varena iron ore deposit, hydrothermal origin, geochronology, metamorphism, geochemistry

Mineralogy, mineral chemistry, and Fe-O isotope geochemistry of IOA-style mineralization and wall-rock alteration at the Yangyang deposit in the central-eastern Korean Peninsula

Heonkyung IM[1]*, Korea Institute of Geoscience and Mineral Resouces (imhk86@kigam.re.kr)
Eui-Jun Kim[2], Korea Institute of Geoscience and Mineral Resouces
Seok-Jun Yang[3], Korea Institute of Geoscience and Mineral Resouces
Sang-Joon Pak[4], Korea Institute of Geoscience and Mineral Resouces
Ji-Hyun Lee[5], Korea Institute of Geoscience and Mineral Resouces

Abstract

The Triassic IOA-style mineralization at Yangyang located in the central-eastern Korean Peninsula occurs in the NW-and NS-trending boundaries between the Precambrian gneissic rocks and the Cretaceous Yangyang syenite complex. The IOA-style orebody at Yangyang can be divided into three areas as follows: the Northern, Central, and Southern, and this study area is located in the Northern orebody. IOA-style orebody strikes N70°E and dips to approximately 85°SE, and cuts across both rocks. It occurs as a discrete lenticular body, which is totally controlled by vertical fractures and has a maximum of approximately 20 m wide, 100 m long, and 40 m thick. The orebody consists of a similar proportion of magnetite and phlogopite with a lesser amount of apatite. Low-grade ore in wall-rock alteration was mainly controlled by foliation. The wall-rock alteration is zoned relative to the orebody, with an innermost part composed of amphibole, magnetite, apatite, and phlogopite, and an outer rich in phlogopite, amphibole, feldspar, and titanite. Within this zone, magnetite tends to be decreased forward wall-rock. The wall-rock alteration occurs both as pervasive and fracture-fill veins, the latter cutting the former. Magnetite both from orebody and wall-rock alteration is homogenous without undissolved, exsolution of other minerals, and overgrowth zoning. The Ti and V values for magnetite from the orebody range from 186 to 749 ppm (avg. 539 ppm) and from 0 to 911 ppm (avg. 548 ppm), respectively, whereas the Ti and V values for magnetite from wall-rock alteration range from 0 to 1,109 ppm (avg. 296 ppm) and from 0 to 1,788 ppm (avg. 711 ppm) one another. These magnetite compositions are plotted into the compositional field of magnetite from the IOCG and Kiruna-type deposit and also into the compositionally overlapped field of igneous and hydrothermal magnetite. Apatite in the study area is euhedral or subhedral, and less than 0.5 mm in size. These apatites have a fluorine ranging from 3.4 to 5.6 wt. %, whereas the content of chlorine is less than 0.01 wt. %. This feature is equivalent to those crystallized directly from the magmatic melt. Phlogopite also occurs in the orebody and alteration and is fine-grained in ore but coarse-grain in wall-rock alteration. Mg# of phlogopite tends to reduce toward wall-rock. Amphibole, the principal alteration mineral proximal to the orebody, is generally coarse-grained, dark green, and euhedral and is plotted into the compositional field of tremolite, actinolite, edenite, and magnesiohornblende. Amphibole partially altered to phlogopite and was also cut by fine-grained titanite veinlets. The euhedral or subhedral titanite is only disseminated in the wall-rock alteration. The δ56Fe values for magnetite from the orebody and alteration range from 0.03 to 0.16 ‰ and

from 0.05 and 0.25 ‰, respectively. The δ18O values for magnetite from the orebody and wall-rock alteration vary ranging from -0.3 to 1.8 ‰ and from -0.4 to 2.6 ‰ respectively. The Fe-O data for magnetite from the Yangyang deposit are also plotted into the compositional field for ortho-magmatic and common igneous magnetite.

Keyword

Yangyang, IOA deposit, alteration, magnetite, Fe-O isotope

Timing of iron skarn mineralization by U-Pb dating of Ca-Fe garnets

Ekaterina Borisovna SALNIKOVA[1]*, Institute of Precambrian Geology and Geochronology RAS, St.Petersburg, Russian Federation (katesalnikova@yandex.ru)
Maria Vladimirovna Stifeeva[2], Institute of Precambrian Geology and Geochronology RAS, St.Petersburg
Alexander Borisovich Kotov[3], Institute of Precambrian Geology and Geochronology RAS, St.Petersburg
Yulia Dmitrievna Gritsenko[4], Fersman Mineralogical Museum, Russian Academy of Sciences, Moscow

Abstract

Timing of ore deposits is of critical importance for understanding the origin of mineralization and related geological processes. However accurate and precise dating of hydrothermal ore deposits could be a challenge due to the lack of suitable minerals directly related to ore formation. Ca-Fe garnets are the main minerals in large diversity of hydrothermal deposits where they growth coevally with ore minerals. Numerous recent studies have focused on the application of the U–Pb system of calcic garnets, where uranium is controlled by isomorphic incorporation, to accurately and precisely date alkaline and carbonatitic intrusive rocks and skarn deposits.

This study presents results of U-Pb ID TIMS dating of garnets from four iron skarn deposits of different age and location namely the Dashkesan (Lesser Caucasus), the Gavasay (western Tian Shan), the Shalym deposit (Gornaya Shoriya) and Leglier deposit group (Siberian craton). Relative timing of the magmatic–hydrothermal events at the Dashkesan mines was previously documented whereas no precise emplacement ages of ore-related intrusions available for the Shalym Gavasay and Leglier deposits.

Studied skarn garnets are characterised by andradite and grossular components predominately, high U concentrations (8-40 ppm), low common Pb and yield the concordant ages. The U–Pb age obtained for skarn garnet from iron deposit of the Dashkesan is at 147 ± 2 Ma, the Gavasay 306±3 Ma, the Shalym is at 499 ± 1 Ma and the Leglier deposit is 1901±5 Ma allows to constrain the absolute timing of ore formation. The geochronological data reported for the Leglier deposit are the first “direct” age of the ore-bearing iron–magnesian metasomatic rocks of the Aldan Shield. These data demonstrate that U-Pb isotopes of Ca-Fe garnet from iron deposits is extremely resistant relatively to later superimposed processes.

The study was supported by grant No. 22-17-00211 from the Russian Science Foundation and FMUW-2022-0003.

Keyword

garnet, U-Pb ID TIMS, iron scarn, geochronology

BIF-hosted iron ore: A mineral system review

Steffen Gerd HAGEMANN[1]*, Centre for Exploration Targeting, UWA
(steffen.hagemann@uwa.edu.au)

Abstract

The BIF-hosted iron ore system represents the world's largest and highest grade iron ore resource. BIF, the precursor to low- and high-grade BIF hosted iron ore, consists of Archean and Paleoproterozoic Algoma-type BIF (e.g., Serra Norte iron ore district in the Carajás Mineral Province), Proterozoic Lake Superior type BIF (e.g., deposits in the Hamersley Province and craton), and Neoproterozoic Rapitan-type BIF (e.g., the Urucum iron ore district).

The BIF-hosted iron ore system is structurally controlled, mostly via km-scale normal and strike-slips fault systems, which allow large volumes of ascending and descending hydrothermal fluids to circulate during Archean or Proterozoic deformation zones including early extensional fault zones. Structures are also (passively) accessed via downward flowing supergene fluids during Cenozoic times.

Hypogene alteration of BIF and surrounding country rocks is characterised by: (1) changes in the oxide mineralogy and textures, (2) development of distinct but variable distal, intermediate and proximal alteration zones defined by distinct oxide–silicate–carbonate assemblages, and (3) mass negative reactions such as desilicification and de-carbonatisation, which significantly increase the porosity of high-grade iron ore, or lead to volume reduction by textural collapse or layer-compaction. Supergene alteration, up to depths of 200 m, is characterised by leaching of hypogene silica and carbonates, and dissolution precipitation of the iron oxyhydroxides.

Four discrete end-member models for Archean and Proterozoic hypogene and supergene-only BIF hosted iron ore are proposed: (1) granite–greenstone belt hosted, strike-slip fault zone controlled Carajás-type model, sourced by early magmatic (±metamorphic) fluids and ancient “warm” meteoric water; (2) sedimentary basin, normal fault zone-controlled Hamersley-type model, sourced by early basinal (±evaporitic) brines and ancient “warm” meteoric water. A variation of the latter is the metamorphosed basin model, where BIF (ore) is significantly metamorphosed and deformed during distinct orogenic events (e.g., deposits in the Quadrilátero Ferrífero and Simandou Range). It is during the orogenic event that the upgrade of BIF to medium- and high-grade hypogene iron took place; (3) sedimentary basin hosted, early graben structure controlled Urucum-type model, where glaciomarine BIF and subsequent diagenesis to very low-grade metamorphism is responsible for variable gangue leaching and hematite mineralisation. All of these hypogene iron ore models do not preclude a stage of supergene modification, including iron hydroxide mineralisation, phosphorous, and additional gangue leaching during substantial weathering in ancient or Recent times; and (4) supergene enriched BIF Capanema type model, which comprises goethitic iron ore deposits with no evidence for deep hypogene roots. A variation of this model is ancient supergene iron ores of the Sishen-type, where blocks of BIF slumped into underlying karstic carbonate units and subsequently experienced Fe upgrade during deep lateritic

weathering.

Keyword

BIF, iorn ore, alteration, fluids, hypogene

High-tech metals are key elements for future technologies – What are the challenges and how are their global market situations ?

Volker STEINBACH[1]*, Federal Institute for Geosciences and Natural Resources
(volker.steinbach@bgr.de)

Abstract

Low-carbon technologies such as wind energy, photovoltaics and energy storage batteries for e-mobility are key for a shift to a low-carbon future. The expected dynamic change towards renewable energy systems will have a major impact on the mineral raw material markets in the next decades. The demand for base and minor metals for clean energy technologies is expected to rise substantially – e.g. lithium, cobalt, germanium, gallium, tantalum, graphite, rare earth, osmium, iridium and indium.

Primary raw material production needs to provide most of the metals for low-carbon technologies, at least for the upcoming decade, because secondary raw material supply alone cannot accommodate the future demand. Therefore, upstream and end-of-life activities of low-carbon technologies must be taken into account to ensure firstly that the mining industry can meet the increasing demand using sustainable and responsible practices and secondly that the products can be recycled in the best possible way.

Hence, reliable estimates of potential future raw materials for emerging technologies are imperative to avoid negative economic impacts and supply shortages. Therefore it is a) necessary to analyze the recent situations and trends in their global markets, b) to carry out research on primary mineral deposits and secondary deposits (recycling) containing these high-tech metals and c) to develop concepts for due diligence in their supply chains.

Keyword

high-tech metals, low-carbon technologies, raw material markets

[Keynote] Envisioning 2050: Strategic Scenarios for the Global Raw Materials Landscape

Christopher KEANE[1]*, American Geosciences Institute (keane@americangeosciences.org)

Abstract

To forge a pathway toward a sustainable mineral resource framework for the future, a comprehensive understanding of potential external factors—those that may expedite or impede the advancement of society's raw material utilization—is crucial. In this context, INTRAW, SAFE, and Fraunhofer have engaged in a collaborative effort to redefine raw material scenarios for 2050, employing a Delphi-method-inspired analysis. This methodical approach yielded four distinct scenarios that delineate the extremities of potential outcomes and the most plausible trajectory given the contemporary socio-political milieu as of 2023. Central to this endeavor was the creation of a detailed fact book. This compendium explicates the rationale behind each scenario, drawing upon insights from a global spectrum of experts spanning government, industry, and academia within the raw materials sector.

This discussion will encompass these four scenarios: an optimistic, idealistic projection; a markedly pessimistic outlook; and two intermediary scenarios that organically evolve from the nascent political, social, and economic currents, particularly the rise of trade blocs and the ambiguous commitment to sustainability investments. These carefully crafted scenarios, along with the accompanying fact book, serve as strategic instruments for policymakers, investors, and corporate leaders. They provide a foundational framework for future strategic planning and offer a versatile toolkit to navigate and respond to the evolving global landscape marked by technological breakthroughs, social and economic upheavals, and shifts in both domestic and international political arenas. These tools are designed not only for foresight but also for readiness, equipping stakeholders to adeptly manage the dynamic interplay of forces shaping the future of raw materials.

Keyword

minerals, resources, economics, policy, sustainability

Mining to meet the challenge of Net Zero

David MANNING[1]*, Newcastle University (david.manning@ncl.ac.uk)

Abstract

The production of minerals as raw materials to meet the needs of the Green Transition has tended to focus on the metals and non-metals that are required for energy, catalysts, and novel products (especially IT and transport). In addition, there is a huge increase in growth projected for mining the minerals used to remove CO2 from the atmosphere through the process of Enhanced Rock Weathering (ERW). This rapidly-growing business sector poses specific challenges in the context of this session.

ERW is a nature-based solution that involves the spreading to land of crushed silicate rocks, especially basaltic rocks. Within the soil these weather, releasing cations which are counterbalanced by bicarbonate ultimately derived from photosynthesis. The biogeochemistry of the process is well understood. A critical aspect that remains to be explored is the implications for the minerals industry of the supply chain that underpins the process at scale.

Based on its chemical analysis, a typical basalt is able to remove approximately 230 kg CO2 per tonne of rock through ERW. This capacity is exploited by companies that are rapidly increasing in both size and number especially since COP26 (Glasgow, 2021). It is not uncommon for publicly-stated targets or aspirations for CO2 removal to be given as ‘1 billion tonnes by 2030’. The corresponding target for the amount of basaltic rock mined is around 5 billion tonnes.

Mining such a large volume of rock challenges society and environmental stewardship. However, the ERW industry is able to take advantage of existing strategic management of minerals mined for construction, for example as established in Europe since the end of World War II for urgent reconstruction. The construction industry globally requires of the order of 22-36 billion tonnes of crushed rock, perhaps 20% of this being basaltic. It is reasonable to assume that this industry operates at a capacity appropriate for the needs of ERW, although it may need to double in size. What is critical, however, is that the extraction of crushed rock for construction is a highly regulated activity, especially as mining takes place close to where materials are needed for construction, so close to population centres.

For the extraction of crushed rock by quarrying, existing regulation and processes for gaining societal consent, through partnership, are established, although there remain challenges and room for improvement. Ideally, extraction is regulated and permitted through well established processes that provide (often local) government with the assurance that sufficient permitted reserves exist to meet the needs of planned construction, with a 10-20 year horizon. In partnership, the extractive industries ideally work closely with local communities and Non-Governmental Organisations to

improve biodiversity and to create infrastructure that improves quality of life for those who live close to a mine. There are many examples of good practice internationally, which suggest that the challenges of meeting the needs of ERW can be met at scale, to help this new industry mitigate the effects of climate change. However, these examples need to be widely disseminated, with global adoption of good practice.

Keyword

Mining, CO2 removal, Enhanced Rock Weathering

Critical raw materials extraction in environmentally protected areas

Vitor Correia[1]*, INTRAW (vcorreia@intraw.eu)
Eberhard Falck[2], INTRAW
Marko Komac[3], INTRAW

Abstract

The European Commission identified in its Action Plan on Critical Raw Materials (CRM) and the 2020 CRMs list those materials that are particularly exposed to supply shortages and disruptions due to their sourcing or processing outside the EU. Without metals such as Li, Co, and Cu, the move away from the use of fossil fuels to renewable source of energy and a large-scale electrification to reduce direct carbon emission currently would not be conceivable. Before this background, the EU-funded project CIRAN (https://ciranproject.eu/) is developing strategies to reconcile society's desire to protect environmentally sensitive areas with society's growing need for such CRMs, while ensuring the resilience of supply through EU domestic sourcing. The project explores ideas for improved permitting procedures based on systemic approaches to policy-making that balance interests and novel social contract frameworks. CIRAN brings together external expert and public stakeholders and aims to advance the development of an inclusive community of practice (CoP) on permitting that is designed to remain active after the funding of the project ends in 2025. The invited stakeholders assist in analysing policies, economic drivers, technology options, mining technology, local governance, social capital, as well as nature conservation and biodiversity protection needs.

The project employs a ‘logical framework’ approach to arrive at a well-founded justification for extraction, based on a system-oriented assessment of all relevant dimensions, including projected raw materials needs, environmental and societal impacts, spatial planning, technological options, and national/international regulatory frameworks. A strong co-creation of knowledge component ensures that the proposed strategies are tested and validated in communities located in or nearby environmentally protected areas. This will stimulate the development of novel social contract models based on identified rights, obligations, and responsibilities of governments (national/regional), communities, and mine operators, capable of dealing with socio-economic transformations and challenges due to climate change. For this purpose, a team of 25 external stakeholder representatives on the environmental, political, societal, economic, and technological dimensions that shape the responses to energy transition needs and the demand for CRMs is brought together. These stakeholders, organised in four Expert Groups (EGs), work with project partners, conveying insights on policy-making and -implementation, economic drivers, technologies, mining, local governance, social capital, nature conservation and biodiversity. The EGs actively engage in CIRAN through synergetic processes combining analysis and deliberation, and participation in project workshops and structured consultations, such as focus groups and foresight analysis.

The CIRAN Consortium is geared to develop proposals for inclusive policy-making instruments that support the EU Green Deal and UN-led reforms to reach the climate commitments and sustainable development goals.

Keyword

Supply of CRMs, Protection of ecosystems and biodiversity, Governance, Empowered citizens, Resilient societies

Ukrainian Salt Sector: Strategy for Post-War Recovery, Sustainable Development, and Advancement of Salt Resources as Input in Green Transition Technologies

Larysa BOSEVSKA[1]*, Ukrainian Salt Research Institute (lara.bosevskaya@gmail.com)
Yuliia DUDCHENKO[2], Institute of Geological Sciences of National Academy of Sciences of Ukraine

Abstract

Ukraine is very rich in fossil salt resources, represented by five salt-bearing formations in the eastern and western parts of the country, corresponding to five geological regions, namely, the Dnieper-Donetsk depression, North-Western Donbass, Carpathian Foredeep, Transcarpathian depression, and Dobruja Foredeep (Khrushchev D., Bosevska L., Environmental problems of salt mining in Ukraine, 2014).

Before the war, salt resources (rock salt deposits and natural brines) were primarily used as the raw material base for chloride-sodium raw materials to produce a variety of salt, including food salt and road salt as the primary de-icing material, as well as salt for chemical production.

For many years, the giant of Ukraine's salt industry has been the state mining enterprise "ARTYOMSOL", which operated based on the reserves of the Artemivsk rock salt deposit located in the eastern part of Ukraine within the North-Western Donbass. This deposit is one of the largest in the world, with estimated reserves reaching 15 billion tons of high-quality salt. Currently, the enterprise is in a combat zone and requires restoration because its surface complex has been significantly destroyed due to military aggression.

The Carpathian region of Ukraine, besides the well-known unique deposits of potassium-magnesium salts (Stebnyk and Kalush-Golyn), is characterized by numerous scattered deposits of rock salt of smaller size and natural saturated chloride-sodium brines. The latter have been extracted in small quantities by the Drohobych salt mining plant for a few centuries. Transcarpathian internal depression is also extremely rich in rock salt resources, where the powerful Baden salt-bearing formation is developed. Under the conditions of applying the geotechnological method of extraction, the resources of rock salt of the Ukrainian Carpathians can become a significant source of table salt and salt for industrial processing.

However, in light of Ukraine's chosen European path, global trends in green transformation, and green energy transition, the further use of Ukraine's salt resources should be considered not only in terms of obtaining salt raw materials but also as an opportunity for addressing green transformation issues. It has already been proven that salt is an excellent geological barrier for creating underground gas storage facilities (e.g., hydrocarbons, hydrogen, and other volatile gases), and large salt arrays will certainly be a key component of the green energy transition.

In the aspect mentioned above, a general strategy for using Ukraine's salt resources is proposed to make a significant contribution to global trends in sustainable development and green energy transition.

Keyword

unique salt-bearing formations, salt green technologies, post-war recovery, sustainable supply chains, salt therapy

Mechanochemical processing of silicate rocks to trap CO2

Mark Stillings[1], University of Strathclyde
Zoe SHIPTON[2]*, University of Strathclyde (zoe.shipton@strath.ac.uk)
Rebecca Lunn[3], University of Strathclyde

Abstract

Milling minerals rich in magnesium and iron within CO2 gas has been proposed to capture carbon as metal-carbonates, for instance through injection of CO2 into basalt. We conduct milling experiments in CO2 and show that polymineralic rocks such as granite and basalt, whether high or low in carbonate-forming metals, are more efficient at trapping CO2 than individual minerals. This is because the trapping process is not, as previously thought, based on the carbonation of carbonate-forming metals. Instead, CO2 is chemically adsorbed into the crystal structure. Additionally, this occurs predominantly at the boundaries between different minerals, which explains why trapping on rock is more effective that trapping within single crustal experiments.

Leaching experiments on the milled mineral/rock powders show that CO2 trapped in single minerals is mainly soluble, whereas CO2 trapped in polymineralic rocks is not. Indeed, under ambient temperature conditions, polymineralic rocks can capture >13.4 mgCO2 g−1 as thermally stable, insoluble CO2.

Polymineralic rocks are crushed worldwide to produce construction aggregate. More than 50 billion tonnes of rock is crushed worldwide every year and the materials and construction industry accounts for 11% of global carbon emissions. If crushing processes could be conducted within a stream of effluent CO2 gas (for instance waste gases produced from cement manufacture), our findings suggest that for every 100 Mt of hard rock aggregate sold, 0.4–0.5 MtCO2 could be captured as a by-product. We estimate that if the technology was adopted worldwide in aggregate production, it could potentially capture 0.5% of global CO2 emissions - 175 million tonnes of carbon dioxide annually.

Keyword

mechanochemistry, carbon capture, mine waste, rock crushing

Mineral resource abundance index: Towards responsible cosmetic ingredients and use of minerals in downstream industries

Nicolas CHARLES[1]*, French Geological Survey - BRGM (n.charles@brgm.fr)
Gaétan LEFEBVRE[2], French Geological Survey - BRGM
Rémy TULOUP[3], L'OREAL Research & Innovation
Audrey CARREAUD[4], L'OREAL Research & Innovation
Antoine BOUBAULT[5], French Geological Survey - BRGM
Anne-Sophie SERRAND[6], French Geological Survey - BRGM
Maxime PICAULT[7], French Geological Survey - BRGM
Virginie PIGUET[8], L'OREAL Research & Innovation
Valeria MANZIN[9], L'OREAL Research & Innovation
Fabien DESWARTE[10], L'OREAL Research & Innovation
Julien AUPOIL[11], L'OREAL Research & Innovation

Abstract

The industrial and technological revolutions over the last few centuries have been accompanied by a substantial improvement of the living environment, while at the same time the consumption and therefore the exploitation of mineral resources, which are globally non-renewable on a human-scale. This ever-increasing use of mineral resources in many industrial sectors has over the past 30 years contributed to the definition of the concept of sustainable development. Many industries aim to achieve a "sustainable" economic growth that is respectful of the environment and human beings. Supporting a rational use of mineral resources while developing economic activity with respect to the environment and social well-being are contributing to sustainable development. Industry has to limit the impacts of all its activities on climate, water, biodiversity and natural resources. These impacts can be also considered in terms of the planetary boundaries. Consequently, sustainability of mineral resources and, in particular their abundance, is a topic of growing interest. Nevertheless, mineral abundance is an extremely complex notion as it not only encompasses geological considerations but also environmental, technical, economic, and social constraints. In addition, to the best of our knowledge, no tools are currently available to allow a comprehensive evaluation of mineral abundance for downstream industries.

This study therefore aims to present an innovative and unique methodology to evaluate the abundance of non-energy mineral resources, and determine a, so-called, Mineral Abundance Index (MAI). Based on a multi-criteria analysis, MAI considers natural abundance of a mineral in the Earth crust (geosphere), its availability on the market (technical-economic sphere) and integrate the influence of factors that could constraint or promote future market changes (socio-epistemic sphere). In that way, the MAI aims to integrate the notions of intrinsic natural abundance and economic abundance, and through innovation, to reconcile the fixed-stock and opportunity-cost paradigms. This index can cover all non-energy mineral resources (metals, industrial minerals and rocks). The MAI, ranging from 0 (very scarce) to 100 (very abundant), aims to qualify the abundance of minerals in a simple and rapid manner, based on published and reliable data. This new methodology could be a powerful decision-making support tool for any downstream

industrials and end-users making use of mineral resources. MAI could be used as one of the criteria to consider in Life Cycle Assessment (LCA) and initiatives by end-users aiming at ensuring that the minerals used in the production of their goods are genuinely abundant.

Keyword

mineral abundance, sustainable development, downstream industry, depletion, green transition

Origin of carbonate cements and their control on sandstone reservoir quality in the First Member of the Eocene Shahejie Formation, Bohai Sea, East China

Xiaojun PANG[1]*, School of Geosciences, China University of Petroleum (East China) (pangxiaojunupc@163.com)
Guanmin WANG[2], School of Geosciences, China University of Petroleum (East China)
Xiaobo HUANG[3], CNOOC China Limited, Tianjin Branch, Tianjin
Xuefang ZHANG[4], CNOOC China Limited, Tianjin Branch, Tianjin
Li ZHANG[5], CNOOC China Limited, Tianjin Branch, Tianjin

Abstract

The widespread presence of carbonate cements in the sandstones of the First Member of the Eocene Shahejie Formation has been regarded as a major diagenetic process leading to strong heterogeneities in reservoir quality. Therefore, understanding the origin of carbonate cements is critical for the prediction of high-quality reservoirs.

Petrographic and geochemical analyses, including helium porosity and permeability, thin sections, cathodoluminescence, scanning electron microscopy, carbon and oxygen stable isotopes, as well as fluid inclusion microthermometry, were conducted to decipher the origin of carbonate cements and understand their influences on reservoir quality.

Physical properties show that the sandstone porosity is typically smaller than 15%, and the permeability is typically smaller than 10 mD. However, some samples have porosity greater than 15% and permeability greater than 50 mD.

The petrography indicates that the samples with high porosity and permeability develops pore types such as biocoelom pore and intergranular dissolution pore. A large number of bioclastic particles, as well as cements such as micrite dolomite coats, pore-filling dolomite and calcite, were developed in the reservoir.

The carbonate cements can be divided into four stages based on the precipitation temperature. Stage 1 consists of bioclastic and micrite dolomite. Micrite dolomite exhibits as grain coats on the particle surface and is in dark red under cathodoluminescence. Stage 2 consists of powdery dolomite, exhibiting as grain coats on the surface of micrite dolomites. They showed the orange under cathodoluminescence. Stage 3 consists of pore-filling powdery dolomite, showing orange under cathodoluminescence. Stage 4 consists of pore-filling sparry dolomites, showing orange under cathodoluminescence.

The carbon isotope range from -4.1‰ to 1.6‰ and the oxygen isotope ranges from -18.2 ‰ to -0.5 ‰. The calculated precipitation temperature ranges from 36.3 ℃ to 109.4 ℃.

The results indicate that the carbonate cements are derived from multi-stage fluids, including saline lake water, saline water at early diagenetic stage, meteoric water and decarboxylation of organic acids. Among them, the intact spiral shells and micrite dolomite coats resisted mechanical compaction during burial process. Early dolomitization preserved primary pore spaces. A large number of secondary pores were generated through the dissolution of dolomite by acidic fluids. Bioclasts preserved a large number of biocoelom pores, which increased the primary porosity. The

early carbonate cements resisted mechanical compaction, preserved primary porosity and therefore protected the reservoir quality. In conclusion, bioclastic and early carbonate cements have positive effects on the reservoir quality.
A number of sandstone reservoirs characterized by bioclastic and early carbonate cements have been found in the First Member of Eocene Shahejie Formation. The daily oil and gas production of wells in these reservoirs exceed 1000 tons, demonstrating an excellent exploration prospect of these reservoirs. The results of this study can provide theoretical supports for the exploration and evaluation of oil and gas resources in Bohai Sea.

Keyword

C–O isotope, reservoir quality, carbonate cement, First Member of Eocene Shahejie Formation, Bohai Sea

Influence of diagenetic fluid on glutenite reservoirs: a case study of the Junggar Basin, China

Zhiguo MAO[1]*, Petrochina (owenmao@126.com)
Zhanguo LIU[2], PetroChina Hangzhou Research Institute of Geology, Hangzhou, Zhejiang 310063, China
Xiangchao MENG[3], PetroChina Hangzhou Research Institute of Geology, Hangzhou, Zhejiang 310063, China
Jian ZHU[4], PetroChina Xinjiang Oilfield Company, karamay, Xinjiang 834000, China

Abstract

In the formation process of oil and gas reservoirs, the properties of the formation fluids and the diagenetic environment have a significant impact on the quality of the reservoir. Junggar Basin is an important oil and gas bearing basin in northwest China. Multiple strata have developed glutenite reservoirs from Permian to Paleogene in Junggar Basin. In this study, the Upper Wuer Formation (P3w) of the Permian in the western depression and Badaowan Formation (J1b) of the Jurassic in the eastern depression of the the Junggar Basin are selected for comparative analysis of the impact of diagenetic fluids on glutenite reservoirs.

The facies of the P3w is fan delta front subfacies, characterized by mixed sand and gravel, large lateral thickness variation and low maturity. The reservoir has poor physical properties, complex pore structures and medium-alkaline formation fluid environment. The P3w belongs to an ultra-low porosity ultra-low permeability reservoir. Its porosity ranges from 0.81% to 15.5%, with an average of 7.31% and a permeability of 0.02%×10-3-3.15×10-3μm2, average 0.06×10-3μm2. However, the facies of the J1b is braided-river delta, characterized by the development of coal seams. The reservoir belongs to low porosity and ultra-low permeability reservoirs, with medium-acidic formation fluid environment. Its porosity ranges from 3.80% to 16.30%, with an average of 9.68% and a permeability of 0.014%×10-3-33.80×10-3μm2, average 1.26×10-3μm2.

Through microscopic observation, electron probe energy spectrum and elemental analysis, it has been found that the fluid environment of the formation determines the quality and intensity of reservoir transformation in the later stage. The medium-alkaline formation fluid mainly dissolves the volcanic ash among sand and gravel particles in the P3w, On the contrary, the medium-acidic formation fluid mainly dissolves calcium interstitial materials in the J1b. Due to the differences in the stages of action, there are also differences in the formation of reservoirs between the two types of dissolution mentioned above. The P3w dissolution mainly occurs in the intermediate diagenetic stage, which helps to develop reservoir pores. However, the J1b dissolution mainly occurs in the early diagenetic stage, making the reservoir easier to compact and not conducive to reservoir development.

Keyword

Glutenite reservoirs, Formation fluid, Interstitial material, Junggar Basin

Lamina-scale diagenetic mass transfer in lacustrine organic-rich shales and the impacts on shale oil reservoir formation

Kelai Xi[1]*, China University of Petroleum (East China) (xikelai@upc.edu.cn)
Miruo LIN[2], China University of Petroleum (East China)
Yingchang Cao[3], China University of Petroleum (East China)
Xiaobing Niu[4], China University of Petroleum (East China)

Abstract

Lacustrine organic-rich shale has become the important petroleum exploration target in recent years. Reservoir is the crucial factor to determine the potential of shale oil exploration and development. In order to fully understand the shale oil reservoir formation processes, it is essential to be engaged in fluid-rock interaction and diagenetic mass transfer in organic-rich shales. Based on the detailed petrographic investigation, in-situ element and isotope testing as well as organic geochemistry analysis, diagenetic mass transfers and the related organic-inorganic interactions were performed on a suite of organic-rich shales from the Triassic Yanchang Formation of the Ordos Basin. The organic-rich shales consist of silt-grained felsic lamina (SFL) and organic-rich lamina (ORL). The SFL is mainly dominated by K-feldspar, while illite is the most abundant mineral in the ORL. Authigenic quartz and euhedral pyrite are the major diagenetic minerals in the ORL, and K-feldspar dissolution extensively occurred in the SFL. It is the first time to find that siliceous resting cyst of algae can play significant roles on silica nucleation, which determines the occurrence and distribution of authigenic quartz. The smectite to illite reaction plays significant role on diagenetic alterations in the organic-rich shales. This reaction not only induced overpressure to generate micro-fracture for authigenic quartz growth, but also provided the major silica source for authigenic quartz precipitation. Petrographic and geochemistry evidence have surely confirmed that organic acids migrated from ORL to SFL, while K+ and aqueous SiO2 from K-feldspar dissolution transported from SFL to ORL. According to organic-inorganic interactions related to authigenic quartz formation, we further conclude that lamina-scale open diagenetic system allows mass transfer occurring at micro-scale inside shales, nevertheless, the buried shale perform as a closed diagenetic system respect to surrounding formations. The lamina-scale diagenetic mass transfer and by-products redistribution significantly contributed to the effective pores formation in shales. This study helps us to better understand the fluid flow and mass transfer process in a mass balance diagenetic system of organic-rich shale formation.

Keyword

Lacustrine organic-rich shale, Organic-inorganic interaction, Diagenetic mass transfer, Authigenic quartz, Shale oil reservoir

[Keynote] Mixing processes and patterns of fluids in alkane-CO2-water systems under high temperature and high pressure—Microscopic visual physical thermal simulations and molecular dynamics simulations

Guanghui YUAN[1]*, China University of Petroleum (East China) (yuan.guanghui@upc.edu.cn)

Abstract

Various types of geofluids exist in deep and ultra-deep layers in petroliferous basins. The geofluids are much more active under high-temperature and high-pressure (HTHP) conditions, but their properties are unclear. We simulated the mixing of different fluids in CH4/C3H8/C6H14/C8H18-water systems and C6H14/C8H18-CO2-H2O systems at temperatures of 25°C to 425°C and pressures of 5 MPa to 105 MPa, using an in-situ micron quartz capillary tube thermal simulation system and molecular dynamics numerical simulation software. The mixing processes, patterns, and mechanisms of various fluids were analyzed at
microscale under increasing temperature and pressure conditions. The results show that the miscibility of fluids in the different alkane-H2O and alkane-CO2-H2O systems is not instantaneous, but the miscibility degree between different fluid phases increases as the temperature and pressure rise during the experiments. The physical thermal experiments (PTEs) show that the mixing process can be divided into three stages: initial miscibility, segmented dynamic miscibility, and complete miscibility. The molecular dynamics numerical simulations (MDNSs) indicate that the mixing process of fluids in the alkane-H2O and alkane-CO2-H2O systems can be divided into seven and eight stages, respectively. The carbon number affects the miscibility of alkanes and water, and the temperature and pressure required to reach the same miscibility stage with water increase with the carbon number (C3H8, C6H14, CH4, C8H18). CO2 has a critical bridge role in the miscibility of alkanes and water, and its presence significantly reduces the temperatures required to reach the initial, dynamic, and complete miscibility of alkanes and water. The
results are of great significance for analyzing and understanding the miscibility of geofluids in deep and ultra-deep HTHP systems.

Keyword

High temperature high pressure, Alkane-H2O-CO2 system, Mixing of geofluids, In-situ visualization thermal experiments, Molecular dynamics numerical simulation

Diagenetic Processes and Low-Permeability Tightening Mechanisms of Reservoirs in the Paleogene Deep Layers under High-Temperature and High-Variability Conditions in the Baiyun Sag, Pearl River Mouth Basin

Xiaoyang Zhao[1]*, China University of Petroleum (East China) (B22010052@s.upc.edu.cn)
Guanghui Yuan[2], China University of Petroleum (East China)
Hui Sun[3], Shenzhen Branch of CNOOC Ltd.
Guangrong Peng[4], Shenzhen Branch of CNOOC Ltd.

Abstract

The oil and gas exploration in the Baiyun Sag of the Pearl River Mouth Basin is gradually shifting from conventional reservoirs in the shallow Hanjiang-Zhujiang Formation to low-permeability to tight reservoirs in the deep-ultra-deep Zhuhai-Enping Formation. The distinctive high-variable geothermal background results in significant differences in the diagenetic stages and compactification mechanisms between these reservoirs and conventional ones..

This paper comprehensively utilizes techniques such as cast body thin section identification, scanning electron microscopy observation, physical property testing, diagenetic process reconstruction, and physical property restoration. It systematically analyzes the differential diagenetic processes of sandstone reservoirs in the lower section of the Paleogene Zhuhai Formation to the Enping Formation in the northwest low uplift to the central depression belt of the Baiyun Sag, under the high-variable geothermal background. By integrating the tectonic evolution background, stratigraphic burial history, and current physical property data, the study explores the main factors influencing the relationship between reservoir properties and elucidates the densification process and mechanism.The results indicate that the reservoirs in the lower section of the Zhuhai Formation to the Enping Formation underwent significant compaction, two stages of carbonate cementation, three stages of siliceous cementation, and three stages of feldspar dissolution to create pores. The variation in geothermal gradients during the reservoir formation process led to different compaction rates, and the water-rock interaction processes in open-closed systems played a crucial role in the differences in physical property relationships in different zones.. Compaction is the main factor to the formation of tight reservoirs, while cementation further strengthens the densification process, and dissolution improved reservoir properties to a certain extent. Additionally, during the reservoir formation process, the transition between open and closed systems and an increase in geothermal gradient leading to an accelerated compaction rate are the primary reasons for variations in physical properties among different structural units in the reservoir .With increase of geothermal gradient and burial depth, diagenetic stages gradually increase from the middle diagenetic stage A2 in the low uplift zone to the middle diagenetic stage B in the slope zone and the late diagenetic stage in the depression zone. The different diagenesis processes lead to significant differences in the evolution of reservoir properties. The reservoirs in the depression zone have already undergone densification before late-stage hydrocarbon charging, the reservoirs in the slope zone gradually densify during the late-stage hydrocarbon charging

stage, while the reservoirs in the low uplift area still exhibit low-permeability characteristics. Matching favorable cap layers, the slope zone with burial depths shallower than 5 km is the key area for exploration in the lower section.

Keyword

Tight, different diagenesis, deeply buried reservoirs, Paleogene, Baiyun Sag

Oxidation of hydrocarbons in deep strata of continental sedimentary basins: Evidences, mechanism, and geological implications

Xun KANG[1]*, Central South University (xunkang@csu.edu.cn)

Abstract

Oxidation of hydrocarbons including methane is part of interrelated hydrogeochemical reactions, and affects the carbon budget in the Earth's crust. To unravel such processes in deep siliciclastic strata, we analyzed core samples from Lower Triassic red beds in the Mahu Sag (Junggar Basin, NW China) by coupling petrological observations with high resolution in situ SIMS stable carbon and oxygen isotopes, and clumped isotopes (Δ47) of authigenic calcite. The strata contain a variable oil and gas content as well as abundant high-valence Fe/Mn oxide. Three generations of cement occur which are characterized as: (i) non-luminescent, early diagenetic calcite (MnO < 0.3%, δ13CVPDB of –5.6 to –4.1‰); (ii) bright-orange luminescent late-stage I calcite (0.75–5.23% MnO, δ13C: –51.4 to –25.8‰), and (iii) dull-orange late-stage II calcite (4.10–12.93% MnO, δ13C: –91.4 to –30.9‰). Clumped isotopic thermometry reveals that their precipitation temperature increases successively from <40 °C, 81–107 °C to finally 107–132 °C, corresponding to three precipitation time slices: (i) before the Late Triassic, (ii) from the Early Jurassic to the Early Cretaceous, and (iii) from the Early Cretaceous to the present, respectively. The δ13C values as low as –91‰ indicate that late-stage II calcite is mainly derived from the thermochemical oxidation of methane (δ13C: –46.8 to –39.3‰) induced by high-valence Mn/Fe oxide, whereas late-stage I calcite is the final product of both oxidation of methane and C2+ hydrocarbon. For late-stage I calcite, hydrocarbon oxidation was most likely promoted by high temperature, though microbial oxidation can’t be totally ruled out. The higher precipitation temperature of late-stage II calcite demonstrates that the oxidation of methane requires higher activation energies than C2+ hydrocarbons. Besides time as a factor, constrained by varying oil and gas emplacement, this sequential oxidation of hydrocarbons is also well visible laterally and vertically in the investigation area.

Due to the pervasive distribution of high-valence Mn/Fe in the analyzed rocks, we suggest that TOH is a common process in the deep crust and has important geologic implications. Within oil or gas reservoirs, the TOH reactions at 81–132 °C alter the chemical and isotopic composition of hydrocarbons, but also modify reservoir quality via mineral dissolution and/or precipitation. Importantly, the consumption of hydrocarbons including CH4 in sedimentary basins and hydrothermal systems reduces CH4 emissions into the atmosphere. This study also highlights the scientific applicability of combining in situ isotope and clumped-isotope thermometry of carbonate in solving complex and interrelated hydrogeological processes with hydrocarbons as educts.

Keyword

Hydrocarbon oxidation, Organic-inorganic interactions, Siliciclastic strata, SIMS stable isotope, Clumped isotope thermometry

Research on exploration technology of sandstone-type uranium deposits in Erlian Basin based on airborne magnetic, aeroradiomeairborne gamma spectrometry and gravity surveys

LIANCHENG SHI[1]*, 1)China University of Geosciences (Beijing), Beijing 100083, China;2)Airborne Survey and Remote Sensing Center of Nuclear Industry,Shijiazhuang, Hebei,050002 (slchejy@163.com)
HUAIYUAN LI[2], airborne survey and remote sensing center of nuclear industry
WEICHONG NI[3], airborne survey and remote sensing center of nuclear industry
XIANG ZHANG[4], airborne survey and remote sensing center of nuclear industry
NANPING WANG[5], China University of Geosciences (Beijing)
PENGHUI HAN[6], Hebei Key Laboratory of Airborne Survey and Remote Sensing Technology, Shijiazhuang, Hebei,050002
ZHENGXIN SHEN[7], Hebei Key Laboratory of Airborne Survey and Remote Sensing Technology, Shijiazhuang, Hebei,050002

Abstract

Erlian Basin is an important base for the exploration of sandstone-type uranium deposits in China. As the exploration work of uranium deposits continues to deepen, the opportunities to discover new outcrops and shallow deposits gradually decrease. The Bayanwula uranium metallogenic belt is located in the eastern part of the basin, and the ore body has a large burial depth. Studying its airborne magnetic, airborne gamma spectrometry, and gravity response characteristics is of great significance for establishing a method for quickly delineating favorable areas for sandstone-type uranium deposits based on 1:50,000 airborne magnetic, airborne gamma spectrometry, and regional gravity data.

The study shows that the anomalous characteristics of radioactive elements in the surface sediments of the uranium mineralization belt are not obvious, mainly showing weak increase. The boundaries of the ancient river channels on the surface often present high-value or anomalous belts of airborne uranium. Based on the fine partition of surface sediment properties and radioactive element distribution characteristics, the active uranium in the sandstone-type uranium mining area is mainly introduced. In addition, irregular annular and banded anomalies of airborne active uranium entropy, uranium increment, uranium migration enrichment coefficient, and geochemical activity index are mainly presented on the surface above the ore bed. Uranium mining areas or ore deposits are mainly located in stable magnetic fields or magnetic gradient zones, as well as the moderate apparent magnetic susceptibility gradient zone where the northeast direction intersects with the northwest direction. The regional gravity field characteristics effectively reflect the undulating shape of the basement in the mineralization belt, and uranium mining areas or ore deposits are mainly located in the gradient-dense zone or the intersection of gradient bands of Bouguer gravity residual anomalies, as well as the intersection of moderate and higher apparent densities.The different burial depth contour lines of apparent magnetic susceptibility and apparent density from 3D gravity and magnetic inversion can effectively reflect the spatial distribution characteristics of the cover layer structure, providing a basis for the

analysis of the genesis of weak uranium information from airborne gamma spectrometry. Based on the comprehensive study of airborne magnetic, gravity, and regional geology, the favorable areas for uranium mineralization can be quickly identified. The information of airborne active uranium, uranium increment, active uranium entropy, and geochemical activity index in the favorable areas can be extracted and identified, which can further delineate the favorable areas for uranium exploration.

Therefore, this study suggests that the sandstone-type uranium deposit detection technology based on airborne gamma spectrometry and 3D gravity and magnetic inversion can quickly identify the sandstone-type uranium ore-forming environment and delineate favorable areas for exploration, which is beneficial for the uranium exploration effect of sandstone-type uranium deposits in airborne geophysical prospecting.

This research was supported by the National Natural Science Foundation of China (U2067204).

Keyword

Airborne gamma spectrometry, 3D gravity and magnetic inversion, Sandstone-type uranium deposit, Exploration Technology

Fluid-rock interaction of deep hydrothermal fluids and its reservoir response in carbonate rocks: A case study from the Ordovician in the Tarim Basin

Jian WANG[1]*, School of Geoscience, China University of Petroleum (East China) (wangjian8601@upc.edu.cn)
Yingchang CAO[2], National Key Laboratory of Deep Oil and Gas (China University of Petroleum (East China))
Dongping TAN[3], National Key Laboratory of Deep Oil and Gas (China University of Petroleum (East China))

Abstract

Hydrothermal process is one of the common diagenetic transformations in carbonate strata, which has a significant impact on carbonate reservoirs. The transformation effect of hydrothermal fluids on reservoirs is a controversial hot topic. One viewpoint holds that hydrothermal fluids have a constructive effect on reservoirs, mainly manifested as hydrothermal dolomitization, hydrothermal fracture and hydrothermal dissolution. Another viewpoint suggests that hydrothermal fluids have a destructive effect on reservoirs, mainly manifested as hydrothermal mineral precipitation and recrystallization. This study takes Ordovician carbonate reservoir in Tabei-Tazhong area of Tarim Basin as the research object. Based on core observation, thin section analysis and relevant geological data, through geochemical tests and numerical simulation methods, the types, characteristics, fluid rock interactions and reservoir responses of hydrothermal fluids are defined.
Research has shown that the hydrothermal fluids developed in the Ordovician strata in the study area mainly include Mg-rich hydrothermal fluids and Si&F-rich magmatic hydrothermal fluids. The main activity period of Mg-rich hydrothermal fluids is from the late Caledonian to early Hercynian period, with characteristics of moderately negative carbon and oxygen isotope values, δEu positive anomaly and δCe negative anomaly. Si& F-rich magmatic hydrothermal fluids are controlled by tectonic movements in the late Hercynian and magmatic volcanic activities in the early Permian, with characteristics of more negative carbon and oxygen isotope values and strong δEu positive anomaly δCe negative anomaly. The comprehensive analysis of geological data and numerical simulation results shows that the diagenetic response of the Mg-rich hydrothermal fluid in the study area to Ordovician carbonate reservoirs is mainly manifested by dissolution, hydrothermal dolomitization, and filling. It has both constructive and destructive transformation effects on the reservoir space, but mainly constructive effects. The diagenetic response of Si&F-rich magmatic hydrothermal fluids to Ordovician carbonate reservoirs is mainly characterized by fracturing, dissolution, metasomatism, and filling, with destructive effects being the main ones. The hydrothermal transformation of carbonate reservoirs is constrained by the strike-slip fault system, and the calcite precipitation filling zone formed in the upper part of the hydrothermal transformation reservoir also plays a certain sealing role.

Keyword

hydrothermal fluid, fuid-rock interaction, reservoir response, carbonate rock, Ordovician

The influence of microscopic petrological characteristics on fracability of tight sandstone in the Yanchang Formation of the Longdong Area, China

Xiaoming SHI[1]*, China University of Petroleum (East China) (shixiaom@126.com)
Guanmin WANG[2], China University of Petroleum (East China)

Abstract

The fracability evaluation of clastic rock is significant for reservoir modification and providing guidance for oil and gas development. The fracability can be characterized by mechanical parameters, but it is essentially determined by petrological characteristics. In this study, we focused on tight sandstone in the Chang 7 member of the Upper Triassic Yanchang Formation in the Longdong area of the Ordos Basin, China. Based on crack propagation mechanism and stress-strain behavior, we propose a method for evaluating fracability using the ratio of strain parameters brittleness index and stress parameters triaxial compressive strength. We analyze the controlling effect of microscopic petrological characteristics such as mineral content, occurrence state, texture, etc., determined by X-ray diffraction analysis and thin sections, on fracability. Regarding composition, the content of brittle mineral quartz has a positive effect on fracability. Feldspar alteration gradually converts the brittle fresh feldspar into plastic altered feldspar, which has a negative impact on fracability. Carbonate minerals are not always beneficial to fracability. Carbonate minerals in the form of particles or debris (mainly dolomite rock debris in this paper) are beneficial to fracability, while dispersed carbonate cementation (mainly ankerite in this paper) is detrimental to rock fracability. Clay minerals with various occurrence states have a weak negative relationship with fracability. In terms of texture, the average particle size and the grain median diameter calculated by Friedman Moment Methods are positively correlated with the fracability, indicating that coarser particle size leads to better fracability. The standard deviation calculated by Friedman Moment Methods shows a positive correlation with the rock fracability, implying that rocks with worse sorting degrees have better fracability. The influence of texture on fracability largely reflects the importance of brittle particles in crack formation. The interplay between composition and texture determines the internal mechanism of rock fracability.

Keyword

Tight sandstone, Yanchang Formation, Fracability, Composition, Texture

Impact of CO2 influx on sandstone reservoir quality: A case study of the Quantou Formation, southern Songliao Basin, China

Zheng Cao[1]*, Chongqing University of Science and Technology (caozheng_upc@126.com)
Chengyan Lin[2], China University of Petroleum (East China)
Keyu Liu[3], China University of Petroleum (East China)
Karem Azmy[4], Memorial University of Newfoundland
Hairuo Qing[5], University of Regina

Abstract

The CO2-gas reservoirs have been recorded in many petroliferous basins worldwide. However, the impact of deep inorganic CO2 influx on reservoir quality has received little attention. Here, a new set of mineralogical and geochemical data collected from the Lower Cretaceous Quantou Formation sandstones in the southern Songliao Basin are presented to address this issue. The sandstones were broadly subdivided into two zones based on their mineralogical compositions: (1) a “normal” zone with higher porosity (av. 13.7%) and permeability (av. 3.27 mD) that is located > 10 km away from the Gudian Fault (composed of ferrocalcite, ankerite, quartz, mixed-layer illite/smectite (I/S), kaolinite, illite, and chlorite), and (2) a “dawsonite-bearing” zone with relatively poor reservoir quality (av. 10.1% and 0.4 mD) adjacent to the Gudian Fault (consisting of dawsonite, ankerite, quartz, I/S, and illite). The carbon sources for dawsonite and ankerite in the dawsonite-bearing zone (13C= -5.7‰ to -0.8‰ and 18O= -20.6‰ to -17.1‰, and Sr= 0.710216 to 0.712472) are mostly a mix of mantle magmatic CO2 and crustal CO2, with a small amount of organic CO2, which is the opposite for the ferrocalcite and ankerite in the normal zone (13C= -10.5‰ to -2.3‰, 18O= -19.3‰ to -14.9‰, and Sr= 0.712060 to 0.714030). Observations of the dawsonite-bearing zone demonstrate higher contents of carbonate and quartz cements, specific clay mineral types (mixed-layer I/S with Reichweite order of R = 3 and illite), and poor reservoir quality and oil productivity due to the influx of deep inorganic CO2 dating back to around 65-44 Ma.

Keyword

Dawsonite, deep inorganic CO2, CO2 and hydrocarbon charge timing, reservoir quality, Songliao Basin

Characteristics and origin of deep and ultra-deep high-quality clastic reservoirs in the steep slope zone of the Minfeng sub-sag, Dongying Sag, China

Jiageng LIU[1]*, China University of Petroleum (East China) (wyzh@upc.edu.cn)
Yanzhong WANG[2], China University of Petroleum (East China)
Yingchang CAO[3], China University of Petroleum (East China)
Shuping WANG[4], China University of Petroleum (East China)
Xuezhe LI[5], China University of Petroleum (East China)

Abstract

Deep and ultra-deep layers within petroliferous basins have emerged as new targets in global oil and gas exploration. However, the characteristics and origin of the high-quality clastic reservoirs within these layers remain poorly understood, posing challenges for effective exploration. This study focuses on the coarse-grained clastic reservoirs in the nearshore subaqueous fan in the lower sub-member of the 4th member of the Shahejie Formation in the steep slope zone of the Minfeng sub-sagDongying Sag. By combining methodologies including casting thin section observation, scanning electron microscopy (SEM), cathodoluminescence microscopy-based identification of minerals in thin sections, fluid inclusion thermometry, and paleopressure reconstruction, as well as the analytical results of the burial and thermal history, the reservoir characteristics, hydrocarbon charging history, pressure evolution and genetic mechanism of the high-quality reservoirs were comprehensively investigated. The coarse-grained clastic reservoirs in the study area are predominantly lithic arkoses and feldspathic litharenites. They exhibit medium to strong compaction and are dominated by ankerite cementation, followed by quartz overgrowth. Dissolution is overall weak and is dominated by feldspar dissolution. The reservoir spaces comprise mostly primary poresalong with some others developed from feldspar dissolution. Two oil charging stages and one natural gas charging stage were identified: an early mature-oil charging between 37.225.8 Ma and a later highly-mature-oil charging from 12 Ma onwards. The natural gas charging has lasted till now since 3.6 Ma. The reservoirs have experienced two distinct pore pressure-increasing cycles: 4524.6 Ma and from 24. 6 Ma to present, corresponding to the two hydrocarbon charging stages. Favorable lithofacies lay the foundation for the development of high-quality reservoirs dominated by primary pores in the study area. The inhibitive effects of overpressure hydrocarbon charging on compaction and cementation are crucial to the development of high-quality reservoirs. The weak dissolution of feldspar and carbonate minerals in the deep closed system leads to a low increment in porosity. However, the reduction rate of the reservoir porosity with depth declines significantly at burial depths beyond 3 750 mand the development of deep high-quality reservoirs dominated by primary pores expands the lower limit of depth for exploration.

Keyword

reservoir characteristics, diagenesis, overpressure hydrocarbon charging, origin of high-quality

clastic reservoirs, deep-ultradeep layer

Study on the Main Controlling Factors of Effective Reservoirs in Tight Beach Bar Sand Oil Reservoirs in the Dongying Depression

Huafeng ZHANG[1]*, 1.School of Geosciences, China University of Petroleum (East China), Qingdao 266580; 2.Exploration and Development Research Institute of Shengli Oil Field, SINOPEC, Dongying 257100 (zhanghuafeng1984@sohu.com)

Abstract

The Dongying Depression, located in Eastern China, is a prominent example of an oil and gas-rich geological depression. During the deposition of the Sha-4 upper sub-member, beach bar sands in shallow lake environments were the primary deposits, covering more than one-third of the depression's total area. Since the Ninth Five-Year Plan, the Shengli Oilfield has identified multiple beach bar sand oil reservoirs in Dongying Depression’s regions, including Liangjialou, Zhenglizhuang, Wangjiagang, Boxing, and Daluhu. As of 2023's end, the Shengli Oilfield reported 426 million tons in proven geological reserves in these reservoirs, marking a significant contribution to the oilfield's reserve augmentation and production. The urgent geological challenge lies in identifying the oil-bearing properties of beach bar sand reservoirs. Currently, the most effective methods, onsite coring and field testing, are also the most costly. Electrical logging interpretation can yield results in identifying effective reservoirs. Beach bar sand reservoirs typically enter production post-fracturing, which can also enhance development in some dry layers. Therefore, accurately determining the main factors controlling the oil-bearing nature of beach bar sands is crucial. This study focuses on the sub-member of the Sha4 member in the Dongying Depression. This study examines factors including micro-pore structure, reservoir thickness, depositional microfacies, diagenesis, and fracture systems. It aims to assess their impact on the effectiveness of thin interlayered beach bar sand reservoirs, offering a geological basis for evaluating sweet spots and predicting favorable reservoirs. Bar sands exhibit superior physical properties and oil-bearing capacity compared to beach sands.Well logging and core data indicate a positive correlation between the oil-bearing capacity of beach bar sand reservoirs and their thickness. Thicker layers are associated with better reservoir properties and higher effectiveness.The closer the beach bar sand reservoir is to the sand-mudstone interface, the more abundant the supply of pore fluid ions from the mudstone, the stronger the diagenesis, and the higher the degree of reservoir compaction. The quality of bar sand concentrated type reservoirs is the highest with the best oil-bearing capacity, followed by the beach bar interlayered type with moderate quality and oil-bearing capacity, and the beach sand dispersed type with the poorest quality and lowest degree of hydrocarbon enrichment.It is important to note that most beach bar sand oil fields currently employ fracturing for production. Additionally, some dry layers achieve increased productivity post-fracturing. Establishing accurate criteria for the lower limit of effective reservoirs under reservoir modification conditions is a key.

Keyword

Dongying Depression, Beach bar sands, Effective Reservoirs

Mixing processes of the oil-water-CO2 systems in different fluid phases: Insights to CO2 sequestration in depleted hydrocarbon reservoirs

Zihao JIN[1]*, China University of Petroleum (East China) (1325022832@qq.com)
Guanghui Yuan[2], China University of Petroleum (East China)
Yingchang Cao[3], China University of Petroleum (East China)

Abstract

The dissolution of supercritical carbon dioxide (scCO2) in saline formation water and remaining oil is a crucial trapping mechanism for geological carbon storage in depleted hydrocarbon reservoirs. Therefore, understanding the physics behind dissolution trapping and mass transfer among scCO2, resident brine and remaining oil is essential to evaluate CO2 storage capacity. During trapping, the dissolved scCO2 in oil leads to oil swelling, viscosity reduction, wettability alteration, and ultimately leads to the miscibility between the scCO2 and oil. However, previous studies have often overlooked the potential of CO2 dissolution trapping in oil as well as the interactions between different phases of mixed fluids. To address this gap in knowledge, we simulated the mixing of different fluids in crude oil (light oil and heavy oil), water (distilled water, various saline solutions), and CO2 at temperatures of 32 ℃ to 200 ℃ and pressure of 5 MPa to 60 MPa, using the in-situ micron quartz capillary tube thermal simulation system along with PVT cell simulation systems equipped with gas chromatograph (GC) and mass spectrometer (MS), as well as Material Studio molecular dynamics numerical simulation software.

The results indicate that the miscibility or dissolution process of mixed fluids were not instantaneous, but rather a result of a series of physical interactions occurring near the interface between oil and scCO2. This process was governed by the solubility between the two phases, and influenced by factors such as temperature, pressure, oil properties, and scCO2 content. The solubility of scCO2 in oil decreased with increasing reservoir temperature, and increased with increasing reservoir fluid pressure. As the temperature approached the two-phase miscibility temperature, changes in pressure will have a more pronounced effect on the solubility of scCO2 in oil. Increasing pressure promoted oil-CO2 miscibility and could even achieve miscibility at relatively low temperatures. For various crude oil types, scCO2 exhibited higher solubility in light oils characterized by low viscosity and density, enabling miscibility to be achieved at relatively low reservoir temperature and pressure conditions. Conversely, scCO2 can effectively extract heavy oils with high viscosity and density while partially forming a miscible fluid zone with the extracted light hydrocarbons, thereby promoting two-phase complete miscibility between heavy oil and scCO2. In closed or slow fluid flow systems, the degree of oil-CO2 miscibility is governed by the scCO2 content; achieving miscibility is easier at lower scCO2 concentrations compared to higher ones. Additionally, the miscibility or dissolution processes of oil-scCO2 near the interface induced density convection, thereby enhancing the interaction between dissolved and incompletely miscible carbon dioxide with oil and gas, ultimately promoting the process of miscibility. These findings hold significant implications for analyzing and comprehending the

mechanism of CO2 dissolution trapping in depleted hydrocarbon reservoirs.

Keyword

Depleted hydrocarbon reservoirs, Carbon dioxide geological sequstration, Dissolution trapping, Mixing of geofluids, In-situ visualization thermal experiments

Study on Diagenetic Fluids and Reservoir Evolution of Near Source Glutenite Reservoirs, Bozhong Depression Paleogene

Jin HU[1]*, China University of Petroleum(East China) (18706488715@163.com)
Shouyu Xu[2], China University of Petroleum(East China)
Guanmin Wang[3], China University of Petroleum(East China)

Abstract

The resource potential of the Paleogene reservoirs in the Bozhong Depression is great, and the development laws of the reservoirs are complex. The properties of the diagenetic fluids have an important impact on the diagenesis and physical properties of the reservoirs.

Based on the core observation, impregnated thin section, fluorescence thin section, cathodoluminescence observation and analysis, scanning electron microscope observation, fluid inclusion homogenization temperature test, carbon and oxygen stable isotope analysis, X-ray diffraction, formation hydrochemistry analysis, combined with the burial history and thermal history of the study area, the diagenetic fluid properties and diagenetic characteristics of the reservoir in the study area are analyzed and discussed in detail.

In a relatively closed diagenetic fluid system. In the early and middle stages of early diagenesis where the formation temperature is below 80 degree Celsius and the burial depth is less than 2000m, the formation fluid tends to be alkaline. Pore water mainly inherits the ion composition and chemical characteristics of sedimentary water, with stable clay mineral composition. Bright calcite and dolomite cementation occur in sandstone, and the carbon source is CO2 with heavy carbon isotopes generated by microbial fermentation. The particles rarely undergo dissolution. In the late stage of early diagenesis and the middle diagenetic stage A1, where the formation temperature is between 80-120 degree Celsius and the burial depth is 2000-3500 meters, multiple layers of source rocks have successively entered the stage of thermal evolution and acid generation. Organic acids and CO2 enter the reservoir, and the formation fluid rapidly turns acidic, greatly changing the ion composition of the reservoir. Feldspar and detritus undergo widespread dissolution under H+ substitution and carboxylic acid anion complexation, resulting in secondary pores and improving reservoir properties. Simultaneously, common siliceous cementitious materials and authigenic minerals of kaolinite are produced, while carbonate cementitious materials undergo minor dissolution, resulting in changes in the composition of clay minerals. In the middle diagenetic stage A2, When the ground temperature exceeds 120 degree Celsius and the burial depth is greater than 3500m, the oxygen to carbon ratio in the source rock has decreased to a lower level, and the acid generation ability has been depleted. The organic acids in the formation decarboxylate and decompose with increasing temperature, and their concentration gradually decreases. During this stage, the pore water is mainly alkaline. K+ released by feldspar dissolution and enriched in pore water is fixed in clay minerals, and the relative content of illite increases rapidly. Calcite, ferrocalcite, dolomite, and ferrocalcite are commonly cemented in sandstone, and the carbon source mainly comes from CO2 with lighter

carbon isotopes produced by the thermal evolution of organic matter. There are also phenomena such as cementation of sodium feldspar, dissolution of quartz particles and enlarged edges, and cementation of pyrite. In relatively open diagenetic fluid systems, atmospheric freshwater leaching plays a strong role in transformation.

Keyword

bozhong depression, near source glutenite, diagenetic fluids, reservoir evolution

Synergistic diagenesis and shale oil enrichment patterns in the Chang 73 sub-member of Triassic Yanchang Formation in the Ordos Basin

Xiaobing NIU[1]*, Key laboratory of deep oil and gas, China University of Petroleum (east china) (likea0619@163.com)
Yingchang Cao[2], Key laboratory of deep oil and gas, China University of Petroleum (east china)
Kelai Xi[3], Key laboratory of deep oil and gas, China University of Petroleum (east china)
Ke Li[4], Key laboratory of deep oil and gas, China University of Petroleum (east china)
Miruo Lin[5], Key laboratory of deep oil and gas, China University of Petroleum (east china)

Abstract

This study of the Chang 73 sub-member of Triassic Yanchang Formation in the Ordos Basin used an integrated approach of core observation, thin sections analysis, XRD analysis, AMICS mineral analysis, SEM, and vitrinite reflectance analysis to clarify the diagenesis characteristics of thin sandstone interlayers and mudstones. The Chang 73 sub-member is mainly composed of thick mudstone interbedded with thin sandstone. Among them, the mudstone exhibits various types of laminae, including silt-grained feldspar-quartz lamina (SFL), tuff-rich lamina (TL), organic-rich lamina (OL), and clay lamina (CL). Different combinations of these laminae vertically form massive mudstone, “organic-rich + silt-grained feldspar-quartz” laminae combination shale (Type A shale) and “organic-rich + tuff-rich” laminae combination shale (Type B shale). Based on different types of shales, the shale strata of Chang 73 sub-member mainly develop three main types of sandstone-mudstone combinations. Type I is massive mudstone and low-density turbidite sand body combination, whose mudstone are characterized by strong compaction and have little effect on sandstone. The sandstone interlayers have strong compaction and poor reservoir properties. Type II is composed of type A shale and hyperpycnal flow deposited sandstones, which have medium reservoir properties. In this type, strong dissolution of potassium feldspar occurred in the SFL, and provided materials for the authigenic quartz in the OL. Mass transfer occurred inside the shales and have limited influence on sandstones, which have medium compaction and weak feldspar dissolution. Shale oil is mainly enriched in the dissolution pores of the SFL. Type B shale and hyperpycnal flow deposited sandstones combination is another type (Type III1). Abundant tuff can catalyze the earlier hydrocarbon generation of type B shale to accumulate in intergranular pores of the interbedded sandstones, which inhibits the latter diagenesis of sandstone. Shale oil is mainly enriched in the primary pores of sandstones and the reservoir properties is best. Type B shale and sandy debris flow deposits sandstones combination is also a type (Type III2). The evolution of type B shale provides calcium rich fluid to promote the formation of calcite cemented crust at the edge of sand body. The reservoir properties in the middle sand body are better, and shale oil is mainly enriched in the sandstones.

Keyword

Shale strata, Synergistic diagenesis, Shale oil reservoir, Ordos Basin

The impact of burial dissolution on the development of ultra-deep fault-controlled carbonate reservoirs: Insights from high-temperature and high-pressure dissolution kinetic simulation

Xiaolin TAN[1]*, College of Geoscience, China University of Petroleum (Beijing)
(txl2021310053@163.com)
Lianbo Zeng[2], College of Geoscience, China University of Petroleum (Beijing)

Abstract

Burial dissolution is a critical diagenetic process influencing ultra-deep carbonate reservoir development and preservation. Artificial carbonate samples with different internal structures were prepared, and high-temperature and high-pressure dissolution kinetic simulations were conducted. The results demonstrate that temperature and pressure exert a significant influence on the intensity of buried dissolution processes. After the experiment, an overall decrease occurred in the intensity of buried dissolution processes in conventional porous-type samples while the reservoir capacity was reduced. Within the faulted samples, there was an overall decrease in the intensity of buried dissolution processes while the reservoir capacity increased. Within the different structural locations of faults, the intensity of dissolution processes exhibits a marked variation. In both fault types of the samples, dissolution expands predominantly along the fault surfaces. The larger the scale of the faults, the more pronounced the dissolution process becomes. Within the special porous-type samples, a three-tiered "string-bead-like" fault-cave structure manifests vertically within SP1. In the case of SP2, an internal fault forms, giving rise to extensive dissolution cavities at the fault's tip. The intensity of burial dissolution is controlled by temperature and pressure, while tectonic-fluid activity influences the development pattern of burial dissolution. Extensive burial dissolution is likely to occur primarily at relatively shallow depths. The development of faults facilitates the maintenance of the intensity of burial dissolution. The maximum intensity of burial dissolution occurs at the tips and overlap zones of faults and intersections of multiple faults. The larger the scale of the faults, the more conducive it is to the development of burial dissolution. Burial dissolution fosters the formation of fault networks characterized by enhanced reservoir capacity and permeability. Burial dissolution controlled by episodic tectonic-fluid activity is a plausible explanation for forming the Tarim Basin's ultra-deep fault-controlled "string-bead-like" reservoirs.

Keyword

burial dissolution, tectonic-fluid, ultra-deep carbonate reservoirs, high-temperature and high-pressure dissolution kinetic simulation

The Stability of the CO2-H2O-Dawsonite-Bearing Sandstone Reaction System: Experimental Study And Thermodynamic Simulation

Kaining WANG[1]*, China Univ Petr East China, Natl Key Lab Deep Oil & Gas, Qingdao 266580, Peoples R China (kningwang2022@163.com)
Fulai Li[2], China Univ Petr East China, Natl Key Lab Deep Oil & Gas, Qingdao 266580, Peoples R China

Abstract

CO2 monitoring constitutes a crucial component of CCUS (Carbon Capture, Utilization, and Storage) technologies, serving as an indispensable tool for ensuring the safety and viability of sequestration projects. This study systematically investigates the reaction system of CO2-H2O-dawsonite-bearing sandstone, clarifying the stability of CO2 reservoirs after mineral trapping, thereby providing significant insights for CO2 monitoring techniques. Experiments and thermodynamic simulations of CO2-H2O-dawsonite-bearing sandstone interactions were conducted under various temperature and pressure conditions using high-temperature, high-pressure autoclaves. A total of 18 physical experiments were carried out at different temperatures and pressures, employing techniques such as scanning electron microscopy, energy-dispersive spectroscopy, and X-ray diffraction to analyze the dissolution and precipitation characteristics of sandstone samples post-reaction and to quantitatively detect the elemental composition changes in key minerals (such as dissolved dawsonite and newly formed minerals). The post-experimental liquid samples were quantitatively analyzed for pH, major ion concentrations, and trace element concentrations. Thermodynamic analysis of the reaction system was performed using the Peng-Robinson equation of state and the van der Waals one-fluid mixing rules to calculate equilibrium state parameters such as pH, CO2 fugacity, ion concentrations, and Gibbs free energy. Thermodynamic simulation experiments on CO2-H2O-dawsonite-bearing sandstone interactions were conducted using Phreeqc, along with the creation of mineral dominance diagrams, to analyze changes in the types and concentrations of ions in the liquid phase at equilibrium, as well as variations in the saturation index of various minerals. The experimental results indicate that the stability of dawsonite decreases under lower CO2 partial pressures, leading to elemental loss and structural transformation into gibbsite and boehmite, with the elemental composition evolving to an O:Al ratio between 3:1 and 2:1, ultimately transforming into gibbsite and boehmite. It is inferred that temperature and CO2 pressure have a comprehensive impact on the stability of the CO2-H2O-dawsonite-bearing sandstone reaction, where high temperatures reduce the system's stability, whereas high CO2 pressures enhance it. An increase in temperature diminishes the inhibitory effect of CO2 pressure on the CO2-H2O-dawsonite-bearing sandstone interaction, necessitating a higher CO2 pressure to maintain system stability, i.e., a lower CO2 pressure is required to preserve system stability under low-temperature conditions. The stability of various minerals changes significantly under different CO2 partial pressures, with quartz, feldspar, and siderite experiencing greater dissolution at 4.3MPa, while remaining stable under other pressures,

and the stability of calcite decreasing with increasing CO2 partial pressure, in contrast to dawsonite and siderite, which increase in stability with higher CO2 partial pressures. Under high CO2 partial pressure conditions, quartz, feldspar, siderite, and dawsonite are relatively stable, indicating a strong "carbon fixation capacity" of the system. This study integrates experimental and thermodynamic simulation data of CO2-H2O-dawsonite-bearing sandstone under various temperatures and CO2 partial pressures, thoroughly investigates the dissolution mechanisms of dawsonite, discusses the stability impact modes of the CO2-H2O-dawsonite-bearing sandstone reaction system under different conditions, and provides a reference for the feasibility and safety analysis of CO2 geological storage.

Keyword

CO2-H2O-rock interaction, thermodynamic simulation, dawsonite, CO2 partial pressure

The use of Airborne Geophysics in Mineral Exploration

Alla DIAW[1]*, National Geological Survey in Senegal (alla.diaw@sgns.gouv.sn)
Rokhaya Samba DIENE [2], Organisation of African Geological Survey
Raymond SAGNA [3], National Geological Survey in Senegal

Abstract

It is essential for a government to play a significant role in attracting foreign investments in the mining and the geology sectors, with a clear legal framework and quality information on the country's potential.

In Africa, mining and geology sector is underexplored, which is why it is important to use much more appropriate techniques that will allow a better understanding of a country's geological and mining potential, hence the interest in airborne geophysics in exploration.

The objectives of airborne geophysics in exploration are:

• Improve the knowledge of the country's natural resources;

• Attract investments in the natural resources sector;

• Identify opportunities related to natural resources in the Energy and Environment sector (water, geothermal);

• Improve the visibility and reputation of the country among investors and multilateral organizations.

Thus, the methodology of airborne geophysics consists in:

• The acquisition of data by overflights following well-defined lines;

• The processing of data by appropriate software (Leapfrog Geo, Oasis montaj or Geosoft);

• The interpretation of data to produce reports and geophysical maps.

The result of this study: Airborne geophysics provides detailed information to reduce the risks, time, and costs of subsequent exploration. Among others, we can mention:

• Integration of data from airborne geophysical surveys (RAD-MAG, EM, gravimetry) with geological data to better identify future prospecting areas;

• Elaborated geological maps defining faults, geo-structures, intrusive dykes, litho-stratigraphy or vein-layers, produce a GIS database containing the targeted minerals with their priority and their attributes;

• Final interpretation reports include all databases: geophysical maps, geological maps, and 2D / 3D modeling of target anomalies to extract geometric information (size, shape, depth, physical properties).

Finally, it is important to note that:

• Airborne geophysics is the initial activity aimed at providing valuable information over vast territories to detect areas of interest;

• Advanced airborne geophysics associated with geology and geochemistry, will have an impact in target areas to maximize the efficiency of investments.

• And the results of these actions will be a set of data for potential investors interested by the

mining sector.

Keyword

Airborne Geophysics, Mineral Exploration, Modeling 2D/3D, Africa, Mining and Geology

Superimposed transformation by multiple types of fluids during diagenesis in ultra-deep carbonate reservoirs

Leilei Yang[1]*, Unconventional Petroleum Research Institute, China University of Petroleum (Beijing) (yangleilei@cup.edu.cn)
Dawei Wang[2], Unconventional Petroleum Research Institute, China University of Petroleum (Beijing)
Hui Wang[3], Unconventional Petroleum Research Institute, China University of Petroleum (Beijing)
Jinlu Zhao[4], Unconventional Petroleum Research Institute, China University of Petroleum (Beijing)
Wenhao Yang[5], Unconventional Petroleum Research Institute, China University of Petroleum (Beijing)
Xiaowei Li[6], Unconventional Petroleum Research Institute, China University of Petroleum (Beijing)
Keyu Liu[7], China University of Petroleum (East China)

Abstract

The potential of ultra-deep ancient marine carbonate rocks for oil and gas resources is tremendous, becoming an important direction for oil and gas exploration. During the diagenetic development of ultra-deep carbonate rock reservoirs, as burial depth increases, the reservoir undergoes multiple stages of fluid injections including atmospheric freshwater, seawater, organic acids, hydrothermal fluids, and fluids rich in CO2/H2S. This triggers fluid-rock interactions, accompanied by mineral dissolution, precipitation, and transformation, gradually forming porosity, which is then either destroyed or preserved by infilling. The transformations induced by fluid-rock interactions, such as "dissolution porosity increase" and "cementation porosity reduction," play a crucial role in the formation and evolution of porosity, and are key to the development of high-quality reservoirs. Identifying the fluid-rock interactions and the mechanisms of mineral dissolution, precipitation, and transformation during the lengthy and complex diagenetic process of ultra-deep carbonate rock reservoirs, and elucidating how porosity forms and evolves, are critical for revealing the formation mechanism of high-quality ultra-deep reservoirs. This study innovatively introduces temperature-fluid-chemical multi-field coupled multiphase, multicomponent reactive solute transport simulation technology, based on petrological testing and physical simulation experiments, to deeply investigate the fluid-rock interactions during the represented diagenetic process of ultra-deep carbonate rock reservoirs, clarify the mechanisms of mineral dissolution, precipitation, and transformation, simulate the cumulative transformation effects of multiple types of fluids on reservoir porosity during different diagenetic stages, and establish a temperature-fluid-chemical multi-field coupled diagenetic physical-numerical simulation system to quantitatively represent the diagenetic-porosity evolution process on a geological timescale, thereby revealing the formation mechanism of high-quality ultra-deep carbonate rock reservoirs. The research shows that the formation of porosity is closely related to the properties of underground fluids. In fluid-rock interactions, the dissolution of minerals releases ions, which recombine in the solution to form new minerals. Therefore, the concentration of ions in the fluid largely determines the trend of mineral dissolution/precipitation and its degree of transformation of the reservoir porosity. The

fluid types experienced during the diagenetic process of ultra-deep carbonate rock reservoirs are complex and numerous, and the secondary porosity, vugs, and caves formed by the dissolution action of different types of fluids are the main spaces for oil and gas accumulation.

Keyword

Ultra-deep carbonate rocks, Diagenesis, Diagenetic fluids, Fluid-rock interaction, Quantitative porosity calculation

The role of transient processes in the generation of giant uranium deposits

Patrick LEDRU[1]*, University Lorraine (patrick.ledru@univ-lorraine.fr)
Julien Mercadier[2], University Lorraine
Guoxiang Chi[3], University Regina

Abstract

The concept of metallogenic system highlights the notion of favorable geodynamic context and self-organized hydrothermal systems. The formation of such systems requires a source of energy which sustains a hydraulic gradient, controls fluid circulation, and allows accumulation of metals in localized traps. These geologic elements are considered critical for the formation of mineral deposits, and the understanding of their functioning is important for identification of the controlling factors of mineralization. Their thermal, hydraulic and mechanical properties are comparable to the parameters involved in the stimulation of fractured reservoirs in geothermal systems. The application of these concepts to the metallogeny of uranium leads to a better understanding of the possible role of transient processes in the formation of giant deposits and in particular unconformity-related uranium deposits.

The location of high-grade uranium deposits in the Proterozoic Athabasca Basin within or near fault systems that have been reactivated multiple times suggests that these faults have propagated within the basin and have guided the circulation of fluids, testifying to the structural control of the mineralization. The coincidence between this reactivation, induced permeability enhancement and the generation of uranium deposits is the first evidence of transient events as illustrated by the relative chronology between deformation, alteration and mineralization. The thermal conditions indicated by mineralogical and fluid inclusion studies and the observation of dissolution and recrystallization phenomena suggest that the leaching of considerable volumes of rocks in the basement and the basin is related to the mineralization system. The system involved fluid reservoirs within the basement derived from accumulation of brines from the basin and fluids of deeper origin. The study of graphite in basement faults hosting uranium deposits suggests that the faults may be reactivated due to the fault-valve mechanism ~5 km below the unconformity surface, in relation to far-field tectonic stresses and/or over-pressured fluids whereas the upper tip of the faults may attracts fluids both from the basement and basin via the suction pump mechanism. According to this model, the formation of these deposits may result from coupled fault-valve and suction pump mechanism. The alternating seismic and interseismic periods associated with this mechanism would thus be entirely comparable to the self-organized hydrothermal systems described for gold deposits or geothermal reservoirs and could correspond to a succession of very short-lived events in the history of the basin. Although no geochronological constraints exist on the time required to form the Athabascan unconformity-related uranium deposits, first-order approximation from Thermal Hydrological Mechanical and Chemical modeling suggest that 0.1–1Myr is a viable estimate for the duration of the mineralizing event. Translation of the new understanding of these geologic processes that are critical for

mineralization into recognizable or mappable geological features or footprints is important for continued exploration for new giant deposits.

Keyword

mineral system, uranium, unconformiuty related deposit, transient events, Athabasca

The relationship between Meso–Cenozoic tectonic-fluid evolution and sandstone type uranium mineralization in Kuqa Depression, Tarim Basin, western China

NIAN LIU[1]*, Beijing Research Institute of Uranium Geology (liuniancup@163.com)
Mingkuan QIN[2], Beijing Research Institute of Uranium Geology
Qiang GUO[3], Beijing Research Institute of Uranium Geology
Qiang XU[4], Beijing Research Institute of Uranium Geology
Jing XIAO[5], Beijing Research Institute of Uranium Geology

Abstract

The apatite fission track, apatite (U-Th)/He, balanced section and organic-inorganic geochemistry are used to recover the Meso–Cenozoic tectonic-fluid evolution of Kuqa Depression in this paper. The relationship between tectonic-fluid evolution and sandstone type uranium mineralization is also discussed. The results show that the tectonic deformation strength of the Kuqa Depression is characterized by “strong in the west and weak in the east”, and there are three tectonic uplifting events: Late Jurasic–Early Cretaceous, Paleogene–Miocene and Pliocene–Quaternary. It is caused by the collage of the Lhasa terrane and the Eurasian plate, the accretion of the Kohistan-Dras island arc and the progressive collision between the Indian and the Eurasian plate, respectively. From Paleogene to Miocene, slow regional uplift and denudation occurred in the study area, and the uplifted and exfoliated marginal strata suffered from surface weathering and leaching and developed large-scale interlayer oxidation, and early uranium mineralization occurred in the Middle and Lower Jurassic and Lower Cretaceous. From Pliocene to Quaternary, the infiltrating fluid penetrated deep into the basin and the temperature rose, forming high temperature hydrothermal water. Due to tectonic extrusion in the later period (Quaternary), the hydrothermal fluid mixed with oil and gas continuously extracted uranium, copper, lead, zinc and other ore-forming materials in the surrounding strata during upward migration, forming the fluid rich in metal ore-forming materials. Due to the change of temperature and pressure conditions, ore-forming fluids are enriched and uranium mineralization occurs in Pliocene. The Meso–Cenozoic tectonic-fluid evolution controls the sandstone type uranium mineralization in the Kuqa Depression, which is generally characterized by “early interlayer oxidation and late exudation relay mineralization”.

Keyword

Tectonic-fluid evolution, Sandstone type uranium mineralization, Ore-forming fluid, Kuqa Depression

Significant Progresses and Prospects in Innovation of Uranium Geology in China Since 2000

Mingkuan QIN[1]*, Beijing Research Institute of Uranium Geology (qinmk9818@163.com)
Ziying LI[2], Beijing Research Institute of Uranium Geology
Zhangyue LIU[3], Beijing Research Institute of Uranium Geology
Shaohua HUANG[4], Beijing Research Institute of Uranium Geology
Yuqi CAI[5], Beijing Research Institute of Uranium Geology
Hu LIU[6], Beijing Research Institute of Uranium Geology

Abstract

Since 2000, the significant theoretical and technological innovations in the field of uranium geological exploration in China have greatly changed the prospecting ideas and directions for sandstone-type and hydrothermal-type uranium resource exploration. These innovations have led and supported a series of major prospecting breakthroughs, reshaping the new pattern of uranium resource exploration in China. This paper firstly analyzes the overall ideas and evolution directions of China's uranium geological research layout over the past 20 years. It then summarizes the progress in major basic geological and metallogenic theories of uranium ore formation, systematically condenses technological innovations and core exploration equipment development achievements that including fields of geology, physical and chemical exploration, remote sensing, drilling technology, analysis and testing, and reviews the progress and application effectiveness of uranium resource prediction and evaluation techniques. Lastly, this paper proposes the main development trends and directions for the next 10-15 years in the areas of major basic geology frontier and metallogenic theories, which including advanced research and development of uranium resource exploration technology, unconventional nuclear energy fission resource exploration technology, and digital uranium resource exploration technology. The authors points out that under the background of the 'dual carbon' goals, the development of nuclear energy and demanding security of uranium resource, it is necessary to strengthen the innovation of uranium geological science and technology, and drive the prospecting breakthroughs in 'new areas, new stratigraphic positions, new types, and new depths'.

Keyword

Science and Technology Innovation, Basic Geological and Metallogenic Theories of Uranium Resources, Uranium Resource Exploration Technology and Equipment, Development Trends and Directions

Progress in the extraction and integration of uranium mineralization information in the basin

Yu RENG-AN[1]*, China Geology Survey (yurengan@163.com)
Chen Yin[2], China Geology Survey

Abstract

Comprehensive information of prospecting sandstone type uranium in the basin is a specific reflection of the phenomenon of uranium mineralization. Because of complex uranium mineralization mechanism, prospecting indicator, deep buried and less differences in physical properties of ore-bearing, etc., the extraction of comprehensive information on uranium mineralization is an important part of uranium exploration. As a radioactive logging method, natural γ logging is one of the main means of geophysical logging in the exploration of oilfields and coalfields. Based on the study of the principles and working methods of natural gamma logging and quantitative gamma logging, combined with the comparative analysis of the natural gamma logging of coal field and oil field holes and quantitative gamma logging data of uranium mines, the empirical equation between the natural gamma and radioactive gamma values of the study area and the logging response of different lithologies are fitted, and the ore body's grade, and other more accurate measurement information modules are established, so as to make a more accurate measurement information module for the unvalidated oil field logging Numerical prediction of grade, lithology and other attributes of the oilfield logging data was carried out, and a preliminary index system for discriminating potential uranium ore layers based on the natural gamma logging data, as well as circling prospective zones and target zones for finding minerals, was established. At the same time, we collected and analyzed geological data, heavy magneto-electricity, remote sensing and borehole logging data of the study area, analyzed and processed them for interpretation, compiled and drew different kinds of basic maps of the study area, combined with relevant drilling and seismic data to speculate on the fracture tectonic system of the study area and discuss its geological significance; the characteristics of the geophysical field of the study area and the relationship between fracture uplift tectonics and sandstone uranium in the study area were created, then the geological background of uranium formation and predicted the prospective uranium prospecting areas were analysed and summarized. This study might be profit to analysis of the geological background of uranium formation and the uranium exploration in the study area.

Keyword

Basin in Northern China, Sandstone type Uranium, Mineralization Information, Comprehensive logging, Ore Prospecting and Prediction

[Keynote] IAEA activities supporting capacity building and innovations in uranium resources, processing and mining

Adrienne Hanly[1]*, IAEA (A.Hanly@iaea.org)

Abstract

The IAEA provides various forms of support for capacity building in countries engaged in uranium exploration, processing, and mining. This support includes technical meetings, training workshops, symposia, review and expert missions, publications, databases, e-learning, fellowships, scientific visits, and procurements.

The IAEA produces publications covering diverse topics in uranium production cycle activities that are an excellent source of recent and historical information, and many are available free of charge as a downloadable PDF file on the IAEA website. To complement publications on uranium and thorium deposits there are databases on uranium (UDEPO) and thorium (THDEPO) deposits.

An IAEA Nuclear Energy Series document (NES No. NF-G-1.1) titled 'Milestones in the Development of National Infrastructure for the Uranium Production Cycle' offers guidance to countries currently undertaking or considering programmes in uranium exploration, production, processing, decommissioning, and remediation of uranium mines and processing facilities.

To assist countries in understanding this guidance, the IAEA is developing a series of e-learning modules. One e-learning module will provide an overview of the Milestones approach in developing national infrastructure for the uranium production cycle. Two additional e-learning modules, one focusing on stakeholder engagement and the other on conventional safety and radiation protection, will further expand on the Milestones approach. A fourth e-learning module will concentrate on uranium exploration, offering a solid foundation in the principles of conducting uranium exploration systematically, safely, and sustainably. This will complement an IAEA Technical Document currently in draft form titled 'Exploration Planning, Management and Practise.'

Keyword

Uranium, Exploration, Resources, Education, Mining

Ore mineralization of some gold deposits of Mongolia: Gold mineralization linking to the crystal forms

MUNGUNTULGA PUREVSUREN[1]*, National University of Mongolia (munguunup@gmail.com)
OYUNGEREL Sodnom[2], National University of Mongolia
YEONGMIN Kim[3], Korea Basic Science Institute
ALTANZUL Chikalov[4], Sudaltmana LLC
ERDENEJARGAL Choindonjamts[5], Institute of Geology, Mongolian Academy of Sciences

Abstract

The gold deposits and occurrences in Mongolia are separated into 23 metallogenic belts with enormous potential for gold mining. These gold deposits and occurrences are genetically classified into many types such as porphyry, VMS, orogenic, intrusion-related and epithermal vein types. In this study, we tried to compare the ore minerals and gold mineralization with their crystal form of a few main gold deposits in Mongolia such as Tavt deposit, Gatsuurt, Ereen, Sujigtei deposits of the Boroo-Dzuunmod ore district, Khan-Altai deposit and North Eagle deposit. In these deposits, the gold mineralization might be related to sulfide minerals whose crystals mostly belong to the cubic crystal system. Arsenic (As) and gold (Au) concentrations in some gold deposits in Mongolia are positively correlated and both arsenopyrite and pyrite occur together. The analyses of ore minerals in these deposits indicate that Au may be found in ore minerals in As-bearing pyrite as well as tennantite (Cu12As4S13), arsenopyrite (FeAsS), enargite (Cu3AsS4) and other ore minerals. Pyrite in a pentagonal-dodecahedral (210) crystal stably holds a larger amount of gold than two primary crystal forms of pyrite such as hexahedron (100), and octahedron (111). Because the pentagonal-dodecahedral (210) pyrite is widely distributed in Mongolian gold deposits pyrites could be used as a mineralogical criterion in exploration survey to prospect gold.

Keyword

Crystal form, Pentagonal-dodecahedral pyrite, Sulfide minerals, Gold deposits, Mongolia

The role of mineral-related industries in Chinese industrial pattern

Weidong LI[1]*, Institute of Mineral Resources, Chinese Academy of Geological Sciences (wadeli55@outlook.com)

Abstract

Mining industry provides raw materials for economic development, and is a basic industry with strong correlation with other industries. Meanwhile, mining industry possess the feature of “high energy consumption, high pollution and high emissions”. Especially in today’s society where environmental protection is increasingly becoming the main theme, it has become an important issue for people to actively coordinate the relationship between mining and environmental protection, and promote the green transformation of mining industry. Combining industrial relationship and complex network, industrial complex network is applied to explore the industrial relevance, which is a perfect method to research industrial pattern. Based on the input-output data of China (1990–2018), this paper constructed the industrial complex network model to describe the evolution characteristics of Chinese industrial pattern. Then we focused on the mineral-related industries, to explore their role and position in Chinese industrial pattern by analysis of network overall and individual indicators and community division. The results show that Chinese industrial network has small world property, and the closeness of various industries is increasing, and the characteristic of industrial clusters ais obvious; The system of Chinese manufacturing industry is becoming more and more perfect and remains an important pillar and foundation of the national economy; Smelting and processing of metals industry plays an important role in connecting the preceding and the following. This paper provides a new perspective for the study of China’s mining industry pattern and puts forward corresponding policy suggestions for the adjustment of industrial structure. At the same time, relevant development experience can also serve as a reference for subsequent countries.

Keyword

Industry pattern, Mineral-related industries, Complex network, Input-output, China

Simulation Analysis of Supply Crisis Propagation Based on Global Nickel Industry Chain

Xingxing WANG[1]*, Chinese Academy of Geological Sciences (xiaoxing0523@126.com)

Abstract

Nickel is a key metal in the low-carbon transition. The industrial chain is a chain network organization system composed of various layers from the initial production of raw materials to the final product sales. The intensified contradiction between supply and demand can easily lead to the problem of resource supply security, and the occurrence of supply shortages will endanger the healthy and orderly development of the whole industrial chain. Therefore, from the perspective of the industrial chain and based on the trade data related to the nickel industrial chain, this study first constructs a multi-layer network model of the nickel industrial chain, and analyzes its trade structure characteristics and the correlation between different layers. It is found that the export policies of resource exporting countries may influence trade structure characteristics. On this basis, a multi-layer network crisis propagation model of the nickel industrial chain is constructed to simulate the impact and its propagation path of Indonesia supply shock on the entire industrial chain. With the increase of supply shock in Indonesia, the impact of crisis gradually concentrates to the downstream. Along the industrial chain, the number of affected countries gradually increases, but the difference in the impact degree gradually decreases. In addition, there are certain differences in countries affected by crisis at different layers of the industrial chain, and the crisis spreads mainly from China and Japan to the countries in midstream and downstream. The research results can provide corresponding policy suggestions for countries involved in the nickel trade.

Keyword

Nickel industry chain, Simulation, Multi-layer network, Crisis propagation, Indonesia supply shock

GEOLOGICAL-GEOCHEMICAL MODEL OF THE DAUGYZ GOLD DEPOSIT (SOUTHERN TIEN SHAN, CENTRAL KYZYLKUM)

JAKHONGIR MOVLANOV[1]*, University of Geological Sciences (ugs.cgt2020@gmail.com)

Abstract

The geochemical model of the Daugyz deposit represents a generalized multicomponent, spatially ordered image of the above-background contents of ore elements of a typomorphic complex from above-ore to sub-ore levels. The formation of the Daugyztau gold-sulfide deposit took place in several stages. During the exogenous-diagenetic stage, the accumulation of ore-hosting terrigenous-flyschoid formation, enriched with dispersed ore mineralization, occurred. During the final stages of diagenesis and the elision-catagenetic stage, sediment compaction and initial redistribution of matter occurred as a result of the movement of fluids from the center and depths of the system to its periphery. The thermofluidic impact of large masses of granitoids and tectonic dislocations caused regional metamorphism of strata, regeneration and redeposition of primary dispersed mineralization from gold-bearing sulfide horizons into subconformable rock bedding and cutting zones. This contributed to the local concentration of disseminated ore mineralization. During the metamorphogenic-hydrothermal stage in tectonic zones, further metamorphogenic-metasomatic transformations of mineralized rocks and deposition of hydrothermal mineralization into steeply dipping veinlet-disseminated ore deposits occur in metasomatites of the beresite and argillicite formation. A paragenetic connection of hydrothermal processes with a large massif of granitoids, the roof of which is located at a depth of 3-5 km from the surface, is assumed.

In the Daugyztau ore field, intense and contrasting primary halos of Au, Ag, As, Sb have a correlated distribution, forming a generally complex geochemical field with concentrations on objects of gold-silver mineralization. Based on the correlation in the primary aureoles, two ore-geochemical associations were identified: Au+As+Sb+Ni (gold-pyrite-arsenopyrite veinlet-disseminated ores) and As+Ag+Sb+ Pb +Ba+Cu+Zn (polysulfide-sulfosalt-silver ores). The association of coherent elements Ni+Co+V+Mn+Cr+(Cu+Zn) is represented by fields of removal from ore-bearing positions and accumulation in their frontal parts in the form of a discontinuous ring. The through elements in the ore and metasomatic associations are Cu, Zn, Ni.

The typical chemical accumulation complex of the Daugyztau deposit is Au, Ag, As, Sb and Hg. The maximums of their concentrations are located near fault zones. Transverse zoning is manifested by a contrasting distribution of the contents of these elements in the footwall, while in the hanging wall there is a wider halo zone with a gradual decrease in the intensity of the haloes from the axis of the ore-hosting fault. Longitudinal geochemical zoning of the deposit - in the direction from north to south there is a consistent increase in the thickness and intensity of the halos of Ag, Cu, Pb, Sb, As, Hg. Ore deposits coincide with halos of Au, As, Ag. Small low-intensity tungsten halos are characteristic of the recumbent side of ore deposits. The vertical zoning of mineralization at the Daugyztau deposit is expressed by various complexes of indicator elements representing lower ore, subore (W, Zn, Cu, Mo), ore (As, Au, Ag), supra-ore and upper

ore (Sb, Hg, Pb, Ag,) sections .
The results were used to assess the prospects for gold mineralization on the flanks of the ore field and at depth.

Keyword

geochemical field, mineralization, generalized, gold-sulfide deposit, ore-hosting

Research on the impact of global mineral trade structure on national economy

XIAN XI[1]*, Research Center for Strategy of Global Mineral Resources, Chinese Academy of Geological Sciences (xixianer01@163.com)
Xiangyun Gao[2], School of Economics and Management, China University of Geosciences, Beijing

Abstract

Mineral resources are considered the upstream raw materials of the industrial chain and represent an important material basis for economic sustainable development. Countries have different mineral resource endowments promote trade development. According to the theory of resource dependence and interdependence, countries have close trade relations, through which they can exchange resources to meet domestic needs and economic development. Different countries have different trading partners, media capabilities and importance in the networks, which make them different in the ability to obtain and provide resources, thus leading to different roles of countries and different influences on their GDP. Therefore, we construct global mineral trade networks and analyze their overall characteristics; we use network parameters to represent the roles of the countries and apply the panel quantile regression method to test the relationship between the roles of the countries and the GDPs. We find that a country's media capacity is beneficial to economic growth, and when a country's resources are readily accessible, it is adverse to the economic development; export is conducive to economic growth, while high dependence on external resources is not conducive to economic growth and it is good for a country's economy to have many important trading partners. In addition, countries with a high economic level should attach more importance to the strategic reserve of mineral resources, while countries with a low economic level should attach more importance to the development of an international market.

Keyword

Mineral resources, Global trade, Complex network, Panel quantile regression

Reinterpretation and 3D visualization of Pine Creek Orogen (NT, Australia)

Gemma Mitjanas[1]*, Sustainable Minerals Institute (Univ of Queensland)
(g.mitjanascolls@uq.edu.au)
Steven Micklethwaite[2], Sustainable Minerals Institute (The University of Queensland)

Abstract

The Paleoproterozoic Pine Creek Orogen (PCO; Northern Territory, Australia) is a multi-commodity province rich in resources, including minerals crucial for the energy transition (1). The large spectrum of metals, the range of rock types of different litho-geochemistry, the presence of Archean basement, and the complex structural and metamorphic patterns, make the PCO an attractive exploration target. However, considering the 15 critical minerals and 13 emerging critical minerals included in the Northern Territory's lists, only 5 commodities are currently being produced (2).

We reviewed and integrated open-source data to provide an updated geological map and a 3D geological model of the Central Domain of the PCO. We used regional geological and geophysical maps to build cross-sections and a preliminary 3D geological model, which was iteratively refined using 2D and 3D geophysical forward and inverse modelling.

Our results underscore the region's geological complexity, particularly in terms of its structural evolution and the spatial distribution of mineral systems. The structural geometries revealed in the final interpretations are suggestive of the possibility that salt tectonics played a role in Paleoproterozoic orogenesis, and the Cullen Supersuite unit and main faults appear to have a key role in the distribution of critical minerals.

The applied methodologies and workflow prove the value of the use of open-source data during the preliminary phases of exploration, thereby, enhancing sustainable practices. In addition, the outcomes of this project provide the basis for stimulating exploration and investment in the Northern Territory, with the opportunity of leveraging the results for mineral systems analysis and informed exploration targeting strategies.

Keyword

3D Modelling, Critical Minerals, Geophysics

Sources of dissolved solutes and physico-chemical conditions of fluorite (±barite) mineralisation at Dongargaon, India: Constraints from geochemical study of bulk rock and hydrothermal minerals

PANKAJ PRALHADRAO VAIDYA[1]*, GEOLOGICAL SURVEY OF INDIA
(pankaj.vaidya@gsi.gov.in)
Mohd Qaim Raza[2], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai

Niketan Prakash Khedkar[3], GEOLOGICAL SURVEY OF INDIA
Sakthi Saravanan Chinnasamy[4], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai
Anushka Singh[5], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai

Abstract

Hydrothermal-type mineralisation is the most abundant genetic types of fluorite mineralisation so far reported in the literature. Characteristically, the involved fluid is consistently low to moderate in temperature (<300°C) however extensively varied in salinity and chemical composition. Sources of dissolved solutes such as calcium, fluorine, rare earth elements etc. are reported from diverse geological reservoirs in varied geological settings. Dissolved solutes are the main constituents of ore deposit formation therefore constraining it's sources will be helpful for understanding the genesis of mineralisation and also for further exploration of deposit.

Dongargaon fluorite (±barite) deposit is situated in the Chandrapur district of Maharashtra, India. Geologically, the Archaean Bengpal gneissic complex forms a basement for all overlying sediments. The sedimentary strata are part of the Gondawana Supergroup, Vindhyan Supergroup, Sulluvai Group, Pakhal Supergroup and Penganga Group. The Sahyadri Group's Deccan Basalts are overlying these sedimentary layers. Fieldwork carried out in the Dongargaon fluorite (±barite) mine area reveal that the dominant lithology of the local area is Penganga chert and a lesser amount of Penganga limestone. At the same time, phyllitic rock materials were highly weathered. The unconformity between Penganga sediments and Gondawana sediments is marked by the presence of a Conglomerate. Penganga chert and limestone are extensively brecciated indicating past fault activity in the area that has created open spaces for hydrothermal fluid circulation. Fluorite mineralisation is hosted within Penganga chert however Penganga limestone is devoid of fluorite mineralisation. The fluorite mineralisation is dominantly botryoidal (stage-1) and developed as radiating crystals perpendicular to the brecciated chert. As per the field observation feeble mineralisation is also observed as alternate chert and fluorite bands and cubic fluorite (stage-2). The veins of cubic fluorite cut across the botryoidal type fluorite indicating the late stage of fluorite mineralisation.

Previously carried out petrography suggests hydrothermal assemblage as fluorite+quartz+baryte. Reported fluid inclusion study of late-stage fluorite mineralisation reveals involvement of low salinity (<1.5 wt.% NaCl equivalent)-low temperature (<180°C) hydrothermal fluid that was probably sourced from meteoric water.

To constrain the sources of dissolved solutes and physico-chemical condition of mineralisation, pure phases of hydrothermal minerals and associated rocks were separated, digested and analysed for major, trace and REE concentration using ICPMS. The fluorites are low to moderate (12—195 ppm) in REEs concentration and consistently show PAAS normalised HREE enriched (NdSN/YbSN= 0.23—0.28) REE+Y patterns. The limestone and host chert shows the PAAS normalised HREE enriched to flat (NdSN/YbSN= 0.58—1.20) REE+Y patterns. Both botryoidal fluorites and host rock show similar Y/Ho ratios (30—49), however the late-stage cubic fluorite shows a high degree of fractionation (Y/Ho =69). Fluorites of both stages show typically positive europium anomaly (1.2—4.3). The cerium anomaly of botryoidal fluorites is negative (CeSN/CeSN* = 0.73—0.76) however that of cubic fluorite is neither positive nor negative (CeSN/CeSN* = 1.0). Lithologically, limestone is the possible source of Ca2+ as chert is devoid of Ca2+. As per the available literature fluorine content is much higher in clastic rocks than the limestone therefore it is suggested that the source of fluorine is dominantly

Keyword

hydrothermal, fluorite mineralisation, geochemistry, dissolved solutes, physico-chemical condition

Ultramafic-Hosted Magnesite Deposits in Southern Peninsular India: Spectral and Stable Isotopic Insights

HARITHA A[1]*, Department of Earth and Space Sciences, Indian Institute of Space Science and Technology, Thiruvananthapuram 695 547, India (harithaanil1994@gmail.com)
Rajesh V.J[2], Department of Earth and Space Sciences, Indian Institute of Space Science and Technology, Thiruvananthapuram 695 547, India
Satish-Kumar M[3], Department of Geology, Faculty of Science, Niigata University, 2-8050 Ikarashi, Nishi-ku, Niigata 950-2181, Japan

Abstract

Magnesite (MgCO3) is a major carbonate mineral that forms through the alteration of magnesium-rich rocks within diverse marine and non-marine geological environments. Magnesite deposits of southern India are mainly confined to the ultramafic rocks and are characterized by intricate network of veins and fractures. The main objective of the study is to investigate the source of the mineralizing fluid and the prevailing physico-chemical conditions that controlled the formation of magnesite deposits, in particular those hosted within the Archean to Neoproterozoic ultramafic rocks. Ultramafic-hosted magnesite is found at several locations within the Archean greenstone belt of the Dharwar craton such as Doddakanya, Jambur, Karya, and Nuggihalli region. These magnesites are confined to ~3.3 Ga-old ultramafic bodies belonging to the Sargur group supracrustals especially, highly weathered dunite. Similarly, magnesite occurrence of southern granulite terrane is observed in the ultramafic of Attappadi, and serpentinized dunite of the Salem mafic-ultramafic complex (SMUC). Mineralization in all these occurrences is restricted up to an average depth of 25m below the surface and within the soil horizon.

We conducted a spectral characterization of magnesite mineralization using various techniques. The hyperspectral data revealed paired absorption at 2.3 and 2.5 μm, attributed to C-O bond vibration overtones and combination tones of C-O stretching and bending. FTIR analysis identified characteristic vibrational frequencies in the spectral ranges of 1434, 880, and 747 cm−1, while laser Raman data showed peaks at or near 212, 332, 735, 1096, and 1460 cm−1. The C-O isotopic data obtained from magnesite samples in Karnataka indicate average 18O(V-SMOW) values of 30.6‰ and 13C(V-PDB) values around -2.6‰ while the isotopic composition of magnesite is δ13C =-3.6‰ and δ18O = 25.5‰ from Salem. Meanwhile, stable isotope analysis of the magnesite samples from Attappadi yielded a δ13C and δ18O value in the range of -5 to -0.6‰ and 26‰ to 28‰ respectively. The stable isotopic values, characterized by lighter carbon and heavier oxygen, imply that the mineralizing fluid cannot be solely sourced from the deep mantle, with the heavier oxygen indicating a meteoric/atmospheric origin. The oxygen isotopic composition depicts the precipitation temperature of magnesite from all the study areas of southern peninsular India indicating a low-temperature replacement reaction. We estimated the formation temperature of magnesite between 23 to 49ºC based on the oxygen isotope thermometry using a fractionation factor from Aharon, 1988. Based on all these observations, we propose a

model of the genesis of the magnesites that invokes the percolation of meteoric water through weak planes and fractures into the ultramafic rocks. The plausible source of the mineralizing fluid involves a combination of surficial reservoirs and carbon produced by the decarbonation of marine carbonates.

Keyword

Magnesite, Southern India, Genesis, Spectroscopy, Stable isotopes

Nanoparticles Observed by TEM from Gold, Copper-Nickel and Silver Deposits and and Their Significance for Mineral Exploration in Covered Terrains

Bimin ZHANG[1]*, Institute of Geophysical and Geochemical Exploration, CAGS
(zbimin@hotmail.com)

Abstract

Geochemical exploration for concealed deposits covered by thick rocks overlying, transported soils present special problems. Geochemists conjectured that ultrafine metal particles or metal elements could be carried onto bubbles or micro-flow of geogas and migrate upward to the surface and ultrafine metal particles or metal elements transported to the surface by gases could be trapped by soil geochemical barriers. After years of study, ultrafine metal particles as nano-scale have been extensively observed in the geogas samples. In this study, nanoscale particles were observed in soils over three concealed ore deposits by using transmission electron microscope (TEM). The particle characteristics in sizes, shapes and chemical compositions are compared for study on the three types of Au, Cu–Ni, Ag Deposits. The results show that (1) nanoparticles of native metals or alloys widely occur in soils, geogas, and ores in the three mineral deposits; (2) nanocrystals occur in soils, geogas, and ores; (3) the sizes of nanoparticles are similar in diameter from 5 nm to 100 nm; (4) the particles tend to agglomerate into clustering forms; (5) the most obvious difference among nanoparticles collected from the three types of deposits is the chemical compositions that nanoparticles at Au and Ag-polymetallic deposits have Au element, while nanoparticles at Cu–Ni deposit have Ni and Cr elements; (6) nanoscale metal particles are not discovered in the samples collected from the background zone. The results indicate that nanoparticles of metals have good inheritance relationships with the deposits. The nanoscale particles of native metals or alloys from the ore body can migrate with the ascending flow of gases through structural fissures or rock pores upwards to the surface. On arriving at the surface, some of the particles persist in the soil, whereas gases and other particles are trapped by soil geochemical barriers. The discovery of nanoscale particles in geogas and soils over concealed ore bodies also provides direct observation evidence for deep-penetrating geochemistry using soil and geogas as sampling media to search for deeply concealed ore deposits.

Keyword

Nanoparticles, Gold, Copper-Nickel and Silver Deposits, Mineral Exploration, Covered Terrains

Analysis of the Safety Situation of Potash Resources in China and Suggestions for Global Cooperation

YAN ZHANG[1]*, Institute of Mineral Resources,Chinese Academy of Geological Sciences (398232175@qq.com)
YANSONG ZHANG[2], Chinese Academy of International Trade and Economic Cooperation

Abstract

Potassium salt is mainly used to produce potash fertilizer, which is an essential material basis for agricultural production and has important strategic significance for ensuring food security. The distribution of potassium salt in the world is extremely uneven, and a large number of resources are concentrated in a few countries, making it a natural monopoly. Major countries in the world have included it in the list of strategic minerals. At present, the global population continues to grow, national protectionism and local geographical conflicts intensify the food crisis, and the demand for potash will continue to grow in the future, which may become the focus of international competition. As the world's largest potassium salt consumer, China relies on international imports for nearly half of its resources. Under the new situation, the safety of China's potash mineral resources must be considered in the global resource governance system, systematically plan the layout of overseas resources, continuously deepen international cooperation, and use political, diplomatic, economic and technological projects to ensure the safety of China's potash supply system. In this regard, this paper puts forward the following suggestions: first, deepen the innovation of potash mineralization theory, broaden the scope of potash resource prospecting, and at the same time carry out technological innovation in potash mining; At the same time, carry out technological innovation in potash mining; third, promote the construction of a resource cooperation system, and promote cooperation in politics, diplomacy, capital, technology, engineering, etc.; fourth, strengthen industry cooperation, form industry alliances, and enhance international competitiveness; The fifth is to improve the construction of relevant service guarantee organizations and expand the communication and exchange mechanism.

Keyword

Potassium resources, Supply potential evaluation, Supply and demand pattern, Resource security situation, Resource security situation

First row transition metals deportment in Cretaceous karst bauxite: the case of the southern Italy and Sardinia Island deposits

Roberto BUCCIONE[1], Department of Sciences, University of Basilicata, viale dell'Ateneo Lucano 10, 85100 Potenza, Italy
Paola MAMELI[2], Department of Chemical, Physical, Mathematical and Natural Sciences, University of Sassari, Via Piandanna 4, 07100 Sassari, Italy
Giovanni MONGELLI[3]*, Department of Sciences, University of Basilicata, viale dell'Ateneo Lucano 10, 85100 Potenza, Italy (giovanni.mongelli@unibas.it)
Giacomo OGGIANO[4], Department of Chemical, Physical, Mathematical and Natural Sciences, University of Sassari, Via Piandanna 4, 07100 Sassari, Italy

Abstract

In the last decade an increasing interest has been paid to the distribution of critical metals and critical raw materials in karst bauxite deposits. Great interest has been devoted to Rare Earth Elements although some deposits show remarkable enrichment in other critical metals including, for instance, W, Ta , and some first row transition metals such as V, Cr, Co, and Ni.

Here we explore the deportment of V, Cr, Co, and Ni in five karst bauxite deposits in southern Italy (Apulia and Campania Districts) and Sardinia Island. These areas are located in the converging zone between the African and Eurasian plates since Cretaceous. Sardinia is a microplate which was part of the southern margin of the European plate whereas Adria is considered a single plate separated from the African plate by the Ionian basin .

According to the Al2O3-SiO2-Fe2O3 diagram the karst bauxite of the Campania and Apulia district are mostly Fe-rich bauxites and bauxites. The Sardinian ores are bauxites and Fe-poor bauxites, although several samples fall in the clayey bauxite field. The ores show larger median values of first row transition metals with respect to the average Upper Continental Crust. Sardinian ore is enriched in V (median value 623 ppm) whereas in the Apulia District are observed the highest median values for Cr (Otranto site: median value 1005 ppm) and Ni (Spinazzola site: median value 470 ppm). Further, the distribution of both Co and Ni is characterized by the presence of several outliers.

R-mode Factor Analysis was performed on each of the five datasets including SiO2, Al2O3, Fe2O3 TiO2, V, Cr, Co, and Ni, devoid of the outliers and after Varimax rotation. Multivariate statistics indicate that three factors always explain more than 84% of total variance. In some deposits Co and Ni share significant weights in the same factor suggesting common fate. In the ores from the Apulian district, Fe2O3 and V share significant weights in the same factor indicating Fe-oxyhydroxides play a role in controlling V. Al2O3 and TiO2 in four deposits show significant weights in the same factor confirming Al-hydroxides and Ti oxide accumulate during bauxitization. In several cases Al2O3 and TiO2 share significant weights with transition metals such as Cr and Co suggesting that Al-hydroxides and Ti oxide may also play a role in distributing these elements.

Keyword

Italian Cretaceous karst bauxite deposits, first row transition metals, R-mode factor analysis

Potential Natural Hazards of Mineral Facility and Effect of Mineral Production Using Geospatial Data for Asia-Pacific Region

Jaewon CHUNG[1]*, National Minerals Information Center, U.S. Geological Survey (jchung@usgs.gov)
Ji Won Moon[2], National Minerals Information Center, U.S. Geological Survey
Sean Y. Xun[3], National Minerals Information Center, U.S. Geological Survey
Steven D. Textoris[4], National Minerals Information Center, U.S. Geological Survey

Abstract

The U.S. Geological Survey (USGS) has recently updated a geodatabase containing mineral facility (mines and plants) data for countries in the Asia-Pacific region. The geodatabase contains data on about 2,410 mines and 3,320 mineral processing plants with the respective annual production capacity of mineral commodities. This study attempted to assess the risk of mineral supply disruption on a regional scale and at a facility level by overlaying the subset (selected mineral commodities, such as lithium-ion battery minerals and tin) of the geodatabase with natural hazards maps showing designated susceptibility of floods and landslides and the severity of probabilistic earthquake. In particular, earthquakes may cause damage to mineral facilities and related infrastructure and trigger earthquake-induced landslides and -fires, which can hinder mineral production and supply availability. Preliminary analysis shows that about 50 bauxite-tin mines and plants in Sumatra, which dominate such mineral output in Indonesia, would be prone to strong-to-severe seismic damages. The ground motion in Sumatra near the subduction zone ranges from 0.3 g to 0.6 g for the peak ground accelerations for 10% probability of exceedance in 50 years (or 475-year return period). Meanwhile, the ground motion in the Malaysian peninsula within the stable tectonic plate is likely to be low, implying facilities in the area are not prone to seismic damage.

Keyword

Geodatabase, Mineral commodities, Supply disruption, Lithium-ion battery minerals

The impact of oil decoupling between EU and Russia on the pattern of global oil trade under the Russia-Ukraine military conflict

Xiu WANG[1]*, +86)15210984055 (wangxiucugb@163.com)
Chonghao LIU[2], +86)13811900135

Abstract

Oil plays an important strategic role in the global economic system and is a strategic resource related to national security. The ongoing conflict between Russia and Ukraine is not only a military conflict, but also another kind of "war" in the field of oil and other energy, which has brought an impact on the global oil supply pattern. The study of the influence of the Russo-Ukrainian military conflict on the pattern of global oil supply is of great significance to the study of oil situation and strategic decision of various countries. This paper simulates the oil decoupling between the EU and Russian by using scenario sham, and uses the method of complex network to analysis the impact of the decoupling on the global oil supply pattern under the background of the military conflict. Before the EU-Russia oil decoupling, the oil consumption of the EU was heavily dependent on Russia, and the EU members and Russia were divided into a same trade group. After the decoupling, the trade group is disintegrated, and Russia enters another trade group where China is the main importer. European countries mainly enter the groups where North America or the Middle East countries are the main exporters. The EU-Russia oil decoupling will lead to a decline in the status of Russia in the global oil trade, while the status of some countries in North America and the Middle East will increase.

Keyword

Russia-Ukraine conflict, oil trade, supply pattern, oil decoupling

Copper-Gold Mineralization in a Covered Basement Complex of North Delhi Terrane, Rajasthan: Implication towards Mineral Potential of Basement Rocks

Arindam MISRA[1]*, Geological Survey of India (arindam.misra@gsi.gov.in)
Debapriya Chatterjee[2], Geological Survey of India
Avik Manna[3], Geological Survey of India

Abstract

The basements rocks of Mangalwar Complex are rarely exposed in the northeastern part of Jaipur and surrounding areas along with Proterozoic cover sequence of Delhi Supergroup within North Delhi Terrane. Limited information on mineral potentiality and nature of mineralization in basement complex is due to paucity of outcrops in this terrain. The present study with geological, geophysical and geochemical mapping followed by targeted drilling has resulted in identification of copper-gold mineralization in the partly covered areas of Dausa district of Rajasthan.

The boreholes drilled in the study area intersected sulphides at different drilled depth in the form of pyrite, pyrrhotite, and chalcopyrite as major sulphide phases whereas bornite, covellite, cubanite and sphalerite are present in minor concentration. At shallow level the primary sulphide association includes bornite-chalcopyrite whereas bornite-covellite-digenite occurs as secondary (supergene) type. The ore association at depth includes only primary ore minerals like chalcopyrite, cubanite and minor bornite and sphalerite. The chalcopyrite-cubanite solid solution is well preserved with blebs and laths of cubanite occurring within host chalcopyrite. At deeper level, chalcopyrite dominant association with minor pyrite and cubanite is present. The chalcopyrite-sphalerite with rare pyrite is another important assemblage. The sphalerite grains show mutual boundary with chalcopyrite in most cases and with pyrite in rare cases.

The textural study of ores shows presence of chalcopyrite with serrated margins and also occupy interstices of silicate grain boundaries whereas pyrite grains are often shattered with healing of cracks by pyrrhotite. At many places, sphalerite occurs as islands within the chalcopyrite host or is being embayed by chalcopyrite. Well-developed chalcopyrite disease has been observed in few sphalerite crystals occurring in association with large chalcopyrite. The mineral chemistry analysis of Cu-ore minerals shows presence of silver and bismuth suggesting hydrothermal activity as possible source of ore fluid generation.

The study of sulphide ores suggests a) the chalcopyrite-cubanite association formed due to probable intermediate composition of hydrothermal ore fluid at 350º-400°C and b) a metamorphism-induced partial melting of sulphide ores facilitates the formation of chalcopyrite disease by producing a Cu-enriched but S-deficient melt phase and Fe- and S-enriched sphalerite. Presence of broken pyrite and pyrrhotite crystals followed by development of chalcopyrite disease indicates towards metamorphism, culminating in sulphide partial melting as one of the mechanism of ore fluid formation.

The observations made in the present study indicates hydrothermal activity as plausible mechanisms for ore generation followed by later metamorphism induced partial melts, producing

chalcopyrite disease which often indicate towards presence of massive sulphide deposits. The discovery of Cu mineralization in a concealed basement complex in North Delhi Fold Belt has opened up a new horizon in context of mineral potentiality of northeastern part of Rajasthan.

Keyword

Copper, Mineralization, Ore-Texture, Basement Complex, NDFB

Genesis of Gold mineralization in Sonakhan Greenstone Belt, Bastar Craton, India: constraints with fluid inclusion studies.

Sathyavani C[1]*, Geological Survey of India (sathyavani.c@gsi.gov.in)
Aneesh SS[2], Geological Survey of India
MM Korakoppa[3], Gelogiacal Survey of India

Abstract

The Neo-Archean Sonakhan Greenstone Belt (SGB) located in the north-eastern fringes of Bastar craton, Central India, is dominated by Basalts, Andesites, Dacites and Rhyolites association. Gold mineralization within Sonakhan schist belt has been studied in terms of its mode of occurrence, structural association, metamorphic setting, metal association, geochemistry of host rocks, nature and source of ore fluids, hydrothermal alteration and tectonic setting. Sulphide mineralisation is more abundant in metabasalt, Quartz-carbonate veins and BIF. Sulphide minerals are pyrrhotite pyrite, arsenopyrite, chalcopyrite with occasional sphalerite. Other associated mineral phases identified in the rocks are cobaltite, tellurobismuthite, lollingite, galena, REE and Pd-Bi-Teluride mineral phase. Gold grains identified within carbonate vein is associated with chalcopyrite and lollingite. PGE (Pd-Bi-Teluride) grain associated with pyrrhotite in metabasalt.

Fluid Inclusion studies of wafers of mineralised quartz and calcite veins indicate the presence of primary and secondary mono-phase/bi-phase aqueous and carbonic inclusions. The major component in aqueous phase is NaCl in the fluid system. The fluid inclusion studies show a low salinity NaCl±KCl±MgCl2 along with H2O fluid which is associated with mineralization in this area. The trends of inclusion plots indicate the Isothermal mixing, boiling and cooler less saline fluids. Homogenization temperature vs. salinity diagram for inclusions with fields for various fluid types shows the fluid source is metamorphic water indicated by the salinity ranging from 1.32 - 12.96 wt.% NaCl equivalents. The inclusions plotted mainly fall in Lode Au, epithermal and massive sulphide type of deposit indicating the field of dominant sulfide complexes which were responsible for carrying epithermal gold which precipitated along with silica in the veins. The two-phase fluid inclusions of L + V having homogenization temperatures from 175˚C to 321˚C (average homogenization temperature is 231.16°C) and salinities from 1.32 to 12.96 wt% NaCl equivalent (average salinity was 7.14 wt% NaCl equivalent). The Lack of gases like CH4, N2, H2, Ar, and H2S indicates the loss and release of such gases during boiling, which is one of the typical characteristics of epithermal mineralization. The intrusion of plutonic bodies together with presence of volcanic rocks like andesite, trachyandesite, basalt, and dacite have provided the conditions required for circulation of mineralizing fluids. The free flow of hydrothermal fluids with intermediate temperatures close to the surface have caused the occurrence of silica veins together with anhydite indicate hydrothermal origin of gold mineralization.

Keyword

Gold mineralization, Quartz carbonate veins, Fluid inclusion studies, Hydrothermal gold deposit, Sonakhan Greenstone belt

Combined Study of Gold-Bearing Arsenopyrite of Orogenic Gold Deposits: High Resolution 3D X-ray Computed Tomography, LA-ICP-MS and EMPA Analyses

Evgeny NAUMOV[1]*, Central Research Institute of Geological Prospecting for Base and Precious Metals (naumovevg@gmail.com)
Yuri Kalinin[2], Sobolev Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences
Galina Palyanova[3], Sobolev Institute of Geology and Mineralogy of Siberian Branch of Russian Academy of Sciences
Lyudmila Kryuchkova[4], St. Petersburg state university
Viacheslav Voitenko[5], Geological Center of SPbSU
Vera Abramova[6], Institute of Geology of Ore Deposits, Petrography, Mineralogy and Geochemistry Russian Academy of sciences

Abstract

Using high resolution 3D X-ray Computed Tomography (HRXCT) and LA-ICP-MS and EMPA analyses the distribution and composition of gold in acicular arsenopyrite of a pyrite-arsenopyrite association from Suzdal (East Kazakhstan), Olympiada (Yenisei Ridge, Russia) and large pseudorhombic arsenopyrite crystals from Bazovskoe (Yakutia, Russia) orogenic-type deposits were investigated. HRXCT allow to reliably identify dense phases, such as inclusions of native gold in crystals of a mineral-concentrator (arsenopyrite, pyrite) without destroying the hosted mineral grains. But, HRXCT study is most effective when it is used together with other studies such as SEM, EMPA, LA-ICP-MS, etc. The combination of HRXCT with the traditional methods of the analysis made it possible to establish that the content of "invisible" gold in the acicular arsenopyrite of the orogenic deposits (Suzdal and Olympiada) vary within 195-1185 ppm. The gold content in arsenopyrite is quite reliably determined by various methods such as atomic absorption, EMPA and LA-ICP-MS. Three-dimensional HRXCT reconstruction revealed micro-inclusions of native gold in the central parts of the acicular crystals and aggregates of the arsenopyrite of Suzdal and Olympiada deposits, although previously researchers assumed the presence only of “invisible” gold in unspecified form in such acicular crystals.

The LA-ICP-MS study for arsenopyrite of the Olympiada deposit determined the contents of other impurity components (Co, Ni, Cu, Zn, Sb, Te, Ba, Pb) and established a uniform distribution of gold within the analyzed grains. Also, in some arsenopyrite grains, regular variations in Sb content were revealed. The distribution of antimony does not correlate with the distribution of other elements, and SEM studies did not show the presence of micro-inclusions of Sb-bearing minerals. This is possibly caused by the zonal structure of arsenopyrite grains.

According to HRXCT studies of gold distribution in large crystals of arsenopyrite from ores of the Bazovskoye deposit (Yakutia, Russia) it was found that gold shows selective crystallization not only within the aggregate of arsenopyrite crystals in the ore zone, but also among the crystallographic directions of a single arsenopyrite crystal.

After research performed, we can suggest that HRXCT technique permits:

1. To do preliminary estimation of the amount of gold inclusions in minerals or host rocks and draw reasonable conclusions about the gold content of the ores.
2. To study in detail the distribution patterns of metal inclusions (associated with certain minerals, cracks, crystal growth faces, etc.) and to evaluate the morphology of grains and veinlets without destroying the matrix.
3. Applying complex methodologies (HRXCT combined with quantitative analysis of gold content) to determine the form of the metal; to define which type of gold makes the greatest contribution to the economic productivity of mineralization - the inclusion of native gold or “invisible” gold in the form of nanoparticles or structural impurities.
4. HRXCT studies offer new opportunities for the development of efficient technologies for ore processing in order to maximize the extraction of the gold, silver and PGE minerals.

Keyword

high resolution 3D X-ray Computed Tomography, gold-bearing arsenopyrite, orogenic gold

The National Geological Plan of Angola (PLANAGEO)

José Luis GARCÍA LOBÓN[1]*, IGME-CSIC (jl.garcia@igme.es)
Enrique Merino Martinez[2], IGME-CSIC
Jorge Fernández Suárez[3], IGME-CSIC
Javier Escuder Viruete[4], IGME-CSIC
Maria Joao Batista[5], LNEG
Joao Carvalho[6], LNEG
Elsa Ramalho[7], LNEG
Jose Manuel Plastov[8], IGEO

Abstract

The National Geological Plan of Angola (PLANAGEO) has been one of the most significant african geothematic projects of recent decades. The Government of the Republic of Angola launched the project through Presidential Resolution 52/09. The project was implemented by the Geological Survey of Angola (IGEO) under the supervision of the Angolan Ministry of Mineral Resources, Petroleum and Gas (MIREMPET). The main objectives of PLANAGEO were to deepen the knowledge of Angola's geological resources, to foster the diversification of the national economy, and to attract foreign investment to promote the socio-economic development of the country. The PLANAGEO consortium, consisting of the Geological and Mining Institute of Spain (IGME), the National Laboratory of Energy and Geology of Portugal (LNEG), and the company Impulso Industrial Alternativo (IIA), was awarded to execute the project in southern Angola, covering an area of approximately 480,000 km2. The contract, worth USD 115,312,500, was signed in October 2013 following an international call for tenders by IGEO. The work was carried out between July 2014 and the end of 2022. The project involved a regional aerogeophysical survey (magnetic/radiometric) and geological mapping at a scale of 1:250,000, along with other detailed geological mapping at a scale of 1:100,000. Additionally, synthesis mapping was carried out at scales of 1:500,000 and 1:000,000. Geochemical prospecting campaigns were conducted at a scale of 1:250,000, and other specific studies were made at a scale of 1:50,000. These studies included Metallic Minerals Mapping (CRMMA) and Rock and Industrial Minerals Mapping (CARMINA) in areas of special interest, for investigation of the potential of metallic and non-metallic mineral resources; as well as hydrogeological studies in the Angola´s Kalahari basin very much needed to relieve the present drought in the basin where underground water reservoirs are poorly known.

Keyword

Republic of Angola, Geological/geophysical/geochemical cartography, Natural resources

Mineral chemistry of tourmaline associated with the Zawar Zn-Pb deposit, Rajasthan, India

ARKODEEP SENGUPTA[1]*, Department of Geology and Geophysics, Indian Institute of Technology Kharagpur (reach.arko.sg@gmail.com)
SOUMI CHATTOPADHAYA[2], Department of Geology, Banaras Hindu University
KUMARI MEENU SINGH[3], Department of Geology, Banaras Hindu University

Abstract

Tourmaline occurs in diverse types of hydrothermal mineral deposits and can be used to constrain the nature of ore-forming fluids as a reliable indicator of the mineralizing processes. It occurs as an accessory phase associated both with the mineralized vein and stratiform-banded type pyritic Zn-Pb ore. The tourmaline grains mostly occur within bands of phyllite intercalated with dolomite as dispersed subhedral to euhedral, rod-shaped isolated grains aligned sub-parallel to the foliation along with pyrite and sphalerite. The grains are typically 50 μm in size, with a few exceeding 250 μm. They are often fragmented but corrosion-free. It most probably represents a relict detrital and/or early-formed metamorphic mineral. The grains are commonly zoned with blue or dark-brown cores surrounded by a light-brown rim of varying thickness. The colour change from the core to the rim is generally gradational and occasionally involves sharp optical discontinuities. Electron microprobe analysis on the tourmaline grains reveals that those with diffuse optical zonation have an apparently homogenous compositional pattern. In contrast, those with a sharp contact display a core-to-rim compositional variation where Al, Na, K, and Ca increase as Fe, Mg, and Si typically decrease. The most prominent change from the core to the rim is an increase in the Al and a decrease in the Fe and Mg. Thus, Fe and Mg substitution for Al is most likely. Microprobe analysis of tourmalines reveals that the FeO and MgO contents vary between 3.3 to 6.6 wt% and 7.8 to 11.70 wt%, respectively. The average Fe/Fe+Mg ratio of 0.42 for the analyzed tourmalines indicates they can be considered intermediate between the dravite and schorl species. The points on the Fe/Fe+Mg vs Na/Na+Ca plot demarcating the fields of dravite, schorl, uvite and feruvite confirm the same. This is in conjunction with available chemical data, which suggest two major compositions for tourmaline associated with sedimentary and metamorphic terranes: one being uvite and the other being intermediate between schorl and dravite. Identifying the usual occurrence of tourmaline in association with the sulfide ore from the deposit suggests that tourmaline can be considered useful horizon markers for hydrothermal activity and a potential prospecting guide for geochemical exploration.

Keyword

Tourmaline, Electron Microprobe, Zawar Zn-Pb deposit

Development Characteristics and Preservation Mechanism of Primary Pores in Ultra-deep Cretaceous Reservoirs in the Kelasu Structural Belt of the Kuqa Depression

Shilong LI[1]*, National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China), Qingdao 266580, China (1244569920@qq.com)
Jian Wang[2], National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China), Qingdao 266580, China
Yingchang Cao[3], National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China), Qingdao 266580, China
Shunyu Wang[4], National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China), Qingdao 266580, China

Abstract

The ultra-deep Cretaceous Bashijiqike Formation (K1bs) sandstone reservoir developed on the Kelasu thrust anticline is the main production layer (>6000m) in the Kuqa Depression, Tarim Basin. The development and preservation of primary pores play an important role in predicting reservoirs under ultra-deep burial conditions. Through thin section observation, cathodoluminescence, SEM, and physical property evolution, the development patterns and main controlling factors of primary pores in ultra-deep clastic rock reservoirs have been clarified. The primary pores of K1bs sandstone reservoir have the distribution characteristics of high in the south and low in the north, high in the extensional zone and low in the compressive zone of the anticline, and high in the middle of the sand body and low at the top and bottom. The original sedimentary components fundamentally control the physical properties of the reservoir. Sandstone reservoirs with better sorting, rounding, and large particle size have the highest initial porosity. The higher content of rigid particles protects the primary pores. The vertical compaction effect is the most important factor in reducing primary pores, with an average porosity reduction rate of 24.42%. Under the control of regional compressive stress, lateral compaction further reduces the primary pores average of 4.97%, and the lateral compaction effect is greater in the high stress area of the northern piedmont. In reservoirs within the same anticline, due to the different horizontal principal stresses intensities in the extensional and compressive zones, the distribution and reducing of primary pores are more complex. Cementation is another destructive factor for primary pores. In the same phase sequence, stronger cementation at the sandstone-shale boundary fills the primary pores in the reservoir. In the middle of the weakly cemented sand body, the primary pores are well preserved. Overall, sandstones with good sorting, large particle size, and more rigid particles have higher initial primary pores. Weak lateral compaction (far from the anticlinal extensional section of the piedmont) and weak cementation (in the middle of the sand body) control the development and distribution of high-quality primary pore type reservoirs.

Keyword

Primary pores, Preservation mechanism, Ultra-deep sandstone reservoir, Kuqa Depression, Tarim Basin

Characteristics of Source Rocks and Formation of Reservoir Bitumen in Yinchuan Graben, Ordos Basin, China

Qingmeng FU[1]*, National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China) (997376492@qq.com)
Jian WANG[2], National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China)
Nan WU[3], School of Geosciences, Yangtze University
Xianfeng LIU[4], School of Geosciences, Yangtze University
Qinghai XIU[5], School of Geosciences, Yangtze University

Abstract

The Yinchuan Graben is an important potential exploration area that is located on the western margin of the Ordos Basin. Over 8000 m of Cenozoic strata have been formed since the Cretaceous. With an integrated approach of cores observation, logging analysis, and geochemical analysis, we analyzed the characteristics of the Cenozoic source rocks in the Yinchuan Graben and determined the formation and destruction of the fossil oil reservoirs. With type III kerogen, the TOC of the dark mudstone in the Qingshuiying Formation is up to 7.5%, and the Ro is 0.95~1.04%, indicating the source rocks have entered the mature stage but the hydrocarbon generation potential is insufficient. A quantity of reservoir bitumen and oil-bearing fluid inclusions (GOI=1.67~4%) were found in the Qingshuiying Formation sandstone in Well YQ-1, which indicates a fossil oil reservoir had existed. The fossil oil reservoir and reservoir bitumen were generated by the unexplored pre-Cenozoic strata under the Qingshuiying Formation in the Yinchuan Graben. The reservoir bitumen has high maturity and is associated with many fluid inclusions with a high homogenization temperature or CO2. This indicates that the bitumen was formed by the pyrolysis of the oil which was caused by the hot fluid migrating along with the deep fault belts.

Keyword

Yinchuan Graben, source rock evaluation, reservoir bitumen

Cross-layer propagation of natural fractures in finely laminated shale

huawei LI[1]*, China University of Petroleum (East China) (lhwvinsmokes@163.com)
qingfeng Meng[2], China University of Petroleum (East China)

Abstract

We conducted quantitative characterization, scanning electron microscopy and geochemical analyses of shale samples from the fractured intervals of the Eocene Shahejie Formations from the Dongying Depression, Bohai Bay Basin, China. The aim is to investigate the cross-layer propagation mechanism of natural fractures in finely laminated shale and elucidate the controlling factors. We found that high angle fractures exhibit different features in argillaceous laminae from calcite laminae. The fractures are largely arranged as a network in argillaceous laminae. The average thickness of argillaceous laminae is 0.18 mm with the average fracture density of 0.96 fractures/mm and an average aperture of 0.1 mm. The fractures in the calcite lamina are mainly vertical. The average thickness of calcite laminae is 0.1 mm with the average fracture density of 1.22 fractures/mm and an average aperture of 0.22 mm. High-angle fractures are highly affected by laminae and characterized by strata-bound development in the strata. The fractures mostly terminate at or near such interfaces. The high-angle fractures in the adjacent calcite laminae are connected by shear fractures developed in the mudstone laminae to form a highly-interconnected fracture network. Our study provides a general model for cross-layer fracture propagation and linkage in finely-laminated shale and carbonate, and yields important implications for fluid flow in low-permeability shale systems.

Keyword

natural fractures, laminated shale, Cross-layer propagation

Fluid migration through an intensively overpressured diapir in the Yinggehai Basin, South China Sea

zhifeng GUO[1]*, China University of Petroleum (East China) (s22010056@s.upc.edu.cn)
qingfeng MENG[2], China University of Petroleum (East China)

Abstract

Multiple mud diapirs have been identified in the Yinggehai Basin, where intensive overpressure is widespread. Here, we present a representative example of the diapirs, namely the DF29-1 diapir, to demonstrate the fluid migration pathways through typical mud diapirs by using integrating analysis of seismic reflection and fault likelihood attribute. We also investigated fluid overpressure mechanisms by logging and MDT data. The diapir is characterized a seismic blank zone beneath a crestal graben developed in the overburden strata. We found that the position of the crestal graben is in the Two-Way Travel Time 280 to 1960ms (Quaternary to Early Pliocene) and is in a hydrostatic pressure environment. The position of the diapir and fractures are in the Two-Way Travel Time 1950 to at least 6000 ms (Early Pliocene to Late Miocene) and are in an overpressure pressure environment. The genetic mechanism chart of overpressure strata shows that the overpressure mechanism are mainly disequilibrium compaction and external fluid injection. While the range of C1 / ∑ C1 ~ 5 of natural gas in the shallow strata is 0.879 - 1, and the range of δ13C1 is -29.09 - -48.69 ‰. Most of them are high maturity coal-formed gas formed in deep strata. So we conclude that the vertical migration path of fluid in the diapir area of the Yinggehai Basin is diapir and its associated fractures and faults. Our results provide important implications for vertical fluid migration pathways in deep overpressure environment.

Keyword

seismic attribute, transporting pathways, overpressure mechanism, diapir, Yinggehai Basin

New Re-Os molybdenite age for the Erdenetiin Ovoo Cu-Mo ore field, North Mongolia

Baatar MUNKHTSENGEL[1]*, Department of Geology and Hydrogeology, School of Geology and Mining, Mongolian University of Science and Technology (tsengel@must.edu.mn)
Dorj-Yunden Altankhuyag[2], Erdenet Mining Corporation SOE
Bayaraa Batkhishig[3], Department of Geology and Hydrogeology, School of Geology and Mining Engineering, Mongolian University of Science and Technology
Muunuu Damdinsuren[4], Department of Geology and Hydrogeology, MUST; Erdenet Mining Corporation SOE
Miao Laicheng[5], Institute of Geology and Geophysics, Chinese Academy of Science

Abstract

Located in North Mongolia, the Erdenetiin Ovoo porphyry copper-molybdenum ore field was discovered in the early 1960*th. The ore field comprises* 4 *deposits, from NW to SE namely Northwest, Central, Intermediate, and Oyut. These deposits are distributed along the NW-striking faults and extend about* 12 *km. The Northwest deposit has been exploited since* 1976 *and presently reaches to a depth of* 440 *m beneath the surface, and the Central deposit was started to mine in* 2014*. No activity for the Intermediate deposit at the moment, while detailed exploration work for the Oyut, the southern end of the ore field started in* 2023*. These deposits are hosted in the Triassic Erdenet porphyry complex, which is composed mainly of granodiorite porphyry intruding into the middle Permian – early Triassic Selenge intrusive complex of diorite and granodiorite. These intrusive rocks show geochemical features of LILE enrichment and HFSE depletion, consistent with those of I-type, calc-alkaline, and subduction-related arc igneous rocks. SHRIMP and LA-ICPMS zircon U-Pb dating suggest that the Erdenet porphyry complex was formed at* 235-248 *Ma and* 243-265 *Ma for the Selenge intrusive complex* (*Munkhtsengel*, 2007; *Munkhtsengel et al*., 2018, *Munkhtsengel et al*., 2020). *Among the deposits, only the Northwest one is well-studied in terms of geology, mineralization, and geochronology, with a molybdenite Re-Os age of* ~240 *Ma having been reported* (*Watanabe and Stein*, 2000). *In this paper we present the new Re-Os molybdenite ages for the Central, Intermediate, and Oyut deposits. Two molybdenite samples of the Central deposit yielded Re-Os ages of* 233.1±3.5 *Ma and* 233.9±3.5 *Ma, respectively. The Intermediate deposit gives a molybdenite Re-Os age of* 222.9±5.3 *Ma, and the Oyut deposit has an age of* 228.9±3.7 *Ma. These age data indicate a southeastward younger tendency for the Cu-Mo mineralization in the ore field. The mineralization period somehow correlates with the span of magmatic activity of the Erdenet Porphyry complex.*

Keyword

Erdenetiin Ovoo, Re-Os, North Mongolia

Element Distribution and REE Dispersal in Sandstone-Hosted Copper Mineralization within Oligo-Miocene Strata, NE Iran: Insights from Lithostratigraphy and Mineralogy

MOSTAFA FEIZ[1]*, Geological Survey of Iran (mostafa_feiz1979@yahoo.com)

Abstract

The lithostratigraphy and mineralogy of the Oligo-Miocene strata in NE Iran warrant particular interest due to the presence of sandstone-hosted copper mineralization. Comprehending the element distribution and mass change within these strata is vital for evaluating the potential for economic mineral deposits. Moreover, the dispersal of rare earth elements (REE) within the mineralization can offer valuable insights into the geological processes influencing these deposit formations. Our objective is to scrutinize the lithostratigraphy, mineralogy, and element distribution in the sandstone-hosted copper mineralization in the Nasar-Chalpo-Sangerd area of NE Iran. Our findings aim to enhance understanding of the geological processes shaping the mineralization in this region.

The Chelpo copper deposit is situated in northeastern Iran, within the structural zone of central Iran and the Sabzevar back-arc basin. The Oligo-Miocene sedimentary strata, which we refer to as the Nasr-Kadkan-Sangerd (NKS) basin, host this copper mineralization. This basin comprises red bed strata, such as red marl, red siltstone, and interbedded sandstone layers. These layers are primarily deposited on the Upper Cretaceous ophiolitic rocks and the intermediate to mafic-post ophiolitic volcanic rocks, forming a nonconformity. The mineralized sandstone layers contain leached zones (5 to 8 meters thick) and mineralized zones with a thickness of 0.5 to 0.7 meters. The ore minerals include sulfide minerals, such as chalcocite, chalcopyrite, and pyrite, as well as secondary minerals (covellite, digenite, malachite, and azurite) that formed during the supergene stage. The primary factors controlling the mineralization in the sandstone layers are the permeability of the sandstone, the presence of fault zones acting as conduits for copper-bearing solutions, and the significant amounts of plant fossils, which create a reducing environment for deposition. Statistical studies on copper layers indicate that Ag, Cd, Mo, and S have the maximum positive correlation with Cu, whereas TiO2, Fe2O3, Al2O3, Sc, Tm, Sn, and the REMs exhibit a negative correlation. Mass change calculations on copper-bearing layers and primary sandstone layers reveal that Pb, As, Cd, Te, and Mo are enriched in the mineralized zones, whereas SiO2, TiO2, Fe2O3, V, Sr, and Ba are depleted. Copper and silver deposited in the sandstone layers may encounter reducing conditions due to abundant organic matter. The sandstone layers bearing copper have been depleted of Fe2O3, TiO2, SiO2, and REEs through leaching processes. The results indicate that during the main mineralization stage, LREEs and MREEs were depleted, but Cu, Ag, and S were enriched.

Keyword

lithostratigraphy, sandstone-hosted copper, REE, Chelpo area, Oligo-Miocene basin, mineralogy

Relationship between vegetation canopy and selected ore bodies of Iran

Shahindokht ABOLMAALI[1]*, geological Survey of Iran employee (abolmaali50@yahoo.com)
Kambiz RANA[2], geological Survey of Iran employee

Abstract

Shahin Dokht ABOLMAALI
Faculty of Science, University of Tehran (abolmaali50@yahoo.com)

The scope of this study is to discover the concentration of selected elements (As, Ag, Au, Ba, Cr, Cu, Fe, Hg, K, Mn, Mo, Sb and Pb-Zn) in vegetation canopy of Iran. Three data layers including mines and ore indications, High potential areas of above elements and vegetation canopy provided by Forests, Range and Watershed Management Organization (FRWO) are used. Vegetation canopy is divided into 75 genera and their dispersion and areas were determined. The related canopies were introduced by intersecting and buffering vegetation canopy layer with mines and ore indication layer and high potential layer in GIS environment with following results. Artemisia Sieberi and Artemisia Aucheri for As, Astragalus sp. and Artemisia Sieberi for Ag, Astragalus Microcephalus, AstragalusGossypinus, Astragalus Eirosphaerus, Astragalus Yueksekovae and Artemisia Sieberi for Au, Artemisia Sieberi and Astragalus spp. for Ba, Artemisia Aucheri, Artemisia Sieberi and Astragalus spp. for Cr, Artemisia Aucheri, Artemisia Sieberi and Artemisia Lehmanniana for Cu, Artemisia Sieberi Juniperus Excelsa and Juniperus Polycarpus for Fe, Astragalus Microcephalus, Astragalus Carduchorum, Astragalus Eriophaerus, Astragalus Persicus and Austragalus Yueksekovae for Hg. Artemisia Sieberi, Hammada Salicornica, Salsola Tomentosa, Seidlitzia Rosmarinus, Suaeda Fruticosa and Tamarix Kotschi for K, Juniperus Excelsa and Artemisia Sieberi for Mn, Artemisia Sieberi and Artemisia Aucheri for Mo, Artemisia Sieberi, Artemisia Aucheri, Juniperus Excelsa, Juniperus Polycarpus and Astragalus Gossypinus for Pb-Zn and Artemisia Lehmanniana for Sb.

Keyword

Geobotany, Lead, Zinc, Artemisia, Gold

A New Approach for Detecting Heat Treatment of Sapphire

Teerarat PLUTHAMETWISUTE[1]*, Chulalongkorn University (T_pluthametwisute@hotmail.com)
Lutz Nasdala[2], Institut für Mineralogie und Kristallographie, Universität Wien, 1090 Wien, Austria
Chutimun Chanmuang Nasdala[3], Institut für Mineralogie und Kristallographie, Universität Wien, 1090 Wien, Austria
Manfred Wildner[4], Institut für Mineralogie und Kristallographie, Universität Wien, 1090 Wien, Austria
Eugen Libowitzky[5], Institut für Mineralogie und Kristallographie, Universität Wien, 1090 Wien, Austria
Gerald Giester[6], Institut für Mineralogie und Kristallographie, Universität Wien, 1090 Wien, Austria
Gamini Zoysa[7], Mincraft Co., 10370 Mount Lavinia, Sri Lanka
Chanenkant Jakkawanvibul[8], The Gem and Jewelry Institute of Thailand (Public Organization), 10500 Bangkok, Thailand
Waratchanok Suwanmanee[9], The Gem and Jewelry Institute of Thailand (Public Organization), 10500 Bangkok, Thailand
Tasnara Sripoonjan[10], G-ID Laboratories, Bangkok, 10120, Thailand
Thanyaporn Tengchaisri[11], Science and Technology Park (STeP), Chiang Mai University, 50200 Chiang Mai, Thailand
Bhuwadol Wanthanachaisaeng[12], The Gem and Jewelry Institute of Thailand (Public Organization), 10500 Bangkok, Thailand
Chakkaphan Sutthirat[13], Department of Geology, Chulalongkorn University

Abstract

Detecting heat treatment of sapphire has been a challenging issue for several decades. High-resolution optical microscopy, optical absorption (UV-VIS-NIR) spectroscopy, Fourier-transform infrared (FTIR) spectroscopy, Raman spectroscopy, and photoluminescence (PL) spectroscopy and imaging were applied in testing natural unheated sapphire before and after heat treatment. Three groups of sapphire (high-density-silk, low-density-silk, and silk-free) were investigated. Most unheated sapphire specimens (except the high-density-silk group) showed orange to red luminescence under long-wave ultraviolet (LWUV) light, whereas under short-wave ultraviolet (SWUV) light, all specimens appeared inert. After heating at 1,650 °C for 10 hours under atmospheric conditions using an electric furnace, most of the sapphire specimens (except the high-density-silk group) showed strong purplish red luminescence under LWUV as well as blue luminescence under SWUV illumination. UV-excited PL indicated a link between the broad emission spectrum of the orange to red region and the orange to red luminescence presented in unheated sapphire under LWUV, as well as a link between the emission band of the green region and the blue luminescence of heated sapphire under SWUV illumination. Consequently, occurrences of the orange to red emission band center around 630-650 nm and orange to red luminescence under LWUV that appeared in unheated sapphire specimens may serve as novel evidence of unheated sapphire, whereas the occurrence of the green emission band at the center around 525 nm and blue luminescence under SWUV that appeared in heated sapphire specimens

may serve as crucial evidence of sapphire that has undergone heat treatment. It is worth mentioning that the luminescence of purplish red under LWUV observed in heated sapphire specimens (except the high-density-silk group) could potentially function as an alternative means of detecting heated sapphire. It is noteworthy that sapphire belonging to the high-density-silk group appeared inert under LWUV and SWUV illumination, both before and after heating. This may be attributed to the abundant presence of ferrous Fe (a luminescence quencher) derived from ilmenite. However, a more detailed investigation is recommended for the exact cause of such mechanism. In addition, fluid inclusions within dissolved silks may indicate high-temperature heat treatment of sapphire. It is also suggested here that applying Fourier-transform infrared (FTIR) spectroscopy alone is inadequate for distinguishing heated and unheated sapphire. Consequently, utilizing orange to red and blue luminescence, both prior to and after heat treatment, together with fluid inclusions, presents a novel and practical method for accurately distinguishing unheated sapphire and heated sapphire.

Keyword

gem, sapphire, heat treatment, luminescence

ANCIENT NEPHRITE QUARRY NEWLY DISCOVERED: CHARACTERIZATION OF NEPHRITE FROM SANWEI MOUNTAIN, GANSU PROVINCE, WESTERN CHINA

YUE SU[1]*, China university of Geosciences (gemlabmem@163.com)
Mingxing Yang[2], China University of Geosciences

Abstract

The newly discovered nephrite deposit in Sanwei Mountain, Dunhuang City, Gansu province, China, is an ancient jade quarry dating back to the Xichengyi Culture to the Qijia Culture, approximately 4000 years ago. It is recognized as the earliest archaeological jade mining site in China and holds significant archaeological and gemological value. However, there is limited information available on the gemological properties of nephrite from Sanwei Mountain. This paper provides a detailed investigation into the gemological, photomicrographic, spectral, and chemical composition features, as well as hydrogen and oxygen isotopic characteristics, and methods for distinguishing it from other major nephrite sources. The nephrite from Sanwei Mountain exhibits various colors, including white, green-white, yellow-white, green, and brown. Chemical composition analysis classified all the nephrites as dolomite-related (D-type) nephrites. Furthermore, the common secondary alteration of nephrite materials in Sanwei Mountain constitutes a distinctive feature of this deposit. Additionally, to differentiate the Sanwei Mountain nephrite from other deposits and establish a basis for tracing ancient jade artifacts, we used chemical composition and linear discriminant analysis (LDA) to construct the origin determination model. Hydrogen and oxygen isotope measurements were also performed and compared with data from other nephrite deposits. The results demonstrate that trace elements and H, O isotopes effectively distinguish Sanwei Mountain nephrite from other high-quality deposits.

Keyword

Nephrite, Jade artifact, Gemmology, Origin determination, Secondary alteration

Ageing Characterization and Origin Traceability of archaeological amber artifacts via FTIR spectroscopy and Pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS)

Yan LI[1]*, China University of Geosciences, Wuhan (yanli@cug.edu.cn)
Jiarong Li[2], China University of Geosciences, Wuhan
Qi Liu[3], Hunan Key Laboratory of Archaeometry and Conservation Science, Hunan Museum

Abstract

Amber (fossil resin) is a complex biogenic polymer originated from ancient plant resin buried underground through many various geological periods and fossilized over tens of millions of years of geological process[1]. The archaeological amber artifacts unearthed from different time periods in China offer significant historical insights into the international trade networks and cultural interactions among ancient civilizations[2]. This research investigated three archaeological amber artifacts (labelled as Arc 1-3) provided by the collection of the Hunan Museum originating from different historical periods in China. The objective of this study aims to demonstrate the aging characteristics of the artifacts and determine their provenance.

The examination of the aging characteristics of the cross-section and weathered surface was carried out using scanning electron microscopy (SEM). Fourier Transform Infrared (FTIR) spectroscopy and Pyrolysis-gas chromatography/mass spectrometry (Py-GC/MS) were utilized to investigate the functional group and chemical composition of amber artifacts. SEM analysis conducted on historical amber has revealed a clear differentiation among different degrees of aging. As the aging process, there were changes in the chemical composition and degradation in the physical properties, manifested as a distinct boundary between the aging and core layers, as well as the presence of deeper cracks. The occurrence of these features indicates that FTIR was ineffective for determining provenance. The results obtained through Py-GC/MS analysis indicate that three amber artifacts were from Baltic amber. Additionally, a set of compounds obtained from Py-GC/MS analysis could act as biomarkers for the identification of Baltic amber. The findings of this study demonstrate that Py-GC/MS was an accurate and effective method to confirm the origin of severely degraded amber artifacts. Additionally, it provided a reference to evaluate the extent of deterioration in archaeological amber collections. Identification of the archaeological amber also provides clues to the trade routes and cultural exchanges on Silk Road during ancient time.

References

[1] XingpingLi, YameiWang, Guanghaishi, RenLu, Yan Li*. Evaluation of natural ageing responses on Burmese amber durability by FTIR spectroscopy with PLSR and ANN models Spectrochimica Acta Part A: Molecular and Biomolecular Spectroscopy, 2023. 285: p. 121936.

[2] Zhao T, Peng M, Yang M, Lu R, Wang Y*, Li Y*. Efects of weathering on FTIR spectra and origin traceability of archaeological amber: The case of the Han Tomb of Haihun Marquis, China. journal of Archaeological Science, 2023, 153 (105753) .

Acknowledgements
The work has been supported by Hubei Gem & Jewelry Engineering Technology Center (No. CIGTXM-03-202304) and Hubei Philosophy and Social Science Program Project (No.21G007). The project was also supported by the ‘‘CUG Scholar” Scientific Research Funds at China University of Geosciences (Wuhan) (No.2022185).

Keyword

Archaeological amber artifacts, Origin traceability, Scanning electron microscopy, Py-GC/MS, FTIR

Chemical Composition and origin of color in Black and Black Cyan Nephrite from Margou Deposit, Qiemo county, Xinjiang, China

Ting FANG[1]*, China University of Geosciences(Wuhan) (funtyfang@163.com)
Mingxing Yang[2], China University of Geosciences(Wuhan)

Abstract

The nephrite belt in the Altun Mountain–Western Kunlun Mountain region, spanning approximately 1300 km in Xinjiang, NW China, constitutes the world's largest pre-eminent nephrite deposit. The Qiemo region in the Altun Mountains is a crucial nephrite-producing area in China, with demonstrated substantial prospects for future exploration. While existing research has extensively investigated secondary deposits in the Karakash River and native black nephrite deposits in Guangxi Dahua, a comprehensive investigation of black nephrite from original deposits in Xinjiang is lacking. Margou nephrite has been found in recently discovered black-toned nephrite deposits in Qiemo County, Xinjiang, warranting comprehensive investigation of this primary source of black nephrite within the region. For this scholarly inquiry, a suite of sophisticated analytical methods were employed, including the use of a polarizing microscope, an electric microprobe, back-scattered electron image analysis, X-ray fluorescence, and inductively coupled plasma mass spectrometry. A rigorous experimental test was conducted to elucidate the chemical and mineralogical composition, further clarifying the genetic types of the black and black cyan nephrite from Margou deposit in Qiemo, Xinjiang. The results reveal that the nephrite is mainly composed of tremolite–actinolite, characterized by Mg/(Mg + Fe2+) ratios ranging from 0.86 to 1.0. Minor minerals include diopside, epidote, pargasite, apatite, zircon, pyrite, and iron hydroxide. Bulk-rock rare earth element patterns exhibit distinctive features, such as negative Eu anomalies (δEu = 0.00–0.17), decreasing light rare earth elements, a relatively flat distribution of heavy rare earth elements, and low total REE concentrations (1.6–38.9 μg/g); furthermore, the Cr (6–21 μg/g) and Ni (2.5–4.5 μg/g) contents are found to be conspicuously low. The magmatic influence of granite emerges as a pivotal factor in the genesis of magnesia skarn hosting the Margou nephrite. The distinctive black and black cyan colors are attributed to heightened iron content, mainly associated with FeO (0.08~6.29 wt.%). The discerned chemical composition characteristics place the Margou nephrite as an exemplary magnesia skarn-type nephrite deposit.

Keyword

Nephrite, Geochemistry, Coloration Genesis, Margou deposite, gemmology

The Structure of Natural Opal-A: An Insight through Synchrotron X-ray Diffraction and Pair Distribution Function Analysis

Seungyeol LEE[1]*, Chungbuk National University (slee2@cbnu.ac.kr)
Huifang Xu[2], Department of Geoscience, University of Wisconsin–Madison
Hongwu Xu[3], School of Molecular Sciences and Center for Materials of the Universe, Arizona State University

Abstract

Opals, historically valued for their unique optical properties and extensive use in jewelry and decorative arts, are classified gemologically into precious, common, and hyalite types based on their color play due to light diffraction. From a mineralogical perspective, opals are categorized into opal-A, opal-CT, and opal-C, according to their X-ray diffraction (XRD) patterns, with 'C' and 'T' representing cristobalite and tridymite, respectively. The structural comprehension of opals is challenging due to the broad and weak peaks in their XRD patterns, suggesting short- and medium-range ordered structures. This research aims to clarify the structure of naturally occurring opal-A using synchrotron X-ray pair distribution function (PDF) analysis, synchrotron XRD, and transmission electron microscopy (TEM). Opal-AN primarily consists of various sizes of nanospheres (<5 nm) forming banded features, while opal-AG exhibits closely packed silica nanospheres about 400 nm in diameter. XRD patterns of both samples reveal one significant peak at approximately 4.0 Å, along with broad peaks at around 2.0, 1.45, and 1.2 Å. PDF patterns of opal-AN and opal-AG show short-range atomic pairs (<15 Å). Our PDF analyses suggest that the opal-A structure can be primarily described as disordered inter-growths of cristobalite- and tridymite-like domains composed of 6-membered rings of [SiO4] tetrahedra, aligning with the previously reported cristobalite/tridymite stacking (interstratification) model. Additionally, our synchrotron X-ray PDF analysis indicates the presence of 4-membered [SiO4] rings in the opal-A structure. The existence of four-membered silica rings in the opal-A structure is attributed to twinning, stacking faults, and interface boundaries of six-membered rings. Trace elements such as K, Na, Al, and Ca can be incorporated into the four-membered silica rings, similar to the feldspar framework, in opal. Indeed, to gain a deeper understanding of the natural structure of opals, it's crucial to conduct additional research on other opal structures, such as opal-CT and opal-C, using a combined XRD/PDF method. For instance, in sedimentary cherts like the Monterey formation, the silica in the sediment undergoes a steady transformation from opal-A (diatomaceous clay) to opal-CT, and finally to chert during the process of diagenesis. This combined methodology can offer in-depth structural data about the phase transformation of opal, which can have significant implications for its stability in geological settings.

Keyword

Opal-A, Pair distribution function analysis, Synchrotron X-ray diffraction, Transmission electron

microscopy

Unusual Synthetic Overgrowth on Natural Rose-Quartz Crystal Aggregate

Thanapong LHUAAMPORN[1]*, The Gem and Jewelry Institute of Thailand (Public Organization)
(lthanapong@git.or.th)
Waratchanok Suwanmanee[2], The Gem and Jewelry Institute of Thailand (Public Organization)
Bhuwadol Wanthanachaisaeng[3], The Gem and Jewelry Institute of Thailand (Public Organization)

Abstract

Rose quartz is a pink-colored variety of quartz mineral (SiO2) and commonly used as a trade name in gem market. Because of its charmingly pink color, rose quartz usually conveys an impression of love and has become one of popular gemstones until now. The GIT Gem and Precious Metal Testing Laboratory received an aggregate (108.2 x 71.9 x 44.0 mm,) of pink-colored crystals for identification in November 2023. Initial observations of the uncut specimen revealed typical large-quartz crystals exhibiting a short six-sided prism with pyramid-like rhombohedral faces at each end. We also noticed color zoning, a distinct boundary between the colorless overgrowth containing breadcrumb-like inclusions and natural pink crystal cores.

Further investigation involved isolating the upper parts of crystals from the rose quartz aggregate and then slab-cut into several pieces. These representatives, colorless overgrowth, and inner pink core, were used for determining their properties and characteristics by employing both basic and advanced gem instruments.

The standard analyses of the polished slabs revealed the following basic gem properties: double refraction. uniaxial positive with RI of 1.552–1.543 (birefringence 0.009), inert to long and short-wave UV radiation, and SG of 2.65, corresponding quite well with those of quartz. Again, the slabs displayed a sharp contact boundary between the natural pink-colored seed crystal at the inner core, and colorless overgrowth zone at the outer rim. The contact boundary is better visible when using immersion with diffused light. Microscopic observation of the synthetic overgrowth zone revealed the following internal features; irregular two-phase inclusions, fluid leaf-like inclusions, breadcrumb-like inclusions and heal fissures, whereas the natural, pink-colored core showed only healed fractures. The true nature of natural pink core was confirmed by the presence of a ~3595 cm-1 peak on the FTIR spectra, while the synthetic overgrowth was also reaffirmed by the existence of a prominent band at ~3585 cm-1 and, especially, a small band at ~3543 cm-1. Overall, this study identified the sample as an aggregate of natural (pink-colored) rose quartz crystals with synthetic colorless overgrowth, highlighting the importance of comprehensive gemological analyses in distinguishing the natural and synthetic materials.

Keyword

synthetic overgrowth, rose quartz, crystal aggregate

Fast identification of imitation pearls against cultured pearls using hyper near-infrared spectroscopy

JINHEE LEE[1]*, HANYANG UNIVERSITY (lindapark8464@gmail.com)
Jin hee Lee [2], Hanyang University
Sanghoon CHO[3], Hanyang University
Hoeil Chung[4], Hanyang University

Abstract

Pearls are one of the gemstones that have been loved by everyone for a long time. Cultured pearls are produced by the secretions of shellfish that leading to form a thin film of artificial nuclei in the body and layers. Aragonite (CaCO3) and conchiolin (protein) form a layer outside the nucleus, and are being stacked during the growth. Materials adopted to make imitation pearls are typically including glass, plastic, and mollusc shells. Meanwhile, plastic beads coated with a pearlescent substance to imitate the natural iridescence of nacre or mother of pearl are rather popular in actual markets. Visual discrimination of imitation pearls against cultured pearls is somewhat feasible due to their differed colors and shapes; however, a method able to provide more objective compositional information of a pearl and analyze a large number of pearls in a short period is practically beneficial. For this purpose, hyper near-infrared (Hyper-NIR) spectroscopy enabling the fast mapping of many pearls was adopted, and the discrimination of imitation pearls against fresh/sea water cultured pearls was attempted. Initially, the NIR spectral features of samples were comparatively analyzed according to the types of pearls and discrimination accuracy was finally assessed using diverse chemometric discriminant methods.

Keyword

Pearl, Raman spectroscopy, Thickness, Evaluation of pearl, Image analysis

Unusual mixed characteristics of sapphires from magmatic deposits in Muling, Northeast China

Yimiao Liu[1]*, China University of Geosciences (Wuhan) (yim2015@163.com)
Ren Lu[2], China University of Geosciences (Wuhan)

Abstract

Muling area in the Heilongjiang province of northeastern China produces sapphires with a full range of hues and saturations. The gem quality of these materials rivals those of world-class sapphires commonly found only in marble-hosted environments. Muling corundum deposits lie in the intraplate basaltic fields of the West Pacific continental margins (Graham et al., 2008), from where classic magmatic sapphire deposits emerged. However, Muling sapphires show unusual mixed characteristics typical of both alkali basalt- and marble-hosted sapphires. Internal features, spectral analyses, and geochemical data provide evidence that the true origin of Muling sapphire is consistent with a mixture of geological formation environments. Inclusion characteristics suggest that Muling pink and light blue sapphires may have crystallized from a silicon-rich environment while part of deep blue sapphires showed a closer relationship with alkali basaltic origin. Spectral analysis further reveals the diverse formation environment among deep blue sapphires. These mixed characteristics are further evidenced in the FeO-Cr2O3-MgO-V2O3 vs. FeO+TiO2+Ga2O3 chemical classification diagram (Giuliani et al., 2015). Combined with the specific geological background, it can be found that alkali basalt may act as a "carrier" in the formation of Muling sapphire as well as an integrated participant in the formation of these gem corundum to some extent. These findings certainly enriched our knowledge of basalt-related gem corundum with various gemological and geological characteristics.

Keyword

sapphire from Muling, China, mixed characteristics, geological formation

Beyond Jewelry: The Quantum Realm of Diamonds

Hyunmin CHOI[1]*, Hanmi Gemological Institute & Laboratory (hmcgem@hanmail.net)
Youngchool KIM[2], Hanmi Gemological Institute & Laboratory
Jaeeun KIM[3], Hanmi Gemological Institute & Laboratory
Soi MOON[4], Dongshin University
Jeongwon SEOK[5], Dongshin University

Abstract

Known for their exceptional physical properties and beautiful gemstones, diamonds have a wide range of applications in existing industries. Diamonds have a variety of defects that are responsible for their color. NV defects give diamonds their pink color and also give diamonds their quantum properties.

There is current research to use diamonds with NV centers for applications in technologies such as quantum sensing and quantum computing.

The use of NV diamond centers in quantum sensing demonstrates a significant sensitivity to tiny magnetic fields, which shows significant potential. This sensitivity has the potential to bring innovation to medical diagnostics, navigation systems, and precise defect detection in battery manufacturing. At the same time, the stable quantum state maintained by NV diamond centers positions them as ideal candidates for quantum computing.

High purity single crystal diamonds are essential for quantum research using NV centers. There are two main methods of artificially producing diamonds: Chemical Vapor Deposition (CVD) and High Pressure-High Temperature (HPHT).

Initially, synthetic diamonds grown by the HPHT method were used in quantum research. However, this method is now rarely used in quantum research due to challenges in controlling impurity concentrations (NV defects) and a lack of cost competitiveness.

While the CVD method has the disadvantage of slow diamond growth, it has the advantage of producing large areas of high-purity diamond. In addition, the 13C isotope concentration can be controlled and NV centers can be generated during the diamond growth phase, making CVD grown diamonds the most widely used for quantum research today.

The future of diamond quantum technology cannot be defined with precision, but advances in quantum sensing and computing are expected to impact fields as diverse as healthcare, energy and computing. This study looks at quantum technology research using diamonds beyond their beauty as jewelry.

Keyword

Quantum diamond, NV center, CVD method, Jewelry

The Special Color Effect in “Chameleon” Amber and its main Fluorescence Component

Yan LI[1]*, China University of Geosciences, Wuhan (yanli@cug.edu.cn)
shiyi li[2], China University of Geosciences,Wuhan
Guanghai Shi[3], China University of Geosciences, Beijing

Abstract

One special variety of Burmese amber is “chameleon” amber, named for the bluish green color that appears to float on its surface. This material is found in the famous Tengchong market in Yunnan Province, China’s largest Burmese amber market. Its bodycolor ranges from golden brown to brownish red or even red. When exposed to sunlight or strong white light against a black background, its surface shows a uniform green color. Chameleon amber is rare and expensive compared to regular Burmese golden or brownish amber, especially with the severe reduction of exports from Myanmar.

This research presents the gemological properties, spectral characteristics and organic components of Burmese 'chameleon' amber. The samples were then examined with 3D fluorescence spectroscopy under the excitation of a continuous-wavelength excitation light source. The three-dimensional (3D) fluorescence spectral showed that Burmese 'chameleon' amber had fluorescence centres near 433,465 and 470 nm, and the excitation wavelengths of the fluorescence centres of Burmese 'chameleon' amber were shifted from the ultraviolet region (380 ± 10 nm) to the visible region (410 ± 10 nm), with the emission wavelengths concentrated in the bluish-green region. Through the colour simulation and superimposition, the phenomenon of floating bluish green fluorescence colour of Burmese 'chameleon' amber is not only derived from bluish-green fluorescence centres, but also enhanced by the mixture of surface fluorescence and its bodycolour. Headspace solid-phase microextraction gas chromatography-mass spectrometry (HS-SPME-GC-MS) analysis demonstrated the variety of aromatic compounds in Burmese 'chameleon' amber was related to geological process and the presence of fluorescent components. The High-performance liquid chromatography-fluorescence detector obtained some fluorescent aromatics, particularly benzo[a]anthracene with yellowish-green fluorescence, which is responsible for the fluorescence characteristics of Burmese 'chameleon' amber.

Keyword

amber, optical effect, spectrum analysis, fluorescent components

Observation of characteristics of synthetic diamonds in ultraviolet illuminating

EUNOK JO[1]*, Seoul Jewelry Industry Support Center (jo@sjc.or.kr)
KYUNGJU NAM[2], Seoul Jewelry Industry Support Center

Abstract

The Korean jewelry market is witnessing a rapid increase in the distribution of synthetic diamonds known as "lab-grown diamonds." In the early days of synthetic diamond distribution in Korea, CVD synthetic diamonds were the majority, but recently, the proportion of imported HPHT synthetic diamonds has more increased. Diamonds exhibit fluorescence and phosphorescence in response to high-energy short-wave ultraviolet light. This is one of the visible characteristics of diamonds, and natural diamonds are generally reported to exhibit blue fluorescence and poor phosphorescence. Synthetic diamonds, on the other hand, exhibit distinctive fluorescence, phosphorescence, and growth patterns that are not found in natural one, depending on the synthesis method and growth conditions. Therefore, the observation of fluorescence, phosphorescence and growth patterns is a very useful method for the identification of synthetic diamonds.

This study collects images of different fluorescence, phosphorescence and growth patterns of synthetic diamonds to discuss about their characteristics. The samples analyzed in this study are Type II natural and synthetic diamonds, which contained no nitrogen. Spectroscopic characteristics of diamonds were identified by FT-IR. The fluorescence, phosphorescence, and growth patterns were observed using a fluorescence imaging device based on a 255 nm shortwave ultraviolet source. Experimental results, the HPHT synthetic diamonds exhibited a mixture of Type IIa and IIb characteristics by infrared spectroscopy due to the boron content. In addition, since natural diamonds crystallize as octahedrons, while HPHT synthetic diamonds grow as cubo-octahedral with a mixture of cubic and octahedral forms, this structure is partially observed in the fluorescence images, mostly showing strong fluorescence and phosphorescence. In the case of CVD synthesis, it can be seen that somewhat less consistent of characteristics when compared to HPHT synthesized diamonds. Since CVD synthesis is grown by depositing carbon seeds onto a diamond substrate, it is characterized by striped or concentric growth lines, irregular fluorescence in color and intensity and often absent phosphorescence.

Keyword

diamond identification, synthetic diamond, lab-grown diamond

The color center of beryllium-treated blue sapphires

Natthapong MONARUMIT[1]*, Department of Earth Sciences, Faculty of Science, Kasetsart University (monarumit@gmail.com)
Thanapong Lhuaamporn[2], The Gem and Jewelry Institute of Thailand
Chunenapa Klomranok[3], Department of Earth Sciences, Faculty of Sciece, Kasetsart University
Pornsawat Wathanakul[4], Department of Earth Sciences, Faculty of Sciece, Kasetsart University
Wiwat Wongkokua[5], Department of Physics, Faculty of Sciece, Kasetsart University

Abstract

The blue color in sapphire is caused by Fe3+ and Ti4+ impurities replacing two adjacent Al3+ in the Al2O3 structure. Based on experimental results, Fe2+ has never been measured by any method. Hence, the intervalence charge transfer theory between Fe2+ and Ti4+ has been proposed to be replaced by the Fe3+ and Ti4+ mixed acceptor states. For over two decades, beryllium-assisted heat treatment has been introduced not only to produce padparadscha, yellow and orange sapphires but also blue sapphires. In this work, we investigate the roles of beryllium atoms in the corundum structure responsible for the blue color of blue sapphire. The chemistry and spectroscopic properties of the light blue samples were collected using EDXRF, LIBS, polychromatic UV-Vis-NIR, monochromatic UV-Vis-NIR, and XAS techniques. The samples were Be-heat treated to yellow with ground BeO mixing in an alumina crucible introduced into an electric furnace then heating up to 1715 °C under an oxidizing atmosphere for 80 h. The yellow beryllium-treated sapphires were later heated under reducing atmospheric conditions at 1680 °C for 10 h and analyzed. The results show that the samples turned blue, although beryllium is still detected. The oxidation state of iron (Fe) is Fe3+ as determined by XANES for both before and after the treatments. The absorption bands of Fe3+/Ti4+ pairs in monochromatic UV-Vis-NIR spectra appear after the latter heat treatment, corresponding to the blue color caused by Fe3+/Ti4+ mixed acceptor states, as observed in natural blue sapphires. Conversely, the Fe3+/Be2+ mixed donor states detected at 425 nm in polychromatic UV-Vis-NIR spectra continue to be present after the reducing heat treatment. As a result, the polychromatic UV-Vis-NIR spectroscopic technique could be used to differentiate between the natural and beryllium-treated blue sapphires. An energy band model is discussed to explain the color mechanism.

Keyword

Beryllium, Blue Sapphire, Color Center, Energy Band, Synchrotron

Chemistry defect, the clue to understand colorations in gem corundum varieties and more

Pornsawat WATHANAKUL[1]*, Department of Earth Sciences, Kasetsart University (pwathanakul2@gmail.com)
Wiwat Wongkokua[2], Department of Physics, Faculty of Science, Kasetsart University, Thailand
Natthapong Monarumit[3], Department of Earth Sciences, Faculty of Science, Kasetsart University, Thailand
Thanapong Lhuaamporn[4], The Gem and Jewelry Institute of Thailand
Phongsakorn Kajornboonsook[5], Gem & Mineral Science Research, Department of Earth Sciences, Kasetsart University

Abstract

Wiwat Wongkokua1, Natthapong Monarumit2, Thanapong Lhuaamporn3, Phongsakorn Kajornboonsook1, Pornsawat Wathanakul2
1Gem & Mineral Sciences Special Research Unit, 1Department of Physics and 2Department of Earth Sciences and, Faculty of Science, Kasetsart University, Bangkok 10900, Thailand; 3The Gem and Jewelry Institute of Thailand

Causes of coloration in gem corundum varieties have been reported and followed by gem scientists since several decades by using different concepts; Red color in ruby caused by Cr3+ based on the crystal field; Yellow by absorptions of Fe3+ and Fe3+ pairs, as well as color center; The blue by Fe2+-Ti4+ intervalence charge transfer (IVCT); Green by Fe2+ or the yellow mixed with the blue. The UV-Vis-NIR absorptions have been mainly used for those explanations.
The in-depth research on gem corundum samples of different varieties has been conducted using quantitative analyses (LA-ICP-MS, EDXRF), spectroscopic methods (poly- and monochromatic UV-Vis-NIR, FTIR), synchrotron techniques (XANES, EXAFS) for the trace element oxidation states as well as their environments. Cr(III), Fe(III) and Ti(IV) are the results obtained regarding the trace element oxidation states. None of the experiments showed Fe(II), except those contaminated by containing Fe(II)-bearing inclusions. Hence, the causes of sapphire colorations have been reviewed based on the experimental results. The chemistry defects produced by those trace elements exist in the real space, whereas the kinds of excited states are thus introduced in the energy space, resulting in optical properties, i.e., absorptions, emissions, and overall luminescence. As the average energy gap of gem corundum varieties containing those chemistry defects has been calculated for about 4eV, covering the range that can be measured by the UV-Vis-NIR for both the poly- and monochromatic ones. The new explanations based on the defect chemistry of trace elements, i.e., Cr, Fe or Ti in corundum structure have been proposed by using the energy space model of the Band Theory. The UV-Vis-NIR and FITR absorptions have been newly designated and explained for the blue and green sapphires of both and basalt and metamorphic rock related ones. The blue coloration is proposed to be caused by the Fe3+/Ti4+ mixed acceptor states in the energy gap. The new concept has been well fitted with the

experimental results and makes more senses to be understood by young gem research scientists. Besides, heat treatment detections by using FTIR absorptions based on molecular water and hydroxyl ions in corundum structures are experimented and reviewed. Though before their trace element chemistry as well as their spectroscopic characteristics for both UV-Vis-NIR and FTIR have been well documented, nevertheless, their crystal chemistry has not been well touched in research, leading to the non-conclusive explanation and confusion on heat treatment determination by using those spectroscopic techniques.
Hence, the chemistry defect is not only the vital clue responsible for coloration of gem corundum, but it also helps determinations and understanding the complexity of treatment as well. Some unveiled research topics related to chemistry defect will be raised and suggested.

Keyword

Defect chemistry, ruby sapphire, band theory, XANES, Fe3+/Ti4+

Comprehensive Spectral and Chemical Characterization of Amber from Xixia, Henan Province

Yan LI[1]*, China University of Geosciences, Wuhan (yanli@cug.edu.cn)
Yilei Feng[2], China University of Geoscience, Wuhan

Abstract

Amber, a fossilized tree resin with geological origins spanning millions of years, encapsulates essential paleoenvironmental information[1]. Xixia amber is produced in Xixia, Henan Province, China. Despite the fact that the largest known amber deposit in China is located in Xixia [2], the spectral studies on Xixia amber are limited. This study fills the gap in systematic spectral characterization of Chinese amber, with a focus on Xixia amber. Employing a combination of microscopic observation, infrared spectra, three-dimensional fluorescence spectra, and pyrolysis gas chromatography-mass spectrometry (py-GC-MS), we comprehensively analyze Xixia amber and compare it with counterparts from the Baltic region, Burma, and Fushun.

Results indicates that Xixia amber, though exhibiting similar gemological traits to other ambers, displays distinctive infrared spectral features, especially in the fingerprint region. Based on the carbonyl band morphology and the doublet signal (1023 cm-1 and 974 cm-1) [3], two varieties of Xixia amber were suggested. Each series encompasses both relatively fresh and oxidized samples.

Three-dimensional fluorescence spectra further differentiate Xixia amber, aligning it more closely with Burmese and Fushun amber than Baltic amber. A detailed examination of peak wavelengths facilitates further differentiation, following the sequence Xixia > Burma > Fushun. The two series of Xixia amber also exhibit subtle differences in fluorescence characteristics.

Using py(HMDS)-GC-MS, the molecular-level similarities between Xixia amber and Burmese amber were investigated. By comparing the test results of individual samples with the co-pyrograms of Burmese amber, it was determined that Xixia amber belonged to Class I b, characterized by a regular configuration and the absence of succinic acid [4]. This result aligns with previous studies suggesting that Xixia amber is most likely contributed by the conifer family Araucariaceae [5].This research significantly advances our understanding of the unique spectroscopic properties of Xixia amber, distinguishing it from other globally distributed ambers.

Figure 1. Amber samples used in this study. Eight amber samples from Xixia, Henan Province: two yellow samples, Y-1 and Y-2, one light brown sample, LB, three orange samples, O-1, O-2 and O-3, and two brown samples, B-1 and B-2 (A is the interior, and B is the crust). Three amber samples of other origins: E-1 from the Baltic Sea, E-2 from Burma, and E-3 from Fushun, China.

Figure 2. FTIR spectra of ambers from the Baltic Sea, Burma, Fushun and Xixia

Figure 3. Three-dimensional fluorescence spectra of yellow amber samples from the Baltic Sea (a), Burma (b), Fushun (c) and Xixia (d).

Figure 4. Total ions chromatograms of Xixia amber (a) and Co-pyrogram of Xixia amber with Burmese amber(b). Framed areas (12-18 min) show partial pyrolyzates of esterified communol and communic acid. Labelled peaks and the corresponding chemical structures are also listed.

References

[1] A. Ross, Amber, Harvard University Press, 1998.
[2] S. Zhou, S. Zhao, Initial study on the Xixia-Neixiang amber deposit of Henan, Miner.

Keyword

Xixia amber, FTIR, Three-dimensional fluorescence, py(HMDS)-GC-MS

BLUE SAPPHIRE GENESIS AND CHARACTERIZATION OF BAW MAR GEM DEPOSIT, MOGOK TOWNSHIP, MYANMAR

Arkar Moe MYINT[1]*, Department of Geology, Faculty of Science, Chulalongkorn University, Pathum Wan, Bangkok, Kingdom of Thailand (6572033823@student.chula.ac.th)
Pitsanupong Kanjanapayont[2], Basin Analysis and Structural Evolution Research Unit (BASE RU), Department of Geology, Faculty of Science, Chulalongkorn University, Thailand
Khin Zaw[3], CODES Centre of Ore Deposit and Earth Sciences, University of Tasmania, Hobart, Tasmania, Australia,

Abstract

Since 2008, the Baw Mar gem deposit located in Mogok Township has become well-known for its exceptional quality blue sapphires within Myanmar's gem industry. The primary production of sapphires has been continually and mainly extracted from the southern part of the deposit. Most mining sites are situated at the northwest of Kyat Pyin, approximately 12 miles (19 km) from Mogok. The finest blue sapphires are primarily found in pegmatitic syenites, intruding into highly weathered gneiss with pocket-like leucogranites. Some sapphires are nestled in clay lenses resulting from the kaolinite alteration from feldspar of the syenite pegmatites. The sizes of the sapphires vary from 2 to 8 millimeters, reaching up to 15 centimeters. Gem-quality blue sapphires typically exhibit distinct pleochroism, ranging from greenish to violet-blue, and are relatively free of inclusions under a microscope. Through observations with high-powered gem microscopes, some show multiple twinning and are associated with whitish needle-like tiny inclusions such as boehmites. Unlike sapphires from other Mogok locations, rutile needle-like inclusions are infrequent in the Baw Mar sapphires. Common internal features include surface-reaching healing fissures, small platelets and needle-like particles (probably ilmenites), negative crystals, and unidentified dark crystal inclusions. Occasionally, mineral inclusions of K-feldspar, mica, and zircon are identified using high-powered gemological microscopes and Raman analysis. EPMA analysis reveals the trace element geochemistry of the Baw Mar sapphires, showing a relatively high iron content, very low titanium percentage, and gallium. The Ga/Mg ratio ranges from 0.5 to 18, indicating that most Baw Mar sapphires originate from both magmatic and metamorphic sources. The findings of this research suggest that the Baw Mar sapphires exhibit distinctive features when contrasted with the other Mogok blue sapphires by the trace element compositions, as well as microscopic and spectroscopic characteristics.

Keyword

Sapphire, Baw Mar, Mogok, Gemological characteristics, Syenite pegmatite

Mahan Carnelian beads production techniques and sociopolitical significance of long-distance trade

JINA HEO[1]*, Chonnam National Univ. (jina3152@gmail.com)

Abstract

In world archaeology, long-distance trade has received attention as an essential element in understanding the sociopolitical development of complex societies. Recently, Korean archaeology has revealed that from the early Iron Age to the Three Kingdoms period, polities on the ancient Korean Peninsula imported beads from various regions of East Asia. In ancient societies, long-distance trade goods included expensive luxury goods, not produced in local societies, or rare goods, such as beads.

On the other hand, studies of social complexity in different parts of the world tend to view long-distance trade and prestige-good economies as one and the same. According to this view, long-distance trade in ancient societies required both the economic ability to pay high transportation costs and the political power to control the distribution and allocation of trade goods. As such, long-distance trade goods such as beads were often used as "prestige goods," with limited access and control over their distribution granted to a certain class of individuals (i.e., elites) who had the political and economic power to do so. As a prestige good, beads may have served to define socioeconomic relationships within a community or symbolize individual power. It is also possible that they were used as an exchange of wealth, a status symbol, a display of limited goods, or as gifts to expand alliances.

In this light, the nearly 50,000 glass and stone beads found in Mahan (100 BCE-300 CE) tombs can be interpreted as suggesting that Mahan elites used beads as prestige goods and were active participants in long-distance trade networks. To test this hypothesis, this study examines the production techniques of carnelian beads, which the ancient Mahan people considered more valuable than gold and silver, to understand the maritime trade network. First, I review ancient bead-making techniques in South and Southeast Asia. Next, I conduct a quantitative analysis of the perforation size of the carnelian beads and a scanning electron microscope (SEM) analysis of silicon samples that molded the interior of the perforations. Based on the analytical results, the origin and trade routes of the carnelian beads are estimated. Finally, I discuss the implications of the carnelian bead trade for the sociopolitical development of Mahan.

Keyword

Carnelian beads, Beadmaking techniques, Long-distance trade, Prestige goods, Mahan

Hauyne of an Unusually Rare Green Color

BUDSABAKORN SRISATAPORN[1]*, The Gem and Jewelry Institute of Thailand (Public Organization) (sbudsabakorn@git.or.th)
WASSANA CHONGRAKTRAKUL[2], The Gem and Jewelry Institute of Thailand (Public Organization)
CHEEWAPORN SUPHAN[3], The Gem and Jewelry Institute of Thailand (Public Organization)

Abstract

Haüyne, a member of the feldspathoid group, derives its named after Rene Just Hauy, who is considered to be the father pioneer of mineralogy and crystallography. It is a constituent mineral of lapis lazuli, sodalite, and lazurite, and belongs to sodalite group. Gem-quality haüyne, renowned for its typically intense blue color, is a rare stone. Recently, GIT's Gems and Precious Metal Testing Laboratory (GIT-GPTL) has identified two green stones facetted as 0.83 ct cushion and 1.19 ct round-brilliant. These stones were examined for their gemological properties by standard and advanced testing instruments. The stones possess attractively bright and unusually rare green color. Both stones are single crystals and singly refractive having a similar RI of 1.498, and specific gravity (SG) of about 2.45. The stones displayed moderate orange fluorescence under long-wave ultraviolet (LWUV) and inert to weak orange fluorescence under short-wave ultraviolet (SWUV). Microscopic observation showed several features, such as crystals, minute particles, needles and liquid inclusions of natural origin. The Raman spectra of both stones showed dominant peaks at 442, 544, 988 and 1089 cm-1 that were perfectly matched with the haüyne reference spectrum from the RRUFF database. The FTIR reflectance spectra showed peaks at 429, 461, 609, 638, 648, 698, 726, 1018 and 1145 cm-1 resembling the spectrum of a typical haüyne sample. The chemical analyses of two stones by EDXRF gave SiO2, Al2O3, SO3, CaO and Na2O as their major components that are consistent with the haüyne chemical formula of Na6Ca2(Al6Si6O24)(SO4)2. Minor components included Cl and SrO with traces of MgO, K2O, MnO, Fe2O3 and TiO2. The chemical comparison results among the samples of green haüyne, blue haüyne, and green-yellow haüyne revealed no significant differences, except for somewhat lower Na2O and higher CaO concentrations in the green samples. Consequently, it is observed that the chemical analysis conducted through EDXRF is unable to distinguish the haüyne samples of various hues. The distinctive coloration of haüyne is attributed to the idiochromatic nature of differing sulfide radical anions in its structure. The UV-Vis spectra displayed a strong absorption band at ~400 nm and a small broad absorption band at ~600 nm that was quite contrast with the spectrum of blue haüyne (i.e., a strong broad absorption band at ~600 nm and a weak absorption band at ~400 nm). In conclusion, based on our comprehensive study of the basic gemological properties and advanced analyses, the gem-quality stones are identified as natural haüyne possessing an exceptionally rare green hue.

Keyword

green hauyne, gem properties, hauyne, sodalite group

Transparent and Bright Greenish-Blue Sodalite: An Extremely Rare Gemstone

Kannatee FUEANGAKSORN[1]*, The gem and jewelry institute of Thailand (public organization) (fkannatee@git.or.th)
Supparat Promwongnan[2], The gem and jewelry institute of Thailand (Public organization)
Wilawan Atichat[3], The gem and jewelry institute of Thailand (Public organization)
Visut Pisutha-Arnond[4], The gem and jewelry institute of Thailand (Public organization)
Thanong Leelawatanasuk[5], The gem and jewelry institute of Thailand (Public organization)
Chakkaphan Sutthirat[6], Chulalongkorn University

Abstract

Sodalite [Na8Al6Si6Cl2] is a feldspathoid, a tectosilicate found in more restricted occurrences, such as in undersaturated igneous rocks of both intrusive (e.g., nepheline-syenites, monzonites) and extrusive (e.g., phonolites, trachyte), also in metasomatized limestone (marble). Transparent or translucent gem-quality sodalite specimens are extremely rare. Recently, the GIT Gem and Precious Metal Testing Laboratory (GIT-GPTL) received a 0.21 ct greenish blue stone facetted as triangular modified brilliant for identification. The stone was characterized by using both basic and advanced gem equipment. The stone possesses an extremely rare transparent to somewhat translucent diaphaneity and attractively bright greenish blue hue. Its basic gem properties are single refraction with RI of 1.495, SG of 2.241, fluorescence/phosphorescence reaction as weak orange in short-wave UV and moderate orange in long-wave UV without tenebrescence effect, in agreement with those of sodalite. Microscopic observation revealed many prominent internal features including curved hollow tubes, fingerprints, fluid inclusions, crystals, and fractures with iron stain. The UV-Vis-NIR spectrum showed two board bands peaked at ~380 and ~606 nm, typical of blue sodalite. The FTIR spectra in the mid-infrared region showed the most prominent peak at 990 cm-1with shoulder 1036 cm-1 and other smaller sharp peaks at 732, 711, 664, 475 and 437 cm-1 that are slightly different from our reference spectra of blue sodalite and hackmanite. The semi-quantitative chemical components of the greenish blue stone obtained by EDXRF are 51.43%SiO2 , 29.88%Al2O3, 8.68%Na2O, 6.11%Cl, 2.34%SO3, 1.02%K2O, 0.36%CaO, 0.08%TiO2, 0.02%Mn2O3 and 0.06% MgO that are fairly consistent with the compositions of our blue sodalite and hackmanite reference samples. Traces of Li (305.3 ppmw), Be (23.2 ppmw), Cr (0.9 ppmw), Co (0.1 ppmw), Ni (0.5 ppmw), Cu (0.4 ppmw) and Zn (0.2 ppmw) were also found in the by LA-ICP-MS. In conclusion, this stone is identified as an extremely rare transparent, attractively bright greenish blue, gem-quality sodalite that deserves a comprehensive documentation.

Keyword

Blue sodalite, Rare gemstones, Transparency

Influence of Electron Radiation on Colour Modification and Colour Stability of Pink Sapphires: A Preliminary Study

WARATCHANOK SUWANMANEE[1]*, The Gem and Jewelry Institute of Thailand (Public Organization) (swaratchanok@git.or.th)
THANAPONG LHUAAMPORN[2], The Gem and Jewelry Institute of Thailand (Public Organization)
NONGNUCH JANGSAWANG[3], Thailand Institute of Nuclear Technology (Public Organization)

Abstract

Padparadscha are a rare and highly desired variety of corundum, prized for their unique coloration that falls somewhere between pink and orange. Most Padparadscha sapphires in the recent market undergo various treatments to enhance their beautiful colour through heat treatments. The heat-treated Padparadscha sapphires are exposed to high temperatures to improve their colour and clarity. This process makes the gemstones more vibrant and brighter in appearance. Another treatment often used is adding beryllium to the gemstone during heating, which can create a more desirable colour. In addition to heating, there is also irradiation treatment. Nowadays, irradiation has increasingly become a concerning issue in corundum enhancement. Recently, some entrepreneurs attempted to irradiate corundum such as yellow sapphire, pink sapphire, and purplish ruby to enhance the color and add value to the gemstone, significantly. It is well-known that the yellow colouration after irradiation of corundum is related to defect structures (colour centres) that are unstable when exposed to daylight or heated for a long time and faded back closer to their original colour.

In case of pink sapphires, their colour was treated to resemble a Padparadscha-like colour due to the addition of yellow shade, the samples were sold to the market without disclosing the treatment. Therefore, the authors have investigated the representative of irradiated pink sapphires to better understand the effect of an electron irradiation treatment and to develop potential detection methods for gem testing laboratories. In this study, pink sapphires were selected from Madagascar and Tanzania to investigate. An electron irradiation experiments on our samples were carried out in a specialized facility in Thailand . All samples were subjected to a colour stability test after being irradiated. The colour modification of the pink sapphire was investigated by UV-Vis absorption spectra and color grading was also subjected to color grading using the Munsell color chart under a lightbox with a 5000K color temperature. In addition, samples were photographed to compare their color before and after irradiation, as well as after the color stability test.

Keyword

Pink sapphire, Irradiation, Electron radiation, Colour stability test

Baddeleyite SK10-2 and Rutile KNW: Two natural reference materials for microbeam U-Pb geochronology

Shitou WU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (shitou.wu@mail.iggcas.ac.cn)
Yueheng Yang[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Microbeam U-Pb geochronology by LA-ICP-MS and SIMS requires matrix-matched reference materials for the correction of elemental fractionation and matrix-induced mass bias. In this study, we presented two natural reference materials SK10-2 and KNW for baddeleyite and rutile U-Pb geochronology, respectively. Baddeleyite SK10-2 is separated from a gabbro rock collected from Northeast China, while rutile KNW is a gemstone quality megacrystal from North Europe. CL and SEM images illustrated these two materials are relatively clean without inclusions and secondary minerals. Baddeleyite SK10-2 and rutile KNW contain U contents of ~500 ug g-1 and 20 ug g-1, respectively. A large multiple spot analyses (n > 150) using LA-ICP-MS demonstrated the homogeneity of U-Pb age at tens um level for both materials. ID-TIMS analyses yielded a weighted mean 206Pb/238U ages of 31.592 ± 0.035 Ma (2s, n = 10) and 1088.1 ± 1.5 Ma (2s, n = 9) for baddeleyite SK10-2 and rutile KNW, respectively. Baddeleyite SK10-2 is a reference material for Hf isotope ratio analysis with the mean MC-ICP-MS 176Hf/177Hf value of 0.282742 ± 0.000008 (2SD, n = 9). Rutile KNW is a reference material for Zr content analysis with the mean LA-ICP-MS and EPMA value of 1252 ± 45 ug g-1. These two reference materials might be useful for the baddeleyite and rutile microbeam U-Pb geochronology.

Keyword

microbeam U-Pb geochronology, reference material, LA-ICP-MS, SIMS

Agrominerals and food security in Africa

Olugbenga Akindeji Okunlola[1]*, university of Ibadan/AGID (gbengaokunlola@yahoo.co.uk)

Abstract

AGROMINERALS AND FOOD SECURITY OF AFRICA
Olugbenga A Okunlola
Department of Geology University of Ibadan, Ibadan, Nigeria
Food security, a situation in which people, at all times, have physical and economic access to sufficient, safe and nutritious food to meet their dietary needs and food preferences for an active healthy life is in three aspects, availability, access and adequacy. Achieving food security in its totality continues to be a challenge for Africa worsening over the years. One of the major challenges to food security in Africa is low fertility soils as a result of severe nutrient depletion ranging between 30 to over 60kg/ha, leading to low crop yields. Agro-minerals which are minerals of importance to agriculture and horticulture are usually essential plant nutrients. Strategic planning to explore and exploit these minerals as main raw materials in additive fertilizers and or direct application to soils will lead to enhancement of soil nutrient status.
The study aims at elucidating the significant agro-minerals of Africa, which includes Phosphate, Limestone (Marble), Potash, Gypsum, Feldspar, and Sulfur, with a view to reveal distribution, mode of occurrence origin occurrence and application
Phosphate deposits found in 41 African countries are mainly of igneous apatite and Sedimentary carbonate-fluorapatite mineralogical varieties. Tonnage varies across Africa with significant occurrence mainly in North Africa which accounts for over 55% of all the phosphate resource. P2O5 content varies from 9.25 % to 30 % across the continent. The main gypsum deposits in sub-Saharan Africa are associated with Mesozoic to Recent sediments and evaporative crusts. They are found in many coastal basins and in various localities in continental basins in West-Central Africa and the Rift valleys. Gypsum as by-product from the phosphate industry (phosphogypsum) is found in large amounts in Senegal and Zimbabwe. In Africa, the most commonly used form of K input in agriculture is potassium salts (potash). Pegmatitie and leuco granites of the Eburnean and Pan African Orogenic origin hosts K-feldspar, leucite, K-micas such as biotite, phlogopite, and glauconite, and are in places weathered into clays such as illite. Leucite-bearing volcanics occur within the volcanic regions of Central Africa. Sulfur as elemental Sulfur is found in relatively small amounts in many volcanic terranes of Africa, but also as part of sedimentary gypsum-(CaS04 2H20) and anhydrite-(CaS04) bearing sequences. Pyrite, (FeS2) occur in areas of mixed sulfide mineralization in countries of East and West Africa and can provide Sulfur to plants. Sulfur deficiencies have been studied in soils of Parts of Africa and are partially due to depletion of S through heavy crop removals, intensive cropping and lack of organic matter recycling.
Improvement in soil nutrient status is essential to achieving soil food security in Africa. Development of strategic approach to exploration and development of a data bank and inventory of agromineral resources of Africa is of necessity. Agrominerals should be treated as critical and

strategic minerals and prioritized. Integrated regional agronomic, agrogeological and a needs assessment study for the development of soil nutrient enhancement through agrominerals should also be

Keyword

Food, Agrominerals, Application, fertilizers, Nutrient

Geochronology of diamond formation in the mantle and its relation to geodynamics

Felix V. Kaminsky[1]*, Russian Academy of Sciences (kaminsky@geokhi.ru)

Abstract

The ages of diamond formation are determined by the ages of their syngenetic mineral inclusions (garnet, pyroxene, sulfide, and rutile). Rb-Sr, Sm-Nd, Re-Os, and U-Pb isotope systems are most common for this purpose. They show a much earlier formation of diamonds than their host kimberlites and lamproites, confirming the xenogenic nature of diamonds in these rocks. The established diamond ages are distributed through the entire Earth's history from 100 Ma to 4.16 Ga (Smit et al., 2022). Most diamond formation ages are usually connected to lithospheric slab subduction into the Earth's mantle. However, geological data do not support such a conclusion. First, the uncertainties in all analytical methods are many hundreds of millions of years, especially for eclogitic inclusions in diamonds. This creates uncertainties in the geological interpretation of data. Second, most of the analyzed inclusions in diamonds belong to the eclogitic association, considered a priori due to the subduction of lithospheric plates. For some kimberlite pipes, several (up to 5-7) epochs of diamond formation are determined from 140 Ma to 4 Ga. These specified diamond formation periods cover the entire evolution of cratons. A large data scatter makes it formally possible to tie almost any diamond age with some subduction event. Meanwhile, a detailed study of eclogitic inclusions in diamonds shows that they initially belong not to subduction products of the oceanic crust but to mantle igneous rocks. There are "eclogites and eclogites". Bimineral (garnet-omphacitic) eclogites of group A (according to the Strekeisen classification) have a mantle formation. They are magmatic due to the formation of "eclogitic magma", in the terminology of Escola, from the mantle melt. For example, among eclogitic xenoliths in the Roberts Victor kimberlite pipe, located in the central part of the Kaapvaal Craton. Two types (I and II) of eclogites are distinguished among them, formed at depths of 120-200 km, which differ in mineralogical and isotopic compositions (Huang et al., 2012). They have different ages of formation: 103 ± 10 Ma (Sm-Nd) and 132 ± 16 Ma (Lu-Hf) for type I, and 738–1,143 Ma (Sm-Nd) and 1,148–1,544 Ma (Lu-Hf) for type II; and no subduction processes of these ages are known in the region. As Huang et al. (2012) conclude, eclogite xenoliths from the Roberts Victor pipe were originally igneous rocks crystallized at depth, not products of oceanic crust subduction. Thus, the ages of most eclogitic inclusions in diamonds cannot be considered chronological indicators of hypothetical subduction processes. It can be assumed that the formation of diamonds with eclogitic inclusions is associated not with tectonic processes in near-surface zones but with the episodic formation of eclogite melts in the mantle caused by deep geodynamic processes. Most peridotitic inclusions are older than 2.5 billion years, corresponding to areas of the most ancient mantle. The ages of both peridotitic and eclogitic inclusions in diamonds can serve as indicators of deep geodynamic processes (mantle convection currents, primary and secondary plumes, etc.).

Keyword

Diamond, Inclusion, Age

Trace element in blue sapphire: Challenge or potential of element analyses by LA-ICP-TOF-MS for origin determination?

Wei ZHOU[1]*, SSEF Swiss Gemmological Institute (wei.zhou@ssef.ch)
Michael S Krzemnicki[2], SSEF Swiss Gemmological Institute
Hao Wang[3], SSEF Swiss Gemmological Institute

Abstract

In this study, we present trace element data of gem quality sapphires showing distinct chemical fingerprint. Sapphire samples which originating from two metamorphic deposits, Kashmir (Zanskar Range, India) and Madagascar (possibly Andranondambo) has been chosen. The analyses have been performed by LA-ICP-TOF-MS (LA-ICP Time-of-Flight mass spectrometry), which specifically adapted to analyze zoning with unexpected trace elements (e.g. from nano-inclusions) by simultaneous multi-element detection.

For several years, the data collection and study on LA-ICP-TOF-MS data of gem-quality sapphires have revealed that the presence and content of elements which known as high field strength elements (HFSE, Zr, Nb, Zr, Hf, Ta, Th, U…) with Ni, Pb are indicative of the origin determination of the host sapphire. In sapphire from Kashmir, part of the light-colored stones with pronounced color zoning often has more noticeable occurrences of HFSEs; the similar situation occurs in sapphires from certain regions of Madagascar. Although these group of elements are present only at levels of a few to a dozen ppm, they are hardly ever encountered in sapphires from other places that have been also tested at SSEF by LA-ICP-TOF-MS. The ultra trace elements occurring in groups are enriched in sapphires from specific origin, in order to address this meaningful phenomenon, in this study the geological and lithological conditions of these two regions, Kashmir and Andranondambo, Madagascar, are further characterized and discussed.

In addition, although similar enrichment of elemental compositions occurs, the content of specific elements is not the same in sapphires from Kashmir and Madagascar. The geochemically significant elements Th and Pb are particular important. According to the classical Th/Pb isotope dating method, the geologic ages of sapphires from the two origins with similar chemical composition and similar inclusions are quite different. By using this direct age dating, the geological ages obtained from sapphires of Kashmir origin are in the approximate range of 25-50 Ma, whereas ages on sapphires from Madagascar exceed 500 Ma. Considering the testing requires only very small amount of samples to obtain the data and the testing is rather performed by a “random” sampling, the direct age dating conclusions, which are highly in line with the geological background of the origin, are more than just acceptable.

By using only 4-8 analytical spots (as commonly applied in commercial gemstone analyses), the presence and variability of certain trace elements already are helpful for origin determination of sapphires.

Keyword

LA-ICP-TOF-MS, sapphire, Kashmir, Madagascar

Three natural reference materials for in situ andradite U–Pb geochronology

Yueheng Yueheng YANG[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (yangyueheng@mail.iggcas.ac.cn)
Shi WU[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Grandite garnets are a solid–solution series of andradite and grossular, and occur widely in a variety of alkaline magmatic rocks, carbonatites and skarn deposits typically associated with economic Fe, Cu, W, Sn and Mo mineralization. Andradite–rich garnet, a common mineral in various rocks such as alkaline and skarn rocks, could have high U/Pb ratios and is suitable and preferable for in situ U–Pb dating. Nevertheless, very limitedly available U–Pb andradite reference material hindered its widespread application for microanalysis. In this study, three new natural andradite (MKWB, DGS and Stanley) have been characterized and evaluated as potential reference material for in situ U–Pb geochronology. We performed U–Pb age measurement in four different laboratories using isotope dilution TIMS and laser ablation (SF, Q)–ICP–MS, to check the homogeneity of euhedral andradite crystals. The ID–TIMS results of MKWB, DGS and Stanley andradite are reported for the first time in this study. We presented ID–TIMS 206Pb/238U age of 264.9 ± 5.8 Ma (2s, n=6, MSWD=3.4), 139.42 ± 0.36 Ma (2s, n=5, MSWD=1.9) and 23.28 ± 0.38 Ma (2s, n=3, MSWD=1.9) for MKWB, DGS and Stanley, respectively. These three new natural secondary reference materials are to contribute significantly to rapidly developing in situ U–Pb andradite–rich garnet geochronology.

Keyword

Andradite, Reference materials, ID-TIMS, LA-ICP-MS, Microanalysis

Different origins of garnet in high-grade metamorphic rocks

Qiong-Xia XIA[1]*, University of Science and Technology of China (qxxia@ustc.edu.cn)

Abstract

Garnet in high-grade metamorphic rocks, including high temperature (HT), high pressure (HP), to ultrahigh-temperature (UHT) and ultrahigh-pressure (UHP) metamorphic rocks of subduction zones commonly shows considerable zonation in major and trace elements as well as mineral inclusions, which bears information on its growth mechanism via metamorphic or peritectic reactions in coexistence with relic minerals and metamorphic fluids or anatectic melts at subduction-zone conditions. It provides an important target to retrieve physicochemical changes in subduction-zone processes, including those not only in pressure and temperature but also in the durations of metamorphism and anatexis. Garnet from different compositions of HT-HP to UHT-UHP metamorphic rocks may show different types of major and trace element zonation, as well as mineral inclusions. Discrimination between the different origins of garnet provides important constraints on pressure and temperature and the evolution history for the HP to UHP metamorphic rocks. Magmatic garnet may occur as relics in granitic gneisses despite metamorphic modification at subduction-zone conditions, with spessartine-increasing or flat major element profiles from inner to outer core and exceptionally higher contents of trace elements than metamorphic mantle and rim. Metamorphic garnet can grow at different metamorphic stages during prograde subduction and retrograde exhumation, with spessartine-decreasing from core to rim if the intracrystalline diffusion is not too fast. The compositional profiles of metamorphic garnet in the abundances of grossular, almandine and pyrope are variable depending on the composition of host rocks and co-existing minerals. Peritectic garnet grows through peritectic reactions during partial melting of HT to UHT rocks, with the composition of major elements to be controlled by anatectic P-T conditions and the compositions of parental rocks and anatectic melts. Trace element profiles in garnet with different origins are also variable depending on the coexisting mineral assemblages, the garnet-forming reactions and the property of metamorphic fluids or anatectic melts. Mineral inclusions not only present key clues to identify the different origins of garnet, but also serve as sound candidates for the temporal constraint on garnet growth.

Keyword

Garnet, multiphase growth, metamorphic reaction, peritectic reaction, subduction zone

Paragenesis of Alteration/Zoning in Meta-Sedimentary Chromite from the Singhbhum Craton, Eastern India.

Asish Kumar DAS[1]*, CSIR-Central Institute of Mining and Fuel Research
(asiskumar.ctc@gmail.com)
Birendra Kumar Mohapatra[2], CSIR-Institute of Minerals and Materials Technology
Somnath Khaoash[3], Ravenshaw University
Patitapaban Mishra[4], Ravenshaw University

Abstract

The chromite occurrences present in southern fringe of Singhbhum Craton, shares a unique position in the mineral map of the world because of its sedimentary genealogy which is a notable divergence from the world's well-established orthomagmatic deposits. However, the altered chromite grains are heterogeneous that are associated with quartzites as host rock and demonstrates a different compositional trend. The change is erratic, generally consisting of two optical zones (bright and dull). Chromite grains often have a high reflectivity core (brighter zone) encrusted by a low reflectivity surrounding zone (dull zone). This change in zoning is in sharp contrast to other chromiferous ores reported from various regions of the world, where the chromite grain has greater marginal reflectivity.

Although the avg. Cr and Al content remains almost same (Cr# 0.78 in core and 0.77 in rim), there is a considerable rise in Fe composition and decline in Mg content from the outer peripheral zone (avg. Mg# 0.24) to the core zone (avg. Mg# 0.48). In the current setup, the chromite alteration essentially represents the outcomes of compositional zoning. The altered chromite exhibits an aluminium trend, with Fe being enriched in the spinel's core zone while Al, Mg, Mn, and Co concentrations are greatest in the periphery zone. The difference in composition suggests that such zoning may have resulted through chromite alteration via solid-state diffusion, in which Mg-Al ions migrate out of the core area and Fe ions diffuse into the core. The plots of many key elements in triangular diagrams, such as Cr-Al-Fe(T) and Cr-Mg-Fe(T) as end members, also show clear patterns from the core to the rim and indicates that there is a process of leaching of Cr and Fe ions from the core, followed by their precipitation in the rim during alteration.

Keyword

Altered Chromite, Singhbhum Craton, Meta-sedimentary, Zoning, Solid-state diffusion

Petrological and structural characterisation controlling gold mineralization in the northern part of the Kon Tum massif, Central Highlands of Vietnam

THÀNH VŨ-TIẾN[1]*, Official of Center for Information, Archives and Museum of Geology, Vietnam Geological Department (tienthanhvudgmv@gmail.com)
VƯỢNG NGUYỄN-VĂN[2], University of Science, Vietnam National University
HOÀI LƯỜNG-THỊ-THU[3], University of Science, Vietnam National University

Abstract

The northern Kon Tum massif, the Central Highlands of Vietnam, has the largest concentration of gold deposits in the country and the Southeast Asia region. However, the relationship between the geological structures controlling gold mineralisation in the area has not yet been fully elucidated. Our study is based on the tectonic movement characteristics, indicating the relationship between gold mineralisation and geological structures. Five structural subzones are divided by several shearzones in the north of Kon Tum massif. They result from tectonic deformation processes occurring around 250 to 230 million years ago (MA), forming interleaved anticlines and synclines. The older structures only leave residual traces. From south to north, the local melting degree of migmatite gradually decreases to zero, and the metamorphic grade transitions from amphibolite with strong migmatization to greenschist. Spatially, gold mineralisation within the study zone is distributed in various formations. Hence, lithological factors do not play an important role in shaping the space and positions of gold mineralisation deposits. In fact, gold mineralisation is found conformably within metamorphic foliation planes or distributed on surfaces of mylonite zones. Dome-shaped structures with brittle deformation at the top create fractures and faults, facilitating ore concentration due to pressure differences. The domes of the anticlines and along the shearzones are potential areas that need to be expanded to research for gold mineralization.

Keyword

Kontum massif, Metamorphic-hosted gold mineralization, Early Paleozoic orogeny, Gold minerals, Central Highlands

Age of the South Ural mines: U-Pb ID-TIMS garnet dating

Yulia PLOTKINA[1]*, Institute of Precambrian Geology and Geochronology RAS (jplotkina@yandex.ru)
Maria Stifeeva[2], Institute of Precambrian Geology and Geochronology R
Ekaterina Salnikova[3], Institute of Precambrian Geology and Geochronology R
Olga Yakubovich[4], Institute of Precambrian Geology and Geochronology R
Alexander Kotov[5], Institute of Precambrian Geology and Geochronology R

Abstract

Skarn mineral associations of the South Ural mines (Eremeevskaya, Zelentsovskaya, Nikolae-Maximilianovskaya, Akhmatovskaya, Perovskite and Shorlomite) are famous mineralogical objects full of amazing variety of minerals which attract researchers as well as simply stone amateur. All mines are located along the western contact of the Mesoproterozoic Kusa–Kopan intrusive complex with country carbonate rocks. About 100 different minerals founded in these deposits including colored tourmalines, green beryl, morganite, topaz, pollucite, perovskite, vesuvian, olivine, tantalum-niobates etc. At this moment interpretation of the origin and age of these deposits are controversial. Some researchers suggest multi-stage mineral formation of skarn mineral association, some authors imply carbonatite origin of these rocks with unique mineralization (Popov, 2010; Stepanov et al., 2020).

U–Pb perovskites ages from silicate-calcite vein rocks from the South Ural mines range from 468 ± 6 Ma (Zelentsovskaya mine) to 497 ± 4 Ma (Perovskite mines) (Stepanov et al., 2020) and are significantly younger than the Kusa–Kopan intrusive complex (1379 ± 8 Ma).

We present U-Pb ID-TIMS ages of the andradite from the Shorlomite mine located in vicinity of Zelentsovskaya and Perovskite mines. Ca-Fe garnet is common in magmatic and metasomatic rocks. Garnet usually forms large (about 5 cm) black single crystals. Studied andradite is characterized by high level of andradite component (up 60 to 80% of andradite component). Numerous recent studies demonstrate the robustness and utility of garnet U–Pb system for precise dating of ore-forming processes as well as compositionally diverse alkaline and carbonatitic intrusive rocks of different ages.

Composition and high U abundance in garnet from the Shorlomite mine may suggests its magmatic rather scarn origin.

Three homogeneous garnet fractions were selected for analysis. The studied sample is characterized by high U contents (19-21 ppm) 275 and low levels of common Pb (Pbc/Pbt = 0.1-0.2). The data points are concordant or slightly discordant and yield an age of 505±15 Ma.

This U-Pb garnet age is in a good coincidence with previously reported perovskite age for neighbor Perovskite mines and confirms the Cambrian age of at least part of famous South Ural Mines.

The study was supported by grant No 22-17-00211 from the Russian Science Foundation and FMUW-2022-0003.

Keyword

garnet, U-Pb ID-TIMS dating, South Ural mines

Review on geochemical, metallogenesis, and geodynamic studies for the origin and mineralisation potential of rare metal pegmatites of Côte d'Ivoire (West Africa).

Felix Oufouet KONAN[1]*, Pan African University, Life, earth and Science Institute (felixhouphouetkonan@gmail.com)

Abstract

Côte d'Ivoire's pegmatite occurrences have been the subject of a limited number of studies. Fifteen (15) zones of interest have been identified, of which only those in the Issia locality have been the subject of rigorous and detailed study, revealing them as columbite-tantaliferous (coltan) deposits. Recent investigations have revealed the numerous rare metal potentials of the pegmatite, particularly in the Boundiali region (north-west of the country) and the Comoé basin (south-east of Côte d'Ivoire), highlighting the significant potential of pegmatites. The pegmatites of the Boundiali region, and more specifically those of the Touvré-Kouto area, appear to be the most interesting in terms of rare metal enrichment. These pegmatites are intrusive into birimian (Palaeoproterozoic), either in parametamorphic formations (mainly amphibolites) or in granites, and are characterised by two main series. The first series, by far the largest, contains volcanic and volcano-sedimentary formations, affected by general greenschist-type metamorphism and general sub-vertical schistosity N20 to N30. The second series made up of detrital sediments, is undeformed and non-metamorphic, also deposited unconformably on the first series. The Boundiali region is characterised by five main types of pegmatites: the lepidolite-muscovite-spodumene-colombo-tantalite type, the green muscovite, and colombo-tantalite type, the green beryl type, muscovite-beryl type, and the biotite-magnetite type. Mainly peraluminous, it is not uncommon to find some of metaluminous origin, showing the pegmatitic diversity of this region. A recent study classified these pegmatites as LCT, based on lithium anomalies identified from soil sampling analyses (14,000 samples, sent for pXRF and LIBS analysis). Purplish lepidolites and spodumene were also identified in isolated blocks of pegmatite, leading to the discovery of a lithium deposit. Also characterised by rocks of Birimian age (Eburnian orogeny), the Comoé region is known for its occurrences of later-stage pegmatitic rocks associated with leucogranite plutons. Recent studies carried out in the Agboville region have identified several pegmatite outcrops with interesting rare metal potential (lithium, tantalum +/- niobium, and beryllium). Four groups of pegmatites are identified based on their mineralogy: beryl-muscovite pegmatite (Aboisso-Comoé), albite-tourmaline pegmatite (Aboisso-Comoé), micas-tourmaline pegmatite (Alosso), and muscovite-garnet pegmatite (Songan). The pegmatites in this region show signatures suggesting a para-derivative origin and are close to the Lithium-Cesium-Tantalum (LCT) type, with diagrams indicating the probable presence of beryl and spodumene-type mineralisation in the muscovite-garnet pegmatite. Overall pegmatite occurrences of Côte d'Ivoire deserve to be further studied and explored for further elucidation of their economic potentials.

Keyword

Côte d'Ivoire, pegmatites, origin, potentiality, economic impact

MINERALOGICAL FEATURES OF GOLD ORES OF THE SARYJAY AREA (BUKANTOU MOUNTAINS, CENTRAL KYZYLKUM)

SHOKHIDA SAMANDAROVA[1]*, MINEROLOGY, PETROLOGY, CRYSTALLOGRAPHY (Sshoxida90@gmail.com)

Abstract

In order to identify typomorphic minerals and their characteristic features, we studied the main ore minerals of the Saryjay gold ore field in the Bukantou Mountains using electron microprobe analysis. Productive parageneses and typochemical features of individual minerals are identified.

The Sarijoy prospective area is located in the eastern part of the Bukantou Mountains in the Uchkuduk district of the Navoi region, belongs to the Bukantou structural-formational zone, and the research area is composed of Meso-Cenozoic deposits, which appear in the form of a platform cover, as well as Precambrian layers and Paleozoic formations that form the lower structural layer [1].

The main part of the studied areas consists of Precambrian rocks, represented by Riphean sediments of the Kyrkkuduk and Kokpatas formations [2].

Mineral rocks are represented by shales, carbon-silica shales, sandstones, siltstones, and carbonate. Shales consist of albite-chlorite-silica-sericite rocks that differ from each other in composition. It has a layered, sometimes striped structure with a distinct texture.

Vein-shaped and lens-shaped quartzization zones are observed in carbon-silicon shales.

Zones of sulfide mineralization form medium to coarse-grained, veined and aggregated textures at rock contacts (predominantly in carbonaceous-siliceous shales) with predominantly quartz veins. In gray and black shales, sulfide minerals are predominantly fine-grained, less often medium-grained, forming a scattered, disseminated texture.

As a result of research, the main types of ores of hypogene minerals are gold, electrum, kustelite, silver, argentite, pyrite, pyrrhotite, arsenopyrite, sternbergite, chalcopyrite, chalcocite, covellite, sphalerite, galena and fahlores; non-metallic minerals are quartz, plagioclase, sericite, chlorite and carbonates (calcite, dolomite), accessory minerals are apatite, alamazite, ashirite, monocyte, rutile.

Ore-forming minerals are found predominantly in hypideomorphic and xenomorphic structures, sometimes in euhedral structures.

The productive ore-forming paragenesis is represented by gold-silver-quartz-pyrite-chalcopyrite and silver-gold-quartz-pyrite-arsenopyrite associations.

Keyword

gold mineralization, minerals, composition, Saryjay area, Central Kyzylkum

The origin of olivine in kimberlite inferred from variably compositional zoning in kimberlite from Karowe mine, Botswana

Wentao Cao[1]*, State University of New York at Fredonia (cao@fredonia.edu)
Tingting Gu[2], Purdue University

Abstract

Olivine, a common crystal in kimberlite, is a critical mineral to interpret the kimberlite petrogenesis, ascent, and evolution. However, the origin of olivine, mantle-derived vs. melt-derived, remains largely disputed. In this study, we examined the olivine macrocrysts or phenocrysts in kimberlite from the AK6 Karowe mine in Botswana with petrography and mineral chemistry, attempting to address its origin in the specimen. The study sample was collected from the Karowe AK6 south lobe in the Orapa kimberlite field. The volume percentage of olivine in the specimen is ~40%, with perovskite, spinel, magnetite, serpentine, and solidified melt as the other major constituents. The olivine crystals are predominantly subhedral along with euhedral to anhedral crystals, with crystal sizes varying from megacrystic (>5 mm) to mesocrystic (<5 mm). Grain-scale cracks commonly filled with serpentine are common in the specimen. Perovskite, large or small, is typically present along with the major olivine phase. Spinel is typically found in the rim of olivine or the matrix.

Backscattered electron (BSE) images of olivine crystals show that the olivine crystals are variably zoned, with either Fe-rich or Mg-rich core of anhedral to subhedral shape. The rims display a variable thickness from ~10 to 100 um, with diffused or sharp transitions. Electron microprobe analysis of different olivine crystals shows that two distinct types of compositional zoning are present. The first and primary type olivine crystals show reverse zoning (i.e. increasing Mg# = Mg/(Fe+Mg)). The analyzed composition shows an Fe-rich core with a Mg# at 82 and low CaO (0 – 0.23 wt%), Cr2O3 (0 – 0.03 wt%) and NiO (0.10 – 0.25 wt%) values, followed by an Fe-poor rim with Mg# at 84 – 90 and higher CaO (up to 1.07 wt%), Cr2O3 (0.02 – 0.09 wt%) and NiO (0.08 – 0.34 wt%). The second and normal (ie. Decreasing Mg#) type olivine crystals display an Fe-poor core, Mg#) at 89 – 94, variable CaO (0 – 0.14 wt%) and Cr2O3 (0.03 – 0.08 wt%) and high NiO (0.32 – 0.47 wt%), along with an Fe-rich rim (Mg# = 88 – 89, CaO 0.02 – 0.08, Cr2O3 0.02 – 0.07 and lower NiO 0.28 – 0.38 wt%). Considering the shape of olivine, compositional boundaries and, these two types of olivine reflect the complicated evolution of kimberlitic magma along with subsequent diffusional modifications.

Keyword

kimberlite, olivine, mineral chemistry, Botswana

Enhancing Ceramic Quality through Mineralogical Adjustments in Highly Silicic Clays: A Case Study from Brunei Darussalam

Yussif IDDRISU [1], Department of Design & Creative Industries, Faculty of Arts and Social Sciences, Universiti Brunei Darussalam
Elena IFANDI[2]*, University Brunei Darussalam (elena.ifandi@ubd.edu.bn)
Rui Oliveira LOPES [3], Department of Design & Creative Industries, Faculty of Arts and Social Sciences, Universiti Brunei Darussalam

Abstract

The sedimentary deposits in Brunei Darussalam are highly silicic, with quartz dominating both the coarser and the finer fraction of the sediments. The focus is on locally sampled clay material, specifically those with a significant quartz content (70-80%), which hitherto were deemed unsuitable for ceramic production. We assessed the mineralogical and geochemical characteristics of the local clay sediment that lead to failures during ceramic firing. This study involved in-depth analysis of the clay deposit's chemical composition, shrinkage percentage, plasticity, and other key factors relevant to earthenware production. The results on the physical analysis of the selected clay show a good plasticity quality, shrinkage percentage of about 2% on average, and a bulk density of 1.57% on average. Thermogravimetric analyses (TGA) result revealed a weight loss of 8.68% on heating and 93.32% undecomposed value after degradation which indicates that the clay sample is thermally stable at high temperature. Furthermore, X-ray diffraction (XRD) analyses showed that the clay contains high amount of quartz (75.3%), with minor occurrence of illite (16.4%), kaolinite (7.3%), and potentially trace amount of the iron hydroxide goethite (0.7%) and vermiculite (0.3%). The TGA and XRD results indicated the need to modify the firing temperature towards the stability limit of quartz. Thus, ceramic samples prepared from the local clay were fired in range of different temperatures, between 573oC to 1196oC. The colours changes before and after firing ranged from terracotta to dark brown. Post-firing XRD analysis of the ceramic samples indicated phase transformations from kaolinite to mullite, and of illite and quartz to melt and form a glassy matrix which results to increase in the ceramic cohesion. The observed densification of the ceramic after firing is assigned to the oxidation of the iron species coupled with the reported colour changes. The ceramic fired in optimised temperature had a good cohesion and developed the characteristic metallic sound used by potters to evaluate the quality of the ceramics. Our comprehensive investigation of the physical, geochemical and mineralogical characteristics of locally sampled clay material allowed us to fine tune the firing temperature and create good quality ceramics. Our study highlights the potential of local clay for earthenware production, suggesting a reevaluation of previously undervalued clay deposits in Brunei Darussalam and elsewhere. Further experimentation with a variety of local clay types is essential for a more comprehensive understanding.

Keyword

Clay, Geochemical, Firing temperature, Earthenware

Understanding the facet-mediated molecular-level interactions between antimony (III and V) oxyanions and boehmite (γ−AlOOH) based on the physicochemical properties of mineral

Seon Yong LEE[1]*, Korea Institute of Geoscience and Mineral Resources (seonyonglee@kigam.re.kr)
Eun Cho[2], Center for Water Cycle Research, Korea Institute of Science and Technology (KIST), Seoul 02792, Republic of Korea
Bong Lim Suh[3], Mechatronics Research, Samsung Electronics co., Ltd, Gyeonggi-do 18448, Republic of Korea
Kyung-Won Jung[4], Center for Water Cycle Research, Korea Institute of Science and Technology (KIST), Seoul 02792, Republic of Korea
Bongsu Chang[5], Department of Earth and Environmental Sciences, Korea University, Seoul 02841, Republic of Korea
Young Jae Lee[6], Department of Earth and Environmental Sciences, Korea University, Seoul 02841, Republic of Korea

Abstract

Molecular-scale understanding on the interactions between Sb oxyanions (Sb(III)/Sb(VI)) and aluminum (oxyhydr)oxides is of great environmental importance. Despite the natural abundance of boehmite (γ-AlOOH), however, the adsorption behavior of boehmite toward Sb oxyanions and their interfacial interaction mechanisms have not been yet studied. We systematically investigated the adsorption behavior of Sb oxyanions on boehmite with defined facets via batch adsorption experiments, spectroscopy-based techniques and theoretical calculations. Considering the Sb-contaminated environmental condition (e.g., acid mine drainage), boehmite sample was synthesized under weak acidic condition through hydrothermal method and the mineralogical properties were characterized using XRD, TEM, SEM/EDS and FT-IR. The synthesized boehmite showed the nanorod morphology and consisted of four crystal facets with the following order: 48.4% (010), 27.1% (101), 15.0% (001), and 9.5% (100). Adsorption behavior of the boehmite sample towards Sb(III) and Sb(V) was different depending on pH and ionic strength. The combined results of X-ray absorption spectroscopy (XAS) analyses and density functional theory (DFT) calculations revealed that Sb(III) formed hydrogen-bonding outer-sphere complexation on the (100), (010), and (001) facets, whereas Sb(V) preferred to form bidentate inner-sphere complexation via mononuclear edge-sharing configuration on the (100), (001), and (101) facets and binuclear corner-sharing configuration on the (010) facet. Furthermore, (010) facet was the most sensitive binding site to changes in environmental factors and favorable for the outer-sphere complexation. These results indicated that the facet-mediated thermodynamic stability of surface complexation determined the interaction affinity towards Sb species, resulting in the different adsorption behavior. Our study will provide a valuable reference for understanding the role of boehmite in Sb-contaminated environments and its impact on the fate of Sb oxyanions.

Acknowledgment: This study was supported by the Basic Research Project of the Korea Institute

of Geoscience and Mineral Resources (Project code: 24–3412).

Keyword

Antimony oxyanions, boehmite, facet-mediated interaction, physicochemical properties, X-ray absorption spectroscopy

Atomistic structure models of nanocrystalline vernadite mineral

Gerica Joie Placido CASTRO[1]*, Kangwon National University (gpcastro@kangwon.ac.kr)
Kideok D. Kwon[2], Kangwon National University

Abstract

Vernadite, a turbostratic nanocrystalline phyllomanganate, is ubiquitous in the environment and a key player in the (bio)geochemical cycling of trace metals. Its high redox and sorption capacity is a result of the high amount of defects in its structure and its nanometer dimensions. However, due to its poor crystallinity, vernadite's detailed structure has been challenging to characterize using traditional diffractometric and spectroscopic techniques. To address these limitations, in this study, for the first time we utilized molecular dynamics (MD) simulations to investigate the structure of nanocrystalline vernadite using Zn(II) as the probe sorptive ion. The MnFn force field, interatomic potentials optimized for manganese oxides, were used and modified for atoms at the lateral edges. Vernadite nanoparticles with diameters of ~3 or ~6 nm and with variations in the number of stacked sheets were simulated in vacuum and in an aqueous phase. MD simulation results showed that vernadite is composed of non-uniformly curved sheets instead of flat or uniformly curved sheets. The degree of vernadite nanosheet curvature depended on the lateral size and number of stacked sheets, with the 6 nm models being more curved compared to the 3 nm models, and the monolayer models had a considerably more curved surface in comparison to the layered models. Vacancy-free models collapsed when placed in aqueous phase, highlighting the importance of octahedral vacancies adsorbed with cations in the stability of vernadite's structure. A minimum of 4.9-6.5% vacancy content was required to ensure vernadite layer stability in aqueous phase. Zn complexes at the exposed basal planes transformed to tetrahedral coordination in vacuum but remained octahedral in aqueous phase. While at the lateral edge surfaces, Zn cations were found to change the coordination and speciation depending on the presence or absence of surrounding water, suggesting that the environment and water play a key role in influencing the coordination geometry of Zn cations adsorbed at vernadite surfaces. These atomistic simulations reveal the details of vernadite structures, offering valuable insights for the experimental exploration of vernadite's chemical reactivity. This understanding is crucial for unraveling the fate and transport of trace metals in the environment by providing a dynamic view of how they interact with Mn oxide surfaces which could aid in the development of environmental remediation strategies.

Keyword

vernadite, molecular dynamics, Mn oxides

Effect of Ca-containing byproducts generated during interzeolite transformation on the sequestration and release of Cs

Seokju HONG[1]*, POSTECH (frederic@postech.ac.kr)
Wooyong Um[2], POSTECH

Abstract

Hydrothermal interzeolite transformation, which can give a strategy for the synthesis of specific zeolite structures often with shorter reaction times, can be applied to the sequestration of radionuclides. Natural zeolites, as well as synthetic zeolites, are frequently used as parent zeolites in the hydrothermal interzeolite transformation because they are inexpensive and abundant in quantity. However, our study revealed that minor amounts of charge-compensating Ca ions present in parent natural zeolites can affect adversely the sequestration of radionuclides (especially Cs-137) by the final byproducts during the hydrothermal interzeolite transformation.

Our study prepared pollucite from natural Korean zeolite by hydrothermal interzeolite transformation without using organic structure directing agents. Only the presence of pollucite was confirmed by XRD, IR, and Raman analyses. However, in pore characteristics and scanning/transmission electron microscopic analysis, we could observe the existence of Ca-containing byproducts other than pollucite. These byproducts showed a wider pore size distribution in the mesopore range and a higher specific surface area compared to the pollucite. Furthermore, these byproducts showed an acicular shape at the hydrothermal temperature of 453 K, which distinguishes them from pollucite.

After the characterizations, we designed our experiment by dividing parent zeolites into three types: Na-exchanged type (NaNZ), original type (OrNZ), and Ca-exchanged type (CaNZ), each of which was used to suppress, proceed, and activate the generation of byproducts. In the Cs release tests, the pollucite made from NaNZ showed less release of Cs compared to pollucite made from OrNZ or CaNZ, and this indicates the presence of byproducts negatively affects the sequestration of Cs. Interestingly, the interzeolite transformation rates of NaNZ, OrNZ, and CaNZ were all different, although the structures of natural zeolites and hydrothermal reaction conditions were the same. The rate of interzeolite transformation slows down when the Ca content of parent zeolite is high, because the dissolved Si should be consumed first for interzeolite transformation to pollucite, resulting in the generation of Ca-containing byproducts.

To the best of our knowledge, we demonstrated the presence of byproducts during the hydrothermal interzeolite transformation, which can cause the negative effect on the Cs-sequestering performance of pollucite for the first time. Our study highlights that trace amounts of byproducts present in the process of mineral transformation for radionuclide-sequestration may cause fatal failure in the long-term (or permanent) immobilization of radionuclides.

Keyword

interzeolite transformation, pollucite, byproduct, Cs sequestration, Cs release

On the crystal structures and thermodynamics of Sr-bearing calcite

Sanggeon KIM[1]*, Kangwon national university (cjsekfdl97@naver.com)
Sangbo SON[2], Kangwon national university
Sung Pil HYUN[3], Korea Institute of Geoscience and Mineral Resources
Kideok D KWON[4], Kangwon national university

Abstract

Calcium carbonates containing diverse divalent metal cations are widely found in rock fractures and fault zones. Experimental studies on Sr-bearing calcite have been prompted by its potential role in mitigating the mobility of radioactive 90Sr dissolved in groundwater. While chemical analysis has identified the presence of Sr in calcite crystals, the elucidation of their crystal structures and thermodynamics remains elusive. This knowledge gap is attributed in part to the natural occurrence of SrCO3 with an aragonite-like structure (strontianite) whereas a calcite-like structure for SrCO3 has not been observed. Herein, we report the examination of the crystal structures and solubility product constants of Sr-bearing calcite using density functional theory (DFT). Geometry optimization well reproduced experimental data, encompassing lattice parameters, Sr coordination numbers, and solubility products of Sr-bearing aragonite. Contrary to expectations, we found a deviation from the conventional six-fold coordination of Sr in calcite to a seven-fold coordination. We also explore the potential use of Sr *K*-edge absorption near edge structure (XANES) spectra as an indicator for the coordination number of Sr in calcite through the analysis of spectra generated by DFT for various Sr coordination. DFT predicted an increase in the solubility product constant of Sr-bearing calcite with rising Sr content, indicating a higher stability of Sr in aragonite than in calcite. These results imply that Sr-bearing calcite within rock fractures may be apt to release Sr, potentially augmenting Sr mobility, an aspect critical in predicting the fate of 90Sr in subsurface environments.

Keyword

Density functional theory, Calcite, Strontium, Calcitic SrCO3

Sorption of thorium, cesium, and lead onto secondary iron minerals and clay minerals

Ilona SEKUDEWICZ[1]*, Institute of Geological Sciences, Polish Academy of Sciences (i.sekudewicz@twarda.pan.pl)
Jan Rohovec[2], Institute of Geology, Czech Academy of Sciences
Šárka Matoušková[3], Institute of Geology, Czech Academy of Sciences
Marcin Daniel Syczewski[4], Helmholtz Centre Potsdam, GFZ German Research Centre for Geosciences
Paweł Działak[5], Faculty of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology
Marek Szczerba[6], Institute of Geological Sciences, Polish Academy of Sciences
Kamil Kornaus[7], Faculty of Materials Science and Ceramics, AGH University of Science and Technology
Michał Gąsiorowski[8], Institute of Geological Sciences, Polish Academy of Sciences
Andrzej Justyn Borkowski[9], Faculty of Geology, Geophysics and Environmental Protection, AGH University of Science and Technology

Abstract

The main objective of the presented research was to investigate the sorption processes of thorium, lead and cesium onto synthetic secondary iron minerals (K-jarosite, goethite, schwertmannite) and natural clay minerals (mixed-layer illite-smectite ISCz-1) under conditions corresponding to the environment affected by the acid mine drainage (AMD). The specific aim of the project was to examine the effect of pH (pH range from 2 to 6) and ionic strength (0.1, 0.5, and 1 M NaNO3) on the sorption of Th, Pb, and Cs onto selected mineral phases. Element concentrations were measured using a multimode microplate reader, ICP-OES, and HR-ICP-MS. The zeta potential and specific surface area (BET) of the minerals were also investigated. Furthermore, the morphology, mineralogical composition, and chemical composition of these minerals before and after sorption experiments were analyzed using a scanning electron microscope coupled with energy dispersive spectrometers (SEM-EDS) and a powder X-ray diffractometer (PXRD). The results of laboratory experiments indicated that an increase in pH enhances the sorption of the studied elements. Sorption of Pb was observed onto all minerals, similarly to Th (except K-jarosite). In the case of Cs, sorption was observed only onto K-jarosite and clay minerals (ISCz-1). An increase in ionic strength resulted in a decrease in sorption in all cases. The research demonstrated that schwertmannite obtained by Fe2+ oxidation has significantly worse sorption properties compared to that obtained by Fe3+ hydrolysis. The parameters of adsorption isotherms and adsorption kinetics under selected pH conditions were also determined for the tested elements.

This work was funded by the National Science Centre (NCN) under the Preludium-20 Project (number: 2021/41/N/ST10/02759) led by I. Sekudewicz.

Keyword

sorption, thorium, lead, cesium, acid mine drainage

Abiotic Catalytic Reaction Dominance in Manganese Removal from an Acidic Mine Water

Joseph GODIRILWE[1]*, Hokkaido University (godirilwej@bgi.org.bw)
Tsubasa OTAKE[2], Hokkaido University
Frances CHIKANDA[3], Hokkaido University
Ryosuke KIKUCHI[4], Hokkaido University
Yoko OHTOMO[5], Hokkaido University
Shingo TOMIYAMA[6], Mitsubishi material company
Tsutomu SATO[7], Hokkaido University

Abstract

Manganese (Mn) is a prevalent metal in acid mine drainage (AMD) and poses a challenge for remediation because of its high mobility across a wide pH range. This research was conducted at a mine treatment facility in Japan, which treats acidic mine water (pH~2.9) associated with high dissolved metal concentrations. Soluble manganese (Mn2+) is inefficiently removed from acidic mine water at the thickener when other toxic metals (Fe, Cu, and Zn) are removed with sludge. As a result, untreated Mn2+ precipitates on the sand in the filtration tank. However, the Mn concentration is negligible in the effluent upon discharge from the filtration tank. This study investigates the mechanisms of manganese oxidation and removal promoted in a sand filter and the Mn2+ removal process facilitated by naturally formed/precipitated manganese oxides on the sand in a filtration tank.

X-ray diffraction (XRD), X-ray fluorescence (XRF), and scanning electron microscopy (SEM) analyses were conducted for the solid characterization of clean/unprecipitated sand (UNS) and manganese precipitated sand (MPS). Batch experiments were conducted to simulate the Mn oxidation and removal conditions that occur in the sand filter. Manganese-precipitated sand [MPS], unprecipitated sand [UNS], and commercial dioxide powder [MnO2] were compared in removing Mn from the mine water [MW] collected from mine thickener and pure water [PW] prepared in the laboratory. MPS was treated by UV irradiation to inhibit bacterial activity.

Solid characterization of MPS indicated poorly crystalline birnessite and manganite. UNS showed no presence of Mn minerals. The results show that MPS rapidly decrease the Mn concentration in MW within 3 hours, while UNS decreases it slowly, leaving most of the Mn dissolved after 96 hours. This suggests that birnessite and manganite on MPS act as a catalyst for Mn oxidation and removal. MPS rapidly decreases the Mn concentration in both MPS + PW (treated) and MPS + MW (untreated), suggesting that physicochemical processes dominate the Mn2+ oxidation and removal at the mine treatment facility. MPS rapidly reduced Mn conc from PW faster than MnO2, demonstrating that MPS is an effective catalyst for Mn2+ oxidation even in abiotic processes. This study sheds light on the role of naturally formed manganite and birnessite on the sand (MPS) in controlling Mn removability from MW in the filtration tank of the mine treatment facility. MPS could be used to optimise Mn removal from the mine water at the treatment facility.

Keyword

Acid mine drainage, Manganese, Oxidation, Catalysis, Mine water treatment

Molecular-scale understanding of the sorption structure and reactivity of heavy metals at mineral-water interfaces

Sang Soo LEE[1]*, Argonne National Laboratory (sslee@anl.gov)

Abstract

Sorption of metal ions on mineral surfaces controls the mobility and bioavailability of the toxic chemicals in natural environments. Direct visualization of the sorbed ion distribution can provide a fundamental understanding of molecular-scale mechanisms at the interfaces. In this talk, I will present how the affinity and speciation of metal ions vary depending on the type of sorbent minerals to emphasize the role of mineralogy over the interfacial structure and reactivity: The basal surface of muscovite mica has a structural negative charge, which can electrostatically attract metal cations in solution. Cation adsorption on the mica surface occurs as a mixture of inner-sphere (IS) and outer-sphere (OS) complexes whose proportions are controlled by ion charge and hydration [1, 2]. For example, divalent metal Sr(II) adsorbs to the mica surface in nearly equal proportions of IS and OS complexes, although its adsorption is significantly stronger than monovalent metal Rb that adsorbs predominantly as an IS complex. When both Rb and Sr compete for sorption on the mica surface, we observe dramatic changes in adsorbed metal speciation, resulting in changes in the sorption free energy for the metal ions [3]. When individual metal ions Pb(II) and Cd(II) interact with the (104) surface of calcite, the most dominant surface of the ionic compound mineral, their sorption behaviors are largely controlled by the dynamic fluctuation of surface morphologies. In particular, metal uptake occurs predominantly via incorporation in the calcite crystal structure even during active dissolution of the host mineral under acidic far-from-equilibrium conditions. The degree of this metal uptake appears to be systematically controlled by the similarity in crystal structure and lattice match between the substrate and incorporated metal-bearing carbonate phases (i.e., cerussite and otavite, respectively) [4]. Experimental observations are made through the application of in-situ synchrotron-based X-ray scattering and imaging techniques. The chemical and structural characteristics obtained from these measurements will be discussed in the context of their impacts on emerging environmental and energy issues including metal contamination, water remediation, and carbon sequestration.

References

1. Park, C., et al., Thermodynamics, interfacial structure, and pH hysteresis of Rb+ and Sr2+ adsorption at the muscovite (001)-solution interface. Langmuir, 2008. 24: p. 13993-14004.
2. Lee, S.S., et al., Hydrated cation speciation at the muscovite (001)-water interface. Langmuir, 2010. 26: p. 16647-16651.
3. Lee, S.S., et al., Nonclassical behavior in competitive ion adsorption at a charged solid–water interface. The Journal of Physical Chemistry Letters, 2020. 11: p. 4029-4035.
4. Kim, Y., et al., Morphological and crystallographic controls in the replacement of calcite and aragonite by cerussite and otavite. Geochimica et Cosmochimica Acta, 2023. 341: p. 16-27.

Keyword

Metal adsorption, mineral-water interface, synchrotron, speciation

Efficient Seawater Splitting with Ni-based Oxyhydroxide Catalysts: A Computational Perspective

Sooyeon KIM[1]*, Korea Institute of Science and Technology (KIST) (skim5520@gmail.com)
Sang Soo Han[2], Korea Institute of Science and Technology (KIST)

Abstract

Electrochemical water splitting is one of the most eco-friendly methods for hydrogen production. However, the reliance on pure fresh water as a proton source increases overall costs and hampers widespread adoption of this process, particularly in water-scarce regions. Consequently, direct seawater splitting has gained significant attention as a promising alternative because of its abundant availability on Earth. Nonetheless, its utilization remains still challenging due to the presence of impurities and detrimental chlorine species, which induce corrosion and compete with the oxygen evolution reaction (OER) of water splitting. In this study, we systematically investigated the catalytic performance of Ni-based oxyhydroxide catalysts for seawater splitting using computational methods. Specifically, we focused on comparing their catalytic activities for both the OER and the chlorine evolution reaction (CER) to determine which reaction would favorably occur. Additionally, we explored the impact of various transition metal dopants on selectivity between OER and CER to provide fundamental understanding in a molecular level necessary for the development of efficient new catalysts for seawater splitting. Our comprehensive analysis not only highlights the suitability of Ni-based oxyhydroxide catalysts for efficient and sustainable seawater splitting, but also offers insights for the development of robust and cost-effective technologies for harnessing hydrogen from seawater.

Keyword

seawater splitting, Ni-oxyhydroxides, density functional theory, oxygen evolution reaction, chlorine evolution reaction

Replacement of Calcium Carbonate (CaCO3) Polymorphs by Cerussite (PbCO3)

YoungJae KIM[1]*, Pukyong National University (youngjkm@pknu.ac.kr)

Abstract

Calcium carbonate (CaCO3) polymorphs, calcite, aragonite, and vaterite, serve as a major sink to retain various metal ions in natural and engineered systems. Here, we visualize the systematic trends in reactivities of calcite, vaterite, and aragonite to Pb2+ dissolved in acidic aqueous solutions using in situ optical microscopy combined with ex situ scanning electron and transmission X-ray microscopies. All three polymorphs undergo pseudomorphic replacement by cerussite (PbCO3) but with distinct differences in the evolution of their morphologies. The replacement of calcite and aragonite occurs through the formation of a pseudomorphic cerussite shell (typically 5−10 μm thick) followed by a slower inward propagation of reaction fronts through a thin solution gap (∼0.1 μm wide) between the shell and the CaCO3 substrate. The replacement of vaterite is characterized by the formation of a thinner cerussite shell (≤1 μm thick) and a larger cavity between the shell and the host mineral. These systematic differences in cerussite morphology for different CaCO3 polymorphs are explained by the relative dissolution and precipitation rates of the reactant and product minerals, coupled with the role of ion transport through the cerussite shells. We also find that the replacement of calcite by cerussite is the slowest when all three polymorphs coexisted. Our results provide mechanistic insights into the growth mode of cerussite on dissolving calcium carbonate and demonstrate these CaCO3 polymorphs as promising substrate materials for removal and recycling of Pb from acidic polluted water and industrial effluents.

Keyword

calcite, aragonite, vaterite, cerussite, mineral replacement

Solid Substrate-Induced Variations in the Heterogeneous Formation of Mn Solid Phases

Seonyi NAMGUNG[1]*, Korea Atomic Energy Research Institute (synamgung@kaeri.re.kr)
Sungsik Lee[2], Argonne National Laboratory
Giehyeon Lee[3], Yonsei University

Abstract

Understanding the geochemical cycling of manganese (Mn) is pivotal, especially regarding the formation of its various solid phases, such as oxides and carbonates. These processes profoundly affect the environmental fate of essential elements and are reciprocally influenced by the cycling of these elements, thereby contributing to the dynamic transformation of Mn phases. While the importance of various formation processes of Mn oxides in both biotic and abiotic processes is well-recognized, the genesis of Mn carbonates in nature has typically been attributed to the reduction of Mn oxides, a process closely linked with microbial activity and organic matter decomposition. This study seeks to explore the competitive formation of Mn carbonates and oxides under oxic conditions in aqueous Mn(II) solutions, aiming to uncover how solid substrates influence these processes. By examining the impact of different substrates, our research demonstrated that the presence and type of substrate play a critical role in determining the pathway of Mn solid phase formation. In homogeneous oxic conditions, Mn carbonate was initially formed, becoming the dominant Mn solid phase alongside the minor oxides. This indicates a preference for Mn carbonate precipitation over Mn(II) oxidation in the absence of a solid substrate. However, the presence of a goethite (α-FeOOH) substrate distinctly promotes the oxidation of Mn(II) to form groutite (α-MnOOH), while the rhodochrosite ($MnCO_3$) substrate inhibits further Mn(II) oxidation. The results highlight the intricate mechanisms that govern the heterogeneous formation of various Mn solid phases, determined by the combined effects of two factors associated with nucleation and electron transfer processes.

Keyword

heterogeneous formation, Mn oxide, Mn carbonate, solid substrate, electron transfer

Insights into the Origin of Pyrite in the Sediments of Brunei Darussalam

Azrina BOEY[1], Universiti Brunei Darussalam
Basilios TSIKOURAS[2]*, Universiti Brunei Darussalam (basilios.tsikouras@ubd.edu.bn)
Elena IFANDI[3], Universiti Brunei Darussalam

Abstract

Disseminated pyrite occurS in the sedimentary formations throughout Brunei Darussalam. Despite its common occurrence, the exact formation mechanisms of pyrite are understudied. This study focuses on the morphological and physicochemical properties of the pyrite and its host sediments to elucidate its genesis and distribution. Furthermore, it aims to reveal the role of pyrite in various geological processes and its potential impact to the environment. Besides, pyrite often serves as an essential pathfinder, for gold and hydrocarbons, while its association with elevated acidity raises environmental concerns. Secondary electron imaging revealed that the pyrite in clay sediments is of authigenic origin characterised by euhedral, octahedral microcrystals and framboids. The formation of pyrite involves complex water-rock and microbial interactions under highly acidic and anoxic conditions. Diagenetic processes play a pivotal role in pyrite formation, particularly the generation of the required sulphides by bacterial-mediated sulphate reduction. The availability of dissolved ferrous ions and organic matter further contributes to pyrite growth. Framboids ranging from 2 to 7 microns, suggest an early diagenetic formation, whereas larger euhedral microcrystals approximately 5-10 microns in size, are consistent with a syngenetic formation. The surface occurrence of pyrite presents significant challenges to environmental integrity and sustainability. In tropical areas, pyrite weathers rapidly when exposed to oxidising conditions. Its dissolution results in the formation of highly acidic leachates containing sulphuric acid and hydrogen sulphide. This elevated acidity facilitates mobilisation of heavy metals into the ecosystems which may be detrimental to public health and biodiversity. Anthropogenic activities, such as excavation and water-flooding, can exacerbate the oxidation of pyrite promoting its dissolution and enhancing the acidic conditions. The absence of carbonate rocks to buffer the acidity contributes to widespread soil acidification in Brunei Darussalam, negatively impacting soil fertility and agricultural productivity. Given these concerns, it is imperative to evaluate the distribution of pyrite, as well as to identify and map regions that are highly susceptible to acidification and other potential environmental risks. This knowledge is crucial for implementing targeted mitigation strategies to protect and safeguard Brunei's biodiversity and people while promoting sustainable economic growth.

Keyword

FeS2, sedimentary pyrite, framboidal, sulphate-reducing bacteria, sulphur

Characterization of Phosphate in Total Suspended Particles (TSP) at Seoul, South Korea

Seungsoo LEE[1]*, Metropolitan Seoul Center, Korea Basic Science Institute (leeseungsoo213@kbsi.re.kr)
Hyojin Lee[2], Metropolitan Seoul Center, Korea Basic Science Institute
Sae Jung Chang[3], Metropolitan Seoul Center, Korea Basic Science Institute
Joo-Ae Kim[4], Department of Earth and Environmental Sciences, Korea University
Su-Hyun Kang[5], Metropolitan Seoul Center, Korea Basic Science Institute
Na Rae Choi[6], Department of Environmental Engineering, Kangwon National University; Department of Environmental Science and Engineering, Ewha Womans University
Hyomin Kim[7], Department of Earth and Environmental Sciences, Korea University
Yong Pyo Kim[8], Department of Chemical Engineering and Material Science, Ewha Womans University
Meehye Lee[9], Department of Earth and Environmental Sciences, Korea University
Ji Yi Lee[10], Department of Environmental Science and Engineering, Ewha Womans University

Abstract

Atmospheric deposition of phosphorus (P) serves as an important nutrient input for many terrestrial, marine and freshwater ecosystems, influencing their bio-geochemical cycling of phosphorus/carbon and primary production. Excessive phosphorus input has the potential to accelerate eutrophication and climate change. Phosphorus occurs in nature primarily in its fully oxidized form as orthophosphate (represented here by PO_4 to encompass the range of protonation states and ion pairs). Phosphorus has no significant gas phases, and is conventionally thought of as having no significant redox chemistry in low-temperature natural environment (< 70°C).

While most of the atmospheric-P are mineral airborne particulate matter (PM) that originated in soils/sea salts (32% of total global P-budget), recent estimations of global P-budget have shown that both anthropogenic combustion of fossil fuels, biomass and biofuels (51% of total global P-budget) and biogenic airborne PM (e.g., plant pollen; 17% of total global P-budget) have significant roles as well (Wang et al., 2014). In agricultural regions, the soil/mineral airborne PM were shown to be enriched in phosphorus, because of their high sorption capacity of anthropogenic phosphorus (e.g., fertilizer-P, livestock excrement-P) (Granger et al., 2018).

In this study, airborne total suspended particles (TSP, size: <ca.50 μm in diameter) were collected over one month (May 7th – June 6th, 2019) in urban region at the Eunpyeong-gu, Seoul, Republic of Korea. The concentration of water-soluble ions (NO_3^-, SO_4^{2-}, NH_4^+, Ca^{2+}, Mg^{2+}, Na^+, K^+, Cl^-, F^-, Br^-), water-soluble organic carbon (WSOC) and elements were measured on TSP using IC, TOC and ICP-MS/OES, respectively. We developed a sequential extraction method for five different forms of phosphate (PO_4) in TSP, including water soluble-PO_4, adsorbed-PO_4, solid-PO_4 (less-crystalline), solid-PO_4 (crystalline) and organic-PO_4. The concentration of PO_4 and elements in the sequentially extracted fractions were determined by UV-Vis spectrophotometer and ICP-

MS/OES, respectively.

The total-PO_4 mass fraction against TSP is very low as 0.6 % of TSP, including water soluble-PO_4 (0.12 %), adsorbed-PO_4 (0.14 %), solid-PO_4 (0.18 %) and organic-PO_4 (0.16 %). Good positive correlations were observed for PO_4 species (total-PO_4, adsorbed-PO_4, solid-PO_4 and organic-PO_4) with TSP ($r > 0.7$) but, no statistically significant correlations were observed with PM2.5 ($r < 0.3$). The water soluble-PO_4, on the other hand, has a good positive correlation with PM2.5 ($r > 0.6$) and other anthropogenic tracers (e.g., NO_2, SO_2, SO_4^{2-}, NH_4^+, WSOC, S, As, Cd, Mo), implying that water soluble-PO_4 is a good tracer of secondary PM2.5 associated and anthropogenic P-sources. Importantly, the input of water soluble-PO_4 through atmospheric deposition can be a major source of bio-available P to the environment. The data we present demonstrates a new application of PO_4 species for the potential use to trace atmospheric-P sources.

Keyword

Total suspended particles, Phosphate, Sequential extraction, Source tracer

Effects of different tunnel cations on adsorption, occurrence, and mobility of water in palygorskite

Jinhong ZHOU[1]*, Nanjing University (zjh12387@126.com)
Xiancai Lu[2], Nanjing University

Abstract

Palygorskite is a fibrous magnesium-rich clay mineral with a typical tunnel structure, and its adsorption properties make it an ideal adsorbent for broad applications. Thus, revealing the confinement effects on tunnel species can help in understanding its adsorption properties. Grand canonical Monte Carlo and molecular dynamics simulations were performed to analyze the effects of different tunnel cations of palygorskite on the adsorption, occurrence, and mobility of tunnel water. Water adsorption isotherm, distribution models, and mobility were achieved from these systematic simulations. Compared with neutral palygorskite, the influences of tunnel cations on water distribution and mobility are obvious. The occupation of Na+Ca2+ or Li+ ions in tunnels can reduce the maximum water amount and affect the spatial distribution of zeolitic water. The water distribution in tunnels can be described by a two-zeolitic water-site model for neutral palygorskite and a one-zeolitic water-site model for the charged one. The zeolitic water confined in the tunnel presents very low mobility, and the appearance of cations in the charged palygorskite further reduces the mobility of zeolitic water. Compared with other clay minerals, the much lower water mobility of palygorskite implies that it may have a more efficient fixation on foreign molecules or ions in environmental applications.

Keyword

palygorskite, molecular dynamics simulations, confining effects, Grand canonical Monte Carlo, water

Investigation of characteristic heavy metal contamination of roadside dusts in Daejeon, Korea: Impacts of car tire, brake pad and traffic paint on the elevated levels of Zn, Cu, Sb and Cr

Seon Yong LEE[1]*, Korea Institute of Geoscience and Mineral Resources
(seonyonglee@kigam.re.kr)
Pyeong-Koo Lee[2], Korea Institute of Geoscience and Mineral Resources
Sangwoo Ji[3], Korea Institute of Geoscience and Mineral Resources
Dong-Wan Cho[4], Korea Institute of Geoscience and Mineral Resources
Gil-Jae Yim[5], Korea Institute of Geoscience and Mineral Resources
Jeong-Ho Lee[6], Korea Institute of Geoscience and Mineral Resources

Abstract

Road dust has the potential to contribute to transport hazardous pollutants, fugitive emissions, and release toxic trace elements into various components of the ecosystem, encompassing water, air, and soils. Many studies consistently report elevated concentrations of heavy metals in road dust, the heavy metal types and chemical forms of which vary depending on contamination sources. The mobility and availability of toxic heavy metals hinge significantly on their chemical species. Therefore, comprehending the fate of harmful heavy metals in urban areas and establishing fundamental pollution prevention strategies necessitate identifying the characteristics and causes of heavy metal pollution in roadside dusts. In this study, we investigated the characteristic heavy metal contamination (especially, Zn, Cu, Sb, Cr, and Pb) in roadside dusts collected in Daejeon metropolitan city, Korea, and the contribution of three anthropogenic traffic sources such as car tire, brake pad and traffic paint to the heavy metal contamination. Roadside dust samples were collected from a total of 120 points in the Daejeon area divided into 72 districts. Additionally, background soil samples were collected from a total of 20 sites within the granitic and metamorphic rock region to take geological origin factors into account. Overall, heavy metals in road dust samples showed a wide concentration range of hundreds to thousands of mg/kg in Zn, tens to hundreds of mg/kg in Cu, Cr, and Pb, and several to tens of mg/kg in Sb. Although concentrations were generally elevated in the vicinity of industrial areas, notable levels were also identified in certain residential or commercial zones, suggesting the significant contribution of other contamination sources, such as traffic. Therefore, we analyzed seven car tires (tread part) and ten brake pads, which are known as representative traffic-related pollution sources, using XRD, EPMA, XRF and ICP-MS. In addition, XPS analysis were further performed on several roadside dust samples with high Cr concentrations to confirm the oxidation state. Characterization analyses revealed that in comparison to other heavy metals, a relatively higher concentration of Zn was detected in tire treads, while particles containing Cu or Sb were found in brake pads. Moreover, Cr in the roadside dust samples predominantly existed as Cr3+ in the industrial zones and Cr6+ in road areas. These findings indicate that Zn in roadside dust may originate from car tires, whereas the presence of Cu and Sb could be attributed to brake pads. Furthermore, traffic paint containing Cr6+ as well as industrial can contribute to the Cr contamination of roadside

dusts. This understanding is useful for devising effective measures to mitigate the environmental impact of heavy metal contamination in road dust and safeguarding public health and ecological integrity.

Keyword

heavy metal contamination, roadside dusts, car tire, brake pad, traffic paint

Molecular simulations of CO2 and H2 insertion into palygorskite

Juhyeok KIM[1]*, Kangwon National University (juhuyg@kangwon.ac.kr)
Kideok D Kwon[2], Kangwon National University

Abstract

Palygorskite, a clay mineral with a ribbon-like structure, possesses nanopores that offer a large surface area, making it a promising adsorbent for greenhouse gases and reactive gas molecules. Studies have shown that palygorskite's CO2 adsorption capacity is approximately twice that of montmorillonite, with additional advantage of lower production costs. There is potential for use in the capture and storage stages in the processes of carbon capture, utilization and storage (CCUS). Palygorskite is also being explored as a potential storage material for hydrogen gas. In this study, the adsorption isotherms of palygorskite for gas molecules were obtained using grand canonical Monte Carlo (GCMC) simulations. Molecular-level insight into the adsorption of CO2 and H2 to palygorskite were obtained using molecular dynamics (MD) simulations. Our findings indicate that with increasing partial pressure, the adsorption of CO2 and H2 increases, although H2 intercalation requires higher pressure compared to CO2. The mean squared displacement was also higher for H2 than for CO2, suggesting that intercalation of H2 is comparatively less favorable. At completely saturation, CO2 molecules exhibited the lattice structures akin to one of the dry ice phases at high pressure (>10 GPa). These atomistic simulation results enhance our current understanding of mineral-fluid interactions and will guide the development of materials for the capture and storage of gas molecules.

Keyword

Palygorskie, CO2, H2, molecular simulation

Mineralogical Study of Bentonite Transformation Under High Temperatures

SeEun CHANG[1]*, Korea Atomic Energy Research Institute (seeun@kaeri.re.kr)
Yoonah Bang[2], Korea Atomic Energy Research Institute
Deuk-Hwan Lee[3], Korea Atomic Energy Research Institute
Changsoo Lee[4], Korea Atomic Energy Research Institute
Dong-Keun Cho[5], Korea Atomic Energy Research Institute

Abstract

Since bentonite as an engineered buffer material for High-Level radioactive Waste (HLW) disposal, understanding mineral transformation at high temperatures is essential. In this study, Bentonil WRK, Ca-type of bentonite, was utilized. A long-term experimental setup has been established to investigate the transformation (alteration) of bentonite when it reacts with potassium ions at temperatures exceeding 100 degrees Celsius. To clarify the estimation of clay mineral types, Ethlyne Glycol (EG) treatment was also conducted alongside EG-dry treatment at 550 degree Celsius. Additionally, to estimate the water layer content, the sample was saturated with deionized water (DIW) was saturated before XRD analysis. From the XRD results, the transformation from bentonite to illite was investigated, with a focus on the illite-smectite (I-S) mineral. There is no clear evidence of bentonite transformation below 175 degrees Celsius during the 6-month experimental period. However, under the same temperature conditions, the solid-to-solution ratio appears to have greater effect on altering bentonite. For example, at temperatures below 150 degrees Celsius, samples with a 10-fold reduction in solid-to-state ration exhibited narrower interlayer spacing (d-001). While the qualification and quantification of clay minerals from XRD analysis remain challenging, we have attempted to understand the possibility that bentonite in deep HLW disposal sites may transform into illite due to the high temperatures.

Keyword

Bentonite, Illitization, XRD, radioactive waste, disposal

Laboratory-scale reproduction of Smectite-Illite transformation using Bentonil-WRK

Mi Rae KIM[1]*, Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea (mirae@smail.kongju.ac.kr)
Sun Young Park[2], Oil & Gas Research Center, Petroleum &Marine Research Division, Korea Institute of Geoscience and Mineral Resources (KIGAM), Republic of Korea
Byeong-Kook Son[3], Oil & Gas Research Center, Petroleum &Marine Research Division, Korea Institute of Geoscience and Mineral Resources (KIGAM), Republic of Korea
Youngseuk Keehm[4], Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea
Hyun Na Kim[5], Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea

Abstract

Smectite is a primary consideration as a buffer material to delay radionuclide migration in the event of a High Level Radioactive Waste(HLW) repository leak, due to its high swelling and adsorption capacity and low permeability. In nature, smectite in sediment basin transforms over time into smectite-illite mixed layer minerals, thereby used as a geothermometer. The potential for similar smectite-illite transformations in bentonite at HLW repositories requires an understanding of the transformation mechanism and rate. However, laboratory-scale research is not yet sufficient. The aim of this study was to reproduce the smectite-illite transition on a laboratory scale using Bentonil-WRK (Clariant Korea), a candidate buffer material for waste repositories in Republic of Korea.

The hydrothermal experiment was conducted with 1 M KCl to accelerate the smectite-illite transformation reaction by variation of temperature and reaction time. X-ray diffraction (XRD) results show that the S(001) peak decreased while the I(001)/S(002) and I(003)/S(005) peaks increased with increasing temperature up to 250 °C, indicating the progress of I-S transformation. The I-S mixed layer samples of R0 and R1 were obtained after 7 days and 21 days of reaction, respectively, as analyzed by NEWMOD. However, above 330 °C, the smectite disappeared and new minerals such as quartz, illite, Kfs were observed, indicating the dissolution of smectite.

In this study, we confirmed the proper experimental conditions for the reproduction of the I-S transformation in the laboratory. Further research involving ICP-MS, Si-29 and Al-27 NMR, and SEM are currently undergoing to enhance the understanding of I-S transformation mechanism.

Keyword

Bentonil-WRK, Smectite, I-S transformation, Hydrothermal experiment, High Level Radioactive Waste repository

The Alteration of Fault Gouge with Supercritical CO2: Changes in Fault Stability by Carbon Sequestration

Yuna LEE[1]*, Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea (sharon1224@naver.com)
Insun Song[2], Korea Institute of Geoscience and Mineral Resources, Republic of Korea
Hyun Na Kim[3], Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea

Abstract

The injected CO2 for Carbon capture and storage (CCS) increases the pore pressure within the storage formation, inducing potential leakage along faults in the cap rock. Leakage alters the frictional properties and change the fault behavior. The fault gouge, one of crucial factors determining the frictional behavior of fault, altered by the chemical reaction with CO2 leaked from carbon sequestration formation. Therefore, understanding the interaction between fault gouge mineral and leaked CO2 is crucial for assessing the fault slip behavior at the cap rock. A systematic lab-scale investigation on fault gouge and CO2 interaction, considering varying particle size, crystallinity, and mineral composition is necessary to evaluate the long-term geological stability of CCS. In this study, various synthetic fault gouges ware produced to simulate the characteristics of natural fault gouge and investigate the effect of mineralogical alteration resulting from CO2 reaction on the fault stability.

The series of fault gouge are synthesized with varying composite minerals; quartz, feldspar, illite, and montmorillonite. Additionally, the crystallinity and particle size were controlled using high energy ball mill: non-pulverized and pulverized. The fault gouge reacted with scCO2 for six weeks using a multiphase fluid flow test apparatus under 75 bar and 40℃.

In pulverized fault gouge with low grain size and crystallinity, significant changes in mineral composition and structure were observed. Depending on the mineral composition, remarkable mineralogical differences occurred due to CO2 interaction, and more clearly in fault gouge with clay minerals. Alteration such as reduction in particle size and acceleration of the dissolution rate of the mineral, was found to be greater in fault gouge containing montmorillonite, a clay mineral with high swelling properties. Therefore, when the CO2 leaks and reacts through the fault, the type of clay minerals present has a crucial influence on the alteration of fault gouge than the grain size and crystallinity. This suggests that the mineral composition acts as a key factor in changing the characteristics of the fault plane.

As a result, the clay-ultrafine particles of the fault gouge generated by fault slip can enhance the reactivity with CO2. Furthermore, the properties of the fault gouge are not fixed and can vary over time and geochemical conditions. Therefore, this study is expected to contribute to understanding the diverse mineral alteration generated by CO2 reactions in a fault.

Fault gouge analogue, high-energy ball mill, Amorphization, Particle size reduction, Multi-composition fault gouge

Keyword

Synthetic fault gouge, CO2 sequestration, mineral-scCO2 interaction, Multi-composition fault gouge

An improved structural model of silicate melts and magmas probed with NMR spectroscopy: implications for planetary sciences

Jeongjae LEE[1]*, Seoul National University (jl635@snu.ac.kr)
Sung Keun LEE[2], Seoul National University

Abstract

The macroscopic properties of silicate melts such as viscosity and diffusivity depend critically on the microscopic short-range structures (interaction radius of <5 Å) and the mesoscopic medium-range (structural features within 5–20 Å) order in these glasses, which is in turn governed by how metal ions distribute within the silicate framework. Information on the nature of such distribution on a varying length scale is therefore crucial for better understanding the dynamics of silicate melts and magmas in the Earth's crust and mantle. While the distribution and local structure of oxygen and silicon atoms in these glasses are relatively well known, such information for metallic ions such as sodium are still poorly understood. In particular, the distribution of sodium with respect to two distinct types of oxygen atoms, namely the bridging (Si–O–Si) and nonbridging (Si–O–Na) oxygens, has remained a controversy for over a century since the introduction of continuous random network by Zachariasen; the conventional modified random network (MRN) model suggests completely segregated Na-rich and silicate-rich regions, while previous NMR data suggested otherwise.

Following this line, here we provide a clear experimental evidence for bonding between the bridging oxygen and sodium atoms through 17O→23Na triple quantum heteronuclear correlation (3QHETCOR) NMR experiments in multiple different sodium silicate compositions. Through 3QHETCOR experiments, we demonstrate the ability to resolve the bridging/non-bridging (vide infra) oxygen NMR signals as well as the capacity to probe the close-by quadrupolar 23Na–17O (I=3/2 and 5/2, respectively) spin pairs simultaneously; this method unambiguously shows the existence of Na atoms in the first coordination shell of bridging oxygen atoms. Our result suggests a more homogeneous Na distribution than that expected from the conventional MRN model, which we name as a perturbed random network (PRN) model; it also illustrates the powerful capability of heteronuclear correlation experiments in advancing our understanding of glass structures. While further confirmations remain, we discuss the potential implications of our perturbed structural model for explaining a number of puzzling phenomena in planetary sciences such as decrease in elastic constants upon densification and an increase in configurational entropy of magmatic melts, highlighting improved prospects for modelling the non-linear changes in viscosity and seismic wave velocity of molten silicates.

Keyword

Silicate melts, Perturbed Random Network model, Solid-state NMR spectroscopy

[Invited] How do transition elements influence viscosity of glasses, melts and lavas?

Daniel R. NEUVILLE[1]*, CNRS IPGP UP (neuville@ipgp.fr)

Abstract

Transition metals such as iron, chromium, nickel, titanium, copper, … are common minor components of aluminosilicate glasses and melts, with concentrations ranging from ppm to some wt%. The effects of transition metals on the properties of glasses and liquids are relatively poorly understood, with the exception of the role of iron, which has been well investigated. However, there is a lack of data on their structural role in glass and how it affects properties such as viscosity.

In order to better understand the role of transition elements on the structure and properties of glasses and melts, we present several new glass compositions with different amounts of Fe, Ti, Cu, Cr, Ni.... Measurements of density, viscosity at high and low temperatures and heat capacity have been carried out on these glasses, and their structure investigated using Raman spectroscopy and XANES spectroscopy at the different K-edge.

As a first approximation, IVFe2+, Cu2+ can be considered as network modifiers, while IVFe3+, Ti4+, Ni2+, Cr3+ seem to play the role of intermediate cations in the glass structure. It seems that element coordination plays a key role in understanding the role of an transition element. We will present and discuss these new results.

Keyword

transition metals, viscosity, structure, glass, melt

[Invited] A multiscale simulation study of supercritical geofluids

Xiandong LIU[1]*, Nanjing University (xiandongliu@nju.edu.cn)

Abstract

With increasing temperature and pressure, solubility of silicate in aqueous fluids increases as well as the solubility of water in silicate melts. When silicate melts are completely miscible with aqueous fluids, i.e. the phase boundary disappears, a single phase is formed, that is termed as supercritical geofluid or supercritical fluid. The unique properties and behaviors of supercritical fluids have attracted great attentions. For example, supercritical fluids have compositions close to those of hydrous silicate melts but have high diffusivity and low viscosity, that is close to aqueous fluids. Aiming at a molecular level view of these properties, we have carried out systematic molecular simulations. To overcome the temporal and spatial scale limitation of FPMD (first principles molecular dynamics), we have developed a general purpose ReaxFF force field (i.e. a reactive force field based on bond order) for simulating silicate materials. This force field was validated against experimental and DFT data on a wide range of systems including minerals, interfaces and melts. We applied this force field to perform molecular dynamics simulations to investigate supercritical fluids. The derived results of microscopic structures, speciation and transport properties will be presented. The future application and further development of the force field will also be discussed.

Keyword

supercritical geofluid, reactive force field, structure, speciation, viscosity

The pyrolite melts of the early Earth: structure, compressibility, viscosity, volatile content

Razvan CARACAS[1]*, CNRS, IPGP (caracas@ipgp.fr)
Adrien Saurety[2], IPGP
Anne H Davis[3], University of Oslo, PHAB

Abstract

As the protolunar disk formed by the giant impact with the incoming asteroid Theia started to cool, the Earth condensed in its center as a molten planet. The outer layer, rich in lithophile oxides, formed the magma ocean, whose dynamical behavior heavily influenced the entire evolution of the early Earth. Here, we employ first-principles molecular dynamics simulations to characterize the magma ocean in its initial stage. We compute the compressibility and the viscosity of the molten pyrolite, which best approximates the bulk silicate Earth composition. With an extensive set of calculations, we span the entire relevant pressure-temperature range. We provide a detailed analysis of the athermal and thermal equations of state in various formulations. We also establish the position of the critical point around 6000K and at pressures of about 1.1-1.2 kbars, at conditions hardly attainable experimentally.

We analyze the evolution of the structure of the liquid as a function of pressure and temperature. The melt structure is formed on a backbone of silica and alumina polyhedra. The other cations, like Na, Mg, and Ca, freely float in between these large polymers. Iron plays a special role in that it may participate in the polymerization or may just lie in between these polymers. We follow the enlargement of the first-coordination sphere with compression.

However, it is the collapse of the second coordination sphere that is responsible for accommodating the increase in pressure. For the first time, having sufficiently large simulation cells, we are able to monitor this collapse correctly. We find that the second coordination number of Si by O goes from about 24 at the top of the magma ocean to 40 at the base of the magma ocean.
We find the viscosity of pyrolite to be about one order of magnitude lower than that of molten basalt.

Finally, we give insights on the behavior of specific volatiles in the pyrolitic melt, with a special regard towards the transport and the loss of noble gases.

Keyword

magma ocean, silicate melts, compressibility, viscosity

Probing the short- to medium range structures of simplified Ti-rich lunar glass using NMR spectroscopy: implication for lunar mantle dynamics

Elias EL GHAZAOUI[1]*, Seoul National University (egi340@snu.ac.kr)
Sung Keun LEE[2], Seoul National University

Abstract

Widening our understanding regarding the evolution of the lunar mantle and the origin of lunar glasses after the Theia Impact event is a challenging task. It remains a topic in lunar science that could be of great importance in comprehending the existence of a lunar dynamo and planetary evolution in general. The lunar mantle melts likely contain substantially more Ti compared to melts found on Earth. Therefore, one can ponder the question to what degree the evolution of the Moon's mantle is affected by this Ti-rich composition. As melt properties like viscosity and density are directly influenced by these compositional differences, studying, and understanding the atomic structure of lunar glasses is fundamental. Despite being a relatively less popular method of probing the structural data of glass materials, NMR spectroscopy has shown to be extremely insightful for certain simple glass compositions in the recent past. In this study, we report the short- to medium range atomic structures of a variety of simple and complex model lunar glasses using high resolution solid-state NMR spectroscopy, revealing the detailed impact of an addition of Ti on silicate melts. The novel structural results include the Ti-driven formation of Ti-O-Si, which tends to increase the bulk moduli of the lunar melts.

Keyword

Titanium-rich Lunar Glass, Melt structure, Lunar mantle evolution, NMR spectroscopy

Bonding transitions in amorphous oxides at multi-Mbar: Insights into the structure of oxide melts in Earth's and super-Earth's Interiors

Yong-Hyun Kim[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, Korea (kyoh19@snu.ac.kr)
Paul Chow[2], HPCAT, X-ray Science Division, Argonne National Laboratory, Argonne, IL 60439, USA
Yuming Xiao[3], HPCAT, X-ray Science Division, Argonne National Laboratory, Argonne, IL 60439, USA
Guoyin Shen[4], HPCAT, X-ray Science Division, Argonne National Laboratory, Argonne, IL 60439, USA
Sung Keun Lee[5], School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, Korea

Abstract

Despite the implications for dense oxide melts in the Earth's and super-Earth's interiors, detailed structures of amorphous oxides at high pressure, particularly beyond Mbar pressure conditions, remain the challenging problems in the geosciences [1]. Structure of the simple oxides, such as B2O3 and GeO2, under Mbar compression can provide the insights into the geochemical behaviors of light- and heavy-elements in the magmatic melts in the planetary interiors. The inelastic X-ray scattering (IXS) of B2O3 glass up to ~2.2 Mbar reveals the formation of post-[4]B above ~1.4 Mbar, with the gradual coordination transformation from [4]B to [5]B over broad pressure ranges. Ab initio calculations suggest that the formation of [5]B partially localizes the boron electronic states, potentially due to the changes in the polarity of B—O bonds. The changes in the nature of electronic bonds upon the coordination evolution may affect the geochemical behavior of boron (i.e., isotope fractionation) in the oxide melts under multi-Mbar conditions, making the isotope signals of super-Earth's interiors to be largely different from those of Earth's [2]. The GeO2 glass provides an opportunity to explore the atomic and electronic structure of silicate melts under multi-Mbar, because pressure-induced phase transitions in germanium oxides occur at much lower pressures compared to silicates. The IXS of GeO2 glass up to ~1.5 Mbar reveals the formation of compressed oxygens, such as [4]O above ~55 GPa, giving rise to the pronounced electronic delocalization by the contributions from Ge d-orbitals. Other heavy-elements may also exhibit such contributions from d-orbitals, making their bonding environments distinct from the light-elements. The dispersion of electronic states around compressed oxygens may lead to enhanced conduction of electrons in deep mantle melts in super-Earth's interiors [3]. The bonding transitions in amorphous oxides revealed by the IXS shed light on the novel structural and electronic behavior of oxide melts in the interior of massive terrestrial planets.

[1] Lee, S. K., Kim, Y.-H., Chow, P., Xiao, Y., Ji, C., & Shen, G. (2018), Amorphous boron oxide at megabar pressures via inelastic X-ray scattering, Proc. Natl. Acad. Sci. 155, 5855-5860.
[2] Kim, Y.-H., Chow, P., Xiao, Y., Shen, G., & Lee, S. K. (2024), under review.

[3] Kim, Y.-H., Yi, Y. S., Kim, H.-I., Chow, P., Xiao, Y., Shen, G., & Lee, S. K. (2022), Pressure-driven changes in the electronic bonding environment of GeO2 glass above megabar pressures, J. Amer. Chem. Soc. 144, 10025-10033.

Keyword

Amorphous Oxide, High Pressure, Planetary Interiors, Atomic/Electronic Structure, Inelastic X-ray Scattering

[Invited] Planetary melts: constraining viscosity via the glass transition.

Donald B. Dingwell[1]*, LMU Munich (dingwell@lmu.de)

Abstract

The role of melts in the evolution and behavior of planetary systems (Earth, Moon, Mars, Venus) is undisputed. The behavior of magmatic and volcanic systems varies with melt chemistry and planetary conditions. In particular, the viscosity of planetary melts varies widely. Analysis of the glass transition provides a valuable window on the low temperature viscosities of these melts, defining their physical behavior both within planetary interiors and on planetary surfaces.

The advent of conjectures of major magmatism and volcanism on exoplanets has enhanced the appeal of understanding these materials under an even wider range of volcanic conditions. The future of their investigation will require concerted efforts, new infrastructure, and an expansion of the boundaries of chemistry and conditions anticipated from terrestrial planets of our solar system to the rapidly growing population of exoplanets.

Glass transition studies have for decades been an essential companion of high temperature viscometry studies of terrestrial melts. The essential link enabling their usefulness for constraining the temperature dependence of viscosity was clarified over 30 years ago. The most recent advances in its study have been provided by 1) a broadening of the target range of melt chemistry beyond terrestrial constraints, 2) a broadening of the range of the glass forming ability of "extreme" melt compositions using novel synthesis and quenching techniques, 3) new "flash" calorimetry methods for the determination of the glass transition of poor glass formers, 4) and a realisation that the variability of planetary surface conditions may place a significant role in volcanism on such planetary bodies and the resultant efficiency of degassing.

These aspects will be evaluated with a series of recent examples of experimental glass transition studies and estimates.

Keyword

silicate melt, glass, glass transition, carbonate, viscosity

Speciation of carbon in silicate melts at high pressure up to 8 GPa

Eun Jeong KIM[1]*, Kongju National University (eunjkim@kongju.ac.kr)
Sung Keun Lee[2], Seoul National University

Abstract

Carbon is one of the most abundant volatiles in the magma. Understanding the speciation of carbon in carbon-bearing silicate melts helps us interpret the changes in the transport properties of carbon-bearing magma in the mantle. While the earlier studies have reported the solubility and carbon species in silicate melts at high pressure up to 4 GPa, experimental data has not been reported above 4 GPa. Here, we explore the carbon species in sodium silicate (Na2O-3SiO2, NS3) and sodium aluminosilicate (NaAlSi3O8, albite) glasses quenched from melts at high pressure up to 8 GPa using solid-state nuclear magnetic resonance (NMR). 13C NMR spectra of carbon-bearing NS3 show the presence of free carbonates, non-bridging carbonates, and bridging carbonates. The fraction of non-bridging and bridging carbonates increases with increasing pressure. With respect to the lower fraction of highly coordinated Si ([5,6]Si) in carbon-bearing silicate melts than in carbon-free melts in 29Si NMR spectra, the increase of bridging carbonates may indicate that the dissolution of carbon in silicate melt changes the silicate network structure and prohibits the densification of silicate melts by lowering the formation of highly coordinated silicon. 13C NMR spectra for carbon-bearing albite glasses show the presence of CO, CO2, free carbonates, and briding carbonates at 1.5 GPa. The fraction of bridging carbonates linked to Si and Al increases the most with increasing pressure. While the increase of bridging carbonates does not affect the peak width of [4]Al in 27Al NMR spectra, the peak intensity of [5,6]Al decreases with the presence of carbon. The 29Si NMR spectra show negligible changes with the presence of carbon in albite melts. The presence of carbon changes the Si environment in sodium silicate melts and Al environment in sodium aluminosilicate melts. With the presence of carbon in silicate melts, the fraction of highly coordinated network former decreases, which indicates that the melt structure is less densified. The lower density of carbon-bearing silicate melts can therefore be due to the carbon-related structural changes. The structural analysis of carbon in silicate melts at high pressure may make us to unravel a relationship between carbon-induced structural changes and related macroscopic properties.

Keyword

carbon, volatile, silicate melt, high-pressure, NMR

The possible role of gold-rich colloids in the formation of high-grade supergene gold ores

Yafei WU[1]*, China University of Geosciences, Wuhan (wuyafei@cug.edu.cn)
Yage WU[2], China University of Geosciences, Wuhan

Abstract

Oxidative dissolution of auriferous sulfides such as pyrite and arsenopyrite within hydrothermal gold deposits under near-surface weathering conditions results in the release and redistribution of a large amount of gold and other related metals (e.g., As, Ag, Cu, Hg, Tl, etc.). The released gold can be subsequently re-enriched to form visible gold grains as well as micron-to-nanoscale gold particles within supergene iron oxides and oxyhydroxides such as hematite (α-Fe2O3) and goethite [α-FeO(OH)]. The supergene gold ores are generally high-grade (up to thousands of g/t) and easily processed, being one of the most important types of gold deposits in the world. However, the formation processes of abundant supergene gold grains largely remain unclear. It has been suggested that gold colloids play a critical role in the formation of supergene gold grains, but processes and mechanisms that control the formation of gold-rich iron oxides have not been fully understood.

Here we utilized scanning electron microscopy (SEM) and transmission electron microscopy (TEM) to decipher the formation processes of high-grade (200 g/t Au) oxidized auriferous pyrite-quartz veins from the Longtougou orogenic gold deposit in the West Qinling orogen, China. Detailed SEM observations show that hematite grains preserve the euhedral morphology of auriferous pyrite and contain abundant fine-grained goethite inclusions and local bright Ag-Cu-rich zonation. Irregular auriferous pyrite relicts are enclosed within hematite. The hematite is crosscut by slightly zoned goethite which contains fine-grained gold inclusions (<1 μm across). The zoned goethite is further overgrown by fibrous to acicular goethite that is intergrown with subrounded to irregular gold grains (5–100 μm across). The TEM results reveal that numerous irregular nanoparticles and nanoveinlets (<500 nm across) that are enriched in Au, Ag, As, Hg, and Bi occur adjacent to large gold grains within the fibrous to acicular goethite. The metal-rich nanoparticles are compositionally heterogeneous and contain spherical gold nanoparticles (5–20 nm across). The metal-rich nanoparticles are connected via veinlets that are depleted in Au and other metals relative to the nanoparticles.

Our results show that oxidation of auriferous pyrite during supergene weathering might proceed via three main stages: replacement of pyrite by aggregates of hematite and goethite with metal-rich zonation; replacement of these iron oxide aggregates by zoned goethite with fine-grained gold particles; formation of fibrous to acicular goethite and associated coarse-grained gold grains. The presence of connected Au, Ag, As, Hg, and Bi-rich nanoparticles and veinlets indicate that these metals released from auriferous pyrite might have formed polymetallic colloids due to the high degrees of supersaturation. These metal-rich colloids were then migrated and aggregated to form larger colloids. Spherical gold nanoparticles might be deposited from the metal-rich colloids,

which is consistent with the heterogeneous compositions of the metal-rich nanoparticles.

Keyword

Gold-rich colloids, Iron oxides, Visible gold, Supergene gold ores, West Qinling orogen

Variations of atomic structures and mechanical properties of natural opal-CT-based geopolymers with synthesis conditions

Hyo-Im KIM[1]*, Department of Geology and Research Institute of Molecular Alchemy, Gyeongsang National University (hyoim@gnu.ac.kr)
Min-Kyung Kim[2], Department of Geology, Gyeongsang National University
Sunhwa Bang[3], Research Institute of Molecular Alchemy, Gyeongsang National University

Abstract

In light of the global imperative for the reduction of carbon dioxide emissions, geopolymers have been considered environmentally sustainable alternatives to ordinary Portland cement, and have widespread applications in construction and building industries. Geopolymers are among the aluminosilicate amorphous materials, which lack long-range structural ordering. The disordered structures are attributed to the alkali-activation process of crystalline raw materials: particularly, the alkali activators such as waterglass and sodium or potassium hydroxide induce the depolymerization and dissolution of Si- and Al-tetrahedra, followed by the re-polymerization with amorphous nature. To date, the efforts have focused on synthesizing geopolymers utilizing solid wastes and industrial byproducts such as fly ash, steel-making slags, and red mud. The synthesis of waste products-based geopolymers, however, poses significant challenges, primarily due to the instability in the supply of raw materials. Therefore, the development of geopolymers based on the natural Earth materials should be necessary. We explored the utilization of the natural opal-CT as the precursor of the geopolymer. Natural mudstone used in this study has predominant opal-CT, obtained from the Miocene Pohang basin, in southeastern Korea. We synthesized the natural opal-CT based geopolymers with varying conditions, such as the fraction of natural opal-CT relative to the metakaolin (which is the source of alumina), the types of activators, the curing time, and the concentration of alkali activators. The mechanical durability of synthesized geopolymers has been obtained by measuring compressive strengths, and the morphology and atomic structures of those materials were explored by the mineralogical and thermal experiments (i.e., SEM, XRD, Raman, and DTA/TGA). These results are critical for fundamentally understanding the performance of natural opal-CT based geopolymers. This research can contribute to the development of sustainable construction materials using natural Earth materials. Additionally, it could open the way for utilizing in-situ materials on the Moon or Mars to build infrastructure during future planetary explorations.

Keyword

Geopolymer, opal-CT, aluminosilicate, atomic structure, mechanical properties

Structure of silica glasses under ultrahigh pressure: ab-initio calculations of nuclear magnetic resonance properties

Jae-Hyeon PARQ[1]*, Seoul National University (parkq2@snu.ac.kr)
Yoo Soo Yi[2], Seoul National University
Sang-Mook Lee[3], Seoul National University
Sung Keun Lee[4], Seoul National University

Abstract

The densification of silica melts under extreme pressure offers useful opportunities to explain the seismic anomalies near the core-mantle boundary (CMB) partly due to the presence of dense silica-rich partial melts at approximately 130 GPa. While solid-state nuclear magnetic resonance (NMR) has resolved the detailed atomic structures of complex silicate melts and glasses under compression. the pressure condition for a direct high-resolution solid-state NMR experiment for compressed materials is limited to ~65 GPa (Li et al., J. Phys. Chem. Lett. 2003, 14, 2078). Alternatively, ab initio calculations of the NMR properties of silicate melts have revealed the nature of densification beyond 100 GPa (Lee et al., J. Am. Ceram. Soc. 2022, 105, 5151).

In this presentation, combined efforts using classical molecular dynamics (CMD) and ab initio calculations for structure relaxation and NMR parameter were carried out for silica glasses to investigate how their structural changes affect the nature of nuclear spin interactions beyond megabar pressures. The pressure-induced changes in geometric factors are consistent with those reported in previous studies. The average Si-O-Si angle is 149.3° at 0 GPa and it decreases with increasing pressure. The correlation between the Si-O bond length and the Si-O-Si bond angle is not clear at 1 atm, but the negative correlation is pronounced between ~20 and ~50 GPa. The Si and O coordination numbers increase with increasing pressure, leading to a nonlinear change in the isotropic chemical shielding (δcs), which is accompanied by an increase in the network distortion around O, parameterized with the quadrupolar coupling constant (Cq). The average 29Si δcs linearly increases with the increasing average Si coordination number. The average 17O δcs and Cq decrease with the increasing average oxygen coordination number. The average 17O δcs linearly decreases with increasing the Si-O bond length, and the 17O Cq of [2]O and [3]O tends to increase with the increasing Si-O-Si angle. These novel relationships between NMR properties and pressure-driven structural changes have potential for the development of new NMR protocols to broaden the application of high-pressure NMR experiments. The results constrain the element-specific densification pathways for multi-component magmatic melts at the CMB, which can provide crucial insights into the evolution of the silicate Earth.

Keyword

silica melts at the core-mantle boundary, molecular dynamics simulations, NMR properties

MAGMATOMIX: a highly efficient post-processing tool for analyzing molecular dynamics simulations

Razvan CARACAS[1]*, CNRS, IPGP (caracas@ipgp.fr)
Kevin Jiguet-Covex [2], CNRS, IPGP
Tim Bögels[3], IPGP
Anne H Davis[4], PHAB, University of Oslo
Adrien Saurety[5], IPGP
Emma Stoutenbourg[6], University of Chicago
Xi Zhu[7], IPGP

Abstract

In a recent effort we have profoundly transformed the UMD package [1] into a highly efficient tool for analyzing molecular-dynamics simulations. The package is written in Python and c, it is parallelized on CPUs, and partly ported on GPUs. While all the scripts are run at the command line, a preliminary GUI version is in use as well.

We propose a simplified format to store the atomic trajectories and relevant thermodynamic information of the simulations, which is saved in UMD files, standing for Universal Molecular Dynamics. For the time being, it has interfaces/parsers with VASP, QBox, and LAMMPS.

The package allows the computation of a series of structural, transport and thermodynamic properties. Starting with the pair-distribution function it defines bond lengths, and builds an interatomic bonding matrix. Using this connectivity matrix, it employs graphs theory to construct the chemical speciation in the fluid. It identifies the coordination polyhedra up to any order, between any combination of atomic types; it can build and extract the polymerization in the fluid. Determining the lifetime of the chemical species allows running a full statistical analysis. Self-diffusion coefficients are obtained from the mean-square displacements; they can be obtained for either atoms or for chemical species. The implemented self-correlation analysis of the atomic velocities yields the diffusion coefficients and the vibrational spectrum. The self-correlation analysis applied on the shear stresses yields the viscosity. The package is available via its GitHub website at https://github.com/rcaracas/UMD_package address, under GNU-CPL v3 and CeCILL v2 licenses, mutually compatible.

Keyword

molecular-dynamics, melts, glasses, analysis

Evolution of Li environment in partially molten magmas during fractional crystallization: A view from solid-state NMR spectroscopy

Seoyoung LEE[1]*, Seoul National University (2seo0@snu.ac.kr)
Sung Keun LEE[2], Seoul National University

Abstract

Lithium (Li) is among the critical elements with strong applications in the energy materials industry. As Li can often be enriched in fluid-bearing felsic melts, proper inference of efficient partitioning mechanisms of Li into silicate melts needs to be established. Geologically important partial melts during crystallization provide constraints to the formation/synthesis of technologically useful glass-ceramics. The atomic environments around Li in the silicate glasses depending on the composition and pressure conditions were previously explored using solid-state nuclear magnetic resonance (NMR) spectroscopy, which demonstrated Li's remarkable mobility in silicate glasses (Park and Lee, J. Am. Ceram. Soc. 99 3948, 2016; Kim et al., J. Phys. Chem. C 123 (43) 26608, 2019). However, the detailed Li environments in glasses in equilibrium with silicate minerals in the Earth's crust have not been explored. In this study, we report the first Li-6 NMR spectra for the Li-Na silicate glass-ceramics, revealing the evolution of the Li environment among the crystalline and silicate melts with varying crystallization paths. Particularly, the NMR spectra revealed the two distinct spectral components, corresponding to the crystalline components, exhibiting a narrow peak due to Li silicate and a much broader peak due to the non-crystalline Li-Na silicate ranging from 2 ppm to -1 ppm. The relative proportions of the two signals vary differently depending on the crystallization paths. The results also indicate that the Li-Na disorder in the melts influences the growth of Li-silicate crystals. This finding is expected to contribute to our understanding of Li behavior and its enrichment during melting and fractional crystallization, accounting for the potential formation of Li-resources within magma reservoirs.

Keyword

Lithium, Silicate melts, Solid-state NMR, Crystallization

Comparative study on phase transition of zeolite in subducting slabs by hydrous and anhydrous environments

HYUNSEUNG LEE[1]*, Pusan National University (hslee07@pusan.ac.kr)
Pyosang Kim[2], Chonnam National University
Soojin Lee[3], Pusan National University
Hyeonsu Kim[4], Chonnam National University
Huijeong Hwang[5], Gwangju Institute of Science and Technology
Donghoon Seoung[6], Chonnam National University
Yongmoon Lee[7], Pusan National University

Abstract

Zeolites are hydrous minerals commonly observed in the lowest metamorphism. Stilbite [(NaCa4)(Si27Al9)O72 · 28 H2O] and clinoptilolite [(Ca1.3, K1.7, Na0.8, Mg0.5)(Si30Al6)O72 · 20H2O] are the most common zeolite in the oceanic crust. These are characterized by a three-dimensional micro porous structure, can content water molecules and exchangeable cations.

Subduction zone is considered initial pathway to transport slab-composed minerals toward the deep interior. During zeolites transport into the Earth interior via subduction zones, they are predicted to engage in interactions with subducting materials. Previous studies investigating minerals in subducting slabs have focused on water contents, bulk modulus, density, structural stability, and dehydration under pressure and temperature of sub-arc depths (around 100 ~ 150 km). However, research remains insufficient the effect of presence or absence of subducting fluids surrounding hydrous minerals. This study focused to reveal the impact of water presence to stilbite and clinoptilolite during subduction.

We performed in-situ high-temperature and -pressure X-ray diffraction experiments to simulate the cold subduction zones conditions. Water and silicone oil were added with the sample as pressure transmitting mediums (PTM) to create hydrous and anhydrous environments. Synchrotron X-ray diffraction analysis confirmed changes in the mineral structure.

Under hydrous cold subduction conditions, stilbite breaks down to single layer smectite and quartz at 230 °C, 1.97 GPa (ca. 64 km) and clinoptilolite breaks down to 3 - 2 layer smectite and quartz at 300 °C, 2.20 GPa (ca. 70 km). Under anhydrous cold subduction conditions, there are no significant changes both stilbite and clinoptilolite.

Our study will provide evidence to understand the water transport mechanisms from the Earth's surface to its interior, contingent upon the hydrous and anhydrous conditions of the subducting crust. Moreover, it can shed new insights into depth-dependent density changes with relevant research results.

Keyword

Zeolite, Subduction zone, Phase transition, Pressure and Temperature, Hydrous and Anhydrous

Mechanochemical amorphization of clay minerals: Understanding the role of low-crystalline fault gouge in slip behaviour

Hyun Na KIM[1]*, Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea (hnkim@kongju.ac.kr)
Jin Woo Kim[2], Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea
Bo Gyoeng PARK[3], Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea
Byung-Dal So[4], Department of Geophysics, Kangwon National University, Republic of Korea
Chan-Hee Jang[5], Department of Geophysics, Kangwon National University, Republic of Korea

Abstract

In geoenvironments with mechanical friction, such as fault zones and subduction zones, mechanical deformation leads to the formation of ultrafine amorphous earth materials with physical and chemical properties that differ from those of bulk minerals. These mechanochemical changes can affect geological phenomena such as fault slip behavior. Given this importance, this study aims to investigate the changes in the inherent properties of clay minerals, including talc and montmorillonite, due to mechanical deformation-induced amorphization. We ground the talc powder by high-energy ball milling, which caused the gradual and significant amorphization. As amorphization by milling progresses, the intrinsic hydrophobicity of crystalline talc decreases, accompanied by an increase in adsorbed water. The adsorbed water in talc, which is rarely present in its crystalline form, can increase up to 11 wt% depending on the milling conditions and is linearly correlated with the specific surface area. Numerical simulations allow us to estimate the essential role of hydrous low-crystalline talc in fault slip behavior by contributing to thermal pressurization. For montmorillonite, a decrease in crystallinity leads to a reduction in its natural swelling capacity, with the swelling index of crystalline Na-montmorillonite decreasing dramatically from 35 ml/2g to 4 ml/2g upon amorphization. These results that amorphization causes changes in the hydration properties of clay minerals suggest that the properties of low crystalline clays in fault gouges differ from those of crystalline clays and may be a critical factor in determining fault slip behavior. Our results also highlight the need for a more systematic approach to studying the effects of mineral amorphization on crustal geological phenomena.

Keyword

amorphization, clay, hydration, talc, montmorillonite

The distribution of H2O bubbles in hydrous albite melts at 0.5 GPa with varying temperature and water contents

Yerin Jeon[1]*, Kongju National University (yerin@smail.kongju.ac.kr)
Eun Jeong KIM[2], Kongju National University
Hyun Na KIM[3], Kongju National University
Takashi Yoshino[4], Okayama University
Byung-Dal So[5], Kangwon National University

Abstract

The explosiveness of volcanic eruption is dependent on the viscosity of magma and the amount of volatiles in the magma. During the upwelling of magma, the solubility of volatile species decreases with decreasing pressure, and the solubility drop causes bubbles to form in magma. The formation of bubbles affects the viscosity of magma due to the changes in volatile contents. The size and the distribution of bubbles in magma change the speed of magma upwelling. Therefore, it is essential to understand the bubble formation in magma and its effect on volcanic eruption.
Mt. Baekdu, located in the northernmost part of Korea, is believed to be an explosive volcano. The composition of the upper part of Mt. Baekdu is rhyolitic. The rhyolitic magma has a high viscosity and can dissolve >10 wt% of H2O at ~0.5 GPa, making the eruption of rhyolitic magma explosive. To better understand the latest eruption behavior of Mt. Baekdu, we used hydrous albite glasses as a model system of rhyolitic magma. The H2O bubble-bearing albite glass samples were synthesized using piston cylinders in Bayerisches Geoinstitut, University Bayreuth in Germany, and Institute for Planetary Materials, Okayama University in Japan. The samples were synthesized at 0.5 GPa at 1000-1200 ℃ for 1 hr with varying water contents from 6 to 14 wt%. As the water contents in bubble-bearing hydrous albite glasses differ from the input amount of water, the water content in synthesized albite glasses was measured by TGA. The viscosity of synthesized glass is estimated by the glass transition temperature and the calculated Qn species of albite glasses using Raman spectroscopy. The Raman spectra show a slight increase of Q0 and Q2 species with increasing water contents, but the estimated changes in the polymerization of glass are subtle. 2D image analysis using backscattered images in SEM and 3D analysis using an X-ray tomography are performed to measure the distribution of bubbles in the albite glasses. 3D analysis showed that large bubbles tend to connect more. The size of bubbles in albite glasses increases with increasing temperature and the amount of input water in the system. The information obtained and further studies with varying pressures will help us understand the changes in magma viscosity with the formation of bubbles.

Keyword

magma, bubble, hydrous albite glass, viscosity, glass structure

Amphibole inclusions in emeralds

Stefanos Karampelas[1]*, Laboratoire Français de Gemmologie (LFG) (s.karampelas@lfg.paris)
Ugo HENNEBOIS[2], Laboratoire Français de Gemmologie (LFG)
Aurélien DELAUNAY[3], Laboratoire Français de Gemmologie (LFG)

Abstract

Emerald is the bluish green to green to yellowish green variety of beryl coloured by chromium and/or vanadium (iron may also contribute to the colour, but to a lesser extent); beryl coloured solely by iron is green beryl (and not emerald). Gem quality emeralds are frequently containing minerals inclusions. These inclusions can give valuable clues on their geological, and sometimes geographical origin. Gem quality emeralds are rare but can be grown under various geological environments. Amphibole crystals are observed in emeralds from different geological environments and countries such us from Austria, Russia, Zambia, and Zimbabwe. Several faceted emeralds from different countries with amphibole inclusions from LFG (Laboratoire Français de Gemmologie) reference collection are studied. In gemmology, only non- (or micro-) destructive methods can be used. Some amphibole inclusions are reaching the surface and are chemically analysed by EDS/SEM. However, in most cases amphibole inclusions are inside the sample. In these cases, micro-Raman spectroscopy is a useful method to analyse these inclusions. It has been found in the part that different amphiboles present different spectra; principally in the hydroxyl stretching vibrations region situated from 3400 to 3800 cm-1. Because of the chromium related luminescence of emeralds, it is better not using some laser excitation wavelengths (e.g. at 532 and 633 nm) so high luminescence in the Raman spectra over 3000 cm-1 is avoided. This is the first study of amphibole inclusions in emeralds from different countries by using chemical and spectroscopic means.

Keyword

emerald, inclusion, amphibole, non-destructive, origin

Geochemistry of blue fluorescence from golden amber in response to thermal maturity

Jing YU[1]*, Gemmological Institute China University of Geosciences (jingyu@cug.edu.cn)
Chaoyang Chen[2], Gemmological Institute China University of Geosciences
Chuting Zhang[3], Gemmological Institute China University of Geosciences
Yamei Wang[4], Gemmological Institute China University of Geosciences
Shukui Zhu[5], Gemmological Institute China University of Geosciences

Abstract

Amber, a fossilized resin originating from exudates of both angiosperms and gymnosperm trees. The fossilization of terpene resin is a complicated maturation process involving cross-linking of terpenoid components and loss of volatile components, spanning hundreds of millions of years. Extensive field observation commonly reveal amber in yellow, red or brown hues. The yellow variety displaying intense blue fluorescence are highly prized gemstones with significant commercial value. To maximize the utilization of amber resources, it becomes crucial to enhance the blue fluorescence effect in lower-quality amber. However, the exact mechanism responsible for the generation of blue fluorescence in amber remains elusive. Additionally, numerous studies have established a strong correlation between the fluorescence of sedimentary organic matter and the thermal maturity of their natural setting. With increasing thermal evolution, the degree of aromatization increases, first through the loss of functional groups and formation of aromatic rings, and subsequently the coalescence of single ring into polycyclic aromatic units or structural degradation from precursors. But how does amber's fluorescence respond to thermal maturity remains unknown.

Herein, five groups of golden amber with different brightness levels and varying hues of fluorescence color were collected for color measurement, excitation-emission matrix spectrum analysis, gas chromatography-mass spectrometric analysis and Rock-Eval analysis. The results revealed that compounds such as alkylbenzene, alkyl naphthalene, and aromatic terpenes contribute to the blue fluorescence. The intensity of fluorescence is determined by the concentration of alkyl benzene and alkyl naphthalene. The hue of fluorescence is governed by the specific category of these substances. Increased methyl groups in alkyl naphthalene induce a red shift in the emission spectrum, altering the fluorescence color towards blue- green. These fluorescent substances are byproducts of terpene resin decomposition and aromatization during the thermal alteration, indicating a correlation between fluorescence and thermal maturity (measured as equivalent Vitrinite Reflectance). This study thus revealed a strong correlation between amber fluorescence characteristics and low thermal maturity of sedimentary organic matter. Correlation models have been established for equivalent Vitrinite Reflectance versus intensity and equivalent Vitrinite Reflectance versus hue: equivalent Vitrinite Reflectance = 21111×fluorescence intensity -3659 and equivalent Vitrinite Reflectance = -254×hue value + 305, respectively. These relationships represent a promising method to assess thermal maturity in sedimentary organic matter during field investigation. However, further research is necessary to explore the

significance of other amber colors for higher thermal maturity.

Keyword

Golden amber, Blue fluorescence, Color measurement, Thermal maturity, Aromatic hydrocarbon

Four thousand years of gem garnet trade in NW Africa

H. Albert Gilg[1]*, Technical University of Munich, Germany (agilg@tum.de)
Laure Dussubieux[2], Elemental Analysis Facility, Field Museum, Chicago
Joanna Then-Obłuska[3], Antiquity of Southeastern Europe Research Centre, University of Warsaw

Abstract

The chemical compositions of thirty-four red garnet beads from Lower Nubian sites dated between about 3200 BCE and 600 CE were characterized by Raman spectroscopy and laser ablation inductively coupled plasma mass spectrometry (LA-ICP-MS). Some LA-ICP-MS analyses yielded additional information on inclusions minerals and materials involved in polishing. All beads from the A-Group to the Meroitic period display a similar Ca-poor almandine composition (69-78% almandine, 15-22% pyrope, 2-6% grossular and andradite, 3-9% spessartine) with high Y (180 to 1205 ppm), moderately low Cr (13-70 ppm) and high Sc (119-213 ppm) contents that is distinct from other calcium-poor garnet types known in antiquity mostly sourced from Indian deposits. The compositions of the Nubian beads match with previous and new analyses of two alluvial garnet deposits in the Bayuda desert near the Forth Cataract of the Nile in Upper Nubia. Additional analyses of Predynastic and Middle Kingdom beads from neighboring Egypt indicate that red almandine garnets were traded for almost four millennia from the Bayuda desert to Lower Nubia and even beyond to Egypt. Northwestern Africa must be considered the cradle for the earliest and longest use of a gemstone harder than quartz.
The youngest, post-Meroitic bead shows unusual faceting, a diamond-tipped drill hole, excellent polish, distinct short- and long-prismatic inclusions and Ca- and Mn-poor pyrope composition. The features indicate that this bead from a Late Antiquity grave was not produced in Nubia but imported most probably from a South Asian site.

Keyword

gem garnet, almandine, Nubia, Egypt

Gemological Characteristics and Heat Treatment of Trapiche-like Sapphires from Changle, Shangdong province, China

Xiaojing LAI[1]*, China University of Geosciences(Wuhan) (laixiaojing@cug.edu.cn)
Suqin XIA[2], China University of Geosciences(Wuhan)

Abstract

Sapphires from Changle county, Shandong province, China are famous for their high yield, large crystalline grains, complete crystal shapes, and diverse varieties. The studies on one of the special varieties trapiche-like sapphires from Shandong, however, are very limited. In this study, systematic research on Shandong trapiche-like sapphires were carried out, including gemological characteristics and heat treatment. When the sample was sliced perpendicular to the c axis, it shows distinctive hexagonal color zoning and trapiche-like phenomenon, that is, a blue-black hexagonal core and six silvery fibrous arms. The shining fibrous arms were mainly caused by thin-film inclusions and fine fissures parallel to their elongation direction and the dark core contains some dark iron oxides etc. as examined by microscope and Raman spectroscopy, The types of inclusions in the core, arms and sectors are different and summarized in this study. The chemical composition results indicate that the Shandong sapphires are of typical basaltic genesis. Trace element characteristics are easier to distinguish from other basaltic origin sapphires. In addition, the spectroscopic features of infrared and UV-VIS-NIR were also summarized.

Heat treatment study was also conducted in this study. The results of heat treatment experiments in air directly to a temperature of 1000~1600°C show that the heating can make the blue color lightened but with a gray hue. And at 1400~1600°C iron and titanium oxide inclusions can be dissolved, making the color more uniform. The trapiche-like pattern became blurry after the heat treatment. The identification of the heated sapphires can be characterized by internal and external characteristics as well as spectroscopic features. Heated sapphires are usually free from yellow goethite or reddish-brown (hematite) iron stains at the fissures. The edges of core and arms are blurry after the heat treatment. The OH-related vibrational absorption peaks are absent in the IR transmission spectrogram. In the reflection spectra, there are changes and displacements of the broad spectral bands between 600 and 700 cm-1. These can be the basis for the identification of heated trapiche-like sapphire from Changle, Shandong, China.

Keyword

Shandong, Trapiche-like Sapphire, Gemological Characteristics, Heat treatment

Spectroscopic Analysis of Defects in Photochromic Yellow Sapphire

Yunqi Yang[1]*, Gemmological Institute, China University of Geosciences (yangyunqi@cug.edu.cn)
Chaowen Wang[2], Gemmological Institute, China University of Geosciences
Chengsi Wang[3], Gemmological Institute, China University of Geosciences
Tian Shao[4], Gemmological Institute, China University of Geosciences
Andy Hsitien Shen[5], Gemmological Institute, China University of Geosciences

Abstract

Color holds considerable importance in the classification and valuation of gemstones. Yet, in recent years, the gemstone market has been troubled by many fancy sapphires, even those backed by authoritative certification, that have experienced varying degrees of fading or color change after a period of displaying or wearing. These sapphires, when exposed to sunlight or ultraviolet light, show reversible color alterations—a phenomenon that is ascribed to the photochromism of corundum. The photochromic effect in sapphires has captivated gemologists for many years. Previous studies indicates that this effect presents in a range of sapphires, including colorless, light blue, yellow, pink, and Padparadscha varieties, independance on their origins, natural or synthetic, and whether they have undergone heat treatment or irradiation. This photochromic phenomenon significantly impacts the grading and valuation of sapphires, but its underlying mechanism is still unclear.

A set of photochromic experiments has been conducted on sapphire specimens using a 254 nm shortwave UV light source and a D65 light source, which simulates sunlight, to generate different color states. The characteristic absorption, emission and excitation spectra have been analyzed, and a correlation has been observed between the color instability and fluorescence instability in yellow sapphires during the photochromism.

We hypothesize that the defect that releases orange fluorescence plays a crucial role in the photochromic effect of yellow sapphires. This is presumed to be associated with electron transfer between defects—specifically, Mg-related defects involving trapped holes and F-centers—during the photochromic process. Consequently, the face sample has been ground into a powder for the analysis of its EPR spectrum regarding the color instability of the yellow sapphire. Notable alterations were detected in the region at $g \approx 2.0$ before and after the color changes, which is indicative of the presence of trapped-hole and F-centers. Additionally, alterations in the fluorescence of Cr during the photochromic process have also been noted. The PL spectra of the sample pre- and post-color change have been tested, with observations showing that the pattern of orange fluorescence exhibited an inverse relationship to that of Cr fluorescence. This may be due to Cr combining with trapped-hole within the corundum structure. To verify that the process did not introduce new defect levels, the fluorescence lifetime of Cr has been measured. The results indicated that the fluorescence lifetime did not change, confirming that no new energy levels were

involved in the emission of Cr, except for the trapped-hole and F-centers during the photochromic process. Our findings indicate that the essence of the photochromic process of yellow sapphire is the electron transfer between trapped-hole and F-centers, which could also influence the electron transitions within impurity elements like Cr.

Keyword

Sapphire, Defects, Photochromic, Color instability

Study of Garnets in GrecoRoman Jewellery from the Collections of Archaeological Museum of Thessaloniki.

Maria Nikopoulou[1], Aristotle University of Thessaloniki: School of Geology
Stefanos Karampelas[2]*, Laboratoire Français de Gemmologie (LFG) (s.karampelas@lfg.paris)
Evangelia Tsangaraki[3], Archaeological Museum of Thessaloniki (AMTh)
Lambrini Papadopoulou[4], Aristotle University of Thessaloniki: School of Geology
Christos Katsifas[5], Archaeological Museum of Thessaloniki (AMTh)
Ioannis Nazlis[6], Archaeological Museum of Thessaloniki (AMTh)
Annareta Touloumtzidou[7], PhD. Archaeologist, Independent researcher
Vasilios Melfos[8], Aristotle University of Thessaloniki: School of Geology
Nikolaos Kantiranis[9], Aristotle University of Thessaloniki: School of Geology

Abstract

Red coloured gems such as garnets, carnelians, sards, artificial glass etc. are quite often seen in GrecoRoman jewellery. In the present study 12 gems which were integral parts of various types of Roman jewellery from the collections of the Archaeological Museum of Thessaloniki (AMTh), Greece, were investigated. The studied artefacts originate from archaeological excavations in the city of Thessaloniki and from the former G. Papailiki's private collection. All jewellery are dated in Roman period (from 2nd century BC to 1st century CE). Most of the studied gems exhibit a brownish red to slightly purplish red hue and they appear in various shapes such as cabochons, intaglios, or engraved forms. All gems were investigated in the AMTh's archaeometry laboratory using strictly non-destructive methods such as a mobile Raman (GemmoRaman-532SG) and an Energy-Dispersive micro-Xray Fluorescence (micro-EDXRF) spectrometer. For the optical examination of the samples, a Zeiss Stemmi 508 microscope was used but as most of the samples are not particularly transparent and are set in jewels, the observation for inclusions was almost impossible. This is the first time these gems were studied with advanced techniques and most of them were either misidentified as sards and carnelians or their mineralogical variety was not identified at all. Mobile Raman spectroscopy defined 10 out of 12 gems as garnets and the remaining two samples as artificial glass beads. Micro-XRF analysis was applied to determine the chemical composition of the garnets and the major chemical elements of the artificial glass beads. Micro-Raman Garnets Evaluation Method (MIRAGEM) was also used to confirm the molar composition of the garnets. In most cases, the results of this method are in agreement with the XRF analysis. Most of the studied garnets are rich in Fe and Mg, therefore they mainly belong to the intermediate of pyrope – almandine series with a low amount of andradite and grossular (~12-20 %). Based on the existing bibliography, on the study of gems in antiquity, the garnets with the above chemical composition are mainly characterized as Rhodolites or as Type III garnets. Some samples correspond to the composition of almandine (over 70%) or in the composition pyrope (over 75%). The above garnet members can be found in Southeast Asia, such as Sri Lanka. Other important garnet deposits in antiquity are located in India, Czech Republic and East Africa. Further research is currently ongoing in order to determine the geographic origin of these garnets

and their trading networks in antiquity along with the identification of more gems from the collections of the AMTh.

Keyword

Garnets, Artificial Glass, Mobile Raman spectroscopy, Roman Jewellery, Micro-XRF

Detecting epigenetic iron staining in ruby and sapphire by using Raman spectroscope

Wei ZHOU[1]*, SSEF Swiss Gemmological Institute (wei.zhou@ssef.ch)
Michael S Krzemnicki[2], SSEF Swiss Gemmological Institute
Pierre Lefèvre[3], SSEF Swiss Gemmological Institute

Abstract

Heat treatment of rubies and sapphires has a long history. It is an effective method of improving the appearance and color. In recent years, unlike conventional high-temperature heating that exceed 1200 °C, a low-temperature heating process for ruby and sapphire has been developed. According to experimental studies, the minimum temperature that can improve the appearance of gem quality corundum is low down to 600 °C. Comparing to traditional over 1200 °C “high” temperature, low temperature heating is not easy to be detected. The present of iron staining (mainly hematite and goethite) in the open fissures in ruby or sapphire is considered as a key argument of absence of heat treatment. Only around 300 °C, the gradual dehydration transformation of goethite into hematite would start to occur. To correctly and efficiently analyses epigenetic iron staining in ruby and sapphire has never been so important.

In this study we examined several gem quality samples with epigenetic iron staining in fissures. All the work has been done by Renishaw inVia spectrometer attached to a Leica DM2500 microscope. The analyses have been performed by an argon-ion laser (green, 514.5 nm) and a RL 405 laser (blue, 405nm) depending of the cases, with a spectral resolution of 1.5 cm–1. The results have been presented by using Renishaw Wire (version 3.3) software.

The very first problems encountered that the signal from host stone affect the spectra of the target mineral, particularly in ruby. To limited the influence of strong fluorescence, blue laser applied on these rubies and gave certain promising results with 10% intensity of the laser power. The green laser with an extra confocal setting has also performed well.

When study sapphire fissure, the less fluorescent trace elements (especially Cr) is allowing better data collections. However, to obtain a better signal-to-noise ratio, the intensity of laser needs to be handled with caution. High laser power applied on the iron staining might cause certain phase transformation and give questionable results. With green laser on sapphire sample, by using a 1% laser power, the goethite peaks are noticeable (247 cm-1, 296 cm-1,399 cm-1, 554 cm-1 and 574 cm-1 peaks). However, at the adjacent area, by raising up the laser power to 100%, only few scans, it starts to appear a “new” peak around 1327 cm-1, which indicating a beginning of an in-situ dehydration process.

To efficiently detect epigenetic iron staining by using Raman spectroscope, extra consideration of the experimental setup is needed. For minimizing the noisy signal from the host gemstone, different type of Raman laser or high confocality setup might offer a solution. The alternation process occurs on iron strain that triggered by Raman laser need to be avoid by using relatively low power setting.

Keyword

iron staining, goethite, hematite, Raman Spectroscopy

A Correlation of Clay Minerals Distribution Map with Jasper Impurities Using Satellite Data in Garut, West Java, Indonesia

Kemala WIJAYANTI[1]*, Universitas Padjadjaran (kemalawijayanti@yahoo.com)

Abstract

Jasper is a type of gemstone that belongs to the cryptocrystalline form of Quartz. In Indonesia, Jasper comes in different colours, such as red, yellow, green, brown, and white. One of the famous types of Jasper in the Bungbulang Garut area is called Pancawarna, which means five colours. This type of Jasper is known for its combination of colours in one rock, which includes red, yellow, orange, green, brown, and white, sometimes forming a Pictured Jasper. Jasper is considered cryptocrystalline Quartz, which contains impurities from clay minerals. Creating a distribution map of clay minerals can help determine the impurities present in Jasper.

This study aims to analyse jasper samples from Garut, which combine red, orange, brown, and green colours. The study uses data from previous research, including XRF analysis, to determine the chemical composition of Jasper and SEM analysis to examine the nanotexture of the samples. The results indicate that Jasper is influenced by iron oxide and contains clay minerals such as illite and chlorite. Raster calculations were performed using data from ASTER, Sentinel, and Landsat maps to create a distribution map of clay minerals in the Garut region. This map provides an overview of the relationship between clay minerals and jasper colour. One of the advantages of using satellite data is that it is free and can be processed using the QGIS application. The study also compares the distribution of ferrous silicate, ferric oxide, kaolinite, chlorite, and illite to determine the composition of clay minerals that produce red to brown jasper colours.

According to the raster calculations based on ASTER data bands 1 to 9, ferrous silicate, ferric oxide, and illite distribution is reasonably high in the area where Jasper is found. Chlorite has a moderate value, while kaolinite has almost no effect. The results suggest that ferrous silicate and ferric oxide impurities mainly produce red to brown colours based on the colour of minerals, while illite affects the appearance of white. On the other hand, chlorite can have a moderate effect on the green Jasper. These findings support the results of previous research, which stated that the colour of Jasper in Bungbulang, Garut, is influenced by iron oxide, illite, and chlorite.

Keyword

Jasper, Impurities, Clay Minerals, QGIS, Raster

The study of external morphology and internal zonal structure of spinel law contact twinned natural macle diamond.

Ahmadjan ABDURIYIM[1]*, Tokyo Gem Science and GSTV Gemological Laboratory
(tgs@gemscience.tokyo)

Abstract

Spinel law contact twinned crystal of natural diamond rough called ‘Macle’ often show a flattened triangular morphology and it has been used to produce an un-cut rough diamond in its natural state and fashioned a brilliant cut jewelry for many centuries. This flattened shape has also been stressed in explaining by the preferential growth at re-entrant corners where two twin individuals contact mutually, the role of the re-entrant corner effect to the morphological change may depend strongly upon the supersaturation conditions. However, no detailed study has been carried out on the possibility of the preferential growth at the opposite side of re-entrant corner called ‘salient corner’ of macle diamond. The effect at ‘salient corner’ is revealed for the first time by previous and present study, and growth morphology appearing as external forms and internal zonal structures of spinel law contact twinned macle diamonds from South Africa were observed.

Based on the external morphology, the macle diamonds are divided into four groups (A, B, C and D) depending upon four types of re-entrant corners: I, II. III and IV which are based on the modification of their re-entrant corners by growth layers generated at the twin boundary. From estimating the degree of flatness of these twinned macle diamonds, the high flattened morphology is not only formed by the preferential growth at the re-entrant corners, but also the preferential growth at the salient corners.

To observe the internal structure, four types of twinned crystals were cut and polished perpendicular to a contact face of twinning. Zonal structure on the polished surfaces was observed by using a scanning electron microscope with cathodo-luminescence mode (SEM-CL), and the twin boundary was also checked by using an X-ray analytical microscope (XAM). By repeating the polishing and the SEL-CL and XAM observations, three-dimension of growth structure was visualized and the center of twinned macle crystals was decided.

The ratios of normal growth rate in the growth stage were estimated in detail by measuring the width along every direction of growth bands of above polished crystals. The measured ratios of normal growth rates among {111} faces at re-entrant and salient corners show predominant difference and change during the growth stage usually. It was confirmed that the morphological change and the flatness of macle diamonds were caused by the preferential growth at both re-entrant and salient corners. In additions, the change of supersaturation conditions was also estimated from the morphological change.

Keyword

macle diamond, spinel law contact twin, re-entrant corner and salient corner effect

Enhanced Provenance Determination of Turquoise through Comparative Analysis of XRF and LA ICP MS Techniques Coupled with Machine Learning

Bahareh SHIRDAM[1]*, Gemmological Institute, China University of Geosciences (Wuhan) (shirdam@gmail.com)
Andy Hsitien Shen[2], Gemmological Institute, China University of Geosciences (Wuhan)
Dalal AL-Alimi[3], School of Computer Science, China University of Geosciences
Mingxing Yang[4], Gemmological Institute, China University of Geosciences (Wuhan)

Abstract

Investigating the geographical origins of turquoise is vital in archaeological and gemological fields. This research conducts a comparative study of two prominent analytical techniques, X-ray fluorescence (XRF) and Laser Ablation Inductively Coupled Plasma Mass Spectrometry (LA ICP MS), focusing on 120 blue turquoise samples from Neyshabur, Baghu, and Meiduk in Iran, collected directly from their deposit. Considering the restrictive use of LA ICP MS on some historical artifacts (including turquoise artefacts) by museums, the study emphasizes improving XRF's accuracy using various machine learning pipelines for pre-processing, training and testing, the data, including Linear Discriminant Analysis (LDA), Random Forest, Support Vector Machine (SVM), Principal Component Analysis (PCA), t-distributed Stochastic Neighbor Embedding (t-SNE) and Neural Networks, integrated with or without Quantile Transformer (QT) and Standard Scaler. Pipelines including Neural Networks and Random Forest frameworks elevated the XRF accuracy to 94.91% from 68.18% , while LA-ICP MS dataset achieved 93% of accuracy with t-SNE and 99.59% with Random Forest, Neural Networks. The study's approach to refining XRF analysis involved selection of elements with low correlation and noticeable variances in distribution origins, and data expansion, aiming to bridge the accuracy gap with LA-ICP MS. This research integrates geochemical methods with computational analytics, advancing the precision in identifying turquoise origins and facilitating future investigations in the fields of gemology and archaeology.

Keyword

Turquoise, Origin Determination, Machine Learning, LA ICP MS, XRF

An “agate”-like mixed-habit diamond from Yuan River, Hunan, south-central China

Xinwei LIU[1]*, China university of geosciences(Wuhan) (azurelau@cug.edu.cn)
Tao CHEN[2], China university of geosciences(Wuhan)

Abstract

Cubic and octahedral mixed-habit diamonds with “agate”-like structure are rare. And the natural growth mechanism of the “agate”-like structure is rarely understudied. Here we present a diamond from Hunan Yuan River with mixed-habit and “agate”-like structure. This unusual diamond was studied by using EBSD, FTIR mapping, UV-Vis and photoluminescence spectroscopy and SEM-CL to analyze defect types, distribution, and texture. EBSD experiments confirmed that the “agate”-like diamond is a monocrystal structure, potentially grown by multicentered crystallization. The primary nitrogen defects are proved to be A and B centers, with no N3 centers but having notable nickel impurities. While hydrogen distribution uneven in the diamond. The content of hydrogen is more highly concentrated in the cuboid regions than those in the octahedral regions and is almost none in the center part. The inhomogenous distribution of hydrogen between the center and the peripheral areas indicates that the mixed-habit diamond growth is staged processes, might influenced by changing hydrogen levels in the growth environment. Moreover, carbon isotope analysis via NanoSIMS indicated that its δ13C values in the range of typical E-type diamonds. Some particular heavy δ13C values suggested a varying fluid source composition. Growth dynamics indicates that this monocrystal diamond initially grows slowly in low carbon supersaturation, exhibiting predominantly tangential growth of {111} facets. As carbon saturation increases, equal growth rates in <111> and <100> directions accelerating the rapid growth in mixed-habit section. Meanwhile excess carbon may combine with hydrogen to form C-H bonds, preferentially integrating at energetically favorable sites.

Keyword

“Agate”-like diamond, Mixed-habit diamond, Carbon isotope, Growth mechanism, Hunan Yuan River diamond

Gem Materials with Unusual Optical Properties

Andy H SHEN[1]*, China University of Geosciences (Wuhan) (shenxt@cug.edu.cn)

Abstract

Most single crystal gemstones can sometimes exhibit interesting optical properties. In the gemological literatures, many examples have been documented. Some of these phenomena are well understood now such as the iridescence in natural quartz are due to the very minute Brazilian twinning during the growth of the quartz crystal, while some are just observations such as the thermoluminescence observed in type IaB diamonds – in these cases, sometime we do not have any idea what has caused this. My research group has been focused on these subjects for years and we have observed unstable colors in the CVD diamonds due to the interplay of different color centers; pleochroism in sunstones due to the geometry and nature of the nanoparticles in the plagioclase feldspars; in addition, the perception of colors in diaspores under different lighting with different color temperatures, and so on. The purpose of this talk is to demonstrate the spread and diversity of these optical properties and to promote future collaborations and research efforts to solve these mysteries.

Keyword

optical properties, pleochroism, nanoparticles, sunstone, diamond

Analysis of the chemical composition of red gem garnets in ancient jewellery by Raman and hand-held X-ray fluorescence spectrometry for origin determination

H. Albert Gilg[1]*, Technical University of Munich, Germany (agilg@tum.de)
Dirk Müller[2], Department for Earth and Environmental Sciences, Ludwig-Maximilians-Universität München, Munich
Michelle Taube[3], Department of Research, Collections and Conservation, The National Museum of Denmark, Brede
Thorsten Allscher[4], Institute of Conservation, Bayerische Staatsbibliothek, Munich

Abstract

Silicate garnets were highly valued red transparent gemstones in Antiquity and medieval times, and remained popular during the Renaissance and Baroque period. Previous studies on the chemical compositions and inclusion characteristics of the gems reveal a great diversity of chemically distinct types of almandines, pyropes and grossulars with a narrow clustering of chemical compositions indicating that several specific deposits were exploited, in part during distinct periods. The mineralogical data allow a geological, and in some cases even a geographical, origin determination of the gemstones. Here we explore the potentials and limitations of portable Raman and energy-dispersive X-ray fluorescence spectrometry to determine the chemical composition of red garnets using a series of 26 reference materials characterized by electron microprobe and LA-ICP-MS analysis, as well as an application of calibrations on ancient gems. Previous attempts to use Raman spectrometry to determine the endmember compositions of garnets resulted in large uncertainties of more than 15 mol%. Our study shows that the spessartine content of almandine-rich garnets cannot be determined with certainty by Raman spectrometry due to the similarity of the Raman band positions of the two endmembers. In contrast, the calcium, magnesium, and in part chromium and titanium oxide contents of the aluminous garnets can be predicted by Raman spectrometry with a precision in the order of about 0.4 wt.%, if the spectrometer has sufficiently high spectral resolution.
Quantitative X-ray fluorescence analysis of single garnet crystals is hampered by diffraction, geometric and matrix effects, as well as mineral inclusions. At least two distinct acceleration voltage and filter settings are required to avoid diffraction peaks and allow detection of the lightest elements. Helium flushing, a vacuum setting or a graphene window on the detector are required to quantify the magnesium content in aluminous garnets. Our study shows that specific matrix calibrations are required for almandine-pyrope-spessartine, Cr-rich pyropes and calcic garnets. Major element oxides can thus be measured with a precision of better than 5% relative. The trace elements Sc, Ti, V, and Cr have a detection limit of about 100 ppm, while the detection limits of Zn, Ni, Zr, and Y are better than 30 ppm.

Keyword

Raman spectrometry, XRF, garnet

Unraveling the role of impurities and thermal energy in sapphire structural relaxation: Insights from Raman spectroscopic analysis of heat-treated specimens

Seung Kwon LEE[1]*, WOOSHIN GEMOLOGICAL INSTITUTE OF KOREA and HANYANG UNIVERSITY (sklee1201@hanyang.ac.kr)
Dongwook SHIN[2], Hanyang University
Shoohack SHON[3], Hanyang University
Jungmin KIM[4], Hanyang University
Sungjae KIM[5], Hanyang University

Abstract

Various trace-element impurities (e.g., iron, titanium, chromium, or vanadium) and chemical reactions contribute to the coloration of natural corundum. These elements have a different atomic radius or charge compared to the aluminum ion. Depending on the degree of substitution, they may lead to localized structural relaxations. Throughout antiquity, corundum has undergone heat treatment for moderate color enhancement. However, contemporary heat-treatment techniques yield dramatic results, surpassing the subtle changes observed in historical practices. With the advancement of these treatments, it is becoming increasingly difficult to distinguish between natural and heat-treated sapphires.

This study has shown that changes in the crystallinity of sapphire or corundum correlate with the iron oxide content and the thermal energy applied, as determined using Raman spectroscopy. The Raman peak at around 417 wavenumber is always the strongest peak in natural sapphire. The full-widths at half-maximum (FWHM) of the 417 peak increase with the increasing iron oxide content due to the larger ionic size of iron compared to that of aluminum.

During the heat treatment of sapphire, impurities (mainly iron) within the sapphire host lattice absorb thermal energy. Consequently, impurity atoms experiencing the general heating treatment temperature could affect the local structure of the sapphire. We suggest that the local arrangement of atoms surrounding a substitutional Fe(III) ion in corundum is primarily governed by kinetics rather than thermodynamics during heat treatment, as the heat treatment process of the sapphire is relatively shorter than the creation process in nature.

We therefore find it reasonable to assume that the FWHM of the 417 peak increases with iron oxide content and the thermal energy applied. The Raman study on the structural relaxation induced by impurities might provide an opportunity to identify both natural and heat-treated sapphires.

Keyword

Heat-treated sapphire, Raman spectra, Crystallinity, Iron(III) oxide content

Formation, identification and color grading of Nanhong agate from the Southwestern of China

Chaowen Wang[1]*, China University of Geosciences(Wuhan) (c.w.wang@cug.edu.cn)
Huimin Huang[2], China University of Geosciences(Wuhan)
Haotian Wang[3], Hubei Provincial Jewelry Quality Supervision and Inspection Center
Lingyue Yang[4], Chengdu Institute of Advanced Metallic Material Technology and Industry Co., Ltd.

Abstract

Nanhong agate is widely welcomed in China because of its bright red color. The pursuit of the red agate is the inheritance of Chinese red agate culture, which can be dated back to more than 3000 years ago. Field survey showed Nanhong agate geographically distributed in Yunnan and Sichuan Provinces, the Southwestern of China. Geologically, Nanhong agate can be either produced as fillers in cracks and pores of the Late Permian E'meishan basalts, or as pebbles in the Early Triassic conglomerates and mudstones. Petrographic analyses revealed the formation of agates could be linked to the alteration of basalts, especially in the process of transformation from pyroxene to chlorite. The formation of Nanhong agates could have experienced multi-stages, which was supported by the occurrence of multi-stage chlorites and different homogenization temperatures of fluid inclusions bearing in the coarse grained quartz. The Nanhong agate was characterized by diffusely distributed hematite and/or goethite, causing the red to reddish orange in color. These iron oxides occurred as aggregates showing dominantly spherical shapes and minor visible ellipsoid, hemisphere, radial and veil shape, with a size generally between 1.2 μm and 43.21 μm. Raman spectra, scanning electron microscopy, and high resolution transmission electron microscopy confirmed the present of hematite with single hematite particles smaller than 100 nm. Wide market survey of the selling Nanhong agates presented the quantified color parameters, including hue, saturation, and brightness, obeyed normal distribution in the Hue-Saturation-Brightness (HSB) color space. After standardization, the hue (H) of Nanhong agate was mainly distributed in a range between [3. 20°, 17. 52°] at a 95 % confidence level. The saturation (S) and brightness (B) were mainly within [63. 82 %, 92. 69 %] and [42. 97 %, 75.37 %], respectively. The Nanhong agate could be statistically classified as different grades by the Two Step Cluster analysis, which is objective compared to subjective visual evaluation. Factors causing the color difference of Nanhong agate were attributed to the color properties and distribution characteristics of hematite and goethite. The hue of Nanhong agate was dependent on the color of the impurity minerals, hematite or goethite. Saturation was affected by the area ratio of impurity minerals. As the area ratio of impurity minerals was both affected by the distribution density and the average particle size, the saturation of Nanhong agate was the largest when the average particle size was near 10 μm. No obvious correlation was observed between the brightness of Nanhong agates and their related properties and characteristics.

Keyword

E’meishan basalt, hematite, HSB, Nanhong agate, Yunnan

XRF and Photoluminescence combined as a tool in the determination of the origin of Colombian emeralds

JAVIER GARCIA TOLOZA[1]*, CDTECGemlab (ceo@gemlabcdtec.com)
Camilo Betancurt[2], Technological Development Centre Fort he Colombian Emerald
Holman Alvarado[3], Technological Development Centre Fort he Colombian Emerald
Carlo Cedeño[4], Technological Development Centre Fort he Colombian Emerald

Abstract

The origin becomes a determining factor in the value of gemstones. The reputation of a region for producing high-quality and highly valued gemstones in the market. For example, rubies from Mogok (Myanmar or Burma) and sapphires from Kashmir (India) are gems that, in addition to standing out for their high quality in terms of color, clarity, size, among other aspects, reach higher prices in the markets due to their specific origin.
In the gemological laboratory, the combination of techniques is essential to deepen the understanding of gemological materials. Photoluminescence is used for various purposes, with its utility highlighted in analyzing the crystalline structure of materials. A specific use is the identification and characterization of a band associated with the chromium element in emeralds, linked to their origin in previous research. Additionally, studies have been conducted to determine the origin of emeralds using chemical composition analysis techniques such as LA-ICP-MS and ED-XRF. Previous research has identified specific parameters, such as concentrations of Ga, Fe, Na, Mg, Cs, lithium, and potassium, that allow differentiation between Colombian emeralds and those from other regions.

Low iron concentrations, less than 3000 ppm, similar concentrations of chromium and vanadium with an average ratio of 1:1, and the location of bands related to chromium between 683.7nm for R1 and 680.6nm for R2 in photoluminescence are some aspects that can be correlated and are associated with Colombian emeralds. This combination of techniques enhances the robustness in determining origin and distinguishing between emeralds from different locations worldwide.

Keyword

origin, photoluminescence, gemology, emerald

A Study of Turquoise Origins Based on Trace Elements and LDA Method: a Case Study of Liangzhu Culture-related Sites in China

YAN JIANG[1]*, Gemlogical Institute,China University of Geosciences,Wuhan
(Jiangyan@cug.edu.cn)
Mingxing Yang[2], Gemlogical Institute,China University of Geosciences,Wuhan

Abstract

Turquoise is a precious gemstone widely used in various civilizations around the world, and it has been used in China for 9,000 years. Turquoise inlays and turquoise beads were found in the Liangzhu Culture (B.C.3300-B.C.2300) in the Yangtze River Basin during the Neolithic period, and they were mostly used in necklaces or for the inlay of animal-face totems on the surfaces of jade artifacts, which proved that Turquoise is considered very precious at that time. Liangzhu culture is a representative archaeological culture of Chinese prehistory, which used a huge number and rich variety of jade artifacts, unique in Chinese prehistory, and was the highest peak of the development of Chinese prehistoric jade culture. The archaeological ruins of Liangzhu City which sited at the center of its cultural area was included in the UNESCO World Heritage List in 2019, and it not only provides reliable evidence of China's 5,000-year civilization, but is also a valuable world heritage site.

The source of turquoise used in the Liangzhu culture area remains unknown because of the lack of information on ancient local turquoise mines, and the evidence provided in this study contributes to the discussion of this issue. This research performed nondestructive gemmological physical and chemical analyses (FTIR, LA-ICP-MS, etc.) and microscopic observations on 40 excavated turquoise samples from six sites in the Liangzhu culture area, in order to study the selection, the processing, and the methods of application of turquoise materials at that time. Linear Discriminant Analysis (LDA) was applied to analyze the trace elements, and compare with the characteristics of Chinese turquoise origins of different genesis, different mining areas and mining zones, to determine the origin of turquoise excavated from Liangzhu culture-related sites. The study found that the turquoise artifacts in the Liangzhu culture area did not come from the nearby Anhui mining area of igneous nature, but from the farther E-Yu-Shaan Mining Area (located in the eastern part of the Qinling orogenic belt, named for the area spanning Hubei, Henan and Shaanxi provinces, the largest turquoise mining area in China) of sedimentary metamorphic nature, and the turquoise from the six sites may have come from three different mining zones. This study not only helps to reveal the source and trade network of turquoise during the Liangzhu culture period, but also deepens the understanding of exchanges and interactions between ancient cultures. Through trace element analysis, it is possible to trace the source of turquoise, and then explore the connection between Liangzhu culture and external cultures in terms of resource exchange and cultural dissemination. This research is of great significance to the understanding of socio-economic development, cultural exchanges and regional interactions in ancient China, providing new perspectives and evidence for historical research.

Keyword

Liangzhu culture area, Archaeological turquoise, Trace element geochemistry, Origin traceability

Synthesis of silica spheres with homogeneous size distribution by electrospray-assisted Stöber method for the fabrication of opal photonic crystals

JUNGMIN KIM[1]*, HANYANG UNIVERSITY (ohyes7017@hanyang.ac.kr)
SHOOHACK SHON[2], HANYANG UNIVERSITY
SUNGJAE KIM KIM[3], HANYANG UNIVERSITY
JAEHYEON EOM[4], SOLIVIS Inc. Hanam
SEUNGKWON LEE[5], HANYANG UNIVERSITY
DOOGWOOK SHIN[6], HANYANG UNIVERSITY

Abstract

SiO2 opal of higher quality is a self-assembled colloidal crystal, which consists of cubic dense packing(fcc) of silica nanospheres. Monodisperse and uniform sized spheres are major factor for obtaining opals with characteristic optical properties. The imperfect monodispersity and wide size distribution produce serious disorders and dislocations in opals.

The Stober process, commonly used to synthesize spherical silica particles by hydrolysis and condensation polymerization with the precursor of tetraethylorthosilicate(TEOS). However, agglomeration and wide size distribution in size obtained through the Stober process are major source of the defects of the opal photonic crystal.

In order to improve the monodispersity and uniformity in size distribution of the spheres, we present an effective method for synthesizing monodisperse silica nanosphere by electrospray-assisted Stober method. The electrospray technique was used to spray a dispersed aerosol of silica precursor (TEOS) into the reaction bath containing ethanol, water, and ammonia solution.

To find the best homogeneity in the size and low polydispersity of synthesized silica nanospheres, two methods of precursor incorporation into the reaction bath were compared: incorporation by drop-by-drop at a constant flow rate, and by continuous fine droplet flow using electrospray technique. Also, a surfactant (triton x100) was added while synthesizing the silica spheres to enhance stability of the silica dispersions and the monodispersity of the spheres. In addition, the concentration of the precursor was controlled to obtain a spherical diameter in the range of 200-350 nm to be able to produce a play-of-color of photonic crystal.

The results confirmed that the size and uniformity of the spheres were profoundly affected by the method of precursor incorporation. We achieved increased monodispersity and homogeneity of the nanospheres under all conditions when the electrospray-assisted method is employed. We obtained nanospheres with exceptionally high monodispersity in the size range from 192.5 nm to 370.5 nm, which can exhibit multicolor when arranged in a regular three-dimensional array.

Keyword

Synthetic opal, Silica synthesis, Electrospray, Stober method

ICE JADE FROM GUATEMALA

Tao CHEN[1]*, Gemology Institute, China university of Geosciences (chentao@cug.edu.cn)
Zhaoyin Huang[2], Gemologu, China university of Geosciences

Abstract

Ice jade is a kind of jadeite jade (also known as Fei Cui) which is translucent (semitransparent), and usually is expensive. A kind of nearly colorless ice jade from Guatemala newly appears in Chinese jewelry market. The ice jade is fine texture, often has white snowflakes impurities. Its glistening effect is difficult to be observed on the polished surface. In this paper, the mineral compositions, chemical composition and structural characteristics of the ice jade were studied by using Raman spectrometer, X-ray diffraction (XRD), electron probe micro-analysis (EPMA), scanning electron microscope (SEM), and cathodoluminescence (CL). The ice jade is mainly composed of jadeite pyroxene. Its impurity minerals include omphacite and albite. The seldom observed pale-green particles are composed of omphacite. The albite is clustered as white snowflake or disperses like crumbs in the jade. The chemical compositions of jadeite are usually pure. While the small or the edge of relatively large jadeite particles have a small amount of Ca and Mg because of isomorphic substitution. The omphacite pyroxene is lack of Fe, whose chemical composition is mainly composed of jadeite-diopside series. The jadeite exhibits micro-granular to fine-grained structure, often shows blue-violet and violet-red CL fluorescence. The origin of ice jade from Guatemala can be distinguished from its characteristic appearance, microstructure, impurity minerals, and chemical compositions.

Keyword

jadeite jade, Guatemala, fine-grained structure, omphacite, Fei Cui

Investigation of Traps in Electron-irradiated Sapphire: Insights from Thermoluminescence and Fluorescence Spectrum

Yuyang ZHANG[1]*, School of Earth Sciences (gembubble@cug.edu.cn)
Meihua Chen[2], /
Wensi Yang[3], /

Abstract

Sapphire is one of the most important gems. Meanwhile, renowned for its exceptional optical properties and chemical stability, sapphire is extensively employed in optical instruments, communication equipment, and various other fields. The color and other material performance of sapphire strongly depends on the type and concentration of internal defects. In this study, we investigated natural sapphire by measuring its thermoluminescence spectra after irradiation with high-energy electrons. The spectra were analyzed and fitted using the Computerized Glow Curve Deconvolution (CGCD) method. By employing this approach, we calculated the activation energy and kinetic order of various traps present in the sapphire samples. Additionally, we compared the three-dimensional fluorescence spectra of the sapphire samples before and after high-energy electron irradiation. By combining the results from thermoluminescence and fluorescence analysis, we found that the trap with a thermoluminescence peak around 450K is the main defect affecting the color, fluorescence, absorption spectrum, and other optical properties of the sample. It is related to Cr3+, with a trap depth of about 1.05eV. The method used in this study optimized the detection of low-concentration traps by combining high-energy irradiation with thermoluminescence and fluorescence spectroscopy, it offers a feasible method for the detection and attribution of low-concentration defects in mineral materials.

Keyword

Sapphire, Electron-irradiation, Fluorescence spectrum, Thermoluminescence

Effect of Fe2O3 Core/SiO2 Shell Nanoparticle Pigments Doping Ratio on the Color of Synthetic Precious Fire Opal

Bowen Li[1]*, China University of Geosciences Wuhan (libowen@cug.edu.cn)
Andy Hsitien Shen[2], China University of Geosciences,Wuhan

Abstract

Precious opal displays iridescent play-of-color due to the diffraction effects of visible light by the three-dimensional periodic ordering of uniformly sized silica nanoparticles. These properties make precious opal a valuable prototype for 3D photonic crystals. More and more researchers have attempted to synthesize precious opals not just for gemological applications but for potential applications in photonics, optoelectronics, and sensors.

Among the wide variety of opal types, precious fire opal has captured people due to its simultaneous display of play-of-color and red-orange-yellow body color. Previous studies believe that the body color of precious fire opal is caused by the dispersion of Fe2O3 nanoparticles. The body color would become darker when the concentration of Fe2O3 nanoparticles increases. In addition, the presence of Fe2O3 particles is equivalent to introducing defects in the opal structure. The increasing concentration of Fe2O3 nanoparticles will change the periodic dielectric structure of precious fire opal and ultimately affect the play-of-color. To study these phenomena quantitatively, synthesizing a series of fire opals with different Fe2O3 nanoparticle doping ratios is a good strategy.

Fe2O3 nanoparticle is one kind of widely used red inorganic pigment with strong tinting strength. However, only a few studies have been reported on synthetic opal with doped Fe2O3 nanoparticles, maybe due to the unstable properties of bare Fe2O3 nanoparticles. Bare Fe2O3 nanoparticles can easily agglomerate in their dispersed system. At high temperatures, bare Fe2O3 nanoparticles can be reduced to Fe3O4, which causes the color to turn dark red. Moreover, chemical pollution can result in the color fading of bare Fe2O3. These problems can be solved by coating Fe2O3 nanoparticle with a SiO2 shell. The SiO2 shell can prevent the aggregation of dispersed particles, adjust the distance between assembled particles, enhance the chemical stability of Fe2O3 core particles, and keep the color stability of synthetic precious fire opal.

In this research, we used Fe2O3 core/SiO2 shell (Fe2O3@SiO2) nanoparticles as red pigments and synthesized a series of opal films. First, the Fe2O3@SiO2 nanoparticles were prepared using a sol-gel process. Then, Fe2O3@SiO2 nanoparticles with different volume fractions were mixed in well-dispersed similar-sized SiO2 nanoparticle suspension. Finally, the opal films were synthesized using the vertical deposition self-assembly method. The nanostructure and color evolution of synthetic fire opal films with different Fe2O3@SiO2 nanoparticle doping ratios were studied and compared to the results of previous reports. It shows that the saturation and brightness of body color were enhanced than bare Fe2O3 particle doped opal. The doping ratio affected the structural color, and the effect reached its maximum when the volume fraction was nearly 50%. The present work would deepen our understanding of precious fire opal's color genesis and

improve synthetic techniques.

Keyword

Synthetic Fire Opal, Color evolution, Pigments Doping, Core-Shell Nanoparticle, Fe2O3 Nanoparticle

Anisotropic photoluminescence in ruby and chrysoberyl

Linling DONG[1]*, China University of Geosciences(Wuhan) (sarah1053839869@163.com)
Ren LU[2], China University of Geosciences(Wuhan)

Abstract

Raman and photoluminescence spectroscopy measurements were performed on ruby and chrysoberyl in different orientations. The polarized Raman spectroscopy was used to confirm the crystalline phase as well as the crystal orientation of the sample, and the photoluminescence properties of the materials for different crystal orientations were studied. In this study, typical gem materials - ruby (uniaxial crystal) and chrysoberyl (biaxial crystal) were used to study the anisotropy of photoluminescence, resulting in a clearer understanding of the structural information of gem materials, such as the local symmetry environment. The photoluminescence spectra of ruby and chrysoberyl were also functions of the observed polarization, which peak shape and relative intensity of R-Lines vary under the different orientations of electric field, magnetic field and crystallography. The photoluminescence spectra of ruby had anisotropy as it exhibited optical absorption anisotropy, could be characterized by the orientation of electric field and largely unaffected by the orientation of magnetic field; however, the Rm and Ri lines of chrysoberyl were not only affected by the orientation of electric field, but also by the orientation of magnetic field. Analysis and comparison photoluminescence spectra can reveal that lower symmetry and multi-site structure containing Cr–doped octahedra results in more pronounced anisotropy in spectra of chrysoberyl in various directions of the polarization than that in ruby.

Keyword

photoluminescence, anisotropy, ruby, chrysoberyl, Raman Spectroscopy

Spectroscopic and DFT study of the orientational order of water molecule and its influence on the coloration of beryl

SUNGJAE KIM[1]*, Hanyang University (sjk310700@gmail.com)
SHOOHACK SHON[2], Hanyang University
JAEHYEON EOM[3], Solivis Inc. Hanam
JUNGMIN KIM[4], Hanyang University
SEUNGKWON LEE[5], Hanyang University
DONGWOOK SHIN[6], Hanyang University

Abstract

Beryl, Be3Al2(SiO3)6, is a natural gemstone with diverse colors. Small contents of chromophore elements like Fe, Cr, V, Cs, Mn and others are related to the colors of beryl. The colors can be altered by atmospheric heat treatments, which induces the valence change of chromophore elements. The studies on the coloration mechanisms have been of great interest with respect to how to improve or induce the color of beryl. By Fourier Transform Infrared Spectroscopy (FTIR), we investigated the correlation between short-range structural arrangement of impurities and their charge states to elucidate the mechanism for this color change.

The color change is largely related to the orientational order of water molecules residing in the beryl channel. The stable orientational states of water molecules are shown to be type I and type II, where the H-H vector is parallel and perpendicular to the c-axis respectively. In this work, a significant change in the FTIR spectra of beryl was observed only in green samples after exposure to reduction heat treatment. The significant decrease of the band at 3633 cm-1 may be related to the position of Na+ ion in the beryl channel along the c-axis, probably due to relocation of Na+ ions from position 2b to 2a. In order to explain these results theoretically, we examined the stability of water molecules under the coexistence of the substituted Fe and Na+ ions using the density functional theory(DFT) total energy calculations.

Firstly, the stable configuration of individual water molecule and Na+ ion is examined. It is found that water molecule is stable at 2a positions with type type I orientation but Na+ ion is stable at 2b positions. By examining the cohesive energy of Fe substituted structure, it is shown that Fe substitutes Al. Secondly, the interactions between water molecule, Na+ ion, and the substituted Fe are examined. Although the position of the Na+ ion is not affected by the existence of water molecule and substituted Fe, the orientation of the water molecule is changed from type I to type II due to the ionic field of Na+ ion. Furthermore, our preliminary results shows that the Fe2+ stabilizes the Na+ ion at 2a position in accordance with the rotation of water molecule into type I configuration.

Keyword

Beryl colors, Beryl channel, position of Na+, water molecules, DFT

Accessory minerals under rock-fluid interaction conditions and remobilization of rare lithophile elements in felsic magmatic and metamorphic systems

Martin ONDREJKA[1]*, Comenius University Bratislava (martin.ondrejka@uniba.sk)
Pavel Uher[2], Comenius University
Igor Broska[3], Earth Science Institute of the Slovak Academy of Sciences
Marián Putiš[4], Comenius University
Peter Bačík[5], Comenius University
Alexandra Molnárová[6], Earth Science Institute of the Slovak Academy of Sciences
Tomáš Mikuš[7], Earth Science Institute of the Slovak Academy of Sciences
Sergii Kurylo[8], Earth Science Institute of the Slovak Academy of Sciences

Abstract

REE bearing accessory minerals (monazite, xenotime, allanite and apatite) are some of the most widespread accessory phases in common magmatic and metamorphic rocks with granitic and metapelitic protoliths. In addition, monazite and xenotime are essential for petrochronology. Although these minerals commonly crystallise as primary magmatic or metamorphic accessory phases, younger postmagmatic or metamorphic hydrothermal fluids can cause their partial-to-complete transformation to low-grade neoblasts. The commonly observed breakdown of monazite includes a subsolidus retrograde corona around its partly dissolved core with distinctive concentric mineral zones of fluorapatite (often REE-rich), Th-silicate/oxide (huttonite, thorite, thorianite), and allanite-(Ce) to REE-rich epidote or clinozoisite. Occasionally, REE carbonates (bastnäsite- or synchysite-group) originated as later low-grade replacement products in these coronae. These microtextures are documented mostly in low- to medium-temperature metagranitoids with primary magmatic monazite-(Ce). However, it can also occur in metapelites if the high-temperature metamorphic monazite-(Ce) destabilises during post-peak metamorphic evolution.

Similar reaction coronae around xenotime-(Y) in granitoids and metapelites or the partial compositional alteration of xenotime-(Y) via dissolution–reprecipitation resulting in a texture characterised by thorite ($ThSiO_4$) and uraninite (UO_2) inclusions, are less frequent. The decomposition of xenotime-(Y) containing boron can results in a reaction corona of fluorapatite and Y-B-Be silicates, e.g., hellandite-(Y) and hingganite-(Y) mineral zones, involving HREE + Y, and also B and Be mobility.

Another example of REE-phosphate decomposition represents the replacement of primary magmatic monazite-(Ce) and xenotime-(Y) during post-magmatic alteration of the host rock by As-S-Sr-rich and high fO_2 fluids. This specific fluid composition led to the formation of a unique complex REE phosphate–arsenate (monazite-gasparite; xenotime-chernovite) solid solutions or to an extremely S,Sr-rich monazite-(Ce). This composition indicates a $(Ca,Sr)S(REE,Y)_{-1}P_{-1}$ substitution as a dominant mechanism of Sr and S entry into the monazite structure. Also, primary magmatic accessory fluorapatite and allanite-(Ce) can be affected by breakdown phenomena to producing a unique secondary assemblage of britholite group minerals as well as REE carbonates, monazite-(Ce), chlorite, epidote, and calcite in A-type granites. These textural and compositional

data indicate extensive replacement and breakdown of primary magmatic REE,Y-bearing phases by subsolidus H2O-, CO2- and F-rich fluids, deliberated during post-magmatic overprint of the host granite.
The investigation of REE-bearing accessory minerals and their stabilities suggests the formation of porous textures, significant dissolution, etching, and alteration dependent strongly on local mineral compositions, on P–T–X conditions as well as on the presence and character of pervasive low-T metamorphic or post-magmatic-hydrothermal fluids in granitic systems, so more complex and variegated breakdown products can originate in specific conditions.

This work was supported by the Slovak Research and Development Agency under the Contract no. APVV-22-0092

Keyword

monazite, xenotime, apatite, allanite, rock-fluid interaction

Hyperspectral Imaging: An effective mineral mapping tool for apatite in the Upper Zone, northern limb, Bushveld Complex

Clement NDOU[1]*, Council For Geoscience (cndou@geoscience.org.za)

Abstract

The technological advances in efficient, rapid, and non-destructive hyperspectral core logging systems for systematic mineral mapping have led to the discovery and exploitation of new mineral deposits. Hyperspectral imaging in the long-wave infrared range has recently been used successfully to identify various phosphate bearing minerals (monazite, xenotime, and britholite), with limited work on apatite associated with mafic-ultramafic layered intrusions. In this study, we investigate the effectiveness of a hyperspectral imaging (HSI) system with long-wave infrared (LWIR) bandwidths to identify apatite in the Upper Zone of the northern limb of the Bushveld Complex. The accuracy of the HSI results was validated by mineralogical and geochemical data. The two apatite-enriched zones detected by HSI suggests a widespread development of apatite throughout the uppermost 600 m of the Upper Zone. The lower apatite-enriched zone is approximately 40 m thick, while the upper apatite-enriched zone is about 23 m thick. This is consistent with previous thickness determinations by traditional logging and analytical methods such as petrography and mineral chemistry using electron microprobe (Ashwal et al., 2005). Spectral mixing observed in the response of apatite is ascribed either to the common association of apatite and olivine in these rocks, or to differences between the spatial resolution of the hyperspectral image and the size of apatite grains. In our study, the visible-near infrared and the shortwave infrared (VNIR-SWIR) range had limited detection capabilities in mafic-ultramafic rocks dominated by silica, some silicates (nesosilicates such as olivine) and oxides, as they did not show prominent spectral features. The results showed the absence of fluorapatite diagnostic prominent VNIR features related to the LREE (Nd) while inconspicuous spectral features were detected in the SWIR range. Nonetheless, HSI in the LWIR range is effective in mapping apatite and should therefore be considered as an exploration tool. This research advances our knowledge of the reflectance spectroscopy of REE-bearing minerals, which makes it easier to detect, identify, and quantify REE-bearing silicate minerals using HSI.

Keyword

Bushveld Complex, long-wave infrared, Apatite, HSI, Upper Zone

Platinum-group minerals, an experimental overview

Anna VYMAZALOVA[1]*, Czech Geological Survey (anna.vymazalova@geology.cz)
Frantisek Laufek[2], Czech Geological Survey

Abstract

There are currently 166 platinum-group minerals (PGM) approved by the Commission on New Minerals, Nomenclature and Classification (CNMNC) of the International Mineralogical Association (IMA). Among 166 PGM there are: 79 palladium, 38 platinum, 23 rhodium, 15 iridium, 7 ruthenium and 4 osmium dominant minerals. The largest class of minerals are sulphides (38) followed by tellurides (23) and arsenides (22) reflecting the chalcophile character of platinum-group elements. There is also a significant class of alloys (20) consistent with the siderophile character of platinum-group elements. Our aim is an experimental assessment of platinum-group minerals, their revision in terms of chemical composition, physical properties, crystal structure investigation and thermal stability. We have experimentally focused on Pd-dominant PGM. A number of PGM display unique crystal structures like lukkulaisvaaraite $Pd_{14}Ag_2Te_9$ or thalhammerite $Pd_9Ag_2Bi_2S_4$. Such minerals with novel atomic ordering might be an inspiration for materials scientists and often show interesting structural properties. There is a significant group of PGM that also display desired properties (e.g. semiconductors or two-dimentional materials). Nevertheless there is still a significant group of minerals poorly characterized. The crystal structure of 33 Pd-dominant PGM is still not determined or solved and require further investigations.
The support from the Grant Agency of the Czech Republic (project No. 22-26485S) is greatly acknowledged.

Keyword

Platinum-group minerals, platinum-group phases, synthesis, experimental study study, crystal structure

Natural Radioactivity of the Mesozoic Granites in the Southern Part of the Korean Peninsula

Chaewon KIM[1]*, Chonnam National University (kimchaewon48@jnu.ac.kr)
Jieun Seo[2], Chonnam National University
Minju Kang[3], Chonnam National University
Eunsil Jang[4], Chonnam National University
Jaebong Park[5], Center for Asbestos and Environment, Chonnam National University
Yul Roh[6], Chonnam National University

Abstract

Naturally occurring radioactive materials (NORMs) refer to radioactive isotopes such as ^{238}U, ^{232}Th, ^{226}Ra, ^{222}Rn, and ^{40}K in geological media. The emission of radiation during their decay causes health risks in case of prolonged human exposure. Previous studies have shown the high concentrations of NORMs in Mesozoic felsic and plutonic rocks present in the southern part of the Korean peninsula. This research deals with the association of natural radioactivity and minerals in order to clarify the putative relationships between natural radioactivity and the mineralogical as well as the geochemical characteristics of the Mesozoic granites.

In this study, Mesozoic granites were collected from several regions of the southern Korean peninsula. Triassic granites were obtained from Hongseong and Yongyu-do. Jurassic granites were obtained from Daejeon and the northern part of Gyeonggi-do. Cretaceous granites were obtained from Chungcheongbuk -do and Jinan. Mineralogy of the granites was identified using XRD and PLM analyses. Gamma-ray spectroscopy analyses were conducted to identify radionuclides and to measure the energy. EPMA analyses were also used to analyze the distribution patterns of those NORMs in NORM-containing minerals.

The radioactivity of the Triassic granites ranges from 47.4 to 341.9 Bq/kg for ^{232}Th, from 17.1 to 248.7 Bq/kg for ^{226}Ra, and from 882.9 to 1961.5 for ^{40}K. The radioactivity of the Jurassic granites ranges from 16.64 to 145.10 Bq/kg for ^{232}Th, from 12.29 to 151.19 Bq/kg for ^{226}Ra, and from 175.02 to 1485.86 for ^{40}K. The radioactivity of the Cretaceous granites ranges from 46.1 to 185.2 Bq/kg for ^{232}Th, from 21.6 to 129.5 Bq/kg for ^{226}Ra, and from 881 to 1,572 Bq/kg for ^{40}K. XRD, PLM, and EPMA analyses revealed the mineralogy of the Mesozoic granites, with the high level of ^{232}Th and ^{226}Ra attributed to accessary minerals such as monazite, zircon, apatite, thorite, and sphene. Additionally, high activity concentration of K^{40} was related with K-containing minerals such as K-feldspar and micas.

Keyword

Naturally Occurring Radioactive Materials, Mesozoic granite, Radium-226, Thorium-232, Potassium-40, Accessary minerals

Reaction Between Feldspar and Water Under the Mantle Transition Zone Conditions

Yeonhak JUNG[1]*, Yonsei University (muts0228@yonsei.ac.kr)
YongJae Lee[2], Yonsei University
Stella Chariton[3], Center for Advanced Radiation Sources, University of Chicago, Argonne, IL, USA
Vitali Prakapenka[4], Center for Advanced Radiation Sources, University of Chicago, Argonne, IL, USA
Nico Giordano[5], Photon Sciences, Deutsches Elektronen Synchrotron, Hamburg, Germany
Hanns Peter Liermann[6], Photon Sciences, Deutsches Elektronen Synchrotron, Hamburg, Germany

Abstract

One significant mechanism for transporting water to the boundary between the Earth's lower mantle and its core involves the formation of stable, high-density hydrous minerals as a result of phase transitions by subduction process. Feldspar, a major mineral component of the crust, is known to transition into a hollandite-type structure under the mantle transition zone conditions, characterized by a tunnel structure. A key feature of the hollandite-type structure is its high affinity for large, low-valence cations such as potassium, which facilitates the transport of heat-producing radioactive isotopes like 40K to the lower mantle, thereby serving as a crucial factor in the thermal evolution of the deep Earth. In this study, we applied conditions of the transition zone, containing 2-3 wt% water, to feldspar composed of equal parts Na and K, to analyze the phase transition process of feldspar in the transition zone. Through synchrotron X-ray diffraction experiments employing diamond anvil cells and laser heating, we confirmed the formation of the hollandite-type structure under both hydrous and anhydrous conditions. The hollandite-type structure formed in the presence of water exhibited a unit cell volume increase of about 0.5% compared to that formed in the absence of water. Additionally, Rietveld analysis indicated that in the hollandite-type structure of feldspar, water and cations alternately occupy the structure's vacant cavities. Therefore, the transition of feldspar to the hollandite-type structure in a "water-rich" mantle transition zone environment suggests a novel mechanism for the co-transport of water and cations.

Keyword

Feldspar, Hollandite, Subduction

A high-precision measurement method for analyzing Sr, Nd and Sm isotope ratios in single-grain minerals

Guiqin WANG[1]*, Guangzhou Institute of Geochemistry, CAS (guiqinwang@gig.ac.cn)
Yuming Xu[2], Guangzhou Institute of Geochemistry, CAS

Abstract

High-precision measurements of Sr, Nd, and Sm isotopes in single-grain minerals are significant in geochemistry. It is also a challenge for analytical techniques. In this study, a single-column separation procedure was developed using TODGA-normal resin to purify Sr, Nd, and Sm from microgeological samples (∼3 mg). The total chemical procedural blank for Sr, Nd, and Sm is less than 80, 7, and 3 pg, respectively; the recoveries are all greater than 91%. Methods have also been developed for the static measurement of Sr, Nd, and Sm isotopes in small size samples using a TIMS with Faraday cups and 10^12 and 10^13 Ω amplifiers. The accuracy and precision of Sr, Nd, and Sm isotope ratios were analyzed using TIMS with three single-element calibration solutions, SRM 987 Sr, La Jolla Nd, and Alfa Aesar Sm, respectively. The results show that the repeatability of 87Sr/86Sr, 142Nd/144Nd, 143Nd/144Nd, 149Sm/152Sm and 150Sm/152Sm ratios at 30 ng each of Sr, Nd, and Sm is 0.710248 ± 11, 141 846 ± 25, 0.511852 ± 13, 0.516845 ± 17, and 0.275998 ± 9 (2 SD), respectively. Five geological rock reference materials and one meteorite sample were weighed at 3 mg and were used to validate the developed chemical procedure and TIMS measurement methods for Sr, Nd, and Sm. The results indicate that Sr, Nd, and Sm isotope ratios of all samples are consistent with the published data with a precision of 11–25 ppm (2 RSD). These methods are suitable for geochemistry studies for single-grain minerals and precious samples.

Keyword

high-precision measurement method, Sr, Nd, Sm, isotopic ratios

ASSESSMENT OF GOLD PROSPECTS AT EXPLORATION OBJECTS IN UZBEKISTAN

Vladimir Denevich TSOY[1]*, Institute of Mineral Resources (vtsoi@inbox.ru)
Sardor Savriddinovich Sayitov[2], Geologist

Abstract

In the process of geological exploration, it is important to promptly determine the prospects of deep horizons of objects and flanks. For this purpose, documentation of mine workings and well cores, testing with reference to sampling depths, spectral semi-quantitative and atomic absorption analyzes for gold and silver are carried out. Based on the results of the analyses, clarke concentrations for oreogenic elements are calculated, geochemical series are compiled for selected depth intervals, and the prospects of deep horizons are determined by comparing them with the stages of hypogene mineral formation. The results obtained are confirmed by mineralogical studies and the presence of typomorphic mineralization.

This technique was used at the Dzhasaul site, located in the Beltau mountains. Ore-bearing zones are confined to places of intense crushing and crumpling in the deposits of the Rokhat (O1-2rh) and Murun (upper subformation - O3) formations, located under the Mesozoic-Cenozoic cover with a thickness of 55-70 meters. The gold content in them is from 1.1 to 22.5 g/t, silver from 0.9 to 1225.0 g/t.

As a result of the study of ores, mineralized and ore-hosting rocks of the Dzhasaul site, selected from wells, depth gradations were identified.

1) 27-80 m (40 samples);
2) 80-130 m (78 samples);
3) 130-180 m (27 samples);
4) 180-230 m (24 samples);
5) 230-280 m (29 samples);
6) >280 m (6 samples).

The site has a very large thickness of Mesozoic-Cenozoic sediments. The Paleozoic basement begins in different wells at different depths. The closest bedrock exposure to the surface in the studied wells was 27 m.

Based on the results of spectral analysis for each depth gradation (sample), the average contents of ore elements were calculated. The obtained average contents of elements are normalized to their clarke abundances in the Earth's crust (according to Vinogradov, 1961). Geochemical series were compiled in descending order of clarke concentration (CC) values for each depth gradation.

An analysis of the abundance of elements by depth gradations and a comparison with a summary scheme of hypogene mineral formation in Uzbekistan was carried out.

In general, at the Dzhasaul site, ore-forming elements of the geochemical series are located in accordance with the stages of hypogene mineral formation, in places complicated by the manifestation of telescoping. The object is perspective at depth.

Keyword

mineralogy, gold, prospective assessment, geochemistry, clarke concentration

APOCARBONATE TYPE OF GOLD MINERALIZATION IN UZBEKISTAN, CONDITIONS OF FORMATION AND PREVALENCE

Bobir Farxadovich ISLAMOV[1]*, Ministry of Mining Industry and Geology of the Republic of Uzbekistan (idilniez@gmail.com)
Vladimir Denevich Tsoy[2], Institute of Mineral Resources
Shamsiddin Paxritdinovich Alimov[3], Uzbek geological exploration

Abstract

Currently, gold in carbonate rocks is known in the deposits of Uzbekistan: Rabinjan, Sintab, Bulutkan, Barkhanny, Northern Taushan, Akba, Akata, Shirotny, Almalyk ore district, etc. In Karamazar, gold-silver objects associated with silicified carbonate rocks located in in the form of lenses, fragments, tectonic packages, plates, blocks among volcanic rocks (Nadak, Charbi, Shkolnoye, Kyzyl-cheku, Aprelevka, Tulusai, Uchkyz, Chadak, etc.).

In the Central Kyzylkum Mountains, the main gold ore objects are located in formations containing carbonate rocks or silicification products of carbonate rocks (chert, quartzite, jasperoids). Thus, the Muruntau and Daugyztau deposits are located in the Kosmanachi formation, the former third Besapan subformation, Auminzatau in the Taskazgan formation and Kokpatas in the Kokpatas formation. At the deposits of Muruntau (in the M mine, quarry), Daugyztau (in the quarry), Bulutkan, Barkhanny, Sautbay, Turbay (in mine workings) silicified carbonate layers, lenses in terrigenous formations, which are often drawn as layered quartz veins, are installed (especially in Muruntau and Daugyztau). There are carbonate layers and lenses in the stratigraphic columns of the Kosmanachi strata, Tasqazgan and Kokpatas formations. In deposits where intensive hydrothermal development takes place, these carbonate layers and lenses are transformed into chert, quartzite, and jasperoids under the influence of essentially silicate solutions.

The presence of carbonate rocks in the Muruntau and Daugyztau ore zones is confirmed by the results of silicate analysis, recalculated to the mineral composition. Carbonates (dolomite, calcite, ankerite) occupy the third or fourth place in abundance after quartz, feldspar and hydromicas.

Layered quartz present in the Muruntau and Daugyztau deposits are apocarbonate formations. The gold content of the latter depends on the degree of silicification. Intensely silicified dolomites and limestones, as a rule, bear gold mineralization. Less silicified carbonate rocks, when their original composition is discernible, contain from zero to tenths of g/t gold. In addition to gold, these rocks contain scheelite, pyrite, arsenopyrite, stibnite and other minerals. At the Daugyztau deposit, carbonate layers, lenses transformed into silicified formations and jasperoids with gold and stibnite mineralization were identified. X-ray diffraction phase analysis revealed mainly the following vein minerals in the composition of apocarbonate formations: quartz, dolomite, sericite.

In the Kokpatas ore field in the early works of E.A. Markova, V.A. Horvat, S.Ya. Klempert, A.M. Gavrilov mention the presence of gold mineralization in carbonate rocks, in particular in the Dzhuskuduk formation. In the Kokpatas Formation, gold and tungsten mineralization is associated

with silicified carbonate layers and lenses among terrigenous rocks.

The presence of carbonate rocks in terrigenous formations is a necessary condition for the localization of gold mineralization, but not sufficient. In order for gold mineralization to form, an ore supply channel is needed, through which hydrothermal essentially aluminosilicate ore-bearing solutions penetrated into the carbonate-terrigenous rock. As a result of the interaction of the solution and the host rock, silicification of carbonate rocks occurs to a quartzite state, and at the same time, under conditions of neutralization of acidic solutions, gold precipitation occurs.

Keyword

apocarbonate formations, gold, condition of formation, prevalence, Uzbekistan

Crystal Structure of Canfieldite

Guanghua Liu[1]*, Jiangxi University of Applied Science and Technology (gstone1698@gmail.com)
Xiangping Gu[2], Guanghua Institute of Gemology and Mineral Resources(GIGM), Jiangxi University of Applied Science and Technology, Nanchang, China
Jiayu Wang[3], Guanghua Institute of Gemology and Mineral Resources(GIGM), Jiangxi University of Applied Science and Technology, Nanchang, China
Zhongliang Cui[4], Guanghua Institute of Gemology and Mineral Resources(GIGM), Jiangxi University of Applied Science and Technology, Nanchang, China

Abstract

Crystal Structure of Canfieldite

Xiangping Gu1,2, Jiayu Wang1, Zhongliang Cui1, Guanghua Liu1*

1 Guanghua Institute of Gemology and Mineral Resources(GIGM), Jiangxi University of Applied Science and Technology, Nanchang, China
2 School of Earth Sciences and Information Physics, Central South University, Changsha, China
* Correspondence: gstone1698@gmail.com

Abstract
Canfieldite is a mineral species recognized and described in 1893 by Samuel Lewis Penfield in honor of Frederick Alexander Canfield of Dover, New Jersey, USA. However, its crystal structure has not been yet precisely determined. This study employs X-ray single-crystal diffraction to determine the crystal structure of canfieldite from the Yukarang lead-silver mine in Tibet, China. The crystal structure of canfieldite is identified as an idealized Ag8SnS6, belonging to the orthorhombic crystal system with space group Pna21, a=15.3084(2) Å, b=7.5521(1) Å, c=10.7072(1) Å, V=1237.86(3) Å3Z =4. Refined indices for a total of 14,811 reflections (2,088 independent reflections) resulted in R1=0.0398and wR2 = 0.1023. The crystal structure exhibits a topology similar to artificially synthesized Ag8GeS6, with isolated SnS4 tetrahedra (average Sn-Sn bond length of 2.379 Å) arranged in a nearly equidistant manner (approximately 7.55 Å) in a three-dimensional framework. Two sulfur atoms (S5, S6) outside the SnS4 tetrahedra orderly occupy the spaces of an octahedron and a tetrahedron formed by six and four SnS4 tetrahedra, respectively, with average distances of S5-Sn and S6-Sn being 5.391 Å and 4.654 Å, respectively. Eight crystallographic sites within the SnS4 tetrahedra and spaces formed by S5 and S6 accommodate Ag atoms (S-Ag distances range from 2.16 to 2.67 Å) which exhibit instances of splitting with Ag-Ag distances ranging from 0.26 to 1.46 Å in multiple positions.

Keyword

canfieldite, crystal structure, positional splitting, sulfide, Yukarang lead-silver mine

Minerals in Thin Section (MINTS) – An open-access interactive website for transmitted-light petrographic microscopy

Juergen REINHARDT[1]*, Department of Earth Sciences, University of the Western Cape, Bellville, 7535, South Africa (jreinhardt257@gmail.com)
Michael M. Raith[2], Institut für Geowissenschaften, Universität Bonn, 53115 Bonn, Germany
Tanja Reinhardt[3], Science and Technology Education Centre, University of KwaZulu-Natal, Durban, 4041, South Africa

Abstract

Polarized-light microscopy remains an indispensable, low-cost tool for the mineralogical analysis of geological samples, and in many instances presents the critical step before taking mineral and rock analysis to the next level such as electron microbe, XRF, ICP-MS analysis. Petrographic microscopy not only reveals the precise mineralogical composition of rocks, but also critical information on textural relationships between its minerals, including crystallization features, reaction textures, and deformation structures. The rise of online teaching and learning resources has seen various websites being developed that use colour photomicrographs, either arranged systematically or by putting emphasis on petrographic analysis of specific rock types. In some instances, the websites focus on historical collections of rock samples.

The open-access MINTS website combines all the advantages of the web-based approach, in particular large storage space and easy accessibility, with the flexibility to modify the database at any time, to upgrade, add and delete as desired. While the previously published online book 'Guide to Thin Section Microscopy' by Raith, Raase & Reinhardt (2012) focuses on the methodical-practical approach to thin section microscopy, the new website is essentially a systematic optical-mineralogical database, sorted by minerals and mineral groups, in combination with thin sections image series.

MINTS involves the following elements:
• A mineral index (A-Z) with links to data pages and thin section image sets;
• A graphical presentation of crystallographic-morphological properties combined with optical indicatrix geometry;
• A graphical overview of refractive index range in combination with a crystal-plate thickness versus birefringence plot using a modified interference colour chart (Sørensen, 2013);
• A condensed, but sufficiently comprehensive listing of optical and morphological mineral properties;
• An extensive archive of photomicrographs involving multiple image sets for each mineral species. These image sets include plane-polarized-light and crossed-polarizers modes showing critical grain sections and orientations as well as lambda-plate overlays.

The website in its present stage comprises close to 140 minerals and mineral groups. The nature of

the project is such that it is never a “closed book” as long as we continue to extend the mineral and data coverage and the photographic documentation. The website is presently hosted by the University of the Western Cape: https://mints/uwc.ac.za/mints.home.php

Keyword

Optical mineralogy, thin-section microscopy, petrography

Semi-quantitative analysis of minerals in manganese nodule from the Magellan seamount cluster in Western Pacific Ocean

Jeongmin KONG[1]*, Pusan National University (wjdals3659@pusan.ac.kr)
Soojin LEE[2], Pusan National University
Hyunseung LEE[3], Pusan National University
Yongmoon LEE[4], Pusan National University

Abstract

Manganese nodules formed in the deep sea are composed of minerals bound to various metals in iron-manganese oxides containing elements such as Co, Ni, Cu, Li, Mo, Zr, and rare earth metals regarding as valuable future resources. The Magellan Seamounts, the study area, is a collection of undersea mountains in the high seas of the Western Pacific where a large amount of manganese nodules are distributed. The purpose of this study is to understand the relationship between the enrichment of metal resources within manganese nodules and the distribution of minerals. As a first step, we aim to understand the qualitative and quantitative distribution of minerals forming nodules within the Magellan Seamounts.

Manganese nodules collected from the tabletop of the Magellan Seamounts (KC-8, KC-2, OSM-XX) in the western Pacific were provided by the KIOST(Korea Institute of Ocean Science and Technology). In order to understand in detail the qualitative and quantitative differences in the minerals of manganese nodules according to the seamounts, samples were segmented into 3 to 5 areas from the center to the rim of the nodules. Each sample was subjected to phase identification analysis through X-ray diffraction measurement and semi-quantitative analysis was performed on manganese minerals through peak area calculation. In all three seamounts, Vernadite ((Mn4+,Fe3+,Ca,Na)(O,OH)2·nH2O) was dominantly distributed at over 95%, and Todorokite ((Na,Ca,K,Ba,Sr)1-x(Mn,Mg,Al)6O12·3-4H2O) and Buserite (Na4Mn14O27·21H2O) were confirmed to be less than 5%.

Keyword

Manganese nodules, Western Pacific Ocean, X-ray diffraction, semi-quantitative

Relationship between distributions of the extra-framework species and adsorption capacity for CO2 gas on synthetic mordenite.

Soojin LEE[1]*, Pusan National University (mark85@pusan.ac.kr)
Yongmoon LEE[2], Pusan National University
Hyunseung LEE[3], Pusan National University
Donghoon SEOUNG[4], Chonnam National University
Huijeong HWANG[5], Gwangju Institute of Science and Technology
Hyeonsu KIM[6], Chonnam National University
Pyosang KIM[7], Chonnam National University

Abstract

Synthetic mordenite, one of the siliceous zeolites, is widely used as a molecular sieve, adsorbent, and catalyst. To improve these performances, it is essential to understand the ion-exchange properties and cation exchange sites of the zeolite. In this study, we observed the structural changes in fully Cs-, Sr-, Cd-, and Pb-exchanged mordenite using synchrotron X-ray powder diffraction under ambient conditions. Structure analysis by the Rietveld method revealed that Cs+ ions are mainly located near the 8MRb due to their low electronegativity and hydration energy. However, Na+ ions are found at the center of the 8MRc and in the 12MRc because they are less affected by these effects. On the other hand, divalent cations such as Sr2+ and Cd2+ ions, with higher hydration energies than that of monovalent cations, are present as hydrated ions at the center of the 12MRc. In the case of Pb2+ ions, with higher electronegativity than framework atoms (Si and Al), exhibit a strong affinity for the electron cloud of framework oxygen atoms, thus positioning close to the wall of the 12MRc. Thermogravimetric analysis showed that, except for Pb-MOR, divalent cation exchanges generally contain more water molecules per unit cell than monovalent cation exchanges, by their higher hydration energies. The differences in the positions of the extra-framework cations were considered due to the electrostatic and hydration effects. The CO2 gas adsorption capacities were compared based on the type and site of exchangeable cations. The results indicate that an increase in CO2 capacity was correlated with the number of cations capable of effectively interacting with CO2.

Keyword

Zeolite, Ion-exchange method, Hazardous elements, Electronegativity, Hydration energy

Infrared behavior of phlogopite from some magnesian skarns in the Banatitic Magmatic and Metallogenetic Belt from Romania

Cristina SAVA GHINET[1]*, Geological Institute of Romania (ghinet.cristina@yahoo.com)
Stefan Marincea[2], Geological Institute of Romania
Delia Georgeta Dumitras[3], Geological Institute of Romania
Aurora Maruta Iancu[4], Geological Institute of Romania

Abstract

The occurrences of phlogopite from the thermo-metamorphic areas of the Banatitic Magmatic and Metallogenetic Belt (Romania) are ascribed to Upper Cretaceous magnesian skarns (Ocna de Fier, Cacova Ierii, Maşca Băişoara, Băiţa Bihor, Pietroasa and Budureasa). The common mineral association includes, besides phlogopite, spinel, forsterite, humite-group minerals (generally clinohumite and chondrodite, but also norbergite), and diopside. They are locally overlapped by magnesian retromorphic zones of pseudoskarn type, composed of serpentine, brucite, calcite, dolomite, clinochlore, and pyroaurite.

The infrared absorption spectra on representative phlogopite samples were recorded in the frequency range between 250 and 4000 cm-1, using both FT-IR and IR devices. The main absorption bands could be ascribed to the following spectral domains: (1) 3800 – 2500 cm-1, which hosts the fundamental stretching modes of the OH groups in the structure. The study of this region can be quite difficult in the case of the strongly hydrated samples or in the case of strongly hydrated phlogopite – serpentine mixtures (e.g., in samples from Ocna de Fier). Depending on the chemical composition, the frequencies of the OH group in the structural Mg3OH units occur in the spectral range between 3692 and 3716 cm-1. The presence of the trivalent cations (Fe3+, Al3+) in one of the three octahedral positions around the hydroxyl group leads to the splitting of the OH stretching band visible in some samples (Pietroasa, Budureasa, and Ocna de Fier). The 3620 cm-1 band can be associated with Mg2+Al3+ coordinating pair, the band at ~3600 cm-1 with Fe2+Al3+ coordinating pair, while 3550 cm-1 with the Fe2+Fe3+ coordinating pair, in good agreement with the chemical composition determined by EMPA; (2) the 1800 – 1400 cm-1 spectral range hosts the bendings of H-OH bonds within the H2O-absorbed molecules in KBr or in the intra-layer water. It is almost impossible to have an unequivocal assignment of the water nature. (3) 1200 – 700 cm-1 characterizes the internal vibrations of the Si(Al, Fe3+)O4 tetrahedrons in the phlogopite structure. A first broad band with an apex at 985 – 1010 cm-1 is due Si-O-Si vibrations of Si2O5 groups. The intensity of the band around the value of 770 cm-1 is clearly visible in the samples with a high content of annite and can ascribed to vibrations of both (Al, Fe3+)-O-Si and Fe3+-O-AlIV type. The splitting or shift to lower frequencies of the bands from 820 to 730 cm-1 is remarkable in the case of samples with higher content of tetrahedral Fe3+, in which Fe3+-Si stretching bands shift to lower frequencies; (4) 700 – 250 cm-1 is the spectral region given by metal – O stretching bands composed with bands materializing O-H vibrations, difficult to be assigned. These bands are visible in the 590 – 615 cm-1 spectral range. Even if the Ca-O

vibrations are expected to materialize through bands located at higher frequencies, they are kept in the far infrared domain, below 250 cm-1.

Keyword

phlogopite, infrared behavior, magnesian skarns, Banatitic Magmatic and Metallogenetic Belt, Romania

Structure vs. FTIR and Raman behavior of spodumene from Conţu (Lotru Mountains, South Carpathians, Romania)

Stefan MARINCEA[1]*, Geological Institute of Romania (smarincea@yahoo.com)
Delia Georgeta Dumitras[2], Geological Institute of Romania
Cristina Sava Ghinet[3], Geological Institute of Romania
George Dinca[4], Geological Institute of Romania
Fabrice Dal Bo[5], Laboratoire de Minéralogie, Université de Liège
Frédéric Hatert[6], Laboratoire de Minéralogie, Université de Liège

Abstract

Spodumene, known for its important role as Li source, occurs as the main mineral species in the pegmatite bodies from Conţu (Lotru Mountains, Romania), of albite-spodumene type. The occurrence is located on the homonym valley, at N 45°33'39" – E 23°52'19". The main associated minerals are albite, microcline, quartz, and muscovite, with an important number of accessories (e.g., beryl, purpurite - heterosite, amblygonite - montebrasite, fluorapatite, triphylite - lithiophylite, maricite, gatehouseite, monazite, schorl, spessartine, cassiterite, columbite - tantalite, uraninite). The average chemical composition, obtained based on 21 electron-microprobe point analyses, with Li deduced for stoichiometry, is (in wt.% oxides): SiO2 = 64.47, Al2O3 = 28.00, Fe2O3 = 0.59, Li2O = 8.05, Total =101.11. The chemical-structural formula, calculated based on 6 oxygen atoms p.f.u., is: Li0.995(Al0.995Fe3+0.013)(Si1.981Al0.019)O6. The mineral can be satisfactorily refined as monoclinic, space group C2/c (with R = 0.0244), and have as cell parameters: a = 9.4670(4) Å, b = 8.3967(3) Å, c = 5.2198(3) Å, β = 110.15(4)°. As expected, the SiO4 tetrahedron is far to describe a punctual Td symmetry. The Si-O distances obtained by refinement are Si-O1 = 1.640(1) Å, Si-O2 = 1.586(1) Å, Si-O3 = 1.621(1) Å, Si-O4 = 1.629(1) Å. All the bands that can be assigned to Si-O-Si vibrations in the FTIR spectrum seems triple degenerate (antisymmetric stretchings at 1163, 1085, 1072 cm-1, symmetric stretchings at 919, 860 and 797 cm-1, in-plane bendings at 695, 641 and 593 cm-1) corresponding to the three dispersed Si-O values given before, whereas O-Si-O are simple degenerate, reflecting the presence of a sole tetrahedron in the chain repeat unit (antisymmetric stretching at 919 cm-1, symmetric stretching at 779 cm-1, in-plane bending at 518 cm-1, out-of-plane bending at 450 cm-1). In the Raman spectrum the trend remains the same: the Si-O-Si antisymmetric stretching bands were recorded at 1092, 1050 and 1017 cm-1, the symmetric stretching at 841, 793 and 706 cm-1 whereas the in-plane bending is materialized by bands at 596 and 523 cm-1, and the out-of-plane bending by a band at ~481 cm-1. The out-of-plane O-Si-O bending was recorded at 446 cm-1. Bands expressing lattice vibrations (principally Al-O and Li-O) were recorded at 396, 357, 299, 249, 114 and 78 cm-1.

Keyword

structure, FTIR, Raman behavior, spodumene, Conţu, Romania

TOURMALINE AS AN INDICATOR MINERAL FOR BASE METAL AND ASSOCIATED MINERALIZATION IN SUPRACRUSTAL ROCKS OF NORTH SINGHBHUM MOBILE BELT

MANSI JAIN[1]*, GEOLOGICAL SURVEY OF INDIA (mansi.jain@gsi.gov.in)
MANSI JAIN[2], GEOLOGICAL SURVEY OF INDIA

Abstract

The emplacement of quartz tourmaline veins along the contact of Chhotanagpur Gneissic Complex and Singhbhum Supracrustal Rocks of North Singhbhum Mobile Belt and in the proximity of South Purulia Shear Zone holds importance from base metal mineralization point of view. They are mainly exposed along the regional foliation in and around Mudidih-Kashidih-Magatdih-Laka area, Purulia District, West Bengal. These quartz veins are milky white and contain profuse amount of black tourmaline crystals with no preferred orientation. Since tourmaline is a chemically stable mineral over large temperature and pressure range, it can be used as a geological indicator because it is highly resistant to modification even during high-grade metamorphism and alteration. Emphasis has been given on geological setting of quartz tourmaline veins, petrography of tourmalines and its mineral chemistry to understand its role in mineralization. Occurrence of quartz tourmaline veins at the regional scale along the shear zone indicates high temperature hydrothermal activity involving boron enrichment. These boron bearing magmatic hydrothermal fluids must have circulated through the entire shear corridor which possibly serves as a structurally favorable domain and suitable conduit for the mineralization. Microscopically, tourmaline is coarse grained and occurs in both elongated and equant variety. Both varieties of tourmaline are zoned; from core to rim the color varies from blue-green to light brown. It is intensely pleochroic and fractured. Quartz grains are present as inclusion within the tourmaline grains. The tourmaline of the present area belongs to the Alkali group. The majority of tourmalines are categorized as dravitic sub-group and only a few are schorlitic. The findings of the present study was correlated with a recent well-known study in the Jervois mineral field and Bonya Hills, Aileron Province by MV McGloin, A Weisheit, RB Trumbull and R Maas, 2019 which stated a close spatial association between epigenetic tourmaline-bearing rocks, felsic igneous rocks and tungsten-copper mineralization, suggesting a genetic link. In their case study, tourmaline in pegmatites and quartz veins is associated with epigenetic tungsten and copper mineralization in the Bonya Hills area. It was noted in the study that analyzed tourmaline has schorl–dravite composition regardless of the associated mineralization, which is similar to the findings of the present study. Moreover, the chemical analytical data of the present study area reveals significant values of copper: 1083 ppm & 1099 ppm; lead: 1001 ppm and REE: 1177 ppm, 1391 ppm & highly anomalous value of 20,930 ppm. These values have been obtained from cherty quartzite and tuffaceous rocks, exposed in the vicinity of quartz tourmaline veins. Thus tourmaline mineral chemistry of the present study area attests to the favourability of basemetal mineralization in the terrain.

Keyword

Tourmaline, Base Metal Mineralization, Supracrustal Rocks, North Singhbhum Mobile Belt, Singhbhum

Structure vs. FT-IR and Raman behavior of wollastonite-2M ("parawollastonite") from Cerboaia Valley, Măgureaua Vaţei (Metaliferi Massif, Apuseni Mountains, Romania)

Delia Georgeta DUMITRAS[1]*, Geological Institute of Romania (d_deliaro@yahoo.com)
Stefan MARINCEA[2], Geological Institute of Romania
Cristina SAVA GHINET[3], Geological Institute of Romania
Aurora Maruta IANCU[4], Geological Institute of Romania
Fabrice DAL BO[5], Geological Institute of Romania
Frédéric HATERT[6], Geological Institute of Romania

Abstract

The gehlenite-bearing, high-temperature skarn from Măgureaua Vaţei occur at the contact of a shallow-level pluton of Upper Cretaceous age, with monzodiorite to quartz-monzodiorite differentiates, with Tithonic - Kimmeridgian reef limestones. The preserved peak metamorphic assemblage includes gehlenite, wollastonite-2M, monticellite, Ti-poor calcic garnet, perovskite, and Ca-Tschermak diopside. Wollastonite-2M is the main component of the outer skarn zone. The mineral occurs as almost monomineralic aggregates of long-prismatic or acicular crystals of 1 to 10 cm in length. A cathodoluminescence zoning of some individual crystals could be observed, but no solid evidence of correlation with the chemical zoning of the mineral was found. Wollastonite from Măgureaua Vaţei exhibit only relatively small deviations from the ideal composition: the substitutions for Ca in the six-fold coordinated sites are minor, with Mn < 0.004 apfu, Fe2+ < 0.107 apfu (generally much lower) and Mg < 0.043 apfu (on the basis of 18 oxygen atoms). The average composition, based on 102 EMP point analyzes is: (K0.002Na0.004Ca5.959Mn0.004Mg0.026Fe2+0.018)(Si5.984Ti0.003Al0.011)O18. The mineral can be satisfactorily refined as monoclinic, space group P21/c (with R = 0.0387), and have as cell parameters: a = 7.0684(3) Å, b = 7.3228(3) Å, c = 15.4206(7) Å, β = 95.34°. All the bands that can be assigned to (SiO4)4- vibrations in the FTIR spectrum are triple degenerate, reflecting the number of three tetrahedrons in the chain repeat unit. Bands assumable to Si-O-Si antisymmetric stretching were recorded at 1085, 1060, and 1018 cm-1, and to the Si-O-Si symmetric stretching at 681, 645 and 565 cm-1. Three other bands recorded at 967, 926 and 902 cm-1 are apparently due to O-Si-O antisymmetric and symmetric stretching, whereas bands at lower frequencies (509, 472 and 453 cm-1) express Si-O-Si bending vibrations and the latter could be reasonably assigned to Ca-O lattice vibrations. The intensities of the bands expressing the stretching vibrations of wollastonite-2M from Măgureaua Vaţei are higher than those of the homologue bands recorded from wollastonite-3T from Băiţa Bihor (Bihor Mountains, Romania), which express a superior structural ordering. In the Raman spectrum, the Si-O-Si antisymmetric stretching seems double degenerate (bands at 1057 and 1042 cm-1) as well as the symmetric stretching (688 and 637 cm-1). The Si-O-Si bending was recorded at 585 cm-1, whereas the bands at frequencies below 450 cm-1 are certainly due to lattice (Ca-O) vibrations.

Keyword

structure, wollastonite-2M, FT-IR, RAMAN, Măgureaua Vaţei

Mineralogical variations of shallow manganese nodules in the East Siberian Sea with respect to water depth

Hyo-Jin KOO[1]*, Future Earth Research Institute, Pusan National University, Korea (ghj6011@nate.com)
Hyen-Goo Cho[2], Department of Geology , Gyeongsnag National University, Korea
Hyo-Im Kim[3], Department of Geology , Gyeongsnag National University, Korea
Sangmi Lee[4], Department of Geology , Gyeongsnag National University, Korea
Hanjin Choe[5], Department of Geological Sciences, Pusan National University, Korea

Abstract

The formation mechanism of Mn nodules is broadly categorized into hydrogenesis and diagenesis, and this difference can be controlled by the redox conditions of the formation environment. Mineralogical investigation of Mn nodules can serve as a valuable tool for acquiring geological insights into their formation. The structures of Mn oxide minerals can be classified into two main types: layer structure (phyllomanganate) and tunnel structure (tectomanganate). Reprensentatve tectomangante mineral include todorokite, and phyllomanganate minerals include birnessite, buserite, and vernadite. In general, hydrogenetic nodules form through the precipitation of metals from seawater or freshwater with a relatively high redox potential. These predominantly comprise layered vernadite characterized by high Fe content and Fe-hydroxide with very low crystallinity such as δ-FeOOH (i.e., feroxyhyte). Conversely, diagenetic nodules arise from the precipitation of metals from pore water within the sediment, and they can be categorized based on their formation within oxic or suboxic diagenesis, determined by the fluctuation of the oxic/suboxic redox front in the sediment. Suboxic diagenetic nodules have abundant of phyllomanganate minerals, while oxic diagnetic nodules are commonly characterized by todorokite. On the other hands, Mn nodules can be classified into deep-sea Mn nodules and shallow-water Mn nodules based on the water depth of the sea area where they are distributed. Shallow-water Mn nodules are generally understood to originate from diagenetic processes, although their specific mineral composition remains unclear at present. In this study, we present the findings of a mineralogical analysis conducted on Mn nodules collected from the shelf-slope region of the East Siberian Sea as part of the Arctic expeditions carried out with the R/V Araon. The Mn nodules in the East Siberian Sea are distributed across the continental shelf and slope, spanning water depths ranging from 73 to 240 m. Previous investigations have noted substantial variations in the morphological characteristics of these nodules corresponding to different water depths. These morphological differences, linked to water depth, suggest potential changes in the nodule formation environment. This phenomenon can be further validated by examining the mineralogical features constituting the manganese nodules. Consequently, the mineralogical study of Mn nodules in the East Siberian Sea could serves as a robust platform for elucidating the mineral composition of shallow-sea manganese nodules and comprehending the distinctions in the formation of Mn oxide minerals based on varying water depths.

Keyword

Manganese nodule, Shallow-water, East Siberian Sea, Mineralogy, Manganate

Occurrence of Perovskite-magnetite hosted REE mineralization in Jashora Ultramafic Alkaline Complex, West Karbi Hills, Assam, India.

TAPAN PATOWARY[1]*, Geological Survey of India (tapan.patowary@gsi.gov.in)
Hrushikesh H[2], Geological Survey of India
Nikunja Bihari Singha[3], Geological Survey of India

Abstract

The Jashora ultramafic alkaline complex (JUAC) of Cretaceous Period located in the northern fringe of the West Karbi Hills occurs as intrusive into the metasedimentary sequence of Shillong Group and the Pan-African granitoids. It is an elliptical shaped body spreading over an area of about 3.2 sq. km. The intrusive complex comprises wide variety of rocks identified as pyroxenite, perovskite-magnetite, olivine gabbro, nepheline syenite, phonolite, ijolite and fenite. Petrographic studies and modal analysis of perovskite-magnetite reveal that the rock is constituted by 65-70% of magnetite and 35-30% of perovskite. Perovskite occurs as euhedral to subhedral phases. It appears pale brown granules set in a matrix of magnetite occurring as opaque and fills the interstitial spaces of the rock. EPMA and SEM-EDX analyses of perovskite-magnetite show that the rock is composed of magnetite and perovskite with accessory phases like monazite, ilmenite and pyrochlore. Systematic surface and subsurface sampling have been conducted in the rocks and regolith developed over rocks of JUAC to assess REE potentiality. It has been observed that the mineralization in the complex is attributed to the perovskite-magnetite rock which occurs as rich fragments within the regolith developed over the pyroxenite (0.3-1.3 m) and as lenses or discrete layers (0.1-0.3 m) within pyroxenite. Studies of 650 nos. of drill core samples of perovskite-magnetite bearing pyroxenite have indicated dissemination of perovskite-magnetite within pyroxenite upto the depth of 130 m and yielded ∑REE value up to 12278 ppm (ave. ∑REE 2038 ppm). The regolith rich in fragments of perovskite-magnetite has yielded ∑REE values 4348-20142 ppm and (ave. ∑REE 9190 ppm), Nb values 975-3132 ppm (ave. 1404 ppm) and Vanadium 1377-2466 ppm (ave.1772 ppm). Mineralized zone chemistry suggests Fe2O3, TiO2 and CaO together constitute 96% of total bulk composition corroborating the unique mineralogy magnetite + perovskite. The correlation bivariant diagrams suggest anomalous REE concentration is contributed by perovskite or the Ti rich exsolution phases in the magnetite which is also contributing Ti, Nb and V.

Keyword

Jashora ultramafic alkaline complex, West Karbi hills, Perovskite-magnetite, REE

Mineral chemistry and trace element variations in index minerals around pyrophyllite deposit in the Mailar village, Lalitpur district, Uttar Pradesh.

MADHUMITA BANERJEE[1]*, Geological Survey of India (madhumita.banerjee@gsi.gov.in)
Surabhi Srivastava[2], Geological Survey of India
Siladitya Sengupta[3], Geological Survey of India

Abstract

Detailed mineral chemistry of the alteration minerals have provided valuable inputs to establish the porphyry related hydrothermal character of the altered granitoids associated with the pyrophyllite deposit in the Mailar village, Lalitpur district, Uttar Pradesh situated in the southern part of Bundelkhand Craton. Variation in the alteration mineralogy and trace element composition in index minerals from different hydrothermal alteration zones- argillic, phyllic, potassic and propylitic have been studied in the present work. The chlorite chemistry from the potassic alteration zone shows that the formation of chlorite was started towards the end of potassic alteration stage and continued progressively in the course of propylitic alteration. The composition of the chlorite within the potassic zone is characterized by relatively higher Fe/(Fe + Mg) ratios (0.57 to 0.66) and AlIV content (2.2 to 2.4) than the other alteration zones. The chlorites from phyllic and potassic alteration zone fall in ripidolite, brunsvigite field, whereas chlorites from argillic, propylitic alteration zone fall in pychnochlorite and diabanite field. Empirical chlorite thermometer after Jowett, E. C, 1991 shows the total temperature ranges from 250°C to 334°C. The highest temperature (298°C- 334°C) is associated with potassic and phyllic alteration zone whereas lower temperature (250°C -298°C) is confined to the argillic and propylitic alteration zone.

Magnetite trace element chemistry carried out from the selective magnetite grains separated from samples collected systematically across the pyrophyllite deposit using LA-ICPMS technique shows elevated values of Ti, V, Co, Ni, Cu, in magnetites from pyrophyllite and associated sericitic alteration zone. The magnetites from the altered granitoids have Ti content, less than 0.1 wt% which correspond to hydrothermal origin of the magnetites. The discrimination diagrams using V, Ti, Fe relationships show that the magnetites plot in the hydrothermal field and the overlapping area between igneous and hydrothermal field. Potassic zone magnetites show high Zn and Ga concentration indicating high temperature hydrothermal character. Sn vrs. Ga discrimination diagram, after Nadoll et al., 2014 shows the magnetite grains plot broadly between the hydrothermal and porphyry related magnetite field. Overall chemistry of major and trace elements, mineral chemistry of alteration minerals, point towards a porphyry type hydrothermal regime experienced by the granitoids of the Mailar area.

Keyword

pyrophyllite, hydrothermal alteration zone, trace element, chlorite, magnetite

A Comparison Study of Quantitative analysis and Morphology of Microlites in the Obsidians Using Electron Probe Micro Analysis

JIN MI-EUN[1]*, HANARO Utilization Division, Korea Atomic Energy Research Institute (jin4860228@gmail.com)
Jwa Yong-Joo[2], Department of Geology, Gyeongsang National University
Sun Gwang-Min[3], HANARO Utilization Division, Korea Atomic Energy Research Institute
Hwang Ga-hyun[4], National Research Institute of Cultural Heritage

Abstract

Obsidian is one of glassy volcanic rocks formed by the rapid cooling of silica-rich rhyolite or decite magma. Within the obsidian, there are numerous microlites, which are crystals usually having a size of about 1 μm. These microlites could be distinguished based on their morphology and composition depending on the composition of magma and tectonic setting. We conducted investigated morphological characteristics and chemical compositions of the microlites included in the obsidians from the Baekdusan in North Korean side and in the obsidians from the Kyushu and Hokkaido in Japan. The morphology of the microlites from the Baekdusan obsidians can be divided into three groups among which trichite-acicular and trichite-asteroidal types are predominant. On the other hand the microlites from the Kyushu and Hokkaido Obsidians show various morphological features such as acicular, margarite, lath, and asteroidal types. Silicate microlites from the Baekdusan obsidians are mostly of Ca-pyroxene compositions (hedenbergite to augite), whereas those from the Kyushu obsidians are mostly of biotite (annite) with small amount of clinopyroxene (ferrosilite). It is well understood that the microlites from the Baekdusan obsidians are different from those from the Kyushu obsidians in terms of the morphology, mineral content and mineral composition. Therefore, results of this study would be a useful discriminator to divide the obsidian provenances.

Keyword

Obsidian, Microlite, Baekdusan

Mineralogical studies of iron ore deposits of Sonhari member of Eocene age, Laki Formation, Sindh, Pakistan

Muhammad Hassan Hassan AGHEEM[1]*, University of Sindh, Jamshoro
(mhagheem@usindh.edu.pk)
Ghulam Mustafa Thebo[2], University of SIndh, Jamshoro
Akhtar Hussain Markhand[3], University of SIndh, Jamshoro
Aijaz Ali Halipoto[4], University of SIndh, Jamshoro

Abstract

Like a few other countries, Pakistan is also bestowed with a variety of mineral commodities including all types of industrial minerals including various ore minerals and a variety of gemstones. Some of these have been discovered before the partition while majority of minerals is also discovered after 1947. Pakistan is not only famous because of diversity of mineral resources but currently is one of the best example of continent to continent collision. Because of this collision, uplifting of Himalayas and finally the rapid denudation; a variety of mineral commodities of secondary origin has been formed in different regions of the country. Along with other mineral resources, Pakistan is also rich in iron deposits. These iron ore deposits are of diverse origin starting from igneous magnetites to sedimentary hematite types. Like, other provinces of Pakistan, the Sindh province is also bestowed with both metallic and non-metallic industrial minerals along with great potential of oil and gas production.

In this regard, a research work was carried out on iron ore deposits and associated clay beds in two sections of Sonhari member of Early Eocene Laki Formation in district Thatta, Sindh, Pakistan where some iron deposits are reported. The major objective of this study was to properly characterize the iron-bearing and other associated minerals and to establish the possible genetic relationship, if any. During the field work, it was noted that the iron ores were alternative with a variety of clay minerals. The laminations and beds are variable both in size and shape and ranging from a few centimeters to as thick as 4-5 feet. The representative samples were collected and then were analyzed on D8 Advance Spectrometer for XRD analysis for proper mineral characterization along with the EDS to know about the chemistry. The XRD analysis indicates that a variety of other minerals is also associated with the iron-bearing minerals. The qualitative and quantitative XRD analysis show that the hematite, goethite, and maghemite are the major iron phases present in various proportions in the analyzed samples while a significant proportion of other minerals in the form quartz and clays is also present. Among the three identified iron-bearing minerals, the hematite is common with higher percentage while the maghemite is present in only four samples and goethite in eight samples. The XRD analysis of alternative clay beds shows the presence of kaolinite, faujsite, calcite, illite, magnetite, maghemite, clinochlore, vermiculite, dickite, and boehmite. In addition, two titanium bearing minerals in the form of titanite and anatase are also identified. The evaporates are in the form gypsum and halite. The EDS analysis also confirms the presence of above minerals identified through XRD.

On the basis of such mineral assemblage, it can be concluded that the source of sediments was

mixed and the sediments were deposited in fluvial to deltaic environments; during the major phase of transgression and regression which occurred during the Late Paleocene and Early Eocene time.

Keyword

Iron ores, XRD, Clay minerals, Laki Formation, EDS

The component analysis and U-Pb dating of cassiterite using LA-(MC)ICP-MS

YounJoong JEONG[1]*, Korea Basic Science Institute (hero0123@kbsi.re.kr)
Sookju Kim[2], Korea Basic Science Institute
Hyojin Kim[3], Kongju University
Giun Han[4], Korea Basic Science Institute
Yeoungmin Kim[5], Korea Basic Science Institute

Abstract

Cassiterite is a significant ore mineral of tin, and research utilizing LA-(MC)ICP-MS for component analysis and U-Pb dating of cassiterite provides valuable insights into geological processes in the fields of mineralogy and geology. This study focuses on analyzing the composition and age dating of cassiterite, a tin-bearing mineral found in the Sangdong and Wangpiri regions of the Korean Peninsula, aiming to understand the characteristics of ore deposits and their geological implications. Cassiterite is commonly associated with metal ore veins, playing a crucial role in both industry and contributing to our understanding of ore formation and vein genesis processes. The LA-(MC)ICP-MS equipment used for this study is installed at the Korea Basic Science Institute. The laser ablation utilized Teledyne's Excite Pharos femtosecond laser ablation. Component analysis was conducted using an Agilent 7900 ICP-MS, while U-Pb analysis was performed using a Nu Plasma II MC-ICP-MS. The component analysis by LA-ICP-MS measured the content of major and trace elements, particularly focusing on the tin content (Sn) and trace elements such as Ti, Na, and K, to discuss the ore-forming environment. Additionally, mapping analysis of ore minerals will help elucidate the distribution patterns of trace elements and reveal the chemical characteristics of the ore veins. Moreover, U-Pb dating of cassiterite using LA-MC-ICPMS yielded results similar to those obtained by ID-TIMS, analyzing ore minerals from the same mounts for consistency. The obtained age measurements for ore minerals in the Sangdong and Wangpiri regions can be used to determine the timing of ore vein formation. These component analysis and age dating results offer crucial information for understanding the formation and evolution of ore minerals. Particularly, by elucidating the timing of ore formation in geological time, it enhances our geological understanding and can be instrumental in resource exploration and geological modeling.

Keyword

cassiterite, component analysis, U-Pb dating, LA-ICP-MS, LA-MC-ICPMS

Production of Montmorillonite Nanosheets using high-energy ball milling: A Study on Milling Methods and Solvent Effects

Bo Gyeong PARK[1]*, Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea (pbk0150@smail.kongju.ac.kr)
Mi Rae Kim[2], Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea
Hyun Na Kim[3], Department of Geoenvironmental Sciences, Kongju National University, Republic of Korea

Abstract

Montmorillonite, a 2:1 phyllosilicate clay mineral with high CEC capacity, swelling index and large specific surface area, has wide applications in various industrial fields such as construction and waste management. In particular, montmorillonite nanosheets can improve the mechanical properties of nanocomposite polymers, and thus the demand for montmorillonite nanosheets in the industry is increasing. Montmorillonite nanosheets are primarily produced by exfoliation using ultrasound or mechanical milling. While milling is cost-effective, it raises concerns about sample reaggregation and potential collapse of the crystalline structure. This research investigated methods to produce montmorillonite nanosheets by milling that preserve its unique crystalline structure.

The experiment was conducted using both dry and wet milling methods with a high energy ball mill. For wet milling, distilled water and ethanol were used as solvents. Milling was performed at 1500 rpm for durations of 1 and 2 hours. In order to understand the effects of milling method and solvent type on particle size, crystallinity and structural changes, analyses including X-ray diffraction (XRD), scanning electron microscopy (SEM), BET specific surface area analysis, laser diffraction particle size analysis (PSA) and Al-27 NMR were performed. Results showed that dry milling significantly increased montmorillonite specific surface area, but almost completely collapsed crystal structure. SEM images also revealed granular morphologies and the unique layered structure of montmorillonite rarely appeared. Wet milling with distilled water preserves the crystal structure but results in a slight increase in specific surface area, indicating poor particle size reduction, which is also supported by PSA and SEM results. Wet milling with ethanol reduces the particle size from ~10 μm to ~3 μm, and the crystal structure is also preserved according to XRD and Al NMR analyses. SEM images clearly showed the particle shapes of the nanosheets formed by exfoliating montmorillonite layers.

This study suggests that wet milling using ethanol as a solvent has the potential to produce montmorillonite nanoparticles without collapsing the crystal structure, and that the choice of milling method and solvent can control the desired particle size and shape of montmorillonite. Our results could be useful in preparing montmorillonite samples for various industrial applications.

Keyword

Montmorillonite, Nanosheet, Milling, High energy ball mill

State of the art of global geochemical mapping in Mozambique

Vicente Albino MANJATE[1]*, National Institute of Mines (sovimanjate@gmail.com)

Abstract

Environmental and natural resource managers throughout the world urgently need the global geochemical database. The Commission on GLOBAL GEOCHEMICAL BASELINES established an international network of applied geochemists throughout the world to implement harmonized sample collection, preparation, quality control, and analysis protocols for geochemical mapping programs. We aim to provide the actual development of global geochemical mapping in Mozambique. Mozambique has a surface of approximately 800 000 km2 and is situated in southern Africa with border extremities varying between 10°30' and 26°52'S and 40°50' and 30°13'E. Mozambique is partially (~50%) covered by geochemical mapping programs. These geochemical programs focus on mineral resource exploration and cover a prospect scale of 2-3 samples/10 km2 sampling densities. In 2021, Mozambique joined the initiative of the Commission on GLOBAL GEOCHEMICAL BASELINES and started the soil sampling in a 160x160km grid for the whole country. This work follows the standard methods established in the International Union of Geological Sciences manual and is aligned with the Global Geochemical Reference Network. In this network, Mozambique consists of 51 grid cells of 160x160 km with 132 observation points (Fig. 1). According to the global geochemical reference network, each cell consists of five random observation points. Up to 2023, the sampling program covered almost 90% of the predefined 132 observation points collecting 117 soil samples. The next challenge is to sign an agreement with an international partner for chemical analyses.

Keyword

global geochemical mapping, sample collection, grid, cell, sample density

[Keynote] International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network

ALECOS DEMETRIADES[1]*, IUGS Commission on Global Geochemical Baselines
(alecos.demetriades@gmail.com)

Abstract

The International Union of Geological Sciences (IUGS) is the organisation responsible for studying geological problems, especially those of worldwide significance. It supports and facilitates international and interdisciplinary cooperation in the Earth sciences. IUGS gives special consideration to (i) international standards; (ii) geoscience education; (iii) geoscience information, and (iv) environmental management and hazards. It does this work through its Commissions, Task Groups and Initiatives. International standards are set up by the IUGS Commissions. Under this premise, the Commission on Global Geochemical Baselines has compiled the "International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network" [1]. It presents, for the first time, a comprehensive overview of the standardised geochemical methods and procedures that should be used across the Earth's land surface to map the distribution of chemical elements in various sample types. As the randomised sampling scheme will cover the whole globe, according to the 7356 Global Terrestrial Network (GTN) grid cells of 160x160 km, the procedure must be consistent for all sample types and, therefore, is standardised to be applicable in all morphoclimatic environments. The Manual of Standard Methods describes in detail all the necessary methods that should be used from planning the sampling campaign, through the sampling of rock, residual soil (A and C horizon), humus, stream water, active stream sediment, overbank sediment (top and bottom) and floodplain sediment (top and bottom); sample preparation; development of project reference materials; analytical methods; quality control and assurance procedures for the production of harmonised data sets; data levelling of existing regional geochemical data sets in relation to the established Global Terrestrial Network datum for each element (or variable); data conditioning for the production of seamless geochemical maps; data management and map plotting and, finally, project management. Applying these standardised methods allows the production of internally consistent quality-controlled data sets for each sampling medium for multipurpose use. Any applied geochemist carrying out a geochemical mapping project at any scale and purpose should find a wealth of useful information within the pages of this Manual.

The Manual of Standard Methods is freely available from the following hyperlink: https://www.globalgeochemicalbaselines.eu/content/174/iugs-manual-of-standard-methods-for-establishing-the-global-geochemical-reference-network-/. Apart from the pdf file of the Manual, there are available the following: (i) Supplementary Material for a few Chapters, (ii) the Microsoft Word and PowerPoint files, and (iii) the original figures of all Chapters. This material is useful for all professionals in applied geochemistry.

[1] Demetriades, A., Johnson, C.C., Smith, D.B., Ladenberger, A., Adánez Sanjuan, P., Argyraki, A., Stouraiti, C., Caritat, P. de, Knights, K.V., Prieto Rincón, G. & Simubali, G.N. (Editors), 2022. International Union of Geological Sciences Manual of Standard Methods for Establishing the Global Geochemical Reference Network. IUGS Commission on Global Geochemical Baselines, Athens, Hellenic Republic, Special Publication, 2, xliv, 515 pages, 375 figures, 35 Tables, 5 Annexes and 1 Appendix, ISBN: 978-618-85049-1-2; https://doi.org/10.5281/zenodo.7307696.

Keyword

Sampling, Sample preparation, Analysis, Database, Data processing

Why stop at the regolith? Plants as an active geochemical mapping sampling media

David Cohen[1]*, Australian Geosci. Council / UNSW (d.cohen@unsw.edu.au)
Joseph Schifano[2], University of New South Wales
Neil Rutherford[3], University of New South Wales

Abstract

When undertaking geochemical mapping at various scales, we are confronted by a large array of potential sampling media, sample spacing and locations, sample processing and analysis strategies, and statistical and data visualisation approaches. The combinations of choices within this array will influence the types and scales of objects and processes that can be detected or characterised by geochemical mapping programs. Plants and related biological materials have received less attention compared with other potential media in geochemical sampling and mapping at various scales.

By sampling large volumes of soil and groundwaters via their root systems, the metal content of plants may present a more representative and spatially coherent geochemical fingerprint of a given location than regolith materials. While regolith materials are typically more consistently available than plants, particularly at sampling scales less than 1 km, the dependence of biogeochemical mapping patterns on species and organs mirrors the dependence of regolith mapping patterns on the origin and subsequent geochemical evolution of the available regolith materials. Controls that plants may exert on the selective uptake of metals will affect their capacity to reflect variations in the chemistry of the substrate. In contrast if the regolith is transported or elements have been leached, a lack of geochemical relationship between the regolith and underlying geology or land use may be present.

Regional studies in various terranes demonstrate the capacity of plants to respond to changes in underlying geology and regolith, and even more strongly to highly atypical geochemical entities such as zones of mineralisation or of contamination. In the Cobar Region of New South Wales, cypress pines display changes in background concentrations of a range of elements (such as As, Ba and Mn) to variations in lithology, as well as strong multi-element responses over a wide range of mineral deposit types (especially Ag, Au, Pb, W and Ni). Similarly, the needles of brutia pines display marked variations in their geochemistry in traverses across the various lithologies of the Troodos Ophiolite and surrounding marine carbonate units, with a dramatic increase in Re contents in the vicinity of Cyprus-style Cu deposits. Adjusting for variations in metal uptake between different plant genera, a number of elements displayed similar spatial patterns in a regional geochemical survey of the New England Region of NSW, in which both stream sediments and leaves or needles of the nearest adjacent tree species were sampled. Further examples are drawn from surveys in Canada and elsewhere in Australia.

Keyword

geochemical mapping, biogeochemistry, regolith, mineralisation, background

The Geochemical Mapping of Ireland: Geological Survey Ireland's Tellus Programme - results, challenges, and outcomes.

Ray Scanlon[1]*, Geological Survey Ireland (ray.scanlon@gsi.ie)
Victoria Lowe[2], Aurum Exploration Limited
Jim Hodgson[3], Geological Survey Ireland
Koen Verbruggen[4], Geological Survey Ireland

Abstract

Since 2011, The Tellus Programme of the Geological Survey of Ireland has sampled soils, stream-sediments, and stream-waters across the island of Ireland. This geochemistry programme has been coupled with a low-flying multi-physics geophysical campaign. Beginning as an EU funded natural extension to the Tellus Project of Northern Ireland, itself based on the BGS GBASE programme. Following IUGS global baseline protocols and design, the geochemical soil sampling programme is scheduled to be complete by mid-2024 with the collection of the final soil sample by July 2024. A sampling density one sample per 4km2 is allowing unprecedented insight into the national baseline geochemistry in applications like mineral exploration, agricultural productivity, soil Carbon stocks. Challenges associated with decade long sampling and analytical programmes, constrained by outsourcing of sampling, sample preparation and analysis via national and EU procurement rules will also be outlined. Mid term reviews of the Programme led to the focus on soil sampling along with product development and close partnerships with other government agencies and central departments. Partnerships with other government science agencies has led to applied products derived from data analytics or sample archive reanalysis to answer specific societal needs. Current governmental policy focus on Critical Raw materials and Soil Monitoring Laws have placed the Programme in an ideal space to provide unparalleled evidence-based policy support across the whole of government.

Keyword

Soil, Baseline Geochemistry, Government, Science for policy

Geochemical Map of Latin America and the Caribbean. Methods for implementation

Maria João Farinha Batista[1]*, LNEG (mjoao.batista@lneg.pt)
Andrea Turel[2], SEGEMAR
Iván Martin[3], IGME
João Larizzatti[4], Serviço Geológico do Brasil
Gloria Prieto[5], CGGB-IUGS
Geochemical Group ASGMI[6], ASGMI

Abstract

The Geochemistry Experts Group of the Ibero-American Association of Geological Services is a group of experts who exchange knowledge on exploration geochemistry and geochemical mapping as a result of the experience of each Geological Service. Currently, the group of experts has started to test the methodology for collecting information for the Geochemical Map of Latin America. The continental data unit used is the Global Terrestrial Network (GTN), following the recommendations for International Geochemical Mapping, but instead of 160x160 km, it will have a 40x40 km cell. The geochemical data will be collected in each cell, and an average value (median or geometric mean) will be determined.

The medium used to harmonize the information will be stream sediments, as most Geological Surveys use and have archives of stream sediment geochemistry data from previous exploration projects. The geological and mineral resource information of the 40x40 km cell will also be part of the attribute table that will make up the database. The criterion for leveling data between contiguous stream sediment analytical datasets will be the greatest similarity in chemical analysis methods, sampling density and stream order. The continental geological map used to prepare the metallogenic map of Latin America and the Caribbean will also be utilized for the geochemical map of Latin America and the Caribbean. This map will include as many chemical elements as possible on a continental scale.

Keyword

geochemical mapping, stream sediments, geological surveys, ASGMI

Soil geochemical mapping of the Aotearoa New Zealand convergent margin

Mark Rattenbury[1]*, GNS Science, New Zealand (m.rattenbury@gns.cri.nz)
A P Martin[2], Earth Systems
Regine Morgenstern[3], GNS Science, New Zealand
Karyne Rogers[4], GNS Science, New Zealand
Rose Turnbull[5], GNS Science, New Zealand

Abstract

Over the last decade, seven systematic soil geochemistry baseline surveys have been undertaken in Aotearoa New Zealand at a variety of scales, from cities and regions to the national scale. These surveys have been conducted using similar sampling and processing methodologies and the same analytical laboratory using common standards. Samples were acquired at 2-20/30 cm below surface (A-depth) for most surveys, while O-depth (0-2 cm) and B-depth (50-70 cm) samples were also collected in many surveys. ICP-MS analyses of 65 elements were acquired for all surveys with additional element analyses and C, N isotope measurements undertaken for some surveys. The results for all surveys have been presented as maps for each element utilising symbolised points and colour-ramped interpolated grids.

City-based surveys were the 2017 Dunedin urban survey involving 83 sites across a 1 km sampling grid with a further 30 sites from school grounds, the 2023 Auckland urban survey involving 112 sites across a 4 km grid and the 2024 Wellington survey involving 151 sites at variable spacing. The regional surveys undertaken were the 2015 southern South Island survey involving 360 sites spaced across an 8 km grid, the 2017 Buller-east Nelson-Marlborough survey involving 446 sites across an 8 km grid with 2 km sample spacing over mineral belts and the 2017 Otago survey involving 463 sites across an 8 km grid with 4 km and 2 km sample spacing over mineral belts. The 2023 national survey utilised samples from a single depth, generally corresponding to the A-depth, from 833 sites at variable spacing. The samples included in the national survey were selected from multiple baseline and other surveys collected earlier and reanalysed collectively.

The soil geochemistry results for all surveys show a strong correlation with underlying mapped geology, particularly outside of built-up areas. In the South Island, basement terrane geology appears to strongly influence soil geochemistry. Within cities and some agricultural areas, some elements such as Pb, Mn and P are elevated compared to natural background levels and are linked to anthropogenic influences such as pollutants and fertilisers.

Aotearoa New Zealand median values for Ag, As, Hg, Li, Mo, Nb, Se and Zn are more than double aqua regia partial digest element concentrations from Australia and median Pr, Te and Zr values are less than half of the Australian median values. Differences could be due to cooler, damper, more maritime conditions in Aotearoa New Zealand as well as denser vegetation, younger soils and a shorter-span geological history dominated by convergent margin and volcanic arc activity compared to Australia's predominantly continental and considerably older craton geology.

Keyword

soil, geochemistry, maps, baseline survey

Addressing the problem of microplastic contamination in soil: Challenges during separation and recovery of natural and anthropogenic organic polymers.

Ariadne ARGYRAKI[1]*, IUGS Commission on Global Geochemical Baselines (argyraki@geol.uoa.gr)
Stefania Koutsourea[2], National and Kapodistrian University of Athens
Andreas Gondikas[3], National and Kapodistrian University of Athens
Karin Mattsson[4], University of Gothenburg
Artemis Kontomichalou[5], National and Kapodistrian University of Athens
Alexandros Liakopoulos[6], Hellenic Survey of Geology & Mineral Exploration

Abstract

Considering the estimated maximum 300k Tn of microplastics (MPs) released yearly in the EU and the scarcity of systematic surveys for MPs, monitoring and managing their potential risks poses notable challenges to researchers and governments worldwide. Primarily owing to their small size and complex composition, the lack of standardization on methodologies for sampling & analysis, reporting units, and QA/QC procedures, present significant challenges for synthesizing research findings, interpreting data, and drawing meaningful conclusions. Furthermore, up to now the focus of research has been mostly on developing methods to estimate the amount and type of MPs in the marine environment. Standardized protocols for the recovery and characterization of MPs in soils are still under investigation, although it has been established that they are characterized by elevated adsorption capacity as the result of their large specific surface area; thus, they adsorb typical soil contaminants such as metals and metalloids, promoting their dispersion in the environment.

In this study, soil samples were selected from the systematic soil dataset of the Attica region in Greece, taken at depths of 0-20 cm and 20-40 cm. Spiking experiments were conducted using a composite mixture of soil collected at natural forest sites and blank samples spiked with cryomilled polymers. Various techniques and reagents were tested to enhance recovery and facilitate characterization. Different reagents were compared regarding their effectiveness on the degradation of organic particles, including Strand solution (0.67 mol/L NaClO, 0.45 mol/L KOH), KOH (2.6%), H2O2 (30%), and one using porcine pancreatic enzymes. Mineral particle removal involved density separation with supersaturated NaCl and ZnCl2 solutions, followed by filtration to retain MPs. Modifications were made in the choice of reagents for repeated experiments. A multi-method approach for identifying and characterizing MPs included analysis with an optical microscope, FTIR, and Raman spectroscopy for evaluating the MP recoveries based on different treatments. All pre-treatment methods effectively removed organic matter, and both saline solutions extracted lighter plastic particles such as polyethylene (PE) and polypropylene (PP). Despite their higher density, PVC and tire particles were able to float in both density separation methods. However, the KOH and Strand solutions were unable to decompose organic aggregates.

Acknowledgements
This contribution is based upon work from COST Action CA20101 Plastics monitoRIng detectiOn RemedIaTion recoverY – PRIORITY, supported by COST (European Cooperation in Science and Technology).

Keyword

soil, emergent contaminants, microplastic

Spatial Distribution of Copper, Iron and Arsenic in soil from the Okahandja 2116 map area in Otjozondjupa Region, Namibia

Badumisa Vicious SIBOLILE[1]*, Geological Survey of Namibia (Badumisa.Sibolile@mme.gov.na)
Gloria Namwi Simubali[2], Geological Survey of Namibia
Wilka Embula[3], Geological Survey of Namibia
Gavine Kavindikiza[4], Geological Survey of Namibia
Ulf Kasuto[5], Geological Survey of Namibia
Benyamen Ndiili[6], Geological Survey of Namibia

Abstract

The contents and spatial distributions of copper, iron and arsenic in 192 soil samples from the selected study area in the Otjozondjupa region, Namibia, were investigated and the findings are presented. The soil samples analysed for this study were collected as part of the ongoing countrywide Regional Geochemical Sampling Programme (RGSP) in Namibia. The RGSP is carried out based on individual 1:250,000 scale index map, measuring 208 km x 110 km (approximately 23,000 km2). Each 1:250,000 index map is further divided into 1:50,000 scale index maps measuring 26 km x 28 km (approximately 720 km2), such that there are thirty-two (32) 1:50,000 scale index maps in one (1) 250K index map. The study area covers four (4) 1:50,000 scale maps of the Okahandja 2116 (1:250,000) index map. The four 50K index maps are identified as 2117DA, 2117DB, 2117DC and 2117DD and are collectively noted as 2117 DA-DD for the purpose of this study. The RGSP employs an established, systematic sampling protocol that involves the collection of composite soil samples at a density of 1 sample/10 km2. A composite sample from a minimum of five holes was collected and screened onsite to recover a coarse fraction (< 2 mm) sample and fine fraction (<180 microns) sample. Only the fine fraction samples were selected for this study and the samples were processed and analysed at the Geological Survey of Namibia (GSN) laboratories. An aliquot of each 180 µm fine fraction was milled into fine powder of < 64 µm and analysed using the handheld Niton Energy Dispersive X-Ray Fluorescence Spectrometer (ED-XRF). The QAQC protocol utilised for this study includes insertion of International Certified Reference Materials (CRM), inhouse secondary standards and duplicates into batches of samples at every 20th interval. From the analysed soil samples, Cu ranges between 5.57 and 94.73 ppm, Fe values ranges from the lowest of 14 494.15 ppm to the highest of 50 033.80 ppm, and As ranges between 1.34 ppm to 5.21 ppm, respectively. Cu and Fe distribution appears to be lithological and structurally (Dome and Basin) controlled. Cu values are consistent with crustal and world soil values determined by Salminen (2005) and Adriano (2005), while Fe values are lower than average crustal concentration determined by Williamson (1998). The As distribution does not appear to follow geological controls or structural orientation, as both low and high concentrations are observed across all major geologic units. Areas with high As concentration are observed near settlements/homesteads, croplands, roads/tracks, fence boundaries, as well as in old workings. This indicates that As distribution in the study area is a factor of anthropogenic influence. Therefore, to comprehensively understand the spatial

distribution of Cu, Fe and As, more related elements should be investigated.

Keyword

Namibia, Sample, Element, Soil, Concentration

Geochemical Mapping in Sweden – establishing baselines at national to local scales

Anna LADENBERGER[1]*, Geological Survey of Sweden (anna.ladenberger@sgu.se)
George Morris[2], Geological Survey of Sweden
Patrick Casey[3], Geological Survey of Sweden
Merita Murtola[4], Geological Survey of Sweden
Mattias Sörengård[5], Geological Survey of Sweden

Abstract

Geochemical mapping is an established method for studying the spatial distribution of chemical elements in different sample media, e.g. rock, sediment, soil, water and plants, and to document variation in chemical compositions within a given area. Apart from the sample type, the scale which determines the grid plays an important role in planning geochemical surveys. There have been many discussions whether low-density sampling is suitable for baseline studies while high-density sampling in mineral exploration and environmental monitoring is a preferred approach., High-density sampling (100 to 1000 samples/km2) is however very expensive when covering large regions therefore many geological surveys worldwide started applying lower sampling densities in order to deliver country wide datasets within a reasonable time frame and cost.

At the Geological Survey of Sweden regional geochemical mapping using till has been carried out for more than 40 years. Since 1995, SGU has been working towards producing a uniform till database covering the whole of Sweden. After the last ice sheet melted, about 10 000 years ago, large parts of the bedrock in Fennoscandia were covered by several generations of glacial deposits with till as most important. Till provides a good proxy for the bedrock composition with glacial transport of only 5 – 15 km from source at most locations.

Modern chemical analyses of till samples are available from more than 40 000 sites. The currently used analytical methods are nitric acid digestion and aqua regia digestion followed by ICP-MS analysis. More than 60 elements can be obtained with the in-house developed method at the SGU laboratory.

The till sampling has been carried out at three major scales: national, regional and local. Regional geochemical mapping provides data with a sample density of ~1 per 7 km2. In parallel, focused studies with higher sampling density were carried out in forest fire areas, at historical mining sites and in urban environments with sampling density up to 10 samples per 1 km2. In 2014, the countrywide Geochemical Atlas of Sweden was published with a sample density of 1 sample per 150 km2. All data is publicly available and can be seen online via SGUs Mapviewer. Modern geochemical mapping relies on building databases and providing digital data services to the society.

The results of geochemical mapping allow understanding of natural processes operating at the continental to regional scale, such as weathering, climate, glaciations, tectonic evolution, but also to understand the consequences of modifications of the natural environments, which are no longer pristine and undergo changes caused by human activities. Geochemical data can be used in

various applications: mineral exploration, environmental monitoring, medical and forensic sciences, agriculture, forestry, land use planning, and in policy making.

Keyword

geochemical mapping, geochemical baseline, glacial till, Sweden

PLANAGEO-Methodology to conduct a geochemical survey for mineral exploration in SW Angola

Maria João Farinha Batista[1]*, LNEG (mjoao.batista@lneg.pt)
Cátia Prazeres[2], LNEG
Iván Martin[3], IGME
Enrique Merino[4], IGME
José Feliciano Rodrigues[5], LNEG
Iván Cuervo[6], IMPULSO ANGOLA
José Manuel[7], IGEO ANGOLA
Daniel De Oliveira[8], LNEG
José Luís Lobon[9], IGME

Abstract

A 7-year project (Plano Nacional de Geologia, PLANAGEO) was conducted in SW Angola, which involved geological mapping at 1:250.000 and 1:100.000 scales, airborne geophysics (magnetics, radiometrics), geochemistry at 1:250.000 scale and investigation on the potential for metallic and non-metallic minerals. The selection of regional potential areas for metallic mineral exploration was backed by the analysis of previous exploration reports, the Mineral Catalogue of Angola, other publications, as well as unpublished theses, that were compiled to create a comprehensive mineral database. The selected targets were: i) rare earth elements (REE) located in the southwestern end of the alkaline-carbonatitic structures related to the Volcanic Belt of Angola, namely Serra da Neve greenfield area, Tchivira-Bonga and Catanda brownfields; ii) the brownfield areas of the Archean terrains and granitic intrusions containing Au-Fe in Jamba-Cassinga-Tchamutete, Chipindo and Cuima-Samboto regions; iii) Cr-Ni and Cu and Nb-Ta-Li-Be in the ultramafic intrusions of Chibia-Humpata region and the granitic rocks and the Giraúl pegmatites, respectively, in the Namibe region. Planning the field campaign was a challenging task due to the diverse terrains in an area over 476,000 km2, ranging from desert areas near the coast to the Angolan Plateau. The time for the field work was very tight and it was divided into two campaigns during the dry seasons. The implemented sampling plan needed to consider the sampling sites within a reasonable distance to the rarely available roads and the tracks covered during the geological mapping. The morphoclimatic conditions guided the field program, e.g.in certain areas, such as, the Plateau during the rainy season where the poor drainage led to flooding and saturation of the land. As a result, sampling stream sediments often becomes impractical because it was difficult to define water flow lines and understand the origin of any anomalies. Sampling in non-perennial streams near the desert should not occur in watercourses with sediment that is markedly lighter than the surrounding rock due to the action of aeolian transport and deposition of desert sand. Instead, it is chosen watercourses sediment that reflects the decomposition of the rock. Clearly the usual criteria of low stream order is not applicable in this case, but rather the colour of the sediment should be considered. This is because even the first-order watercourses on the desert border can contain desert sands. Soil sampling in the desert

boundary is frequently impossible because it is almost absent. Regions such as the Serra da Neve alkaline complex rocks were used to represent the distribution of chemical elements, and in the surrounding area of the complex, stream sediments were considered the best option.
Under these circumstances and considering the wide area where the target raw materials occurred, it was decided to collect different sampling media according to the region and type of existing surface material to highlight the geochemical signal and ensure a clear contrast between background and anomalous values of chemical elements. In summary, multimedia sampling was more efficient but, interpretation needs to be somewhat cautious.

Keyword

Mineral potential, geochemical signal, sampling, geochemistry

A COMPREHENSIVE REVIEW OF ABANDONED MINING WASTE FACILITIES TO ASSESS THE REPRESENTATIVENESS OF THEIR SAMPLING

Paula ADANEZ-SANJUAN[1]*, Geological Survey of Spain (IGME-CSIC) (p.adanez@igme.es)
Julio C. Arranz-González[2], Geological Survey of Spain
Adrián J. Rosario-Beltré[3], Geological Survey of Spain
Marcelo F. Ortega[4], ETSI Minas y Energía (UPM)
Francisco Javier Fernández-Naranjo[5], Geological Survey of Spain
Virginia Rodríguez-Gómez[6], Geological Survey of Spain

Abstract

The investigation of mining waste facilities intended for use as secondary resources is gaining importance in recent years and tailings dams are especially relevant because of their greater recovery potential. These deposits are quite heterogenic due to the grain selection from the discharge point and secondary weathering processes. Thus, the representativeness of the surface samples with respect to the waste mass will highly depend on the degree to which all processes have occurred.

A review was performed on published reports providing data measured in abandoned sulphide flotation facilities that were obtained from boreholes. In total, 36 reports were published between 2000 and 2021, corresponding to different facilities. All continents are covered, with 6 sites in North America, 3 in South America, 7 in Asia, 12 in Europe, 7 in Africa and 1 in Oceania. The studied mining waste facilities provide information on total elemental contents (ICP-OES, ICP-MS, XRF) of at least Fe and S, Cu, Zn and Pb and some include information on other elements.

This study aims to make a preliminary global comparison of the significant differences or similarities between the elemental contents of samples taken from the surface and at depth. For this purpose, the samples were classified as P1 (the most superficial samples taken from each borehole) and P2 (the rest of the samples taken at depth). To draw more reliable conclusions at a global level, two other factors, climate and main commodity exploited, were considered as having the greatest influence on the variability of elemental contents in the facilities studied. So, a variable was developed according to aridity. Hence, the location of each facility was classified as hyperarid, arid, semiarid, dry-subhumid or humid. With the classification according to the main commodity mined, 11 classes were generated (Au, Cu, Cu-Zn, F-W-Cu, Ni-Cu, Ni-Cu-PGM, Pb-Ag, Pb-Zn, Pb-Zn-Ag, Pb-Zn-Cu, Pb-Zn-Cu and Sn-W).

The graphical and statistical study of the depth variation according to aridity classes and main commodity produced interesting results regarding the practicality of sampling. In the specific case of Cu and Zn, it can be stated that in most installations the depth-related differences are not significant, and if they are, these elements are more abundant at depth, regardless of the ore. In terms of climate, it is found that in arid and hyperarid areas, there is a very significant enrichment in the surface samples, which is explained by the effect of dissolution and capillarity. In the case of Pb, this phenomenon does not occur, due to its lower mobility. In this case, the largest

differences occur in the Pb-Ag ores that are more enriched in the surface samples, which does not seem to be related to climate.
This study evaluates patterns of behaviour at a global scale in abandoned mining waste facilities and its application can be extrapolated to the sampling method. In particular, conclusions are drawn on surface samples and their representativeness in relation to the entire mining facility and the content of certain elements contained in the wastes.

Keyword

mine waste, secondary resources, sampling, global scale, geochemistry

Cadmium content in soils of the Upper Silesia Region – an analysis based on geochemical mapping in Poland

Irena Agnieszka WYSOCKA[1]*, Polish Geological Institute National Research Institute (irena.wysocka@pgi.gov.pl)
Agnieszka Konon[2], Polish Geological Institute National Research Institute
Angelika Szczypczyk[3], Polish Geological Institute National Research Institute
Paulina Kostrz-Sikora[4], Polish Geological Institute National Research Institute

Abstract

A detailed geochemical mapping project for the Upper Silesia Region (scale 1:25,000) has been conducted at the Polish Geological Institute since 1996. One of the main goals of this long-term assignment is to investigate the industry impact on soil condition and assessment of the degree of soils contamination with heavy metals. For many years the most important sectors in the Polish part of the Upper Silesian Coal Basin have been coal mining and iron metallurgy, as well as zinc metallurgy (operating mainly in the past). Nowadays this area shows a diverse relief, locally highly altered as a result of industrial activity. There are many landfills of slag and mining waste near historical and present-day metal smelters.

Within the framework of the detailed geochemical mapping project, 21 map sheets were developed and released in the form of separate atlases until 2021. Here we present the outcome for cadmium contamination in soils of the most recent map sheets (~20% of the whole investigated area). The selected area covers 329 km2 with sampling density of 16 samples/km2. As the studied area covers different land usage including grasslands (~5%) and croplands (~29%) we look at the obtained data in the context of the risk assessment based on the cadmium threshold value 1 mg/kg. In total 5241 topsoil samples were collected and analyzed by ICP-OES after aqua regia digestion.

Cadmium is one of the most toxic elements within the heavy metals group that are considered as a major threat to human health when their concentrations exceed a certain threshold. However, at the EU level there is no common agreement on cadmium threshold values in soil for the definition of risk. According to the analysis based on LUCAS topsoil database about 14% of the soil samples in Poland are above 1 mg/kg, that is generally considered limit for the risk assessment. In absolute numbers Poland has 236 out of 1648 soil samples with Cd higher than 1 mg/kg and according to the publication by Ballabio et al. (2024). In this work we focus on data for cadmium in soils located in the region strongly affected by industrial activity at the aim to provide a detailed assessment in term of land use, regional Cd content and risk of high Cd. We compare our results to (1) the outcome of the analysis based on LUCAS data and (2) the Cd limit values used by the Polish law for the ground classification (Regulation of the Minister of the Environment on the method of conducting the assessment of land surface contamination. Journal of Laws 2016, item 1395).

Ballabio, C., Jones, A., & Panagos, P. (2024). Cadmium in topsoils of the European Union - An

analysis based on LUCAS topsoil database. Science of the Total Environment, 912, 168710.

Keyword

cadmium, soil, contamination, geochemistry, mapping

Determination of Rare Earth Element Baselines in the Brunei Darussalam Soils.

Haezan JANGARUN[1]*, Universiti Brunei Darussalam (Hznjgrn@gmail.com)
Elena Ifandi[2], Universiti Brunei Darussalam
Khairunnisa Nazirah Karim[3], Universiti Brunei Darussalam
Basilios Tsikouras[4], Universiti Brunei Darussalam

Abstract

The notable recent surge in soil research reflects the increasing awareness of its fundamental significance. In Brunei Darussalam, limited research has been conducted on the mineralogical and geochemical characteristics of the soil, even though healthy soil is essential for agricultural activities and sustainable food production. This project aims to determine the geochemical baselines and threshold values of rare earth elements (REEs). Topsoil (0-20 cm depth) and subsoil (50-70 cm depth) samples were collected with the aid of a 10 x 10 km grid and subsequently analysed using INAA and ICP-MS to determine the distributions, possible sources of any soil-related pollution and sinks of the REEs. Statistical analysis and geochemical heatmaps were used to determine the threshold values and the distribution of the REEs. Certain geochemical anomalies or elevated baseline values are spatially associated with agricultural and industrial activities and landfill areas. Potential reasons for the elevated REEs values include the excessive use of fertilisers, herbicides, pesticides, and animal food additives. In addition, REEs may originate from utilising or dumping numerous technological items such as automotive catalytic converters, fibre optics, superconductors, and electronic devices. The REEs usually accumulate in an area because they are trapped by different mechanisms. Clay and organic matter are often associated with the adsorption of REEs in the soil, leading to elevated values in the area. The REEs are bound onto the surface of clay minerals and organic matter via ion exchange and surface complexion. The cation exchange capacity (CEC) in clay and organic matter favours the REEs adsorption to their surface. This study provides REEs geochemical baselines on both topsoil and subsoil of Brunei Darussalam, which aims to aid policymakers in developing sustainable land use practices.

Keyword

Soil, Rare Earth Elements, Geochemical Baselines, Geochemical Heatmaps, Sustainable land use

Challenges and Opportunities in Compiling a Complete Africa Geochemical Database for Medical Geology Applications

Theophilus Clavell DAVIES[1]*, Mangosuthu University of Technology
(daviestheophilus2025@yahoo.com)

Abstract

ABSTRACT

The significance of a complete, high quality Africa Geochemical Database (AGD) for addressing the range of Earth and environmental science issues (e.g., mineral exploration, resource evaluation, agriculture, land use planning, processes of crustal evolution, and modelling of environmental systems) cannot be over-emphasised; because, for such applications to be made in a robust fashion, we need to understand how the Region's unique and complex geochemical landscape was carved out in the first place. The distinctive nature of Earth processes such as intense tropical weathering, leaching, erosion, podzolization and gleying, as well as later imprints of urbanisation and industrialisation, have engendered the mobilisation and clear redistribution of all but the most refractory elements. As a consequence, it is not uncommon to find large tracts of the Continent's surface environment containing anomalous trace element contents or deficiencies in essential micro-nutrient elements. Through water and food crops, extremes in trace element variation in soils are transmitted into the food chain, with often undesirable consequences for human and animal health. It is thus considered that one of the most important applications of an AGD would be in understanding the hydrological, chemical and biological processes that determine the behaviour of nutritional and toxic elements in the surface environment, in relation to how they may affect the health of man and animals (Medical Geology). This is so, because most of the population still live close to the land, and depend on it for their daily sustenance.

Important scientific problems that have confronted the construction of an AGD include: defining and understanding "regional background", and the evolution of appropriate sampling and analytical protocols that would take into account the Regions' unique and complex element distribution patterns. These problems are apparently intractable, but are not unsolvable.

Other challenges include longstanding operational and logistical problems that have impeded previous (largely uncoordinated) efforts at an AGD compilation such as the limited availability of state-of-the art analytical instrumentation and requisite laboratory infrastructure. An even more important limitation has been the dearth of a sufficient number of highly skilled analytical geochemists and other technical personnel located at appropriate regional centres, who are able to install, operate, trouble-shoot and maintain modern analytical equipment. These problems are compounded by the lack, up to now, of adequate international funding to undertake such a high precision and systematic mapping exercise.

In this presentation, recommendations are put forward for carrying out a successful and complete compilation of a high quality AGD that would be invaluable for studies in Medical Geology, as well as in an array of other multipurpose, multi-national environmental applications; and proposed measures given for counteracting potential limitations in its development.

Africa, geochemical database, applications, Medical Geology, addressing issues.

Keyword

Africa, geochemical database, applications, Medical Geology, addressing issues

Overview of geochemical mapping in the Geological Surveys of Ibero-America.

Iván MARTÍN-MÉNDEZ[1]*, IGME-CSIC (i.martin@igme.es)
Maria Joao Batista[2], LNEG
Gloria Prieto[3], The Commission on Global Geochemical Baselines (CGGB), IUGS
Andrea Turel[4], SEGEMAR
Geochemical Expert Group ASGMI[5], ASGMI

Abstract

In recent years, the Geological Surveys of Ibero-America have collaborated through the Association of Iberoamerican Geological and Mining Surveys (ASGMI) experts group to exchange information about the status of the different geological and mining activities in the region and to share experiences in geosciences programs in each country. The Geochemistry Expert Group (GEGOQ-ASGMI) has proposed the development of a manual of geochemical methodologies (Batista et al. 2023) employed by as its main ASGMI member countries that could be used for other countries to promote their knowledge of geochemistry and its applications.

The preparation of this manual has allowed us to understand the status of geochemical work in each country. While most of the Geological Surveys have systematically generated geochemical information for their projects and programs, the methodologies employed to generate this information have been diverse and have not corresponded to homogeneous standards. Most of the countries of the GEG have only partially mapped their territory geochemically, with varying sampling densities. Spain and Portugal are the only countries to have achieved complete coverage of their territory. Honduras, Ecuador, and Argentina and Brasil have covered 30 to 40% of their territory. Colombia has covered 95%, while Cuba and Peru have covered 77%. Most countries have achieved regional coverage with different objectives, using distinct sampling media and diverse analytical techniques to obtain data. However, this has not yet allowed us to create a geochemical map of the entire region

The exchange of information has corroborated the need to work jointly among the ASGMI member countries to have more harmonized information at the continent level.

Keyword

geochemical mapping, Ibero-America, geological surveys, ASGMI

USE OF NATIONAL SCALE GEOCHEMICAL DATA FOR THE DEVELOPMENT OF A GEOSTATISTICAL METHODOLOGY FOR INTERACTION ANALYSIS OF VARIABLES AT DIFFERENT SCALES

Paula ADANEZ-SANJUAN[1]*, Geological Survey of Spain (IGME-CSIC) (p.adanez@igme.es)
Juan Antonio Luque-Espinar[2], CN-Instituto Geologico y Minero de España (CSIC)
Eulogio Pardo-Egúzquiza[3], Instituto de Geociencias

Abstract

The development of this work is based on the data of potentially toxic elements (As, Sb and Pb), as well as total organic carbon from the Geochemical Atlas of Spain, provided by the Geological Survey of Spain, and of water points from wells for consumption, piezometers and springs, provided by the Ministry of Environment. This work therefore exemplifies the importance and options provided by the availability of data for studies with different objectives. In this case, the aim is to study the interaction of these elements in topsoil in relation to lithology and groundwater, by considering different scales of variability at a national level.

Kriging and its multivariate version, cokriging, have been used as geostatistical tools to develop the necessary probabilistic framework for the decomposition of spatial variability into scales of variation. Experimental variograms have been estimated and modelled using the linear co-regionalisation model. Finally, the different scales of variability related to the ranges observed in the experimental variograms have been estimated. The ranges established for the optimised models were 5 km, 35 km and 135 km. Factor cokriging was also used to determine the correlation between different variables and to separately map the structures in the fitted variogram models. In general, the shorter range detects local anomalies of both natural and anthropogenic origin, the middle range reflects larger anomalies as well as the natural geochemical background, while the long range is related to the geochemical background and is also able to reflect faults and other tectonic features. Finally, a contingency analysis has been performed to verify the spatial relationship between pairs of variables.

Among the results obtained, it can be highlighted the relationship between high values in water bodies and anomalies detected in the short range in the case of Sb, As, especially in large river basins, although sectors with a high influence of geochemical background are also identified. Areas with low background values in soil and high values in groundwater bodies are interpreted as influenced by industrial activities. The contingency tables show a high degree of affinity of the three elements, as well as with TOC, in groundwater and in soil at all scales, being the higher the range the higher the affinity.

Using factorial cokriging, the relationship between elements in soil and groundwater is better explained, confirming the association of elements in soil and groundwater with the influence of the scales of variation. This method enhances more traditional approaches to environmental studies and the methodology is exportable to other areas. This work therefore exemplifies the importance and options provided by the availability of geochemical data for a wide range of

studies with different objectives.

Keyword

Geostatistics, potentially toxic elements, multiscale

Nonlinear nature-based localization criteria for the resource potential assessment and interpretation of the anomalous structural-geochemical fields

Igor SPIRIDONOV[1]*, FSBI IMGRE (imgre@imgre.ru)
Sergey Grigorov[2], FSBI IMGRE
Viktor Tatarinov[3], FSBI IMGRE

Abstract

Traditional approaches to prediction, exploration, and assession of hydrothermal, metasomatic and magmatic mineral deposits using geochemical data and based upon the assumed history of the linear (historical) evolution of mineral matter and energy, have exhausted their potential and mismatch the efficiency level required.

The parent processes of geochemical halos, by definition, are nonlinear and follow the fundamental law of self-organization in an open dissipative system. During the course of its evolution, the primary planetary geochemical field forms structural-geochemical ensembles where the constant form associates with an infinite variety of content provided by the periodic system of chemical elements.

The structural ordering is conditioned by a combination of the four key types of geochemical zoning, i.e., synchronous, lateral, centrifugal and centripetal in the context of fractal fragmentation that controls the taxa hierarchy within the system.

The nonlinear nature of the halo and ore formation requires a fundamentally different approach to the analysis of prospecting information, determination of the boundary criteria of the mineralized objects in question and evaluation of the geochemical field's anomalousness grade.

Using real case histories we present the structure of a system of geochemical fields that displays a discontinuous-continuous series: ore body – ore zone – ore field – ore cluster – ore region – mineragenic region.

The target localization criteria at different exploration / prospecting stages are developed, as for mineral resources, as well as for ore reserves.

The geochemical anomaly ranking criteria by their prospectiveness, the rules for the ore showing's sorting out, and criteria for assession the completeness of knowledge on the mineralized objects, including assessment of blind mineralization, are developed.

Keyword

planetary geochemical field, nonlinear process, exploration criteria

THE RESOURCE POTENTIAL ASSESSMENT OF SOLID MINERALS BASED ON THE RESULTS OF MULTI-PURPOSE GEOCHEMICAL MAPPING OF THE TERRITORY OF RUSSIA

Viktor KILIPKO[1]*, FSBI IMGRE (kilipko@rambler.ru)
Igor Spiridonov[2], FSBI IMGRE
Yuriy Sharoiko[3], FSBI IMGRE

Abstract

In order to increase the reliability of prediction, identification and estimation of mineralized objects thus creating a prospecting reserve on the Russian territory, IMGRE carries out the overview, regional and medium-scale geochemical surveys. The regional and medium-scale projects prevail here, and their key result is the creation of the geochemical bases of the so-called State Geological Maps, scale 1:1M, employing the multi-purpose geochemical mapping technology. In turn, such maps serve as the update sources for the summary prognostic geochemical map, scale 1:2,5M.

During 2023, this map was updated using data from the multipurpose geochemical mapping projects performed at 1:1M and 1:200k scale. In total, geochemical data on 52 1:1M mapsheets were used to update the prognostic geochemical map covering the territory of the Russian Federation.

The updated prognostic geochemical map displays the anomalous geochemical patterns correlated to the mineralized objects in the rank of ore district and cluster combined into geochemical zones, which mineragenic specialization by the major groups of minerals (precious, non-ferrous, ferrous, etc.) and relative prospectivity grade (high, medium, unclear and low) is specified.

A cadastre accompanies the map that lists the characteristics of anomalous geochemical fields and confirms the assessments made.

The results of the analysis of the updated prognostic geochemical map of Russia at a scale of 1:2,5M confirm the thesis that regional-scale geochemical exploration is an effective tool identifying mineralized objects, what supports the following conclusions:

1. The 1:2,5M geochemical map of Russia in GIS format makes the fundamental basis for justifying exploration directions. Its updated version identifies anomalous geochemical patterns on the territory of the Russian Federation which delimit territories for future geological, geophysical and geochemical studies of various scale and extent.
2. The main task of geochemical research aimed at increasing the information content of the 1:2,5M prognostic geochemical map of Russia is its updating with actual geochemical data.

Keyword

multi-purpose geochemical mapping, regional geochemical survey, prognostic map, mineral prospectivity

Continental-scale distribution of niobium and tantalum in catchment sediments throughout China: Prospecting implications from the China geochemical Baselines project

Hanliang Liu[1]*, Institute of Geophysical and Geochemical Exploration, Chinese Academy of Geological Sciences (liuhanliang912@163.com)
Xueqiu WANG[2], Institute of Geophysical and Geochemical Exploration, Chinese Academy of Geological Sciences
Bimin ZHANG[3], Institute of Geophysical and Geochemical Exploration, Chinese Academy of Geological Sciences

Abstract

Niobium (Nb) and tantalum (Ta), which are chemical twins with very similar geochemical properties, are critical mineral resources for emerging global industries. Owing to increasing demands, understanding their concentrations and distributions in the pedosphere is essential for assessing potential Nb and Ta resources in China. To address this, we used geochemical data obtained from the China Geochemical Baselines (CGB) project, which began in 2008 and has since then yielded continental-scale datasets. With a density of approximately-one sampling site per 3,000 km2, the CGB project involved catchment sediments from two horizons at each site: a top sample collected at a depth of 0–25 cm and a deep sample collected at a depth greater than 100 cm. In total, 3,394 samples each of top and deep catchment sediments were collected, and Nb and Ta concentrations were measured using inductively coupled plasma mass spectrometry under strict quality control conditions. The Nb concentrations in the top and deep sediment samples varied in the ranges 0.04–89.86 ppm with a median value of 12.71 ppm and 1.20–104.12 ppm with a median value of 12.41 ppm, respectively. Further, the Ta concentrations in the top samples ranged from 0.01 to 26.41 ppm with a median of 0.97 ppm, while those in the deep samples ranged from 0.14 to 26.41 ppm with a median of 0.96 ppm. Furthermore, both the top and deep samples had similar 2.5th, 25th, 50th, 75th, and 97.5th percentile Nb and Ta contents, indicating that Nb and Ta in the catchment sediments underwent similar and consistent formation processes. Our results also

indicated that the
concentrations of both elements varied widely across regions, and their distributions in the catchment sediments
throughout China were predominantly governed by the parent rock, particularly granites and alkaline rocks.
Mineralization and sedimentation properties also played roles at a regional scale. Overall, the spatial distributions
of Nb and Ta in the top and deep catchment sediments were relatively consistent, with concentrations being
higher in southeastern China and lower in northwestern China. Twelve large-scale geochemical Nb-Ta belts were
delineated based on continuous anomalous point distributions wherein many well known Nb-Ta deposits are
already located. These nationwide Nb and Ta concentrations and distributions provide foundational large-scale
data for further exploration and geological studies.

Keyword

Concentration, Spatial distribution, Niobium, Tantalum, China Geochemical Baselines project

K isotope separation based on liquid solution centrifugation and its application to cation exchange experiments between birnessite and aqueous solution

Jiayang CHEN[1]*, Nanjing University (840513732@qq.com)
Weiqiang Li[2], Nanjing University
Huan Liu[3], Nanjing University

Abstract

Enriched isotope tracers play a crucial role in various geochemical, biological and environmental research endeavors, however, isotope tracers are generally expensive and difficult to produce. Recently, liquid solution centrifugation was emerged as an efficient method for isotope separation. We generated millimole-level 39K enriched (δ41K < -8‰) and 41K enriched (δ41K > 8‰) KCl solutions through ultra-centrifugation. Using the produced stable K isotope tracers, we investigated the exchange and fractionation of K isotopes between aqueous solutions and K-bearing birnessite. The results reveal that the cation exchange between K in birnessite and aqueous K are very fast, and efficient exchange of K between the two phases can be achieved within 1 hour. The K isotope results align well with the model for first-order rate reactions. A fractionation facotr (Δ41Ksolid-aq) of -0.11 ± 0.02 ‰ was derived after two systems, progressing from opposite directions, achieved equilibrium. Our results also indicate an obvious influence on the exchange rate caused by the particle size of birnessite. Our study highlights the promising potential of the solution centrifugation method in isotopic exchange experiments, offering a viable alternative to traditional isotope spikes for measuring isotope fractionation and tracing kinetic processes. The measured Δ41K fractionation between birnessite and solution indicates insignificant fractionation between natural Fe-Mn oxides and their surrounding solutions. The efficient exchange of K between the solution and birnessite suggests that the K in natural Fe-Mn oxides is likely to be labile and sensitive to the surrounding solutions.

Keyword

isotope separation, cation exchange, isotope fractionation, manganese oxides

Comprehensive assessment of Cu, Mo, Pb, and Zn isotopes in contaminated groundwater, surface water, and soil in Erdenet city, Mongolia

Dukmin KIM[1]*, Sangji University (kdukmin8@sangji.ac.kr)
Bayartungalag Batsaikhan[2], Institute of Geography and Geoecology
Dae-Gyu Im[3], Korea University
Hyeon-Soo Seo[4], Korea University
Oyungerel Sarantuya[5], Mongolian University of Science and Technology
Telmen Turmunkh[6], Institute of Geography and Geoecology
Erdenetsetseg Tsogtbayar[7], Institute of Geography and Geoecology
Seong-Taek Yun[8], Korea University

Abstract

Major mining cities worldwide have been developed near places enriched with ore deposits. These cities, however, have also suffered from contamination of soil and water. Erdenet, the second largest city in Mongolia, has a world-class Cu-Mo mine, and surface water, groundwater, and soil have been contaminated by Cu, Mo, As, and SO42-. Surface water, groundwater, soil, and ore samples were analyzed for δ65Cu, δ2HH2O-δ18OH2O, δ98Mo, 208Pb/206Pb, δ34SSO4-δ18OSO4, and δ66Zn.

Cu and Mo contents were particularly high in the S-T1 soil sample, which was collected as surface dust, possibly originating from a tailings dump. δ65Cu, δ66Zn and 208Pb/206Pb in soil approached those of S-T1 with increasing Cu, Zn, and Pb content, suggesting that wind-blown tailings were the dominant soil contamination source. Also, Cu, Mo, Pb, and Zn isotopic ratios and Zn/Cd ratios revealed that the eastern part of the residential area was influenced by the tailings.

δ65Cu and δ98Mo in surface water and groundwater in the area in front of the tailings dam and near the open pit were higher than those in S-T1 and ore minerals, respectively. This indicated that oxidative dissolution increased δ65Cu and subsequent adsorption and/or precipitation (e.g., wulfenite) increased δ98Mo. Groundwater wells near the heap leaching area also exhibited higher δ65Cu and δ98Mo than those of soil in the waste rock area, suggesting contamination from heap leaching activity. In contrast, another well in the heap leaching area had distinguished δ65Cu, δ98Mo, δ2H, and δ18O, which suggested the other Mo and water source from the east. Downstream of a coal ash pond used in a power plant, stream water exhibited increased Mo concentrations and distinctly low δ98Mo, which increased after the junction with seepages from the tailings dump, suggesting the mixture of Mo contamination and adsorption of Mo in the stream. In the advanced argillic alteration zone in the northwest, groundwater had low pH and δ34SSO4 and high Zn and SO42- concentrations and δ66Zn, indicating alteration characteristics. δ34SSO4, δ65Cu, and δ98Mo of groundwater and surface water in the residential area were similar to those of groundwater in the alteration zone, indicating the influence of contamination by the alteration zone.

Overall, contamination sources and geochemical reactions in the region could be comprehensively

described using various isotopes. Use of δ65Cu, δ2HH2O-δ18OH2O, δ98Mo, 208Pb/206Pb, δ34SSO4-δ18OSO4, and δ66Zn could track diverse sources of water and soil contamination. Also, the geochemical reactions were indicated by specialized isotopic ratios. Particularly, oxidative dissolution, sulfate reduction, and adsorption could be effectively revealed by δ65Cu, δ65Cu-δ34SSO4-δ18OSO4, and δ66Zn-δ98Mo, respectively.

Acknowledgements: This research was partly supported by the Korea Environmental Industry and Technology Institute (KEITI) through the project funded by the Korea Ministry of Environment (MOE) (2021002440003). This research was also partly supported by the Development of Source Identification and Apportionment Methods for Toxic Substances in Marine Environments Program of the Korea Institute of Marine Science & Technology Promotion (KIMST) funded by the Ministry of Oceans and Fisheries (KIMST-20220534) and by Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR) in 2024.

Keyword

mining, tailings, metal isotope, soil contamination, water contamination

The Cenozoic Seawater Conundrum: New constraints from Mg isotopes

Zhongya HU[1]*, Tongji Univeristy (zhongyahu@tongji.edu.cn)
Weiqiang Li[2], Nanjing Univerisity
Shouye Yang[3], Tongji Univeristy
Zhiguang Xia[4], Nanjing Univerisity
Chuan Liu[5], Nanjing Univerisity

Abstract

The Mg/Ca ratio of seawater increased from ~1.5 to its present value of 5.4 over the Neogene, indicating a fundamental imbalance in the Mg–Ca cycle during the late Cenozoic. The imbalance in Mg–Ca cycles since the late Cenozoic, however, is contrasted by an arguable constancy in the Mg isotope compositions of seawater (δ26Mgsw) reconstructed from several low-resolution carbonate records. Addressing such Cenozoic Seawater Conundrum requires reliable seawater Mg isotopic records. The Xisha Islands in the South China Sea host large Cenozoic dolostone sequences that record seawater chemistry over the past 23 Myr. This study reports the Mg isotopic and trace elemental compositions of island dolostones in the well-studied Xike-1 drill core from the Xisha Islands. Petrographic, C–O–Sr isotopic, and paleomagnetic data from the drill core samples collectively support a “fluid-buffered”, syn-depositional origin for the dolostones. The dolostones from the Xike-1 core have a narrow range of δ26Mg (-2.83‰ ± 0.12‰), confirming that δ26Mgsw have been stable around the modern value (-0.83‰) since the late Cenozoic. This record provides a new opportunity to better understand the Mg–Ca cycle during the late Cenozoic. To better constrain the δ26Mg value of silicate weathering flux, we present mineralogical, elemental, and Mg isotopic compositions of terrigenous siliciclastic sediments in the Changjiang (Yangtze River) estuary and the adjacent continental shelf of the East China Sea. δ26Mg values of the clay-sized sediments vary from -0.15‰ to 0.00‰ and lack of the correlation with the proportion of different clay minerals. An isotopic mass balance calculation indicates that the δ26Mg value of silicate weathering flux on a continental scale is ca. -0.60‰ to -0.40‰. With these up-to date flux and isotope fractionation data, we ran numerical models of global seawater Mg-Ca contents and δ26Mgsw. The results show that the contrast between the constancy of δ26Mgsw values and the dramatic increase in seawater Mg/Ca ratios cannot be explained by a single mechanism (i.e., a decrease in the rate of phyllosilicate formation on the seafloor alone). Instead, processes involving different Mg fluxes need to be coupled to explain the observed trends in Mg content and isotopic compositions of Cenozoic seawater. The solution to the Cenozoic Seawater Conundrum includes simultaneous decreases in the rates of both clay formation and dolomitization on the seafloor, or an increase in the rate of both continental weathering together with decreased seafloor clay formation. Our study underlines the sensitivity of the Mg cycle to the interactions between climate, continental weathering, and seafloor processes during the late Cenozoic.

Keyword

Mg isotopes, late Cenozoic, Mg/Ca ratios, Mg cyle

Experimental determination of kinetic isotope fractionation during chemical diffusion of alkaline and alkaline-earth elements in aqueous solution

Weiqiang LI[1]*, Nanjing University (liweiqiang@nju.edu.cn)
Zhihan Ji[2], Nanjing University
Xianglong Luo[3], Nanjing University
Yuqi Li[4], Nanjing University

Abstract

We developed a “diffusion-cell” method to determine diffusion-driven kinetic isotope fractionation factors of seven metal cations in aqueous solutions. This method utilizes a Rayleigh process to magnify the isotopic effect associated with diffusion and enables continuous determination of the isotopic evolution of fluids during the Rayleigh fractionation, thus it provides superior efficiency and precision compared with other methods for experimental determination of diffusion-driven isotope fractionation in aqueous solutions. Using the “diffusion-cell” method, we measured the kinetic isotope fractionation factors (α) for seven alkaline and alkaline earth elements (Li, K, Rb, Mg, Ca, Sr, Ba) in aqueous solutions at 25ºC, and calculated the index of mass dependence of isotope fractionation during diffusion (β) for these elements. The obtained isotope fractionation factors are, α7/6Li = 0.996139α41/39K = 0.998572α87/85Rb = 0.999333α26/24Mg = 0.999877α44/42Ca = 0.999704α88/86Sr = 0.999781α138/135Ba = 0.999716. The β factors show a strong dependence on the charge of the cation and the ion-water bond length for the aquo ions of the metals, suggesting that the isotope effect of diffusion of cations in aqueous solutions is fundamentally controlled by the strength of cation-water interaction, with more prominent kinetic isotope fractionation occurring for the case of weaker cation-water interactions. Therefore, heavy elements can still exhibit large diffusion-driven isotope fractionation in supergene environments, this is opposite to equilibrium isotope fractionation which decreases in magnitude dramatically for heavy elements. Therefore, attention to diffusion is needed particularly for stable isotope studies of heavy elements.

Keyword

Diffusion, isotope fractionation, alkaline elements, alkaline-earth elements, aqueous solution

Stable chromium isotope fractionation during the alteration of abyssal peridotite: Implications for marine chromium isotope mass balance

LiJuan Li Xu[1]*, China University of Geosciences (Beijing) (xulj@cugb.edu.cn)
Yang Chun Liu[2], China University of Geosciences (Beijing)
Hai Bo Ma[3], China University of Geosciences (Beijing)
Sheng Ao Liu[4], China University of Geosciences (Beijing)
Ping Ping Liu[5], Peking University
Xiang Li Wang[6], Institute of Geology and Geophysics, Chinese Academy of Sciences
Ning Shu Li[7], Peking University

Abstract

The stable chromium isotope system has been widely used as a redox proxy to reconstruct the oxygenation history of ocean atmosphere systems. However, the Cr isotope mass balance in modern oceans (i.e., inputs and outputs) remains poorly constrained. To investigate the influence of seawater-peridotite reaction on the global marine Cr isotope mass balance, we report high-precision Cr isotope data (d53Cr) on a series of fresh and altered abyssal peridotites from the Gakkel Ridge and the Southwest Indian Ridge (SWIR). The least altered peridotites give a d53Cr value of –0.08 ± 0.06‰ (2SD, n = 4) for the oceanic mantle which is consistent with the established d53Cr of the Bulk Silicate Earth. Compared to fresh peridotites, a subset of altered peridotites exhibit a loss of isotopically light Cr with relatively positive d53Cr values (up to 0.04‰). These altered peridotites are characterized by significant Cr loss and likely have been subject to serpentinization. By contrast, seafloor weathering has limited influence on the Cr concentrations and isotopic compositions of the altered peridotites. Monte Carlo (MC) simulations of marine alteration suggest a net Cr flux into seawater from altered abyssal peridotites of ~3.5 × 108 mol/yr, which is on the same order of magnitude as the riverine input flux of 108–109 mol/yr. Furthermore, the MC results suggest that the peridotite-sourced net Cr flux has a negative d53Cr signature (−0.33 ± 0.21‰, 2SD). Thus, seawater-peridotite interactions must be considered when evaluating the modern oceanic Cr isotope mass balance.

Keyword

Oceanic Cr mass balance, Chromium isotope, Seafloor weathering, Serpentinization, Abyssal peridotite

Applying standard addition to measure antimony isotopes in low-Sb samples using HG-MC-ICP-MS

Jian-Ming ZHU[1]*, State Key Laboratory of Geological Processes and Mineral Resources,China University of Geosciences (Beijing) (jmzhu@cugb.edu.cn)
Honggang Zhu[2], State Key Laboratory of Geological Processes and Mineral Resources,China University of Geosciences (Beijing)
Decan Tan[3], State Key Laboratory of Environmental Geochemistry, Institute of Geochemistry, Chinese Academy of Sciences
Zhuo Lu[4], State Key Laboratory of Geological Processes and Mineral Resources,China University of Geosciences (Beijing)
Hongfei Liao[5], State Key Laboratory of Geological Processes and Mineral Resources,China University of Geosciences (Beijing)

Abstract

The standard addition (SA) method has been successfully employed in measuring metal stable isotopes in recent years. Here, using hydride generation (HG)-multicollector inductively coupled plasma mass spectrometry (MC-ICP-MS, Nu Plasma II and Neptune Plus), we evaluated the method's robustness through achieving the high-precision data of the δ123/121Sb(antimony) values (relative to NIST 3102a) in samples with more complex matrices and low-Sb concentrations. By using element doping (113/111cadmium) coupled with sample-standard bracketing (SSB), the Sb isotope ratios of numeral geological and environmental reference materials (GRMs/ERMs) were reported, and selected GRMs agreed well with previously published values. Then, five of which with low-Sb concentrations were chosen to conduct the SA. According to the isotope binary mixing and error propagation model, the analytical precision (2 standard deviation: 2SD) is a function of only sample fraction(fspl). The ideal mixing range for calculating δ123/121SbNIST 3102a ratios of low-Sb samples using the SA method is suggested as fspl = 0.4 – 0.6, and better precision can be achieved with ≤ 0.09‰ (2SD) during this range. The δ123/121Sb ratio calculated for basalt BCR-2 (Sb = 0.30 μg/g) was 0.28 ± 0.09‰, confirming that the accurate and precise Sb isotopes can be measured for samples with as low as 5 ng Sb and the uncertainty is adequate to distinguish the natural variation of Sb isotopes with the total range of ~1.93‰ that found so far. Validating the measurement of Sb isotope composition in low-Sb samples with complex matrices by SA will expand the application of Sb isotopes in environmental, agricultural, life and Earth/Planetary sciences.
This work was financially supported by Natural Science Foundation of China (No. 41973018).

Keyword

Antimony isotopes, Standard addition, Low-Sb samples, Reference materials, HG-MC-ICP-MS

Lithium rich salt lakes in small-scale basin on the Qinghai Tibet Plateau——Tracing by lithium isotope

Maoyong HE[1]*, State Key Laboratory of Loess and Quaternary Geology, Institute of Earth Environment, Chinese Academy of Sciences (hemy@ieecas.cn)
Zhengyan Li[2], Taiyuan university of technology
Yulong Li[3], Qinghai Institute of Salt Lakes, Chinese academy of Sciences
Binkai Li[4], Qinghai Institute of Salt Lakes, Chinese academy of Sciences

Abstract

Lithium-rich salt lakes have attracted much attention as important lithium resources. The source and enrichment mechanisms of lithium in salt lakes are fundamental to uncovering the genesis of brine-type lithium deposits. However, the origin of lithium in salt lakes has been controversial, especially for the holistic study on the source-transport-storage of lithium rich salt lakes, there is still a lack of research at present. The lithium isotope, which serve as discerning geochemical tracers, can facilitate the monitoring of geological processes and sources. Among the numerous lithium rich salt lakes on the Qinghai Tibet Plateau, small-scale salt lakes have become an important part of salt lake research due to their unique geological background and short transportation distance. We investigated the hydrochemistry, Li isotope characteristics of surface brine and recharge river samples collected from the Lakko Co and Kushui lake on the Qinghai-Tibet Plateau in China, and further analyze the sources and transport process of lithium elements in lithium rich salt lakes. The results indicate that the main material sources of the two lithium rich salt lakes are basically related to rock weathering, deep crustal water rock interaction, and hot springs. However, due to the different geological backgrounds of the two lakes, the contribution of these factors also varies. The transportation process is characterized by the precipitation of secondary mineral, resulting in an increase of δ^7Li. Meanwhile, source-transport-aggregation models for both lakes have been established, this investigation of the lake contributes to a more comprehensive understanding of the origins and mechanisms involved in the transportation and storage of lithium in lithium-rich salt lakes.

Keyword

Li-rich salt lake, Li isotope, source of Li, Enrichment mechanism

Links between the Archean anoxic continental weathering and the Great Oxidation Event

KE SHAN[1]*, China University of Geosciences, Beijing, China (keshan@cugb.edu.cn)
Li Rui-Ying[2], Institute of Geology and Geophysics, Chinese Academy of Sciences, Beijing, China
Li Shuguang[3], China University of Geosciences, Beijing, China
Wan Yusheng[4], Institute of Geology, Chinese Academy of Geological Sciences, Beijing, China
Song Shuguang[5], Peking UniversityBeijingChina
He Yongsheng[6], China University of Geosciences, Beijing, China
Liu Sheng-Ao[7], China University of Geosciences, Beijing, China
Liu Jingao[8], China University of Geosciences, Beijing, China

Abstract

Continental composition shift from mafic to felsic in the late Archean was widely proposed to have induced the Great Oxidation Event (GOE). Here, using iron isotopes of 3.0-2.5 Ga crustal rocks, we show that anoxic weathering of Archean continents caused the rise of continental oxidation and signifcantly contributed to the GOE. S-type potassic granites show statistically heavier Fe isotope compositions compared to I-type potassic granites and tonalite-trondhjemite-granodiorites (TTG), indicating anoxic chemical weathering recorded in their sedimentary precursors. Because during anoxic weathering processes, soluble Fe2+ with light isotopes was finally transported into the ocean and insoluble Fe3+ with heavy isotopes retained in the regoliths. Notably, younger (2.5 Ga) S-type potassic granites have higher δ56Fe and K2O/Na2O ratios than the older (3.0 Ga) ones, suggesting that prolonged anoxic weathering led to Fe3+ accumulated in the sediments towards the end of Archean. Taking the global Archean granitoids into account, a statistic result shows a growing S-type potassic granites from 3.5 Ga to 2.5 Ga. Acorrdingly, more volcanic oxidized gas equilibrated with S-type potassic granitic magma would be released, accelerating atmospheric oxygen increase and subsequently contributing to the GOE. Besides, in the process of the anoxic continental weathering, large amounts of Fe2+ were released into the ocean over a billion years from 3.5 Ga to 2.5 Ga, providing abundant iron for massive banded iron formations (BIF) during the GOE. Therefore, anoxic weathering of Archean continents was a key contributor to oxidation accumulation of continental crust, the GOE and the large-scaled BIF formation.

Keyword

Archean, anoxic weathering, GOE, Fe isotopes, granitoids

Tracing meltwater discharge with Ba isotopes from West Greenland fjords

Ruifang C. XIE[1]*, Shanghai Jiao Tong University (ruifang.xie@sjtu.edu.cn)
Xuewei Jin[2], Shanghai Jiao Tong University
Te Liu[3], GEOMAR Helmholtz Centre for Ocean Research
Jana Krause[4], GEOMAR Helmholtz Centre for Ocean Research
Mark Hopwood[5], Southern University of Science and Technology

Abstract

Climate-induced meltwater discharge from high-latitude glaciers comprises of an important component of the global water and nutrient budgets. How the fluxes of glacier meltwater vary in space and time in response to climate change is the frontier in marine sciences, yet also remains a matter of intense debate. In this study, we present dissolved Ba and δ138Ba from three fjords (Disko, Arfersiorfik, Qasigiannguit) in Disko Bay, West Greenland to investigate the magnitude of meltwater release and the subsequent nutrient discharge within these fjord systems. Preliminary data show contrasting results regarding the biogeochemistry of Ba and Ba isotopes at different fjords. The Ba concentrations ([Ba]) at the Arfersiorfik fjord (up to 400 nmol/kg) are drastically higher compared to those from the Disko fjord (50-60 nmol/kg), with the former corresponding to a much higher fresh water flux. Correspondingly, surface water δ138Ba at the Arfersiorfik fjord approaches near crustal values. At the Arfersiorfik fjord, strong binary correlations between [Ba] and salinity, and between δ138Ba and 1/[Ba] are observed. These correlations suggest conservative, binary mixing of meltwater vs. seawater endmembers, contrary to previous observations that reported nonconservative behavior of Ba and δ138Ba at continental margins. Conversely, no significant correlation is observed at either Disko or Qasigiannguit fjord. Our study suggests that contrasting lithologies and the magnitude of meltwater fluxes along West Greenland post the dominant control at land-to-sea Ba discharge, and that Ba and δ138Ba could reliably trace hydrodynamic mixing processes in West Greenland fjords.

Keyword

West Greenland, Meltwater, Barium isotopes, Water mass mixing, Climate Change

Cadmium Isotope Fractionation during Adsorption onto Edge Sites and Vacancies in Layered Manganese Dioxides

Hui YIN[1]*, Huazhong Agricultural University (yinhui666@mail.hzau.edu.cn)
Xinran Yan[2], Huazhong Agricultural University
Chuanwei Zhu[3], Chang'an University
Kideok D. Kwon[4], Kangwon National University
Xueyuan Gu[5], Nanjing University
Wei Zhao[6], Northwest A&F University
Bruno Lanson[7], Univ. Grenoble Alpes, Univ. Savoie Mont Blanc
Wei Li[8], Nanjing University
Jingyuan Ma[9], Chinese Academy of Sciences
Xionghan Feng[10], Huazhong Agricultural University
Wenfeng Tan[11], Huazhong Agricultural University
Hanjie Wen[12], Chang'an University
Fan Liu[13], Huazhong Agricultural University

Abstract

Heavy metal pollutants cause serious threats to animal and human health, and have been widely concerned. The primary work of heavy metal pollutants control is to determine the source of pollution. With the rapid development of Multi-Collector Inductively-Coupled-Plasma Mass Spectrometry (MC-ICP-MS), the isotopic compositions of metals can be accurately measured, and thus makes it possible to use metal isotopes to metal pollution sources in the environment. In terrestrial and marine environments, manganese oxides exist widely and have high reactivity towards heavy metals through adsorption processes. This will cause isotopic fractionation, and hinder the application of metal stable isotope in the environment. But the underlying mechanisms are not clear yet. In this study, the isotope fractionation behavior and mechanism of Cd during adsorption on layered manganese oxides were elucidated. Results show that Cd adsorbed on triclinic birnessite reaches isotope equilibrium within 72 h, and the light Cd isotope is preferentially enriched on the mineral surfaces, which belongs to the equilibrium fractionation model. The theoretical isotopic fractionations ($\Delta^{114/110}Cd_{solid\text{-}solution}$) during Cd^{2+} adsorption onto triclinic birnessite and hexagonal birnessite are -1.54 ± 0.11‰ and -0.96 ± 0.06‰, respectively. EXAFS and DFT analysis show that Cd forms triple-corner-sharing complexes at vacant sites and double-corner sharing complexes at the edge sites. Based on the relative proportions of Cd^{2+} binding on vacancies and edge sites of hexagonal birnessite determined by surface complexation modeling, the Cd isotope fractionations on edge sites and vacancy sites are calculated to be -1.54 ± 0.11‰ and -0.68 ± 0.15‰, respectively.

Keyword

manganese oxide, metal isotope fractionation, Cd, adsorption

Coupling of Molybdenum, Barium, and Sulfur (Mo-Ba-S) biogeochemistry in demarcating past methane seepage episodes

Sai Pavan Pillutala[1], csir-National Institute of Oceanography
aninda mazumdar[2]*, CSIR-National Institute of Oceanography (maninda@nio.org)
Aditya Peketi[3], csir-National Institute of Oceanography
Anjali Zatale[4], csir-National Institute of Oceanography
Kalyani Sivan[5], csir-National Institute of Oceanography

Abstract

Molybdenum (Mo) concentrations and isotope ratios can serve as indicators for past occurrences of methane seepage/ sulfidic events at the sediment-water interface in marine realms. These events may often be episodic in nature and may be traced through geological history from high-resolution studies of sediment cores. Methane seep regions are typically characterized by episodic flux enhancement leading to hydrogen sulfidic enrichment at the sediment-water interface. The recent discovery of extensive occurrences of active methane seep sites in the Krishna-Godavari basin has opened up the opportunity to investigate such episodic methane/ H2S enrichment events. Here we present a high-resolution Mo concentration, Mo isotope ratio (d98Mo), pyrite-sulfur isotope ratio (d34SFeS2), and Ba concentration measurements in a core from the KG- basin seep site. Sediment sampling was carried out on board ORV Sindhu Sadhana (SSD-045) at a water depth of 1760 meters. The pyrite-S contents range from 0.13 to 2.54 wt%. The Mo concentrations and d98Mo ratios vary from 1 to 17.4 ppm, and +0.3 to 2.37‰ respectively. Throughout the core several Mo concentration peaks (Mo concentrations > crustal average of ~2 ppm) are observed which may be attributed to focussed precipitation of MoS42- (Thiomolybdate). The Mo concentration peaks are closely associated with the low d34S values (-18 to -38 ‰) suggesting sulfidization at the sediment-water interface. The whole sediment d98Mo values range from typical seawater value (~2.3‰) to as low as 0.1‰ suggesting variable contributions of iron minerals, siliciclastic and organic matter. The consistent presence of barium fronts (high Ba/Al compared to non-cold seep cores) on the other hand suggests a recent drawdown and methane flux and drop in the depth sulfate–methane transition zone (SMTZ). Our results are tell-tale signatures of remarkable variation past methane flux and accompanied sediment biogeochemistry. A detailed Mo-speciation work is being carried out to deconvolute the deposition versus diagenetic overprinting of Mo isotope signature
Keywords:

Keyword

Mo-isotope, sulfur, SMTZ, barium front

Equilibrium metal isotopic fractionations at the calcite-water interface

SANGBO SON[1]*, Kangwon National University (s3247@kangwon.ac.kr)
Weiqiang Li[2], Nanjing University
Kideok Kwon[3], Kangwon National University

Abstract

The non-traditional metal isotope composition of natural calcite has emerged as a potential indicator to infer insights into the Earth's paleo-geochemical history. A key observation from experiments is that the isotopic fractionation factors of metals between calcite and aqueous solution depend on the crystal growth rate. As the growth rate increases, the isotope fractionation factor increases for some metals, but it decreases for some metals. However, underlying mechanisms of the growth rate-dependent isotopic variations have not been established yet. In this presentation, we demonstrate that equilibrium isotopic fractionation at the calcite-water interface, which has been neglected so far, can play an important role in the isotopic variation during crystal growth. For some divalent metal isotopes (Ni, Mg, Zn, Ca, Sr, Ba), we calculated their reduced partition function ratios [= (10^3)lnβ] of the calcite-water interface and of bulk calcite using density functional theory calculations. The calculated metal (10^3)lnβ values at the interface are distinctively greater or smaller than in the bulk lattice, depending on the metal element. Comparison of these values with the observed isotopic variations indicates that the isotopic composition shifts from the bulk composition toward the interface composition at faster growth rates. We shall discuss the roles of equilibrium isotopic fractionation at calcite-water interface in the isotopic variations during mineral crystallization.

Keyword

non-traditional metal isotope, crystal growth rate, density functional theory, bulk and surface isotopic composition

Zinc isotope fractionation during wastewater treatments

Jeonghun KIM[1]*, Department of Earth and Environmental System Sciences, Pukyong National University (hyun6569@naver.com)
Jong-Sik Ryu[2], Department of Earth and Environmental System Sciences, Pukyong National University
Kongtae Ra[3], Marine Environmental Research Center, Korea Institute of Ocean Science and Technology (KIOST), Busan, Korea

Abstract

Environmental pollution is a significant issue in modern urban areas, in which zinc (Zn) can accumulate in plants, animals, and humans within the ecosystem, leading to severe health issues. In recent, Zn isotopes have been used to trace the origin of contamination sources and understand the behaviors in the aquatic environment, although Zn isotopes could be fractionated during wastewater treatment with either inorganic or organic reactions. Here we collected dissolved and particulate samples during three different treatments, and measured their Zn isotopes in order to examine how and to what extent they may be fractionated.

Measured δ66ZnJMC values in particulate (PM) and dissolved (DM) samples range from 0.00 to +0.29 ‰ and –0.05 to +0.47‰, respectively. Furthermore, the differences in δ66ZnJMC values between PM and DM samples (Δ66ZnPM-DM) during wastewater treatments indicate that abiotic process can fractionate Zn isotopes up to –0.32‰, while biotic process up to +0.33‰, respectively. This result suggests that abiotic and biotic processes favors light and heavy Zn isotopes, respectively, although the magnitude of Zn isotope fractionation is similar. Although the magnitudes of Zn isotope fractionation by abiotic and biotic processes is a slightly less than those in previous experimental studies, the direction of Zn isotope fractionation is consistent with them. However, the difference in Zn isotopes between the influent and effluent is only –0.04‰ because the combination of abiotic and biotic processes during wastewater treatments with three different methods hinder the effect of Zn isotope fractionation.

Keyword

Zn isotope, WWTP, fractionation, abiotic/biotic, biotic

Influence of estuaries on chromium isotope ratio and geochemical behavior: A study in two rivers, Kochi, Japan

Akane ITO[1]*, Kyushu University (aito@mine.kyushu-u.ac.jp)
Kazuto ISAMOTO[2], Kwansei Gakuin University
Masaharu TANIMIZU[3], Kwansei Gakuin University

Abstract

Chromium (Cr), a redox-sensitive element, has two stable oxidation states, Cr(Ⅵ) and Cr(Ⅲ), with Cr(Ⅵ) being more soluble than Cr(Ⅲ) under oxidative conditions. The Cr isotope system ($^{53}Cr/^{52}Cr$, hereafter $\delta^{53}Cr$) is a promising redox proxy due to the highly variable isotope fractionation in the surface environment, mainly resulting from the conversion between Cr(Ⅲ) and Cr(Ⅵ). Recently, $\delta^{53}Cr$ values recorded in marine sediments have attracted researchers to reconstruct ancient atmosphere-ocean redox conditions. Such an application is only possible if some variables can be constrained, such as Cr flux and $\delta^{53}Cr$ of the global river input, isotopic fractionation factors during the removal process. Rivers are important sources of dissolved chromium to the ocean. However, the effects of the estuarine mixing zone on changes in Cr flux, redox speciation and $\delta^{53}Cr$ in rivers are not well understood (Mallick et al., 2022). To better understand estuarine Cr isotopic and geochemical behavior, this study investigated Cr concentration, speciation, and isotopic ratios along salinity gradients in two rivers in Kochi Prefecture, Japan.

The Kuma and Sakura Rivers flow through serpentinite and limestone area, respectively, and finally flow into the Pacific Ocean. River water and riverbed sediment porewater samples were collected from each river in the winter and summer of 2023. The concentrations of major anions and cations were measured by IC, and trace element and Cr speciation were determined by ICP-MS and HPLC-ICP-MS, respectively. The total Cr isotope ratios of river water samples were analyzed by double-spike TIMS after pre-concentration of Cr by Fe(Ⅱ) coprecipitation using 0.5 to 2 L river water samples, followed by 3-step column separation.

In both rivers, Cr(Ⅵ) was dominant, with a decreasing concentration downstream, and the $\delta^{53}Cr$ values increased until salinity reached 10 PSU and then decreased downstream. The logarithm of total Cr and $\delta^{53}Cr$ were negatively correlated at low salinity. This suggests that Cr(Ⅵ) may have been partially reduced to Cr(Ⅲ) and removed from river water. For the estuarine mixing zone of the Sakura River, a simple mixing model between river and seawater end members roughly explained the trend of $\delta^{53}Cr$ along the salinity, suggesting that conservative mixing may control Cr concentration and isotopic variations. In contrast, downstream of the Kuma River showed a slight increase in total Cr and a significant decrease in the $\delta^{53}Cr$ values. This may be due to the inflow from porewater, supported by the fact that porewater contains higher Cr concentration than river water and $\delta^{53}Cr$ values of sediment porewater reported so far are relatively lower than those of river water. Alternatively, dilution by river water with unidentified low Cr concentrations could

be responsible. These results suggest that most dissolved Cr has been removed and redox induced isotope fractionation has occurred before the estuary. In the estuarine mixing zone, the main mechanism controlling Cr isotopic ratios may be conservative mixing with seawater, although release of Cr from benthic sources may also have some effect.

Keyword

chromium isotopes, speciation, river, estuary, redox reactions

Geochemistry of shale, quartzite and carbonaceous shale of the Cumbum Formation of Kadapa Basin: Implications for provenance, weathering and tectonic setting

Raghunath MISHRA[1]*, Geological Survey of India (raghunath.mishra@gsi.gov.in)

Abstract

Representative fresh bed rock samples were collected from shale and quartzite lithounit for whole rock analysis to decipher their provenance, paleo-weathering conditions and tectonic setting. The shales have high Al2O3, Fe2O3, K2O, TiO2,Ga, La, Nb, Rb, Sc, Sr, Th and Y content more than the quartzites, whereas, quartzites are higher in SiO2, Cu, Hf and Zr than the shales. The shale samples plot on the two triangular diagrams in the relatively more weathered region and also in the A–CN–K diagram above the granodiorite and shale suggesting a source which had suffered relatively a high degree of chemical weathering. Al2O3 is positively co-related with other elements as well as the abundance of Ba, Ce, Th, Rb, Zn and Zr suggest that these elements are primarily controlled by the dominant clay minerals. From the Fe2O3/K2O versus SiO2/Al2O3 plot the studied samples classify as shales and out of four quartzite samples, one sample falls in the sub-arkose field and the rest three falls in Fe-sand field. For the quarzitic samples, La/Sc, Th/Sc, La/Co and Th/Co values are more similar to values for sediments derived from felsic source rocks than to those for mafic source rocks, thus suggesting felsic source rock. Th/U ratios in the quartzites range from 0.83 to 1.45 indicating the quartzites neither suffered intense weathering nor intense recycling. Th/Sc ratio is used to know the composition of the source rocks. When Th/Sc is plotted on the diagram of Zr/Sc–Th/Sc, the recycled source rocks for the all quartzite samples from the study area are further supported by their high Zr/Sc ratio. Out of four samples two samples are enriched in zircon due to sedimentary sorting and recycling and the rest two samples fall in between andesitic to felsic magmatism field. On a chondrite-normalised diagram, the studied shales display slightly enriched LREE patterns (average LaN/SmN = 5.27), small negative Eu (average Eu/ Eu* = 0.69) and fairly flat HREE patterns (average GdN/YbN = 0.13) except for Yb which are characteristic of sediments derived from upper continental crust. The chondrite-normalized REE patterns for the studied quartzitesare characterized by high light REE/heavy REE (LREE/HREE) ratio (6.79-15.52), flat HREE pattern except Yb and pronounced negative Eu anomaly.LREEs are fractionated, (La/Sm)n = 4.98 and the HREE patterns are almost flat, (Gd/Yb)n = 0.15. This chondrite-normalized pattern is typical of sediments and sedimentary rocks enriched in light REE (LREE), flat heavy REE (HREE) and negative Eu anomaly. The ratio of log K2O/Al2O3 vs log MgO/Al2O3 was used to demarcate the marine and non-marine clay and it shows that studied samples fall in the marine part. Tectonic discrimination diagrams revealed that the carbonaceous shales are mostly of quartzose sedimentary provenance, suggesting that they were derived from a cratonic interior or recycled orogen. The ternary diagram of V-Ni- Th*10 indicate that the studied carbonaceous shales are derived from felsic source rocks. V/(V + Ni) ratios of carbonaceous shale suggest that the carbonaceous shales were deposited in a marine

environment with euxinic conditions.

Keyword

Kadapa, carbonaceous shale, whole rock geochemistry, diagenesis, depositional environment and tectonic setting

Anthropogenic Activities Have Accelerated the Global Sulphur Cycle

Haoyang NIE[1]*, Nanjing University (niehy@smail.nju.edu.cn)
Shilei LI[2], Nanjing University
Yang CHEN[3], Nanjing University

Abstract

The oxidation weathering process of sulfides is increasingly recognized as a significant negative feedback mechanism in the carbon cycle, potentially playing a crucial role in stabilizing the global climate during the Cenozoic era. Recent findings indicate that the carbon flux coupled with sulfide oxidation weathering may be considerably underestimated, and precise calculations of its actual flux are still lacking. It is widely acknowledged that sulfur sources in rivers primarily include sulfides, evaporites, and human activities. The dissolution of evaporites is generally believed to have a neutral impact on the carbon cycle and remains stable over a specific period. We focus on human activities in this work partly because they can interfere with the signal of sulfide oxidation weathering entering the ocean and partly due to the complex impact of this process on the carbon cycle. To accurately estimate the flux of sulfide oxidation weathering, it is necessary to exclude the influence of human activities.

We have identified that human activities predominately affect the global sulfur cycle in two ways: first, by entering rivers through direct emissions and second, by notably increasing the release of sulfur element through glacier activity influenced by climate change. Spatially, these two processes collectively accelerate the sulfur cycle in rivers both downstream and upstream. Our research involved gathering data on sulfate concentrations in major rivers globally, supplemented by new test results. Overall, there is a discernible upward trend in sulfate concentrations. Endmember decomposition analysis highlights anthropogenic activities as key sulfur sources, primarily driven by the combustion of fossil fuels. Additionally, we observed significant growth in sulfate concentrations in some high-latitude basins, attributed mainly to changes in glacier activity in these regions.

Our study offers new insights into the influence of human factors on weathering processes. While Human activities can markedly accelerate river acidification, they also have potential to reverse this trend. For instance, the sulfate concentration in the Yangtze River has decreased in recent years, largely due to stricter environmental regulations. Considering this, alongside the environmental protection commitments of nations worldwide, we have formulated informed predictions regarding the future sulfur cycle in rivers, which may serve as valuable references for shaping relevant policies moving forward.

Keyword

sulfides, Anthropogenic, fossil fuels, glacier

Heavy metal migration and Lithium isotope fractionation under extreme weathering of basalt on tropical Hainan Island, China

Weihua WU[1]*, Nanjing University (wuwh@nju.edu.cn)

Abstract

Basalt contains a higher concentration of heavy metals that are harmful to the environment. As basalt weathers into soil, heavy metals can easily enter the environment and cause environmental risks. This weathering process can be traced by lithium isotope. However, the relations among intensity of the chemical weathering, migration of heavy metals, and fractionation of Li isotopes remain unclear. We conducted systematic examinations of a basalt weathering profile on the tropical Hainan Island in China. The primary minerals in the fresh basaltic bedrock include olivine, plagioclase, pyroxene, and quartz. In the semi-weathered basalt zone, primary minerals remain but peaks are diminished, and a few kaolinite peaks emerge. In the saprolite layer and above, the peaks of olivine, plagioclase and pyroxene diminish markedly or disappear while secondary minerals such as kaolinite and Al-Fe (hydro)oxides (gibbsite, goethite, hematite, magnetite, and ilmenite) are observed. Both the saprolite and laterite layers exhibit chemical index of alteration (CIA) values >99, meanwhile mass transfer coefficients of Ca, Mg, Na, and K close to −1, indicating the characteristics of extreme weathering. Among the major elements, there is a significant decrease in alkalis/alkaline earths and Si from the fresh bedrock to the topsoil, whereas Fe, Al, and Ti increase. The heavy metals except Co increase from bottom to top with Pb showing the largest increase (six-fold). Fe and heavy metals Cr, V, Co, and Cu have the highest contents at the depth of 210 cm, showing the crucial role played by Fe-(hydro)oxides. From bottom to top there are increasing and decreasing trends in Li content (from 3.6 mg/kg to 15.7 mg/kg) and Li isotopic ratio (from +2.8‰ to −2.4‰), respectively.

There are strongly negative correlations between mass transfer coefficient of Al (an index for weathering intensity to replace CIA under extreme weathering conditions) and Li isotopic ratio (R2 = 0.91), enrichment factors of Ni, Cd, Cu, Co, and Cr (R2 is from 0.31 to 0.93). During the initial-intermediate weathering stage, clay minerals such as kaolinite that are prone to adsorb lighter 6Li and heavy metals are rapidly formed, leading to decrease of Li isotopic ratio and accumulation of heavy metals in the weathering products. As weathering proceeds, these clay minerals are further converted to Al-Fe-Ti (hydro)oxides, and the adsorbed heavy metals become desorbed and leached into the local environment. This process may be a distinct characteristic of extreme basalt weathering and warrants more attention in the investigation of environmental risks associated with heavy metals in tropical basaltic regions.

Keyword

tropical basalt, chemical weathering, element migration, Li isotope fractionation

Regional Geochemical Survey of the Rooikraaldam Area, Eastern Bushveld Complex, South Africa.

Mehdi BENSID[1]*, Council for Geoscience (bmehdi@geoscience.org.za)
Abdul Kenan[2], Council for Geoscience

Abstract

As part of the South African national regional geochemical programme, the Council for Geoscience carried out a geochemical regional survey in the Roikraaldam area which is part of the Eastern Bushveld Complex within the North West Province, South Africa. The primary objective of this survey is to generate a geochemical data layer of the present erosional surface which will serve a wide range of industries including mineral exploration, environmental management, agriculture, construction, etc.

Soil samples were collected in the Rooikraaldam area at a density of one sample per km2 and analysed using simultaneous quantitative X-ray fluorescence spectrometry (SXRF). Two types of single-element geochemical maps, namely bubble plots and contour maps, were generated. The bubble plots display five interval classes that were generated using the Jenks Natural Classification system combined with the knowledge of the average abundance of each element in the soils. Conversely, the contour maps display ten interval classes and were produced. The primary objective of the bubble plots is to delineate anomalous areas that may be prospective for mineral exploration, whereas the contour maps are designed to demarcate the different geological units within the study area.

To facilitate the interpretation of the geochemical data and the generation of multi-element maps, a Pearson's Correlation Matrix was compiled. Additionally, a Principal Component Analysis (PCA) was conducted. These statistical techniques aided in the identification of element associations that were used to compile the multi-element maps represented mainly by Weighted Sum maps.

The geochemical interpretation revealed that the most prominent mineral targets correspond to V-Fe-Mg-Cu anomalies, which are particularly associated with the magnetites of the Upper Zone of the Rustenburg Layered Suite. Additionally, the Principal Component Analysis yielded Ni-Cu-Sr-Co targets that may be indicative of Ni-Cu-PGE sulfide deposits in the southeastern portion of the mapped area. Furthermore, two distinct Pd-Pt anomalies, identified through the Pearson's correlation matrix, warrant further investigation as they could represent potential mineralization zones. Within the felsic rock units, several Nb-Rb-Y-W targets were delineated, potentially signifying the presence of Nb, rare earth elements (REE), and U mineralization in the study area.

The study delineated several mineral target zones that should be further verified and followed up in addition to delineating areas of potential environmental risk.

Keyword

Regional geochemical survey, Rooikraaldam, Bushveld Complex

Isotopic Behavior and Distribution of Bromine and Chlorine in Evaporites: Insights from the Salina Formation in the Michigan Basin

Yon-Gyung RYUH[1]*, University of Waterloo (yryuh@uwaterloo.ca)
Randy L STOTLER[2], University of Waterloo
Shaun K FRAPE[3], University of Waterloo

Abstract

Processes controlling the isotopic range of δ81Br values in natural waters and evaporite deposits are not well understood due to limited available data. While previous studies have explored δ81Br in natural water samples, recent research on evaporite deposits has not yielded clear answers regarding bromine isotopic systematics and distribution. For a better understanding of the isotopic system, it is essential to comprehend the δ81Br values of evaporites, which serve as one of the primary reservoirs of bromine. This study aims to address this gap by investigating the δ81Br of evaporites within the Salina Formation in the Michigan Basin, where a diverse range of evaporites is present in a sedimentary rock sequence.

Our objective is to characterize the distribution of Br isotopes within the sedimentary rock sequence to comprehend the influence of geological and geochemical processes on isotope compositions. To achieve this, the δ81Br and δ37Cl of Salina Formation cores were analyzed and compared with data from previous studies, including isotopic, litho- and fluid geochemistry, as well as features such as color, textures, and facies that provide insights into depositional environments and diagenetic processes.

The δ81Br values range from -1.78 to +1.40‰ (SMOB), while δ37Cl range from -1.81 to +1.04‰ (SMOC). Although no significant correlation between δ81Br and δ37Cl is evident, it seems that depositional environments and secondary processes (e.g., hydrothermal alteration) may influence isotope compositions. Most halite samples exhibit positive δ81Br, while carbonate tends to exhibit negative δ81Br. Samples with hydrothermal alteration features show a more varied range of δ81Br values.

In conclusion, this study provides valuable insights into the isotopic behavior of bromine within the sedimentary basin, contributing to a better understanding of the processes that further fractionate δ81Br. Such knowledge is crucial for utilizing δ81Br as an environmental tracer in various applications.

Keyword

Bromine isotopes, Evaporites, Salina Formation

Geochemistry, mineralogy, and origin of Late Cretaceous ironstone deposits, Northern Oman Mountains

Salah Al-Khirbash[1]*, Sultan Qaboos University (khirbash@squ.edu.om)
Ahmed Hassan Ahmed[2], King Abdulaziz University
Khadija Semhi[3], Independent consultant, 4, Rue de Marlenheim Strasbourg France

Abstract

Seven ironstone occurrences (Fe-1 to Fe-7) are geochemically and mineralogically investigated in the Northern Oman Mountains to constrain their origin and economic importance. These ironstone deposits were formed on the top of the lateritic soil of both peridotites and layered gabbros of the Semail ophiolite complex of the early Cretaceous time. The studied ironstones vary in thickness from a few meters up to 13 m. and vary in textures from well-rounded to ellipsoidal-like oolitic and pisolitic types to mainly laminated massive texture types. The mineral composition of these ironstones is hematite, magnetite, and goethite (Ni- and Al-rich) as the main iron minerals, in addition to clays (kaolinite), calcite, dolomite, gypsum, and birnessite, and inherited chromite and chamosite. Ilmenite and apatite are also recorded in some localities. Hematite is replacing magnetite and chromite along cleavage planes and grain boundaries. Chromite occurs as massive or fractured grains filled with secondary hematite and magnetite. Chlorite and clays are concentrated mainly within the nuclei of ooids and the matrix. Pentlandite and Co-rich pentlandite appear as blebs within magnetite matrix. Calcite is found as fracture filling cross-cut other mineral phases. Iron content (as Fe2O3) forms the majority of the bulk-rock constituents of ironstones; it ranges from 31.14 to 83wt.%. SiO2 (2.23-14.14 wt.%) and Al2O3 (1.38-15.5 wt.%) form significant components of the ironstones. The summation of these three oxides forms the major components of the studied ironstone deposits. MgO (0.27-4.94 wt.%) and CaO (0.13-30.31 wt.%) are relatively low compared with Fe2O3, SiO2, and Al2O3. Nickle (as NiO) and chromium (as Cr2O3) form substantial components (mostly > 2 wt.%) in the studied ironstones. Other detectable minor elements include Sc, V, Co, Cu, Zn, and Sr.

Compositional variations and elemental relationships showed that the studied ironstones mostly fall within the shallow water environment and in the detrital compositional field. In addition, the paleosol mineralogy, their oolitic texture, and bulk-rock REE patterns suggest that the Oman ironstone deposits most probably formed in a shallow-water environment with substantial inputs from detrital sources, which is similar to many other ironstone deposits described in the literature. The high NiO and Cr2O3 contents in the studied ironstones support the derivation of Fe2O3 from the peridotites and layered gabbros parent rocks by in-situ leaching from the Fe-rich minerals such as olivine, pyroxenes, amphiboles, and chromite, which are all major components in the protolith bedrocks.

Keyword

ironstone, Oman Mountains, Semail Ophiolite, Late Cretaceous

Geochemical preservation of Mid-Ordovician carbonates in the Taebaeksan Basin: Insights from strontium isotope analysis

Joonseok LIM[1]*, School of Earth and Environmental Sciences, Seoul National University (joonseok98@snu.ac.kr)
Jena Jeong[2], School of Earth and Environmental Sciences, Seoul National University
Sunhwa Bang[3], Research Institute of Molecular Alchemy, Gyeongsang National University
Seung-Gu Lee[4], Geology Division, Korea Institute of Geoscience and Mineral Resources
Youngsook Huh[5], School of Earth and Environmental Sciences, Seoul National University

Abstract

Isotope data from past sedimentary rocks are considered useful for interpreting paleoclimatic and paleoceanographic conditions. The Joseon Supergroup, consisting of marine-deposited sedimentary strata spanning the Cambrian-Ordovician period, forms part of the Taebaeksan Basin in the central-eastern part of the Korean Peninsula. However, the basin is known for its hydrothermal ore deposits due to Mesozoic intrusions. Given that hydrothermal alteration during the late diagenesis stage can critically affect the chemical properties of the rock, its influence must be excluded before interpreting the isotope data. This study aims to assess the geochemical preservation of carbonates in the Jigunsan and Duwibong formations, the two uppermost strata of the Joseon Supergroup in the Seokgaejae section, by comparing their 87Sr/86Sr ratios with those of contemporary global seawater.

Concentrations of major and trace elements, including calcium (Ca) and strontium (Sr), were analyzed using an Agilent 8900 QQQ ICP-MS at Seoul National University while the 87Sr/86Sr ratios of the samples were measured using Nu plasma 3 MC-ICP-MS at Seoul National University or Neptune Plus MC-ICP-MS at Korea Institute of Geoscience and Mineral Resources. Prior to isotope analysis, a column separation method was applied to the dissolved carbonate to remove rubidium (Rb) and Ca, which could potentially affect the accuracy and precision of the 87Sr/86Sr measurement. The analyzed samples generally exhibited higher 87Sr/86Sr ratios compared to the contemporaneous global seawater value. While more radiogenic 87Sr/86Sr ratios in carbonates can originate from hydrothermal fluids with granitic signatures, a corresponding decline in Sr concentrations in the samples would be expected during the water-rock interaction. Nevertheless, the Sr/Ca ratio of the samples ranged between 1.1 and 1.3 mmol/mol, with no observed trend of decreasing Sr concentrations. Therefore, it is reasonable to consider that the 87Sr/86Sr values of the samples represent their initial values, despite differing from those of the global seawater.

Keyword

Strontium isotopes, Joseon Supergroup, Mid-Ordovician

Simultaneous measurement of 147Sm/144Nd and 143Nd/144Nd ratios in natural geological samples by MC-ICP-MS after one stage chemical purification using TODGA resin

Zhuyin Chu[1], Institute of Geology and Geophysics, Chinese Academy of Sciences
Yueheng YANG[2]*, Institute of Geology and Geophysics, Chinese Academy of Sciences
(yangyueheng@mail.iggcas.ac.cn)

Abstract

The classic 147Sm-143Nd isotopic system has been extensively used as a powerful tracer or chronometer since the 1970s. Isotope dilution (ID) mass spectrometry, without doubt, is a well-known technique for its excellent precision and accuracy when properly used. Isotope dilution thermal ionization mass spectrometry (ID-TIMS) is still regarded as a benchmark technique for Sm-Nd measurement, despite its tedious, time-consuming and restrictive or extensive source filament and loading preparation procedure. Recently, isotope dilution multiple collector inductively coupled plasmas mass spectrometer (ID-MC-ICP-MS) has become a competitive technique for Sm-Nd analysis with high sample throughput and comparable precision to classical ID-TIMS. In this contribution, we demonstrate the capability of the simultaneous measurement of 147Sm/144Nd and 143Nd/144Nd ratios, in natural geological samples by MC-ICP-MS, after one stage chemical purification using TODGA resin, which can be a potential alternative to isotope dilution method. After sample digestion, one-step chemical isolation of Sm and Nd with almost 100% recovery from sample matrix elements, was accomplished by employing TODGA extraction chromatography resin. Then, simultaneous determination of 147Sm/144Nd and 143Nd/144Nd ratios, was conducted in single analytical session using MC-ICP-MS. The present analytical protocol relies on mathematic correction of isobaric interferences, thus alleviates the separation of Nd and Sm from each other, and usage of enriched tracer. The feasibility of the present protocol was investigated by duplicates analyses of international certified reference materials (CRMs), which encompassed wide range of chemical composition, and found to be nearly on the similar precision, as those obtained data using isotope dilution method, but at a fraction of the cost and time consumption, both chemical preparation and mass spectrometric measurement.

Keyword

Sm-Nd isotope, TODGA resin, Geological sample, Simultaneous measurement, MC-ICP-MS

Submarine groundwater discharge in coastal zones of a mountainous island: the evidence of trace elements and uranium isotopes

Ruo-Mei WANG[1]*, Institute of Earth Sciences, Academia Sinica, Taiwan (rmwang4112@gmail.com)
Chen-Feng You[2], Department of Earth Sciences, National Cheng Kung University, Taiwan
Chen-Tung Arthur Chen[3], Department of Oceanography, National Sun Yat-Sen University, Taiwan
Tsung-Ren Peng[4], Department of Soil and Environmental Sciences, National Chung Hsing University, Taiwan

Abstract

Growing evidence indicates that the flux of terrestrial materials to the ocean through submarine groundwater discharge (SGD) plays a significant role in the hydrological cycle, marine chemistry, and coastal ecosystem. However, the impact of SGD on elemental cycles and chemical budgets in the ocean remains debated. To trace SGD and understand its effects on elemental and isotopic variations in the coastal ocean, we analyzed major and trace metals, as well as uranium (U) and strontium (Sr) isotopes, in pore water, freshwater, and seawater samples collected from the coast region of southwestern Taiwan.

Our results indicate that dissolved U is removed in pore water at middle to high salinity levels and covaries with elevated barium (Ba) contents, which are likely due to Ba desorption triggered by changes in ionic strength and redox conditions at the freshwater-saltwater mixing zone. Compared to seawater, lower U concentrations (average 7.31 nM) and higher U isotopic ratios (average 1.178) are observed in the pore waters, suggesting a terrestrial origin and indicating the presence of fresh SGD in our study area. This finding is further supported by the low salinity observed in the pore waters and the distribution of trace elements, as well as the relationship between (234U/238U) and Sr isotopes, which indicates the source of fresh SGD and the mixing between groundwater and seawater. The results presented here demonstrate the potential of U isotopes as tracers for SGD and water mass mixing in the coastal areas. Moreover, our findings highlight the influential role of SGD in the variations of oceanic trace elements and uranium isotopes.

Keyword

SGD, uranium isotopes, strontium isotopes, trace element

Data recovery of incomplete rare earth element data sets

David M ERNST[1]*, Critical Metals for Enabling Technologies - CritMET, Constructor University, Germany (dernst@constructor.university)
Malte Mues[2], Department of Computer Science, TU Dortmund University, Dortmund, Germany
Michael Bau[3], Critical Metals for Enabling Technologies - CritMET, School of Science, Constructor University, Bremen, Germany

Abstract

Rare earth elements (REEs) are a group of elements with similar physical properties and coherent geochemical behaviour. As a result, REEs are widely used as proxies for many geochemical sources and processes. Availability of analytical data on REEs increased significantly in the 1960s with the advent of neutron activation analysis (NAA) and later of isotope dilution techniques (ID). However, due to the limitations of these methods, concentration data cannot be determined for all of the REEs. In the case of ID, praseodymium (Pr), terbium (Tb), holmium (Ho) and thulium (Tm) are typically missing due to their monoisotopic nature. In NAA data sets, praseodymium, dysprosium (Dy), holmium, and erbium (Er) are usually missing, and many data sets are even more incomplete. However, since the interpretation of REE data is primarily based on distribution patterns in normalised graphs, missing REEs can alter the appearance of the REE patterns and, hence, the interpretation. In the 1970s, inductively coupled plasma atomic emission spectroscopy (ICP-AES) became capable of measuring all 14 naturally occurring REEs. However, although incomplete, published ID and NAA data are generally of superior quality. Unfortunately, samples from these older publications are often not available anymore for re-measurement, sampling locations may no longer be accessible, or the samples may represent past states of the sampled ecosystem (e.g., soil or water samples). It is, therefore, of great scientific interest to extract as much information as possible from such old yet high-quality datasets. We present our recent results on the determination of missing REE data from incomplete datasets based on regression analysis via REE shape coefficients [1]. Our approach provides accurate and precise REE data (<10% relative deviation) well within the common analytical uncertainties of modern analytic approaches, for example, routine ICP-MS measurements. The accuracy and precision were determined via a method verification dataset consisting of >13,000 individual samples. The data recovery can be easily applied to REE datasets with missing data for some REEs, which need not be exactly the same as those missing in ID and NAA datasets. The re-modelled REE data can be used to interpret the overall pattern and to quantitatively determine anomalies, one of the most important tools in REE research. Another application for high-precision REE data is the determination of partition coefficients, for example, between minerals and melt.

[1] O'Neill, H.St.C., 2016. The Smoothness and Shapes of Chondrite-normalized Rare Earth Element Patterns in Basalts. Journal of Petrology 57, 1463–1508. https://doi.org/10.1093/petrology/egw047

Keyword

rare earth elements, data approximation, regression analysis, long tail data, data lakes

Formation of H2 by serpentinization of (ultra)mafic rocks

Sookyung KIM[1]*, Division of Earth Environmental System, Pusan National University
(sukyoung0421@naver.com)
Yoojin Cheon[2], Division of Environmental System, Pusan National University
Hoon Young Jeong[3], Pusan National University

Abstract

Hydrogen can be produced via serpentinization of (ultra)mafic rocks. The extent and kinetics of H2 generation were assessed for a range of (ultra)mafic rocks, which included two peridotite, one serpentinite, one pyroxenite, two gabbro, and four basalt. Prior to serpentinization, their major elemental composition, mineralogical composition and Fe speciation were characterized by using X-ray fluorescence, X-ray diffraction, scanning electron microscopy-energy dispersive spectroscopy, and Mössbauer spectroscopy. Subsequently, a series of kinetic experiments were conducted to monitor H2 production under the ambient condition. A peridotite from Horoman River, Japan (PR-HR), with olivine being the major Fe(II)-bearing mineral, showed hydrogen production on an order of magnitude greater than the other one from Jackson County, USA (PR-JS). The lower H2 production of the latter may have resulted from its higher amount of talc which would passivate the reactivity of Fe(II)-bearing minerals (e.g., olivine). A serpentinite from Yellow Dog Plains, USA (SP-YD), which was mainly composed of serpentine with a minor fraction of magnetite, produced H2 a half as much as PR-JS. In this case, Fe(II)-bearing serpentine largely accounted for H2 generation. A pyroxenite from Harcourt Township, Canada (PY-HC), with ~90% of Fe(II) present in pyroxene, showed only one tenth of the H2 production by PR-HR despite its greater Fe(II) amount. This suggest the lower reactivity of pyroxene-bound Fe(II) than olivine-bound Fe(II). In case of gabbro, one from Duluth, USA (GB-DL) showed a greater H2 production than Funehiki-machi, Japan (GB-FH) due to the presence of Fe(II)-bearing olivine in the former. All basaltic rocks but the one from Sinsanri, Korea (BS-SS) showed lower H2 production than peridotite and gabbro. Due to the greater Al2O3 amounts, serpentinization of basalt is known to make Fe(II) incorporated into nonreactive, secondary phases (e.g., chlorite). Nevertheless, a relatively higher amount of Fe(II)-bearing olivine in BS-SS would lead to its greater H2 production. Upon the completion of kinetic study, we will characterize the solid products and analyze the solution chemistry to better asses the effect of Fe oxidation state and its distribution amount constituent minerals on H2 production during serpentinization.

Keyword

hydrogen, serpentinization, (ultra)mafic rocks

The Biogeochemical Cycle of Rhenium in the Yangtze River Basin and Perturbations by Human Activities

Ye Wang[1], MOE Key Laboratory of Surficial Geochemistry, Nanjing University
Yang CHEN[2]*, Nanjing University (chenyang@nju.edu.cn)
Shilei Li[3], MOE Key Laboratory of Surficial Geochemistry, Nanjing University
Pengxiao Xu[4], School of Earth and Atmospheric Sciences, Georgia Institute of Technology
Haoxian Wang[5], MOE Key Laboratory of Surficial Geochemistry, Nanjing University
Jun Chen[6], School of Earth Sciences and Engineering, Nanjing University

Abstract

Rhenium, which is primarily found in sedimentary organic matter, is commonly used to estimate the rate of petrogenic organic carbon (POC) weathering. Accurately understanding the cycle of rhenium on Earth's surface is crucial for using dissolved rhenium (Re) in rivers as a marker for POC weathering. However, human activities, particularly those related to mining, industry, and chemicals, which frequently use Re, can impact the usefulness of this marker. This study collected water samples from the Yangtze River and industrial wastewater from 2018 to 2019 to analyze Re and major ion concentrations, with the aim of examining the primary sources and anthropogenic effects on riverine dissolved Re flux. The concentration of dissolved Re in the Yangtze River ranged from 67.7 to 167.6 pmol/L, significantly higher than the global average of 2.3 pmol/L, and the calculated Re flux was 16.98 tons per year. Assuming that all denudation materials in the Yangtze River basin are weathered, the calculated upper limit of Re flux provided by natural weathering processes is approximately 1.48 t/yr, accounting for only 8% of the total measured Re flux. Thus, it is estimated that human activities contributed at least 92% of the dissolved Re flux in the Yangtze Basin. Analysis of wastewater from factories closely related to Re use in the Yangtze River basin showed little influence on the dissolved Re flux. Therefore, other human activities along the Yangtze River, such as mining or coal utilization, may contribute a significant amount of Re. With human activities being the primary driver of the riverine dissolved Re flux in the Yangtze River, the annual Re flux may have increased from 9.44 t/yr to 16.98 t/yr from 2007 to 2019. The findings of this study suggest that human activities can rapidly and significantly impact the geological elemental cycle of Re over decadal timescales.

Keyword

Sources of dissolved Rhenium, River geochemistry, Yangtze River, Anthropogenic impact, Weathering of petrogenic organic carbon

Geochemical significance of Eu Isotope Ratio in Carbonate rocks

Seung-gu LEE[1]*, KIGAM (sgl@kigam.re.kr)

Abstract

Chondrite-normalized REE pattern based on the concentration in various kinds of the geological rocks have provided a lots of information for understanding the evolution history of Earth system including mantle and crust. Particularly, Eu anomaly in the chondrite-normalized REE pattern produced by feldspar crystallization during magma differentiation provides us a valuable information to understand the evolution history of igneous rocks. Eu has only two stable isotopes (151-Eu and 153-Eu). Lee and Tanaka (2019, 2021a) developed a method that Eu isotope ratio can determine precisely by MC-ICP-MS using Sm internal standard (combined standard-sample bracketing and internal normalization, C-SSBIN). Lee et al. (2023) also reported that Eu isotope ratio in igneous rocks has a relatively systematic relationship with the variation of the magnitude of Eu anomaly suggesting that Eu isotope fractionation in igneous rocks may occurred during magma evolution process. Ismail et al. (1998) showed that isotope effects in Eu2+/ Eu3+ exchange reaction can occur in aqueous solutions during cation exchange chromatography and also found that the heavier 153-Eu isotope is preferentially fractionated in Eu2+ solution phase which forms part of the Eu2+/Eu3+ electron exchange system. It means that Eu isotope fractionation occurred in carbonate rock, which is a product of climate change in a low-temperature environment. Therefore, Eu isotope ratio in the carbonate rocks including geochemical reference materials of the Geological Survey of Japan was measured using MC-ICP-MS to check whether Eu isotope fractionation in carbonate rocks occurred. In this conference, I will discuss a geochemical implication of Eu isotope fractionation in carbonate rocks.

Ismail, I.M., Nomura, M., Fujii, Y. (1998) Isotope effects of europium in ligand exchange system and electron exchange system using ion-exchange displacement chromatography, Journal of Chromatography A. 808, 185–191.

Lee, S-G., Tanaka, T. (2019) Determination of Eu isotopic ratio by multi-collector inductively coupled plasma mass spectrometry using a Sm internal standard. Spectrochimica Acta: Part B, 156, 42–50.

Lee, S-G., Tanaka, T. (2021a) Eu isotope fractionation in highly fractionated igneous rocks with large Eu negative anomaly. Geochemical Journal, 55/6, e9–e17.

Lee, S-G., Tanaka, T. (2021b) Gd matrix effects on Eu isotope fractionation using MC-ICP-MS: Optimizing Europium isotope ratio measurements in geological rock samples. International Journal of Mass Spectrometry, 469, 116668.

Lee, S-G., Tanaka, T., Lee, M.J. (2023) Geochemical implication of Eu isotopic ratio in anorthosite: new evidence of Eu isotope fractionation during feldspar crystallization. Geosciences Journal, 27, 271-284.

Keyword

Eu isotopes, Isotope fractionation, Carbonate rocks, Rare Earth Element

CONTRIBUTION TO THE GEOCHEMICAL ATLAS OF THE KINGDOM OF SAUDI ARABIA: GEOCHEMICAL SURVEY OF THE MAHD ADH DHAHAB QUADRANGLE, 23E

Ibrahim Osman ABDALLA[1], Saudi Geological Survey
Abdulrahman A SABBAHI[2], Saudi Geological Survey
Yasser S AL-GHANMI[3], Saudi Geological Survey
Fawwaz M AL-FIDANI[4]*, Saudi Geological Survey (Fidani.FM@sgs.gov.sa)
Mohammed O AL-NASHRI[5], Saudi Geological Survey
Mazen B BALKHEYOUR[6], Saudi Geological Survey

Abstract

The regional geochemical survey of the Mahd adh Dhahab quadrangle, utilizing stream sediments, aims to augment the Geochemical Atlas of the Kingdom of Saudi Arabia. The primary purpose of this geochemical survey is to systematically sample stream sediments at a density of one sample per 25 km^2, determine the concentrations of elements, and present the spatial variations of the elements as geochemical maps of various styles. The stream-sediment samples were meticulously collected from 699 sites across Proterozoic supracrustal/plutonic basement terrain, as well as Tertiary volcanic and sedimentary facies. Subsequent multi-elements analysis, employing ICP-OES and AAS techniques following HF/HClO4/HCl/HNO3 digestion, were performed on the -2 mm/+0.177 mm fraction of the sediments. The resultant analytical dataset facilitated the production of diverse geochemical maps, crucial for delineating targets for mineral exploration. Thorough scrutiny of individual element distributions and associations revealed 38 multi-element targets potentially conducive to sulfides, precious metals, and rare earth elements mineralization. These encompass 16 Priority 1 anomalies, 10 Priority 2 anomalies, and 12 Priority 3 anomalies, classified based on the consistency of their elemental associations.

The Priority 1 and 2 targets, all associated with Proterozoic supracrustal/plutonic terrain, feature anomalies suggestive of precious metal/sulfide and high-temperature vein mineralization. Priority 3 targets exhibit a spectrum of element associations, including some indicative of precious metal/sulfide mineralization and others of barium and Fe-Ti mineralization.

Beyond assessing the mineral potential of the Mahd adh Dhahab quadrangle, the program has significantly enriched a comprehensive geochemical database suitable for environmental monitoring, geological mapping, and land-use planning. The analytical data underpinning this report are archived within the National Geological Database (NGD), accessible via official request to the Saudi Geological Survey management (visit https://sgs.gov.sa/en).

Keyword

Geochemical Atlas, Arabian Shield, Geochemical survey, Mahd adh Dhahab, Mineral exploration

Geochemical features of intrusion related gold deposits (IRGD) in the Yana-Kolyma Gold Belt (Northeast Asia)

Anna Igorevna NESMEYANOVA[1]*, Russian Mineral Resourse Institute – VIMS (nesmeyanova_a@vims-geo.ru)
Evgeniy Gennadievich Eremenko[2], Russian Mineral Resourse Institute – VIMS
Pavel Igorevich Chernov[3], Russian Mineral Resourse Institute – VIMS

Abstract

The studied deposits lie within deformed lower greenschist-facies rocks of the eastern part of the Yana-Kolyma Gold Belt (Inyaly-Debin basin). The deposits are genetically related to Cretaceous felsic stocks of intermediate oxidation state. The intrusion-hosted gold deposits most commonly are of stockwork type. Gold may also be concentrated more distally (1–2 km) with respect to the intrusions, where deposits are of auriferous, sheeted quartz vein/veinlet type.

The geochemical studies incorporated a variety of analytical techniques (fire assay, AAC, ICP-MS) and sample media (residual soil and bedrocks). Surficial geochemical criteria include anomalies of Au, As, Bi, Te, Ag, W, Mo, Co, Ni, Pb, Cu. The structure of the geochemical field play major role in the secondary halos of Au, As, Bi, W. Anomalies of these elements are spatially related to the central zones of deposits and inherit the chemical composition of auriferous ores. Aureoles of Sb, Pb, Zn, Cu, Mo surround anomalies of the central zone. Secondary halos of Co, Ni, Ti, V are characterized by limited development, and they are widely extended around anomalies of Au, As, Bi, W. The general pattern of the geochemical field is determined by the obvious concentric zonality in the distribution of elements.

The distributions of elements in samples of bedrock suggest the existence of the aureoles of Au, As, Bi, W, Ag, Sb, Cu, Mo. The Au, As, Bi geochemical association is the strongest and is associated with ore bodies at the present level of erosion.

Keyword

Geochemistry, intrusion related gold deposits, secondary halos, Yana-Kolyma Gold Belt, ore prospecting

Assessing fluoride occurrence in groundwater and related factors in the Eumseong Basin area

Jong Hyun OH[1]*, University of Science and Technology (ohjong2009@naver.com)
Dong-Chan Koh[2], Korea Institute of Geoscience and Mineral Resources
Hyo-Sik Seo[3], University of Science and Technology
Sung Won Kim[4], Korea Institute of Geoscience and Mineral Resources

Abstract

If water with high fluoride is consumed for a long period of time, there is a risk of causing problems with bones or teeth. In groundwater, fluoride usually originates from minerals in rocks, and the longer the reaction period, the higher the concentration. In this study, we aim to understand the distribution characteristics of fluoride concentration in groundwater in relation to other elements and stable isotopes of oxygen and hydrogen, and to investigate the origin of fluoride and factors that may affect fluoride concentration. The study area is the Eumseong Basin and nearby areas, where large-scale faults and various lithologies appear. A total of 146 groundwater samples and 14 rock samples were collected at the site. Groundwater samples were subjected to on-site water quality measurements, chemical analysis, and isotope analysis, and rock samples were subjected to microscopic observation and chemical analysis. Considering that Ca2+, Na+, and HCO3- account for most of the dissolved ions, it is considered that the hydrochemical properties of groundwater in the study area are generally controlled by water-rock reaction. In the case of F- concentration, it appears to have a positive correlation with Na+ and HCO3- concentration and a negative correlation with NO3- concentration. Therefore, F in groundwater in the study area appears to originate from minerals in rocks. Groundwater samples with high F- concentration have depleted δ18O and δD values, which is presumed to be because the groundwater was recharged from high-altitude area and reacted with surrounding rocks for a long time through longer flow paths. Some chemical characteristics of groundwater vary depending on the bedrock lithology. Typically, groundwater in granite and metamorphic rock areas tends to have a higher F- concentration than groundwater in sedimentary rock areas. Few other fluorine-containing minerals were observed in granite and metamorphic rock samples, but biotite was observed well in most samples. Biotite is one of the representative mineral that efficiently dissolves F when reacting with groundwater. Therefore, it seems likely that most of the F in groundwater in the study area originated from reaction with biotite. Fault zone also appears to be a factor that can affect the F- concentration of groundwater, because in groundwater groups with high F- concentration, F- concentration tends to decrease as the distance from the fault zone increases. One of the reasons for these results is the possibility that some fault zones act as groundwater flow paths, causing deep groundwater to flow upward and mix with shallow groundwater. Precipitation of fluorite or calcite is also likely to have an effect on the F- concentration in groundwater. Although the upper limit of F- concentration in groundwater in the study area is partially influenced by precipitation of fluorite, calcite generally precipitates before

fluorite. So it seems likely that the precipitation of fluorite will be slowed down, and F-concentration will continue to increase. This work was supported by the Basic Research Project (24-3121) of the Korea Institute of Geoscience and Mineral Resources (KIGAM), Republic of Korea.

Keyword

water stable isotope, hydrogeochemistry, bedrock lithology, fault zone, mineral-water equilibria

Glaciovolcanic processes between the Campbell Glacier and Mt. Melbourne Volcano, Antarctica: Ice and Fire

Hyun Hee RHEE[1]*, Kongju National University (hyun1741@kopri.re.kr)
Min Kyung Lee[2], Korea Polar Research Institute
Yeong Bae Seong[3], Korea University
Sunghan Kim[4], Korea Polar Research Institute
Jae Il Lee[5], Korea Polar Research Institute
Kyu-Cheul Yoo [6], Korea Polar Research Institute
Byung Yong Yu[7], Korea Institute of Science and Technology

Abstract

The application of cosmogenic nuclides (in-situ 10Be and 26Al) in surface exposure dating has provided valuable chronological constraints for understanding changes in Antarctic terrestrial glaciers. Building on previous data related to Marine Isotope Stage (MIS) 5 simple exposure ages of Campbell Glacier moraines, we conducted further analysis on the palaeo-subglaciated bedrock. This analysis revealed simple exposure ages during MIS 3 (49.8~35.3 ka), confirming continuous glacial lowering throughout the late Quaternary, including the Last Glacial Period (MIS 4~2). Notably, our findings indicate that the Local Last Glacial Maximum (LLGM) occurred at an elevation of 150~90 masl during MIS 4, rather than MIS 2.

The new and recalculated dataset for the Campbell Glacier stands out compared to other outlet glaciers flowing into Terra Nova Bay. It suggests that Mt. Melbourne's volcanic activity may have directly influenced the glacier through glaciovolcanic processes during the late Quaternary, challenging the notion of a general influence from climate and oceanic factors. Further investigations into palaeo-glaciovolcanic interactions on the East Antarctic Ice Sheet (EAIS) could provide more robust insights. Such studies hold the potential to refine models predicting future accelerated glacial melt and sea level rise, particularly concerning the numerous volcanoes beneath the West Antarctic Ice Sheet (WAIS).

Keyword

Cosmogenic Nuclides Surface Exposure Dating, Subglacial Bedrock, Local Last Glacial Maximum, Glaciovolcanic Process, East Antarctic Ice Sheet

Extent of the marine-based ice sheet in the western Ross Sea during the Last Glacial Maximum

Jae Il LEE[1]*, Korea Polar Research Institute (leeji@kopri.re.kr)
Sunghan Kim[2], Korea Polar Research Institute
Kyu-Cheul Yoo[3], Korea Polar Research Institute
Hyun Hee Rhee[4], Korea Polar Research Institute
Min Kyung Lee[5], Korea Polar Research Institute
Heung Soo Moon[6], Korea Polar Research Institute
Hyo Jin Kim[7], Korea Polar Research Institute
Myung-Il Kang[8], Korea Polar Research Institute
Hyoung Jun Kim[9], Korea Polar Research Institute
Rob McKay[10], Victoria University of Wellington
Jamey Stutz[11], The Ohio State University

Abstract

During the Last Glacial Maximum (LGM), a marine-based ice-sheet occupied the Ross Sea Embayment. The LGM grounding line position in the western Ross Sea is suggested by the presence of a grounding zone wedge (GZW) north of Coulman Island, but radiocarbon dates on biogenic carbonates support more limited LGM ice extent. We used acoustic sub-bottom profile data from the Northern Drygalski Trough in the westernmost Ross Sea, palaeoenvironmental proxy analyses on marine sediment cores, and radiocarbon dating on biogenic carbonates to reconstruct changes in depositional environment since the LGM. We show that the maximum extent of LGM grounded ice in the western Ross Sea was smaller in its extent than previously thought, and an open marine condition was present on the outer continental shelf during the LGM. The large GZW north of Coulman Island probably formed during larger ice sheet advances prior to the LGM because older sediments are preserved on and south of the GZW. Periods of glacial advance during the LGM are interrupted by establishment of open marine condition in the Northern Drygalski Trough, concurrent with Antarctic Isotope Maximum 2 warming event at ~24ka. The onset of deglaciation in the Northern Drygalski Trough started as early as ~19.5 ka in response to rising atmospheric and oceanic temperatures. Our results imply that marine-based ice sheet was highly sensitive to environmental forcing, even during the peak glacial period.

Keyword

Antarctic, ice sheet, ross sea, LGM

Sensitivity of the West Antarctic Ice Sheet to +2°C (SWAIS 2C)

Richard Levy[1], GNS Science
Tina Van de Flierdt[2], Imperial College London
Molly Patterson[3], Binghamton University
Huw Horgan[4], ETH Zurich
Gavin Dunbar[5], Victoria University of Wellington
Denise Kulhanek[6], Christian Albrecht University - Kiel
Jae Il LEE[7]*, Korea Polar Research Institute (leeji@kopri.re.kr)

Abstract

The West Antarctic Ice Sheet (WAIS) presently holds enough ice to raise global sea level by 4.3m if completely melted. Despite previous land and ship-based drilling on and along the Antarctic margin, unequivocal evidence of major WAIS retreat or collapse in times of past warmth has remained elusive. Yet such data are vital to inform numerical models aimed at quantifying predictions of future sea level rise.

Sensitivity of the West Antarctic Ice Sheet to a Warming of 2°C (SWAIS 2C) is supported by the International Continental Drilling Program and aims to constrain past and current drivers of WAIS dynamics and identify temperature thresholds and ice sheet tipping points.A primary goal is to acquire records of WAIS extent during late Quaternary “super-interglacials”, which were characterised by warmer than present conditions. Researchers, engineers, and logistics providers representing ten nations have established a partnership to achieve this goal. Our team of geologists, glaciologists, oceanographers, geophysicists, microbiologists, climate and ice sheet modelers, and engineers will recover and examine Neogene and Quaternary geological records from the West Antarctic interior adjacent to the Kamb Ice Stream and at Crary Ice Rise.

Scientific and technological advances developed through SWAIS 2C will enable us to test whether WAIS collapsed during past intervals of warmth. Connection to similar research efforts in Greenland offers an opportunity to examine bi-polar response to past climate change and determine the sensitivity of WAIS and GIS to a +2°C global warming threshold. Together our communities can identify when, where, and by how much Earth’s most vulnerable ice sheets melted in the past and drove sea level change across the planet.

Keyword

West Antarctica, Sea Level, Ice Sheet, Interglacial, Quaternary

Diatom- to coccolithophore-dominant surface production shift during the MPT in the Ross Sea and its implication

Sunghan KIM[1]*, Korea Polar Research Institute (delongksh@kopri.re.kr)
Jae Il Lee[2], Korea Polar Research Institute
Christian Ohneiser[3], University of Otago
Ki-Tae Park[4], Korea Polar Research Institute
Sookwan Kim[5], Korea Institute of Ocean Science and Technology
Kitae Kim[6], Korea Polar Research Institute
Min Kyung Lee[7], Korea Polar Research Institute
Kyu-Cheul Yoo[8], Korea Polar Research Institute
Heung Soo Moon[9], Korea Polar Research Institute
Jinku Park[10], Korea Polar Research Institute
Denise Kulhanek[11], Christian-Albrechts-University of Kiel

Abstract

Biological processes have changed atmospheric composition on tectonic- and orbital-time scale via biological pump. Surface biological processes changed in both high latitudes during global climatic cooling events (Northern Hemisphere Glaciation at 2.73 Ma and Mid-Pleistocene Transition; MPT during 1.25 – 0.7 Ma). However, little is known about the feedback of changed surface biological processes on the earth climate event. Here we provide sedimentary evidence from the Antarctic Zone for a biotic shift from diatom- to coccolithophore-dominant surface production during the MPT from cores RS15-GC107 and RS15-LC108 in the Ross Sea continental rise. We found increased CaCO3 (calcareous nannofossils – coccolithophores) along with decreased biogenic opal in core RS15-GC107 during the MPT. In addition, CaCO3 concentration of <20 μm fraction, indicative of coccolithophore production, showed significant amount of CaCO3 was produced by coccolithophores. As coccolithophores produce dimethylsulfoniopropionate (DMSP) 10–100 times more than diatoms and DMSP is linked to enhanced cloud formation, we suggest that cloud formation in the Antarctic zone increased during the MPT, resulting in increased albedo in the Antarctic Zone and increased snowfall in the Antarctic. These findings suggest that climate-driven biological processes can influence back the climate changes. Further investigation and atmosphere-ocean-cryosphere modelling simulations are required in the future.

Keyword

Mid-Pleistocene Transition, Ross Sea, Cloud formation, DMSP, CaCO3

Dinoflagellate cyst assemblages in surface sediments from the Ross Sea, Antarctica

So-Young KIM[1]*, Korea Polar Research Institute (kimsy@kopri.re.kr)
Fabienne Marret[2], University of Liverpool
Kyu-Cheul Yoo[3], Korea Polar Research Institute
Jeong-Hoon Kim[4], Korea Polar Research Institute
Hyoung Sul La[5], Korea Polar Research Institute
Lorena Rebolledo[6], Instituto Antartico Chileno
Sun-Yong Ha[7], Korea Polar Research Institute

Abstract

Dinoflagellate cysts are known to be valuable tracers to infer paleoceanographic parameters such as sea-surface temperature, salinity, nutrients and sea-ice cover. However, this potential has yet remained largely uncovered, particularly in Antarctic proximal regions of the Southern Ocean. Sixteen surface sediment samples were collected from the Ross Sea, Antarctica during R/V ARAON expeditions and investigated to determine the distribution, abundance and species composition of resting stages of dinoflagellates (dinoflagellate cysts). This study is the first to document the distribution of the dinoflagellate cysts in the area. The data presented here reveal a clear longitudinal trend in species diversity, concentration and taxa dominance. Results indicate dinoflagellate cyst concentrations vary between 46 cysts/g and 145,159 cysts/g. A total of 11 dinoflagellate cyst taxa were identified. The assemblages were dominated by Polarella glacialis, Selenopemphix sp.1, Nucicla umbiliphora and Islandinium minutum. Accompanying taxa included Cryodinium meridianum, Gymnodinium microreticulatum and Impagidinium pallidum. A particular note is for the cysts of P. glacialis, which show a restricted distribution along the western Ross Sea coastal areas. This result tentatively suggests a potential use of dinoflagellate cysts as tracers of past oceanographic conditions, particularly Antarctic proximal regions of the Southern Ocean. Our study also highlights the importance of further investigation to identify the main environmental drivers of the dinoflagellate cyst distribution patterns, several regional and in situ environmental parameters.

Keyword

Antarctica, Ross Sea, sediment, dinoflagellate cysts

Ice loss from the East Antarctic Ice Sheet in the Ross Sea during late Pleistocene interglacials

Min Kyung LEE[1]*, Korea Polar Research Institute (mklee@kopri.re.kr)
Sunghan Kim[2], Korea Polar Research Institute
Kwangchul Jang[3], Yonsei University
Boo-Keun Khim[4], Pusan National University
Michael Bollen[5], University of Lausanne
Jae Il Lee[6], Korea Polar Research Institute
Heung Soo Moon[7], Korea Polar Research Institute
Rob McKay[8], Victoria University of Wellington
Richard Levy[9], GNS Science
Kyu-Cheul Yoo[10], Korea Polar Research Institute

Abstract

Understanding the behavior of ice sheets in the geological past is crucial for assessing the cryosphere's role in the climate system and for predicting the rate and extent of sea level rise in future warming scenarios. While both geological data and ice sheet models suggest that marine-based sectors of the East Antarctic Ice Sheet experienced instability during Pliocene and late-Pleistocene warm intervals, the dynamics of the East Antarctic Ice Sheet remain highly uncertain. Here, we present evidence from marine sedimentological and geochemical records indicating ice margin retreat near the Ross Sea during warm late Pleistocene interglacial periods. The most notable changes in sediment provenance, reflecting the retreat of the WAIS and EAIS, occurred during marine isotope stages (MIS) 9, 11, 17, and 31. During these stages, Antarctic air temperatures were at least two degrees Celsius warmer than pre-industrial levels for 2,500 years or more (MIS 9 and 11), and marked the end of the Mid-Pleistocene Transition (MIS 17). MIS 31 is recognized as one of the "superinterglacials" in the Northern Hemisphere and around Antarctica, characterized by elevated temperatures and potential instabilities in the Antarctic ice sheet. Consequently, our study reveals a strong connection between prolonged Antarctic warmth and ice loss from the Ross Ice Shelf and the Western Ross Sea, offering continuous data for the last 1.3 million years that support the contribution of interglacial intervals to sea level rise.

Keyword

late Pleistocene, Ross Sea, East Antarctic Ice Sheet, Climate warming

Enhanced terrestrial methane cycle during the early Eocene hyperthermals

Zuoling CHEN[1]*, Institute of Geology and Geophysics, CAS (chenzl@mail.iggcas.ac.cn)
Peizong Lü[2], College of Geosciences, China University of Petroleum (Beijing)

Abstract

The early Eocene was characterized by a series of transient global warming events (hyperthermals), including the Paleocene-Eocene Thermal Maximum (PETM), ETM2/H1, H2, I1, and I2 (Nicolo et al., 2007; Zachos et al., 2010). These events can provide insights into the biogeochemical response to extreme climate states. Increased terrestrial methane (CH4) cycling has been evidenced during the PETM (~56 Ma) (Pancost et al., 2007; Inglis et al., 2021); however, whether other subsequent smaller-magnitude hyperthermals share common terrestrial CH4 feedback remains unknown due to the lack of sedimentary records. Here we report new biomarker data from a wetland deposit sequence in the Fushun Basin which records four early Eocene hyperthermals to examine CH4 cycling response to different levels of elevated warming. Increased 3β-methylhopane index and highly negative $\delta^{13}C$ values of hopanes (<-45‰), synchronous with carbon isotope excursions, indicating vigorous wetland CH4 cycling during all hyperthermals. These results suggest that the wetland CH4 emissions acted as a common positive feedback mechanism for all hyperthermals, sustaining elevated temperature levels and producing prolonged carbon isotope excursions. Our data also suggest that the methane-climate feedback scaled with warming levels, with warmer climatic modes invigorating more intense CH4 cycle and thus greater methane fluxes.

Refences

Inglis, G.N., Rohrssen, M., Kennedy, E.M., Crouch, E.M., Raine, J.I., Strogen, D.P., Naafs, B.D.A., Collinson, M.E., et al., 2021. Terrestrial methane cycle perturbations during the onset of the Paleocene-Eocene Thermal Maximum. Geology, 49, doi:10.1130/g48110.1.

Nicolo, M.J., Dickens, G.R. Hollis, C.J., Zachos, J.C., 2007. Multiple early Eocene hyperthermals: Their sedimentary expression on the New Zealand continental margin and in the deep sea. Geology, 35, 699–702, doi:10.1130/G23648A.1.

Pancost, R.D., Steart, D.S., Handley, L., Collinson, M.E., Hooker, J.J., Scott, A.C., Grassineau, N.V., Glasspool, I.J., 2007. Increased terrestrial methane cycling at the Palaeocene-Eocene thermal maximum. Nature, 449, 332–335, doi: 10.1038/nature06012.

Zachos, J.C., McCarren, H., Murphy, B., Röhl, U., Westerhold, T., 2010. Tempo and scale of late Paleocene and early Eocene carbon isotope cycles: Implications for the origin of hyperthermals. Earth Planet. Sci. Lett., 299, 242–249, doi:10.1016/j.epsl.2010.09.004.

Keyword

methane cycling, hyperthermals, global warming, PETM

Lithium isotope evidence for enhanced weathering during the Middle Ordovician

Jena JEONG[1]*, Seoul National University (jenajeong@snu.ac.kr)
David Wilson[2], University College London
Sunhwa Bang[3], Gyeongsang National University
Youngsook Huh[4], Seoul National University

Abstract

The Ordovician period is known for substantial environmental changes within the Paleozoic era, marked by rapid temperature fluctuations from an early warm climate to a later ice age. Furthermore, beginning in the Middle Ordovician, the continental weathering environment experienced significant changes, coinciding with increased tectonic activity and active volcanism. Lithium isotopes have been widely used as a silicate weathering proxy due to the higher concentration of lithium in silicate minerals compared to carbonate minerals. Therefore, lithium isotopic composition of past seawater can help interpret paleoclimate and paleoenvironmental conditions.

The objective of this study is to interpret environmental changes during the Middle Ordovician period by analyzing lithium isotopes in Darriwilian carbonate rocks from the Taebaeksan Basin in South Korea. These samples are shallow platform carbonate rocks, within which the Middle Darriwilian Carbon Isotope Excursion (MDICE) has been documented. Major element concentrations were analyzed by Agilent 8900 ICP-QQQ at Seoul National University, and lithium isotopic compositions were analyzed using Nu Plasma 3 MC-ICPMS at Seoul National University and University College London. The lithium isotopic ratios of standard reference materials (NASS-7 = 31.1 ± 0.4 ‰, L-SVEC = 0.3 ± 0.5 ‰) agree well with published values.

The data reveal a significant decrease of 10‰ in lithium isotopic ratios from the Middle to Late Darriwilian. A dynamic (non-steady state) model is applied to investigate the causes of the negative lithium isotope excursion over a relatively short period (1 Ma). This study provides additional evidence for increased weathering during the Middle Ordovician.

Keyword

Ordovician, Weathering, Lithium isotopes, MDICE, Taconic orogeny

Depositional records by the active glacier in the northern Drygalski Basin in the Ross Sea since the Last Glacial Maximum

Sangbeom HA[1]*, Korea Polar Research Institute (sb_ha@kopri.re.kr)
Jae Il Lee[2], Korea Polar Research Institute
Kyu-Cheul Yoo[3], Korea Polar Research Institute
Young_Suk Bak[4], Jeonbuk National University
Boo-Keun Khim[5], Pusan National University

Abstract

The Drygalski Basin, which is the deepest basin in the Ross Sea, was generated by the advanced ice sheet during the glacial periods. The advanced ice sheet eroded the continental shelf sediments and formed large-scale lineations. During the deglaciation, the retreating ice sheet transported sediments to develop grounding zone wedge on the continental shelf. After the retreat of the ice sheet, the northern Drygalski Basin became the sub-ice shelf environment. The sediments were mainly supplied to the deepest basin from the grounding line or shallow banks by the debris flow originated by the instability of deposited sediments and/or breakup of ice sheet. Four gravity cores were obtained (DG12-GC03A, DG12-GC03B, RS15-LC100, and RS19-GC02B) at the three sites (DG12-03, RS15-100, RS19-02) from the northern part of the Drygalski Ice Tongue. Sediment properties, geochemical proxies, carbon isotopic values of organic matter, clay mineral composition were analyzed with AMS 14C dating from bulk organic matter. Based on the core descriptions, X-radiograph, and grain size distribution, the core sediments were classified: muddy diamicton, bioturbated mud, massive mud, sandy mud, laminated mud, laminated muddy sand, muddy sand, and scattered mud chunks. Diamicton was deposited proximal to the grounding line during the deglaciation. Several erosional boundary and upward fining facies might form by the debris flow from the grounding line under the sub-ice shelf condition. The previous studies reported that the readvance of the ice sheet during the deglaciation at the Drygalski Basin, based on the sea floor features like recessional moraines or grounding zone wedge. In this study, the sedimentological properties, geochemical proxies, and diatom assemblages indicate that the debris flow was originated by the readvance of the ice sheet during the mid-Holocene at the north of the Drygaslki Ice Tongue. After the retreat of the ice shelf, biogenic materials increase from the surface water under the seasonal open marine condition. The glaciomarine depositional process on the northern Drygalski Basin were closely linked with the ice sheet dynamics and ice shelf activity.

Keyword

antarctic, ross sea, drygalski basin, sediment, ice sheet

Minor and trace elemental ratios in coral Porites lobata from Koshiki Island (Japan): evaluation of the temperature proxies

Claire Rollion-Bard[1]*, CNRS-LSCE (claire.rollion-bard@lsce.ipsl.fr)
Pierre Burkel[2], IPGP-CNRS
Jessica Hargreaves[3], MARUM—Center for Marine Environmental Sciences
Nicolas Duprey[4], Max Planck Institute for Chemistry
Thomas Felis[5], MARUM—Center for Marine Environmental Sciences
Tsuyoshi Watanabe[6], Department of Natural History Sciences, Hokkaido University

Abstract

Temperature of the ocean is one of the major parameters to understand the climate changes. Minor and trace elements measured in the aragonitic coral skeleton can be used as environmental proxies. Here, we present analyses of Li/Ca, Li/Mg, B/Ca, Na/Ca, Mg/Ca, Sr/Ca, and U/Ca ratios in one slab of scleractinian corals, Porites lobata collected alive in 2008 from Koshiki Island (Japan). These corals have the particularity to experience a large sea surface temperature (SST) seasonality, with winter SST of a about 15°C up to 28°C in summer. This kind of seasonality is quite exceptionnal for tropical corals, and it offers the opporunity to test the temperature proxies on a large range of temperature.

About 250 samples were micromilled with a spatial resolution of 300 µm. Solution ICP-MS measurements were carried out on an Agilent ICPMS. The isotopes of 7Li, 11B, 23Na, 24Mg, 43Ca, 44Ca, 88Sr and 238U were measured after dissolution with ultraclean nitric acid. Possible contamination was checked by the determination of Al and Mn contents. The standard JCp-1 was analysed every 5 samples to ensure the stability and the accuracy of the measurements.

The X-ray photography of the sample highlighted 4 growth stops during 7 years sampled in this study. These stops are likely linked to the low seawater temperature of winters. The annual extension rate is between 6.8 and 10.4 mm. The Li/Ca, B/Ca, Sr/Ca and U/Ca ratios show well defined seasonal cycles. From these cycles, it was possible to develop some age models. Three age models were tested: fortnightly, monthly and in depth. Whatever the age model used, all these ratios are negatively correlated with temperature. The relation between B/Ca and temperature is in agreement with previous studies (e.g. Hart and Cohen, 1996; Montagna et al, 2007). Uranium to calcium and Sr/Ca ratios are positively correlated with a correlation coefficient R2 close to 0.9. This correlation is in agreement with the data of Min et al. (1995) and Cardinal et al. (2001). The geochemical signals were examined in more details to highlight their potential use as environmental proxies, including those analysed across the growth stops to provide more insights into a potential “cold bleaching” response.

Cardinal et al (2001) Chem. Geol., 176, 213-233.
Hart and Cohen (1996) GCA, 60, 3075-3084.
Min et al (1995) GCA, 59, 2025-2042.
Montagna et al (2007) Quaternary Sci. Rev., 26, 441-462.

Keyword

Coral, elemental ratios, temperature proxies, calibration

Biologically mediated trace element mobilization and isotope fractionation: Are certain redox-sensitive trace elements bio-proxies rather than redox-proxies?

Dennis Kraemer[1]*, Federal Institute for Geosciences and Natural Resources (BGR) - Germany (dennis.kraemer@bgr.de)
Timmu Kreitsmann[2], University of Tartu, Estonia
Robert Frei[3], University of Copenhagen, Denmark
Stefan Weyer[4], Leibniz Universität Hannover
Michael Bau[5], Constructor University Bremen

Abstract

Microbes, plants and other organisms actively shape the Earth's surface by a variety of processes. Current research suggests that they have a significant impact on the mobility of trace elements and there is growing evidence that they may have done so since the dawn of life. The secretion of extracellular compounds that bind strongly to iron and other micronutrients are evolutionary traits that may, besides acquiring bio-essential trace metals, also have helped mitigating the toxicity of certain heavy metals. An example of such compounds are siderophores which are produced by many different plants, microbes and fungi and which are ubiquitous in many parts of the pedo- and hydrosphere, with concentrations up to the millimolar range, for example in the rhizosphere. Besides iron, they increase the (bio)availability of different highly-charged cations in the natural environment. The hydroxamate siderophore desferrioxamine B (DFO-B), for example, promotes the mobilization of certain trace elements that hydrolyze easily, and hence were traditionally considered 'immobile' during water-rock interaction. The impact of natural organic ligands on redox-sensitive elements may thus be largely underestimated. Siderophores are omnipresent today and chemically similar compounds may have been present since the advent of life on Earth. In paleoclimate studies, a range of redox-sensitive trace elements (e.g., Ce, Cr, Mo, V, U) are commonly used as geochemical proxies (e.g., Ce anomalies, Th/U ratios, stable isotopes of Cr, Mo, U) for reconstructing atmospheric oxygen levels through time. In the past decade we thoroughly investigated the effect of siderophores on the mobilization of rare earth elements (REE), Cr isotopes, Th and U (isotopes) from natural rocks under anoxic, hypoxic and oxic conditions. Siderophores have the potential to significantly promote the (oxidative) fractionation of redox-sensitive elements even under hypoxic and anoxic conditions. We show that experimental water–rock interaction in the presence of siderophores even under strictly anoxic conditions produces positive Ce anomalies – a geochemical signal that is usually attributed to the presence of atmospheric oxygen. Siderophores also affect the Th/U ratio, as U is preferentially mobilized over Th during WRI in the presence of siderophores. However, our recent investigations revealed that this siderophore-promoted mobilization is not accompanied by significant U stable isotope fractionation. Likewise, siderophores mobilize Cr from igneous rocks and chromite ores, but do not induce a significant stable isotope fractionation. In summary, the oxygen-independent mobilization and fractionation of some redox-sensitive trace metals during geo–bio interaction may thus hold the potential to use certain trace elements as a bio-proxy in

addition to or rather than as a redox-proxy. While the interaction of trace elements with biogenic ligands will further complicate the use of geochemical redox-proxies, our results open an exciting venue for future studies and potential applications, including the field of astrobiology.

Keyword

Redox proxies, Siderophores, Biota, Water-rock interaction, Bioligands

Giant discoveries for magnetofossils from Cretaceous and Quaternary marine sediments

Courtney WAGNER[1]*, Kent State University (courtneywagner.geo@gmail.com)
Nitin Kadam[2], National Museum of Natural History, Smithsonian Institution
Ioan Lascu[3], National Museum of Natural History, Smithsonian Institution

Abstract

Here we report recent magnetofossil discoveries and highlight advantages of using magnetofossils as paleoenvironmental proxies. Conventional magnetofossils are the magnetic mineral remains of redox and nutrient-sensitive iron-biomineralizing organisms called magnetotactic bacteria. Magnetotactic bacteria are prolific microorganisms that live near the oxic-anoxic interface within a variety of modern aquatic environments (e.g., oceans, lakes, hot springs, and more). Conventional magnetofossils are nanometer-sized (20-150 nm) and have magnetite or greigite compositions. These biominerals may be consumed by other organisms, dissolved into the water column, or preserved in the geologic record. Conventional magnetofossils are abundant within sediments spanning the Late Cretaceous (~85 Ma) to present, although metagenomic studies suggest that the genes responsible for iron-biomineralization by magnetotactic bacteria may have originated during the Archean (~3.3 Ga). Giant magnetofossils are the micrometer-sized (>1 μm) remains of, as yet, unidentified organisms. Giant magnetofossils have only been identified within global records of the upper Paleocene and Eocene (~56-40 Ma), leading to the interpretation that they are linked to environmental conditions exacerbated by large-scale climatic events.

We report two new records of conventional and giant magnetofossils, from Cretaceous (~97 Ma) and Quaternary (~30-1.8 ka) marine sediments. Together, these reports 1) highlight that giant magnetofossils are more widely distributed in the geologic record than we thought, 2) showcase the oldest robust record of both conventional and giant magnetofossils, and 3) provide clues toward understanding the ecological thresholds and sensitivities of the iron biomineralizing organisms responsible for producing magnetofossils. The widespread distribution of magnetofossils both in the modern and the geologic record suggests that these organisms have played an important role in iron cycling and regulating environmental pressures throughout Earth's history. This information, combined with the cost-effective, straightforward, non-invasive magnetic detection of magnetofossils, underscores their usefulness as environmental proxies.

Keyword

magnetofossils, biominerals, environmental magnetism, paleoceanography, climate change

Geochemical evidence for an increased primary productivity during the Bölling-Alleröd interstadial period compared to Holocene along the south-western continental margin of India

Busnur Rachotappa Manjunaha[1]*, Mangalore University (omsrbmanju@gmail.com)

Abstract

The south-western continental margin of India (SWCMI) is one of high primary productivity (PP) regions in the Northern Indian Ocean (NIO) owing to the dominance south-west monsoon winds (S-W MW) during the summer monsoon, followed by north-east winds during the winter monsoon. The decreased PP during the glacial conditions attributed to the weakened S-W MW, however, this study shows that the S-W MW seems to have been increased during the interstadial conditions, particularly during the Bølling–Allerød (B-A) period than the Holocene. Geochemistry of a radiocarbon dated sediment core from SWCMI at 1400 m depth around 13o N latitude indicates that the PP indicator elements, such as Zn and Ni show contrasting behaviour from late-Glacial to the Holocene period. The Al-normalized Zn and Ni data of the core studied show an inverse trend particularly during the B-A period and to some extend during the mid –Holocene. Further, Al-normalized Zn ratios to Al-normalized Ni ratios are nearly two-fold higher during the B-A, than the entire core, particularly the Holocene section. This suggests that the diatom productivity was much higher during the B-A period relative to the Holocene time span. This finding is in agreement with the increased rainfall inferred from speleothems over the terrestrial regions of the Indian sub-continent, and decreased salinity, enhanced PP and increased denitrification rate noticed in the continental marine realm surrounding the India during the B-A period. Although many trace elements required for primary productivity, the biochemical/metabolic reactions of a cell and uptake of carbon by the phytoplankton, the most preferred trace element is Zn rather than Ni. Henceforth, Zn and Ni in marine sediments, particularly in the pristine continental margin can be used as proxies to delineate paleo-primary productivity variations. The utility of the trace elements suggested here is in agreement with the similar trace elemental isotopic investigation made by the GEOTRACES group in the productive upwelling regions.

Keyword

Bölling-Alleröd, Climate cycle, India, Arabian Sea, Trace Elements

A new method for quantifying astronomical forcing in paleoclimate proxies by evaluating spectral power distribution

Cheng PENG[1]*, China University of Geosciences (Beijing) (pengc@cugb.edu.cn)
Changchun ZOU[2], China University of Geosciences (Beijing)

Abstract

The quantification of astronomical forcing in paleoclimate proxies is the basis for many studies on important issues in the field of geosciences (e.g., astronomical timescale, astronomically forced climate, sea/lake level fluctuation and ancient solar system behavior). However, how to accurately identify astronomical cycle signals in paleoclimate proxies in the absence of absolute age constraints is still the focus of debate. Here, we propose a new quantification method of astronomical forcing in paleoclimate proxies based on multiple features of power ratio. This method uses power ratio accumulation value to quantify the relationship between the power spectrum of proxies and target curve of astronomical solution under the constraint of astronomical cycle length ratio. The synthetic series containing astronomical cycles and noise signals are used to validate the effectiveness of this new method. The new method is successfully applied to three types of paleoclimate proxies from different periods, namely Late Paleogene color data in South Atlantic, Late Cretaceous thorium content logs in Songliao Basin and Late Triassic depth-rank series in Newark Basin. These paleoclimate proxies belong to core measurement data, downhole geophysical log data and rank data, respectively. The analysis results provide new evidence related to astronomical cycles from the perspective of power ratio to support the previous cyclostratigraphic interpretations. This study will contribute to the decryption of paleoclimate information from proxies worldwide and promote the development of cyclostratigraphy. Acknowledgment: We acknowledge the financial support of National Natural Science Foundation of China (No. 42002029).

Keyword

cyclostratigraphy, astronomically forced climate, astronomical forcing, power ratio

Land Snail Shell Morphology Records Multiple Orbital Cycles of the Asian Monsoon

RUI Bao[1]*, Nanjing Normal University (baorui@njnu.edu.cn)
HUA SHEN[2], Nanjing University
XUEFEN SHENG[3], Nanjing University
MIN WU[4], Nanjing University

Abstract

Both loess proxies in northern China and speleothem δ18O in southern China are purported to be capable of recording changes in the Asian summer monsoon (ASM) on the orbital scale. However, their understandings regarding the evolution cycle and forcing mechanism of ASM are inconsistent and remain controversial. These disputes may arise from the uncertainty and complexity of the climatic significance of previous physical-chemistry proxies, such as those influenced by pedogenesis processes and sedimentation rates in the case of loess proxies. These necessitate the development of a new proxy, particularly the biogenic proxy, which offers the advantage of greater sensitivity and direct responsiveness to climate change. Here, we selected the morphology of land snail shells as a proxy to evaluate its potential for reflecting climate change and further recoding the variations in ASM. To this end, we investigate the morphology variations in fossil Cathaica orithyia shell from the Chinese Loess Plateau over the past ~470 ka and compare them with current ASM records. Our findings indicate that the aperture morphology, which plays a crucial role in regulating the shell's anti-drought ability, exhibits a distinct precession (23-kyr) cycle similar to that of Chinese speleothem δ18O, as well as potential obliquity (41-kyr) and eccentricity cycles. These results validate the use of shell morphology as a reliable proxy for reflecting climatic aridity or humidity, which may be influenced by multiple climate factors. Additionally, this proxy suggests that the ASM variations are forced by multiple orbital periods with the precession predominates.

Keyword

land snail, morphology, Asian monsoon, biogenic proxy, orbital periods

Evolution of sea surface temperature in the North Pacific over the past 10 million years

Kyung Eun Lee[1]*, Korea Maritime and Ocean University (kyung@kmou.ac.kr)
Tae Wook Ko[2], Korea Maritime and Ocean University

Abstract

Various past temperature proxy records indicate long-term cooling of Earth's climate during the past 10 million years. Yet, the existing records lack the temporal resolution needed to identify climate dynamics. Here, we present a new, extremely highly resolved (1 to 3 kyr), continuous alkenone temperature record spanning the past 10 million years, from the middle latitude northwestern Pacific margin, to understand temperature response to climate forcing. Comparisons between changes in temperature, sea level (e.g., polar ice sheet volume) and astronomical cycles reveal that the two completely different climate records of temperature and sea level have very similar periodicities over the past 10 million years, and changes in periodicity of temperature and ice sheet volume were generally modulated by those of eccentricity and obliquity over the past 10 million years. However, the intensity of temperature and ice sheet volume changes varied over the entire time period. The intensity increased toward the present during the northern hemisphere glaciation. These indicate that climate responses to astronomical forcing varied over the time period. We compared our temperature record with those from the subarctic and western and eastern equatorial Pacific oceans, anticipating being able to reconstruct the evolution/variability of the subpolar front and North Pacific subtropical gyre during the northern hemisphere glaciation.

Keyword

Alkenone temperature, astronomical cycles, 10 million years

The effect of barrier layer's evolution in the western Pacific warm pool on the deglaciation

Shuai ZHANG[1]*, Hohai University (zhangshuai5@126.com)
Zhoufei Yu[2], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Fengming Chang[3], Institute of Oceanology, Chinese Academy of Sciences
Tiegang Li[4], Key Laboratory of Marine Sedimentology and Environmental Geology, First Institute of Oceanography

Abstract

The role of the El Niño-Southern Oscillation (ENSO) in modulating global climatic changes is critical, while the role of the barrier layer (BL, a salinity stratification above the thermocline) in forming this phenomenon, which could reduce subsurface entrainment cooling into the mixed layer and impede the energy transmission downward and finally determine the ENSO state, is not clearly discussed, and prior BL changes are weakly restricted by marine archives. Here, we used the Ontong-Java Plateau sediment core KX97322-4 (00º01.73'S, 159º14.66'E, water depth 2362 m) to reconstruct previous changes in the BL. Based on the minor difference in calcification depth between two surface species of planktonic foraminifera (Globigerinoides ruber and Trilobatus sacculifer), we used stable isotopes of oxygen and Mg/Ca ratio analyses to document temperature and salinity variation (considering the linear correlation between the sea water δ18O and salinity, it is represented by residual δ18Osw) of surface water in the centre of western Pacific warm pool over the last 140 kyr. The comparison of vertical temperature and salinity change amplitudes suggests that the BL was strengthened during the last two deglacial, and a larger scope of BL was developed during the Termination II, which would intensify the warming in MIS5e compared to MIS1. This is compatible with the maritime continent's increasing precipitation and open ocean of the warm pool's decreased rainfall. In the modern short-term climate state, increased rainfall in the warm pool during the deglaciation period may have produced in higher vertical salt stratification in the surface water, resulting in BL thicknessening. While our results shown that on long time scale, the BL is determined by the lateral hyperhaline intrusion. It might provide positive feedbacks to the La Niña-like condition that existed during the deglaciation and amplified the ENSO's global impact. Earlier in the Holocene, the BL is thinner and associated with an El Niño-like condition. Moreover, 169 δ18Osw measurements gathered throughout the whole western Pacific suggest that rainfall in the western section of the warm pool rose while rainfall in the eastern part of the warm pool declined. This rain band's westward migration may have contributed to the BL's thinning. Our data give fresh light on the dynamics of ENSO-like events during the deglaciation.

Keyword

barrier layer, western Pacific warm pool, El Niño-Southern Oscillation, deglaciation, planktonic

foraminifera

MULTIPLE MIOCENE TROPICAL STORMS RECORDS IN THE EQUATORIAL CARBONATE PLATFORM OF BRAZIL

Orangel AGUILERA SOCORRO[1]*, Universidade Federal Fluminense (orangelaguilera@id.uff.br)
Olga Oliveira De Araújo[2], Federal University of Rio de Janeiro
Ricardo Tadeu Lopes[3], Federal University of Rio de Janeiro
Beatriz Teixeira [4], Universidade Federal Fluminense
Ana Paula LINHARES[5], Museu Paraense Emílio Goeldi

Abstract

Sedimentary carbonate outcrops in NW Brazil represent the exposed portion of the entire carbonate succession of the western equatorial Atlantic coast. Most of the Neogene succession of this carbonate-siliciclastic platform consists of the late early to late middle Miocene Pirabas Formation. During the Neogene high-energy coastal storms and hurricanes, developed as a consequence of trade wind anomalies, impacted the shallow-water marine heterozoan assemblage deposits of the Pirabas Formation in NW Brazil. A chaotic superposition of benthic infauna and epifauna, and of demersal and pelagic species in the same section was analyzed using petrography, micro- and micropaleontology diversity and abundance, taphonomy, geochemistry (XRF and XRD), high-resolution microCT imaging, and 3D reconstructions of heterozoan fossil assemblage to understand the sedimentary and paleoenvironmental processes. The equatorial carbonate platform of Brazil reveals a high-energy setting and evidence for multiple tropical storms during the Miocene. This high-energy wave environment caused severe damage to the shallow-water heterozoan assemblages at the seafloor in the inner to middle marine platform, resulting in the chaotic faunal arrangements observed, including a mixture of elements from different paleoenvironments. The resilience and turnover of successive carbonate heterozoan layers took place after each storm episode. The combination of storm removing of fine-grained particles and the diagenetic dissolution of hard shells was favorable for the development of high porosity and permeability of the carbonate.

Keyword

Pirabas Formation, climate anomalies, heterozoan, carbonate framework, Neogene

Characteristics of late Pleistocene TEX86-based temperatures in the northern Okinawa Trough

Tae Wook KO[1]*, Korea Maritime and Ocean University (ted09@g.kmou.ac.kr)
Kyung Eun LEE[2], Korea Maritime and Ocean University
Masanobu Yamamoto[3], Hokkaido University

Abstract

This study reconstructed seawater temperature using the TEX86 proxy from marine sediments of U1429 (31°37.04' N, 128°59.85' E, water depth 732 m) in the northern Okinawa Trough. Continuous TEX86 temperatures were reconstructed with a 2 kyr resolution over the past 400,000 years. TEX86 temperatures varied in the range of 17-26 °C during 400,000 years, clearly presenting glacial-interglacial cycles. The result of spectral analysis of TEX86 temperature showed a strong 100 kyr cycle. The TEX86 temperatures during the last three interglacial periods (MIS 5, 7, and 9) are in the range of 24-26 °C, which is broadly similar to that of the mid-to late Holocene. The temperatures for glacial periods were between 17 and 19 °C. During the transition period of glacial termination, the temperature rapidly increased by nearly 6 °C. During the transition period of glacial inception, the temperature of TEX86 decreased by 3 °C. Reconstructed U1429 TEX86 temperatures were compared with other proxy temperatures (planktonic foraminiferal Mg/Ca ratio and alkenone) reconstructed in previous studies on U1429. The TEX86 temperatures were always lower than foraminiferal Mg/Ca-based temperatures over the entire period. Meanwhile, they were either similar to or lower than alkenone temperatures over the entire period. In particular, during the glacial termination periods, the TEX86 temperatures were characterized by low temperatures compared to alkenone temperatures. One possible reason for these differences is likely to be caused by differences in the seasonality and production depth of each temperature proxy and the resulting differences in sensitivity to climate forcing.

Keyword

TEX86-based temperature, late Pleistocene, Okinawa Trough

Short-term anomalous sea surface temperature events controls growth rates in giant clamshells (Tridacna maxima) of the Lakshadweep Archipelago, India

Fousiya Athirigothi AOUGE[1]*, Department of Earth Sciences, Indian Institute of Technology Kanpur India (fousevs@gmail.com)
Javed N Malik[2], Department of Earth Sciences, Indian Institute of Technology Kanpur India
Debajyoti Paul[3], Department of Earth Sciences, Indian Institute of Technology Kanpur India
Supriyo Chakraborty[4], Ministry of Earth Sciences, Indian Institute of Tropical Meteorology, Pune, India
Hema Achyuthan[5], Anna University Chennai India

Abstract

Marine calcifiers are the most important components of the marine ecosystem that grow in the Tropical Oceans. They are widely known as the best marine archives to provide high-resolution records of ocean atmospheric variability on sub seasonal to daily scale resolution spanning up to a few hundred years. However, the atmospheric CO2 rise during the post-industrial era has resulted in a decrease of ~0.1 unit in surface ocean pH, a process commonly known as Ocean Acidification (OA), which has highly threatened the growth and existence of these marine calcifiers. Lakshadweep Islands located in the north Indian Ocean harbor various types of such marine calcifiers and various workers have recently studied them for paleoclimatic/paleo-environmental reconstruction. In the present study, we highlight the isotopic (δ18O, δ13C) and microstructure records of a giant clam shell (Tridacna maxima) collected from the Lakshadweep Archipelago, India. Our records show relatively slow growth rate during 2010 caused by exceptionally warm sea surface temperature. The results reveal that even short high-temperature events can significantly perturb the biology of giant clams and require long recovery phases. These results are particularly significant for conservation efforts of some of the most endangered marine calcifiers growing in regions in with on-going global warming trends.

Keyword

Marine carbonates, Lakshadweep, Isotopes, Giant clam, Lakshadweep Archipelago

Cretaceous alkenones from Southern high latitudes: potential for paleoceanographic proixies

Takashi HASEGAWA[1]*, Kanazawa University (jh7ujr@staff.kanazawa-u.ac.jp)

Abstract

Mid-Cretaceous was characterized by high sea levels, elevated average temperatures, and increased carbon dioxide concentrations, resulting in an exceptionally warm climate. Around 94 Ma, a significant perturbation event in carbon cycling (OAE2) occurred, accompanied by a pronounced excursion of carbon isotope values (d13C) observed worldwide. Previous study has detected ethyl alkenone with 40 carbon atoms (C40:2 Et) from IODP Site U1516, located on the southern margin of the proto-Indian Ocean, and applied its d13C values for international correlation. Additionally, C40:3 ethyl alkenone was also identified, leading to proposals for paleotemperature estimates using the ratio of C40:2 Et to C40:2 Et + C40:3 Et. However, GCMS analysis consistently revealed spectral overlap between C40:3 Et and C40:2 Et-derived spectra in the mass spectrum at m/z 572.5. Some results clearly indicated the presence of an isomer peak distinct from the main peak (all trans) of C40:2 Et, occurring at the same retention time as C40:3 Et.

On the other hand, high S/N analysis with GCMS (SIM mode) enables detection of alkenones with extremely low concentration. This technique provided unique alkenone data from Southern high latitude sites including new finding of Santonian C37-40 alkenones and C41:2 Me from OAE2 interval which is the third report from world marine sediments. Isomers of C37:2 Me, C38:2 Et and C39:2 Me are firstly found from Cretaceous sediments.

In this presentation, I summarize current findings then potential of Cretaceous alkenones for understanding paleoceanography, especially how to address paleotemperature variations under the influence of the isomers will be discussed.

Keyword

Cretaceous, Alkenone, Paleoceanography

Seawater temperatures, pH and water mass provenance reconstructions over the last century from cold-water coral geochemistry in the North Atlantic Ocean

Kathrin Brocker[1], University of Padova
Evan Border[2], Heidelberg University
Paolo Montagna[3], National Research Council - CNR
Manuel RIGO[4]*, University of Padova (manuel.rigo@unipd.it)
Stefán Áki Ragnarsson[5], Marine and Freshwater Research Institute, Reykjavik
Valdimarsson Valdimarsson[6], Marine and Freshwater Research Institute, Reykjavik
Steinunn Hilma Ólafsdóttir[7], Marine and Freshwater Research Institute, Reykjavik
Steffen Steffen Therre[8], Heidelberg University
Jens Fohlmeister[9], Potsdam Institute for Climate Impact Research
Julie Trotter[10], University of Western Australia
Malcolm McCulloch[11], University of Western Australia
Marleen Lausecker[12], Alfred Wegener Institute
Patrick Blaser[13], University of Lausanne
Gilles Reverdin[14], Sorbonne Universités
Christophe Colin[15], Université Paris-Saclay
Norbert Frank[16], Heidelberg University

Abstract

The geochemical composition of the aragonite skeleton of cold-water corals (CWC) can provide unique information on the physico-chemical changes and dynamics of water masses at intermediate depths at high temporal resolution (e.g. sub-decadal). Previous studies have shown that variations in seawater temperature, water ventilation age, and water mass provenance can be inferred from measurements of skeletal Li/Mg ratios, paired U/Th and 14C, and neodymium isotopes, respectively. In particular, the solitary azooxanthellate scleractinian coral species Desmophyllum dianthus is particularly valuable due to its widespread distribution, century long lifespan, and stratified skeletal growth, which facilitates the use of geochemical tracers at sub-decadal intervals.

Here, we investigated several Desmophyllum dianthus samples retrieved in 2012 from the Northern Iceland Basin at depths of 570-700 m during the ICE-CTD R/V Thalassa expedition, using the Remotely Operated Vehicle Victor 6000 operated by IFREMER. Sub-samples of the coral skeletons collected along the growth axis were analysed for Li/Mg, stable isotopes (d11B, d18O, d13C), U/Th, 14C and Nd isotopes, with the aim to reconstruct the physico-chemical changes of the North Atlantic intermediate water masses (Iceland-Scotland Overflow Water, Sub-Arctic Intermediate Water and Western North Atlantic Central Water), and quantify how their contributions have varied over the past few decades. The Li/Mg ratios revealed sub-decadal temperature records that vary between ~2 to ~6 °C, which is closely related to changes in Nd-isotopic compositions. These results can be explained by decadal fluctuations in the North Atlantic Oscillation and East Atlantic atmospheric patterns, with those atmospheric drivers causing strengthening or weakening of the Atlantic Subpolar Gyre, leading to changes in the amount of

warmer Subtropical Gyre-sourced water or colder SPG-sourced water. Additionally, the prevalence of ISOW is shown to have roughly halved over the past ~70 years, suggesting an increase in northward transport of warm subtropical waters over recent decades, which may have contributed to recent warming in the Arctic region, as well as substantial multi-decadal weakening of Nordic Sea overflow currents.

Keyword

cold-water coral, seawater temperatures, pH, North Atlantic Ocean, geochemistry

Quantitative constraints on the environmental conditions of bauxite formation since Mesozoic

Xiujuan BAO[1]*, Institude of Geology and Geophysics, Chinese Academy of Sciences (xbao@mail.iggcas.ac.cn)

Abstract

The bauxite is a critical paleoclimatic proxy, and it is also the main material for refining aluminum. Therefore, it is of great scientific, economic and strategic significance to study the mineralization of bauxites. The formation of bauxites is largely affected by intense chemical weathering, closely related to temperature, precipitation and vegetation cover. In paleoclimatic studies, bauxites are used to qualitatively indicate warm, humid and vegetated environmental conditions, but how bauxites in the deep time were quantitatively related to temperature and precipitation has not been established, which limits the paleoenvironmental indication of bauxites and the metallogenic prediction. Here, we combine geological records with climate simulations to establish the quantitative relationships of bauxites with temperature and precipitation since the Mesozoic era. The Earth system model CESM1.2.2 and the vegetation model BIOME4 were combined to simulate the climate and vegetation distribution. Then the environmental information of the paleo-locations of bauxites is extracted, and the quantitative relationships between bauxites, and temperature, precipitation and vegetation are established. We show that bauxites formed with an annual mean temperature of 24.8 °C and precipitation of 1097 mm y-1 after 250 Ma. The climatic variations of bauxites are due to land distribution, climate states, and vegetation coverage. Our research results provide a new understanding of the mineralization of bauxites, and also offer a reference for the exploration of bauxites.

Keyword

deep-time climate evolution, bauxites, kaolinites, temperature, precipitation

Pliocene palaeoceanographic changes reconstructed by biomarker analysis of sediments from the Gulf of Alaska of the northeastern North Pacific

Kotaro HOSHI[1]*, Division of Natural History Sciences, Graduate School of Science, Hokkaido University (souryuu1223@eis.hokudai.ac.jp)
Akemi FUKUMURA[2], Division of Natural History Sciences, Graduate School of Science, Hokkaido University
Ken SAWADA[3], Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University

Abstract

The past 5 million years from the Pliocene to Pleistocene started off with a warm climate represented by the Pliocene climatic optimum (PCO; ca. 4.4~4.0 Ma) alongside with the partial closure of the Central American Seaway (CAS), gradually altering the boundary conditions of Pacific Ocean. Global climate faced a significant cooling after the onset of Northern Hemisphere Glaciation (NHG; ca. 3.2 Ma~) until modern day. At the Gulf of Alaska (GOA), the development of Alaskan alpine glaciers started after 4.2 Ma, which enhanced sedimentation at the GOA. In the present day, enhanced nutrient input via glacial meltwater as well as coastal upwelling during the spring and summer results in algal blooms composed mainly of diatoms. In the present study, we analyzed biomarkers in sediment core samples from the GOA to reconstruct the variations in paleoenvironments and primary productions in the sea surface layers since the early Pliocene (ca. 5.3 Ma) in the northeastern N Pacific.

We used the sediment cores recovered at the distal Surveyor Fan in the GOA (Site U1417; 56° 57.5'N, 147°6.5'W) by Integrated Ocean Drilling Program (IODP) Expedition 341. Freeze-dried sediments were extracted by solvents and then separated into fractions by silica-gel column These fractions were analyzed by GC-MS and GC-FID.

We identified various algal biomarkers including long-chain alkenones (haptophyte), long-chain alkyl diols (diatom and eustigmatophyte), C25 highly branched isoprenoids (HBI) alkane (diatom), and steroids such as dinosterol (dinoflagellate), brassicasterol (haptophyte and diatom), ostreasterol (diatom), and occelasterol (diatom). Sea surface and subsurface temperatures estimated by alkenone unsaturation indices (UK37 and UK’37) and long-chain diol index (LDI) varied with global cooling since the late Miocene as previously reported foraminiferal δ18O records, and also showed remarkable increase/decrease during the warming/cooling events such as the PCO and NHG, respectively. Upwelling intensity estimated by diol index shows major spikes corresponding to the climatic events. Concentrations and mass accumulation rates (MARs) of the algal biomarkers show that marine paleoproduction frequently varied over the past 5 Ma. Diatom production generally increased towards the Pleistocene, matching the global cooling trend.

Keyword

Algal biomarkers, IODP, Primary productivity, northeastern North Pacific, Northern Hemisphere

Glaciation

Sediments of the Baker-Martinez fjord system (48°S) in Patagonia, Chile, reveal land-ocean interactions over the past 500 years

Javier Eduardo MALDONADO[1]*, Institute of Low Temperature Science (ILTS), Hokkaido University, Japan (javiermugarte7@gmail.com)
Carina Beatriz LANGE[2], Universidad de Concepción, Chile; Centro de Investigación Oceanográfica COPAS-Coastal, Chile; Centro de Investigación Dinámica de Ecosistemas Marinos de Altas Latitudes (IDEAL), Universidad Austral de Chile, Chile
Sebastien BERTRAND[3], Renard Center of Marine Geology (RCMG), Ghent University, Belgium; GEOPS, Paris-Saclay University, France
Jerome KAISER[4], Leibniz Institute for Baltic Sea Research Warnemünde (IOW), Germany
Benjamin SRAIN[5], Centro Interdisciplinario para la Investigación Acuícola (INCAR), Chile
Victor ACUÑA[6], Centro de Investigación Oceanográfica COPAS-Coastal, Chile

Abstract

The Baker-Martínez fjord system is an estuarine system located between the Northern Patagonian and the Southern Patagonian icefields. It connects the Andes Mountains to the east with the Pacific Ocean to the west and receives freshwater and sediment from four glacier-fed rivers and from the Jorge Montt Glacier.

In this study, we use a sediment core recovered from the Martínez Channel (47.81°S, 74.06°W; water depth 400 m) to investigate land-ocean interactions in Patagonia during the past 500 years. The core chronology, which is based on a combination of radionuclides and radiocarbon ages obtained on plant remains and carbonate shell fragments, shows a continuous record starting in 1520 -185+155 CE (Common Era). Sea surface temperature (SST) reconstructions based on the TEX86 paleothermometer reveal that SST was low (8 – 10 °C) between 1600 and 1900 CE, in line with offshore records from the entire western coast of Patagonia.

These results point to an equatorward shift of the Southern Westerlies coeval with the observed lower SSTs. All terrestrial input indicators (δ13Corg, sterols, n-alkanes, BIT) provide evidence for an increased detrital supply during the same period, and, grain-size measurements on the detrital fraction show the presence of particles >150 μm. Together, organic biomarkers and grain-size can be interpreted as precipitation-favored mass removal sediments from the steep slopes surrounding the basin, between 1550 and 1870 CE. Two coarse-grained maxima in 1600 – 1650 CE and 1840 – 1870 CE coincide with the lowest sea temperatures (8 – 9 °C), the most depleted δ13Corg values (-26 to -27‰) and a high BIT index (0.44).

Our results from this multi-proxy high-resolution record show that the pre-1900 CE SST decrease previously observed along the Patagonia coast also reached inland regions, and that the concomitant changes in climate affected river discharge and/or sediment mass removals, as a result of enhanced precipitation.

Keyword

Patagonia, fjords, Southern Westerlies, precipitation

Radiolarian Events and Palaeoceanography of Core ABP-06, Station-I (Section 6), Central Indian Ocean.

ABHISHEK KOHLI[1]*, DEPARTMENT OF GEOLOGY, KUMAUN UNIVERSITY, NAINITAL (kohliabhishek96@gmail.com)
GIRISH KUMAR SHARMA[2], 2Department of Geology, University of Delhi, Delhi-110007

Abstract

The study area, Akademic Boris Petrov (ABP) -06, Station I, Section 6 lies between Latitude $11^0$44.004'S and Longitude $76^0$3.311'E in Central Indian Ocean. 198 cm long having 51 Samples from ABP-06 #I, 5, 400-404 depth 5236 to ABP-06 #I, 6 596-598 depth from 5237.98 m were taken to carry out the study. The Section is composed of radiolarian ooze and dark brown fine grained clayey material having disturbed and loose sediments.

The sediment was first disaggregated in dilute hydrogen peroxide (H2O2) for 2 hours, followed by heating to just below the boiling point. One tea spoonful of Calgon (R) was added to further disaggregate the samples and complete the treatment. The sample was then sieved through a 63µm mesh stainless sieve. After final wet sieving the residual material was dried and used for the preparation of slides.

40 radiolarian taxa were identified and presented in the temporal distribution of these taxa. On the basis of first and last common occurrences and abundance of radiolaria, one radiolarian Zones i.e. *Anthocyrtidium angulare* Zone has been established. The base of the *Anthocyrtidium angulare* is defined on the morpho typic last appearance of *Pterocanium prismatium* and it coincides with the upper limit of the *Pterocanium prismatium* zone. However, the base of this zone could not be marked due to the absence of *Pterocanium prismatium*. This zone is equivalent to NR5.Two Events are marked in this zone viz., - Bm *Lamprocyrtis nigriniae* and -Tm *Lamprocyrtis neoheteroporous*. The radiolarian assemblage consists of Tropical, Subtropical, Northern Indian Ocean Group, Bimodal Group and Temperate latitudes Group. This region is fed by the Antarctic bottom water currents evident by the presence of sub-Antarctic species.

Keyword

Radiolarian Events, Paleoceanography, Radiolarian Assemblages of Central Indian Ocean

Morphological Variations On The Growth Of Quaternary Saturnalids Radiolaria In The Antarctic Ocean

Girish Kumar SHARMA[1]*, university of delhi, delhi (gksharma61@yahoo.com)

Abstract

This work presents the morphological variations in the growth and evolution of Saturnalid radiolaria in the Antarctic region and compared with other world oceans. The area is located on a large sediment drift at the base of the Southern slope of the Kerguelen plateau at 59°35.71'S and 85°57.60' E. The 284 samples were collected at a water depth of 4082.5m and length of the core is 214.05 m. The sample was first disaggregated in dilute hydrogen peroxide followed by heating and then add Calgon for further treatment. The wet sample was sieved through 63um sieve. The strewn and picked slides was prepared by using Canada balsam as a mounting medium.

Significant, well-preserved and diversified taxa of Saturnalids viz.,*Saturnalis* and *Saturnulus* were recovered from twenty-three sections (1H to 24H) from Site 745B Leg 119 of Southern Ocean Region

The morphometric analysis includes thickness, shape of the connecting ring and size of polar spines of Saturnalids was carried out and 8 new taxa of *Saturnalis* and 15 *Saturnulus* were identified respectively. The single shelled *Saturnalis* nspp present in the early late Miocene of Tau zone and evolved into two shells of *Saturnulus* nspp in the Late Miocene and became extinct in the late Chi zone of Middle Pleistocene. It is interpreted that there is a progressive evolution in the sizes of shell of *Saturnalis* circularis and *Saturnulus* nspp whereas *Saturnalis* nspp showed retrogressive evolution in the growth of shell. Around 1.5 My.,the Antarctic Ocean was rich in silica and have favorable environment for the growth of the siliceous skeleton which results in the increase of the size and thickness of the shell.

Keyword

Morphological variation, Saturnalids, Morphometry, Antarctic ocean

Millennial scale variability of Indian Winter Monsoon during mid-late Holocene and its links to Solar Changes: New Evidence from Coastal sediments from Sri Lanka

Hewa Marambage Kusala Madhushani Madhushani PREMARATNE[1]*, IOW
(kusala.premaratne@io-warnemuende.de)
Rohana Chandrajith[2], Department of Geology, Faculty of Science, University of Peradeniya, Peradeniya, 20400, Sri Lanka.

Abstract

Solar forcing is a broadly expressed prospect of earth´s climate history. Monsoonal response to Sun´s energy output is evident in many paleo-monsoon records at a range of time scales. Considering the Indian monsoon domain, the response of winter monsoon to solar forcing is not well understood though summer monsoon show asynchronous variations with solar activity throughout the Holocene. This study aims to explore the variability of Indian Winter Monsoon and possible links to solar activity during Holocene. Here we present mid to late Holocene Indian Winter Monsoon record in an AMS 14C dated sediment core from Pottuvil Lagoon. Paleo-monsoon reconstruction was based on geochemistry of trace elements and Rare Earth Elements (REE) of coastal sediments from south-eastern Sri Lanka. A 5.1m core was logged for concentrations of K, Rb, Mg, Al, Ti and REE at a 5cm interval using ICP-MS. The extracted monsoon signal was compared with Holocene records of solar proxies (14C and 10Be nuclide production rates). Results revealed a distinct variability of Indian Winter Monsoon during mid-late Holocene with three phases of intense monsoon activity at 2553-2984 yrs BP, 3899-5021 yrs BP, and at 5244-5507 yrs BP intervals. Further, spectral analysis on elemental proxies showed an occurrence of dominant 1 kyr and 1.6 kyr periodic bands in Lomb Scargle spectra. The millennial scale pacing detected in Pottuvil monsoon record show a close coherence with variations of 14C and 10Be nuclide production rates, implying a possible link to solar forcing. Notably, 1000-year millennial-band is consistent with Eddy solar cycle. The geochemical approach executed in this study provides new perception on millennial scale variability of Indian winter monsoon and ´Sun-monsoon´ climate connection.

Keyword

Deglacial, Solar Proxies, Trace Elements, 14C and 10Be Isotopes, REE

Reconstructing Temperature Changes in the Upper Ocean of the Central South China Sea Since the Industrial Revolution Using Cold-water Corals

Xinru HUI[1]*, State Key Laboratory of Marine Geology, Tongji University (306900680@qq.com)
Xiaoli ZHOU[2], State Key Laboratory of Marine Geology, Tongji University
Peijun QIAO[3], State Key Laboratory of Marine Geology, Tongji University
Xiangtong HUANG[4], State Key Laboratory of Marine Geology, Tongji University
Xiaoying JIANG[5], State Key Laboratory of Marine Geology, Tongji University

Abstract

Since the Industrial Revolution, the continuous increase in atmospheric carbon dioxide concentration has led to global warming. Ice core and observational data, however, indicate that "global warming hiatus" happened in the mid-20th century and the early 21st century. This phenomenon is explained partly by changes in ocean heat storage. The deep ocean is a vast heat reservoir, thus changes in deep ocean heat content may result in short-term decreases in atmospheric temperature. Therefore, understanding the mechanisms of deep ocean heat storage and their historical changes is of great practical significance for predicting future climate change and mitigating global warming.

Cold-water corals, due to their wide distribution, slow growth rates, and unique structure, can record various environmental changes over their lifespans. This study aims at reconstructing seawater temperature changes in the upper ocean of the South China Sea since the Industrial Revolution using cold-water corals collected from water depths between 300 and 2000 meters in the central South China Sea. The growth rates and lifespans of corals were obtained by radiocarbon dating. It is estimated that the radial growth rates range from several micrometers to tens of micrometers per year, yielding lifespans ranging from several decades to several centuries. By analyzing the carbon and oxygen isotopic compositions at the radial direction of the sectioned calcium carbonate skeletons, changes in seawater temperature during coral growth were determined. The results show that samples from shallower depths exhibited larger temperature variations. Additionally, by analyzing the elemental composition of the calcium carbonate skeleton, seawater temperature was reconstructed by applying the modern seawater Mg/Ca-temperature calibration. The results show that Mg/Ca generally decreases from the center to the edge consistently in different radial directions on the long term, while displaying short-term periodic fluctuations for corals from different water depths. According to the modern calibration of Mg/Ca and temperature data, the positive correlation between the two suggests that temperature in the upper and intermediate seawater of the South China Sea may have been decreasing in the past decades to hundreds of years. Nevertheless, other factors such as vital effects also have to be considered while reconstructing temperature from Mg/Ca records. The results of this study have the potential to provide new evidence for understanding the relationship between ocean heat storage and atmospheric carbon dioxide concentration, as well as the "global warming hiatus" event.

Keyword

cold water coral, radiocarbon dating, carbon-oxygen isotopes, Mg/Ca-T proxy

Late Cretaceous high-resolution sea and lake-level reconstructions based on sedimentary noise modeling: water circulation and orbital forcing

Kaixuan JI[1]*, Peking University (jikaixuan_cug@163.com)
Mingsong Li[2], Peking University
Fanhao Gong[3], Shenyang Geological Survey Center, China Geological Survey
Dejun Zhang[4], Shenyang Geological Survey Center, China Geological Survey

Abstract

Research on water dynamics within greenhouse settings is drawing more interest due to its significance in understanding the connection between orbital forces and the mutual evolution of organisms and their environments. A major challenge lies in deciphering the fluctuation of water levels in the world's oceans and continents under conditions absent of ice and identifying what primarily influences sea level shifts. Conventional methods such as sequence stratigraphy and sedimentology have only offered limited and imprecise data, which restricts a thorough analysis of ancient water circulation patterns. Thus, the precise measurement of changes in sea and lake levels becomes crucial for the exploration of the Earth's historical hydrology. This study introduces the use of sophisticated sedimentary noise models (DYNOT and ρ1) derived from astrochronology and time-series analysis to map out fine-scale changes in water levels across different landscapes: the continental Songliao Basin in Northeast China, the Basque-Cantabric Basin off the coast of Spain, and the Espírito Santo Basin in the western South Atlantic, spanning the Maastrichtian Stage to the Cretaceous-Paleogene (K-Pg) boundary. Through sedimentary facies analysis and paleosol studies, this research uncovers periodic shifts in sea and lake levels every 1.2 million and 2.4 million years, displaying a contrasting pattern of rises and falls. These findings suggest that sea level variations could be related to the fluctuating volumes of continental waters, shedding light on the intricate relationship between land and ocean water circulations.

Keyword

Late Cretaceous, astrochronology, sea and lake-level change, water circulation

Catastrophic Flooding during Late Holocene in Northern Bihar Plains, India: A Geo-archaeological Perspective

SHANKER SHARMA[1]*, ARCHAEOLOGICAL SURVEY OF INDIA
(shanker.sharma74@yahoo.co.in)

Abstract

Generally we consider that the growth and downfall of several civilizations have been directly or indirectly related to changes in climatic conditions. The Northern Bihar plain was one of the areas which were affected from short term adverse environmental conditions during the late Holocene time (circa 1400 BP) causing catastrophic flooding. Probably, this occurred because of unprecedented amount of glacial melt on the Himalayas and lake outbursts due to changes in temperature. Some reconstructed palaeoclimatic data also suggests that at the same time there were some environmental backdrop that ascended due to changes in climatic conditions. The data over reconstructions of past climate have also revealed that large-scale changes in temperature and rainfall patterns have occurred throughout the geological history over almost all time scales ranging from decades to centuries to millennia and spatial scales from small regions to almost the entire globe.

Archaeological sequences are often found buried under thick fluvial sediments. The sediments found during excavations in the study region have revealed an identical physical context including floodplain deposits of silt and clay and marked by prominent discontinuities in the human settlements at all the sites. Several episodes of fieldwork by the author has demonstrated that abandonment of the region was probably a result of catastrophic flooding in the low lying area of northern India and southern Nepal. The archaeological evidence is supported by some contemporary historical texts and travelogue accounts. The present perception has been conceptualized through various scientific investigations using DEM model, absolute dating method, palaeobotanical remains, sedimentological analysis and archaeological evidences. Indeed the paper is a geo-archaeological perspective which provides an insight into the past climatic conditions of the region and its impact on life during that time span.

Keyword

Catastrophic flooding, Holocene, climatic condition, geo-archaeological perspective

Spatial and Temporal Distribution of Typhoons during the Joseon Dynasty (1392 – 1910)

Jin Gu KANG[1]*, Department of Sustainable Environment, Catholic Kwandong University (kang99104@cku.ac.kr)
Kwang Hee CHOI[2], Department of Geography Education, Catholic Kwandong University

Abstract

Sea surface temperatures are increasing due to global warming, leading to more intense tropical cyclones such as typhoons. Veritable Records of the Joseon Dynasty, a historical document from AD 1392 to 1910, is an important source of information on typhoon occurrences in South Korea, especially considering the relatively short period of modern typhoon observations. This study aimed to analyze the spatiotemporal distribution of typhoons in the Korean Peninsula during the last half millennium, using the Veritable Records of the Joseon Dynasty. The study extracted past typhoon records from the documents and determined their occurrence time and affected spatial area. A GIS program was used to convert each record into a point datum, and the paths of past typhoons were calculated by combining the points with similar dates. The analysis identified 580 records related to strong winds, with 97 classified as past typhoons occurring between July and September, accompanied by precipitation. The study found that typhoons during the Joseon Dynasty were mainly distributed in the southern and eastern coastal regions of the Korean Peninsula, similar to the current spatial pattern of typhoons affecting Korea. The southern region, including Goseong, Sacheon, and Suncheon, was the area most affected by typhoons. Nearly half of the typhoon records were concentrated in the 17th century, related to the Little Ice Age in East Asia. The path of typhoons during the Joseon Dynasty was similar to today's, from west to northeast or south to north. The study is significant in estimating the characteristics of typhoons by examining their spatiotemporal distribution in the past and representing the paths of typhoons and affected areas geographically. However, there is a possibility of duplicate or erroneous records and intentional omissions of records unfavorable to the ruling class of the time, as the study relied on documentary records as a source of research data.

Keyword

Tropical storms, Historical records, Spatial distribution, Climate change

Terrestrial n-alkane and alkenones flux and its relationship with climate and paleoceanogrphy of the low-latitude Indian Ocean during the Quaternary

Sangmin HYUN[1]*, Korea Institute of Ocean Science and Technology (smhyun@kiost.ac.kr)
Jeongwon Kang[2], Korea Institute of Ocean Science and Technology
Hiroyuki Takata[3], Pusan National University

Abstract

We investigated Quaternary two biomarkers of alkenones an terrestrial organic compounds, n-alkane, in core GPC 1803 from the eastern equatorial Indian Ocean since ~740 ka to examine the relationship between alkenones-n-alkane influx and climate-paleoceanographic variations. The oxygen isotope result shows cyclic glacial-inter glacial variation, it reachs marine isotope stage(MIS) 18. As the oxygen, the total alkenones concentration shows cyclic variation with increase during glacial periods except for MIS18. Also, the total sum of terrestrial n-alkanes (nC25~nC35) high during glacial periods except for MIS2. Given them that terrestrial n-alkanes influx controlled by relative strong wind strength during glacial periods, both biomarkers of alkenoens and n-alkenes are characterized by high concentration of total alkenones and high concentration of total n-alkanes during glacial periods, implying strong relationship between climate and in situ paleoceanography. This implying increase of paleo productivity during glacial periods. Alkenone-based SST(Sea Surface Temperature) shows high amplitude variations throughout, ranged about 27oC to 29oC. However, the alkenones-based SST does not follow glacial-inter glacial patterns, high temperature in inter glacial and low temperature in glacial periods. In this study, C37:4, C37:3, C37:2 were detected, the C37:3 compounds are generally less than 5%, and C37:2 % is much higher than 85%. Therefore, calculated alkenoen-based SST may be over estimated, hard to interpretation. We will conduct additional alkenones analysis and will compared with previously published paper in this study.

Keyword

Terrestrial n-alkene, Climate, Paleoceanography, Indian Ocean, oxygen isotope

The Strontium and Neodymium isotopic signatures of the Zambezi River Basin in Southern Africa: From source to sink.

Sonwabile Kidwel RASMENI[1]*, University of South Africa (65104129@mylife.unisa.ac.za)
Lindani Ncube[2], University of South Africa
Elna Van Niekerk[3], University of South Africa
Baojin Zhao[4], University of South Africa
Junsheng Nie[5], Lanzhou University
Jing Yang[6], Lanzhou University

Abstract

The isotopic signatures of radiogenic strontium (Sr) and neodymium (Nd) are commonly employed to trace the movement of sediment particles in rivers and reconstruct alterations in tectonics and climate during particle formation. These signatures are widely acknowledged as dependable indicators of sediment provenance due to their minimal isotopic fractionation during chemical weathering. Since the Cretaceous period, the Zambezi River has been transporting and depositing substantial detritus particles, causing natural fluctuations in river flow, erosion, and sedimentation before reaching the Indian Ocean. A comprehensive understanding of sediment transportation pathways from initial source regions to the ocean is crucial for discerning the origin of these detrital particles.

This study represents the inaugural in-depth analysis of the Zambezi River's provenance, utilizing Sr-Nd data from various segments of the main river and some major tributaries. Results reveal that the isotopic signatures of river sediments closely align with the underlying geology of distinct river sections, implying a significant influence of local geology on sediment origin. Consequently, sediments carried by upper Zambezi River sections draining interior continents predominantly accumulate in on-land sedimentary basins rather than marginal seas. This underscores the limitation of using sediments from marginal seas to infer mountain uplift and exhumation history in the hinterland, as these materials originate from three distinct Zambezi River sections exhibiting diverse precipitation patterns, geology, and geomorphology.

Therefore, it is recommended to consider the isotopic provenance of riverine sediments instead of solely relying on marine sediments deposited off marginal seas as proxies for river sediment. This approach enhances the accuracy of interpreting erosion history associated with mountain uplift and exhumation in the Zambezi River region.

Keyword

Zambezi River, Provenance, Radiogenic, Strontium (Sr), Neodymium (Nd)

Calcareous Nannofossil and Paleoclimatic Evolution Across the Eocene–Oligocene Transition at IODP Site U1509, Tasman Sea, Southwest Pacific Ocean

Allyson Viganò[1], Dipartimento di Geoscienze, Università di Padova, Padova, Italy
Edoardo Dallanave[2], Faculty of Geosciences, University of Bremen, Bremen, Germany
Laia Alegret[3], Departamento de Ciencias de la Tierra & IUCA, Universidad de Zaragoza, Zaragoza, Spain
Thomas Westerhold[4], Center for Marine Environmental Sciences (MARUM), University of Bremen, Bremen, Germany
Rupert Sutherland[5], School of Geography, Environment and Earth Sciences, Victoria University of Wellington, Wellington, New Zealand
Gerald R. Dickens[6], School of Natural Science, Trinity College Dublin, College Green, Dublin, Ireland
Cherry Newsam[7], Network Stratigraphic Consulting Ltd., Potters Bar, UK
Claudia AGNINI[8]*, Dipartimento di Geoscienze, Università di Padova, Padova, Italy (claudia.agnini@unipd.it)

Abstract

Around 34 Ma, the Earth's climate shifted from a Warmhouse to a Coolhouse state marked by a rapid temperature drop and the formation of permanent ice-sheets on Antarctica. This transition, known as the Eocene-Oligocene transition (EOT), stands as one of the most important climate event in the Cenozoic. During this time, significant changes and turnovers in marine fauna and flora occurred and primarily related to major modification in ocean thermal and trophic structure.

In order to assess how climate changes across the EOT impacted the surface-ocean conditions, we generated a high-resolution calcareous nannofossil and geochemical datasets (δ18O, δ13C and % CaCO3) over a ~5 Myr stratigraphic interval from IODP Site U1509 (Tasman Sea, southwest Pacific Ocean). Site U1509, located between the Southern Ocean (high-latitudes) and the Equator (low-latitudes), represents an ideal case study to reconstruct the paleoclimatic evolution of the Southwest Pacific Ocean and to understand the impact of high latitude cryosphere changes on lower latitude calcareous nannoplankton communities.

At this site, major trends and shifts in the calcareous nannofossil assemblage indicate four distinct phases characterized by a temperature decrease and variations in paleocurrents: (a) late Eocene warm-oligotrophic phase, (b) precursor diversity-decrease phase, (c) early Oligocene cold-eutrophic phase and (d) steady-state cosmopolitan phase. Overall, these phases point to a decline in warm-oligotrophic taxa and to an increase in opportunistic genera better adapted to cooler and more eutrophic conditions. The shift in the assemblage composition was likely driven by sea-surface water cooling and eutrophication, resulted by the northward transport of cooler and nutrient-rich waters from the circum-Antarctic area caused by the inception of a proto-Antarctic Circumpolar Current (ACC).

The most significant change, documented by the marked and permanent loss of the late Eocene

warm-oligotrophic community, occurred during the precursor diversity-decrease phase, a transitional time window of ~550 kyrs, characterized by relatively high bulk δ18O and % CaCO3 values, and followed by a phase of maximum glacial expansion (Earliest Oligocene Glacial Maximum, EOGM) and eutrophication.
To conclude, data from the Tasman Sea provide further support to the idea that e modifications and invigoration of Southern Ocean circulation profoundly influenced and shaped also middle latitude regions.

Keyword

calcareous nannofossils, Eocene-Oligocene, Southwest Pacific Ocean, paleoclimate

Paleoceanographic changes in the Western Equatorial Pacific Ocean since the latest Miocene: Insights from Planktic Foraminiferal Census Data

Ayushi RAM[1]*, Indian Institute of Technology Kharagpur (ayushiram.richi@gmail.com)
Anil Kumar Gupta[2], Indian Institute of Technology Kharagpur

Abstract

Understanding the dynamics of air-sea interactions in the tropical Pacific holds significance in unraveling climate variability. A focal point of our study lies in assessing the mixed layer thickness in the Western Equatorial Pacific (WEP), as it offers an opportunity to understand strength of the Walker circulation and the resulting strength of air-sea interactions, both of which play pivotal roles in recent high-frequency tropical climate variability. To investigate this dynamics, we chose Ocean Drilling Program (ODP) Site 803D (2°25.98'N, 160°32.46'E) located within the core region of WEP to analyze planktic foraminifera relative abundance to investigate the evolution of the oceanographic system in this area since the latest Miocene (~ 6 Ma). Fluctuations in the relative abundance of thermocline dwelling species (TDS) serve as qualitative indicators of changes in the depth of thermocline. During the early Pliocene (~ 5.5 to 4.7 Ma), a moderate decrease in the relative abundance of TDS, coupled with an increase in mixed layer species (MLS) suggest a simultaneous deepening of the thermocline and thickening of the mixed layer, which is attributed to the prevailing warmth during this time. A significant shift in the relative abundance of TDS occurred from 3.5 to 2.7 Ma, with their relative abundance increasing from approximately 55% to 70%. During this time, the Indonesian Throughflow was restricted, which led to the buildup of more southern-sourced water, including the cold and nutrient-rich Subantarctic Mode Water (SAMW) and Antarctic Intermediate Water (AAIW). This event is followed by a gradual decline of TDS to ~50% from ~70% alongside an increase in MLS relative abundance at around 2.7 Ma. This indicates a deepening of the thermocline and a thickening of the mixed layer, signifying the development of Western Pacific Warm Pool to its current state. Notably, *Neogloboquadrina* spp. exhibited a remarkable increase during ~ 2.2 to 1.7 Ma and 1.0 to 0.3 Ma, indicating enhanced productivity in the WEP. Despite the minor fluctuations in Sea Surface Temperature (SST) in the Western Pacific region, our planktic foraminiferal abundance data suggest greater variability indicating that the distribution and ecology of planktic foraminifera were influenced not only by SST but also by productivity, nutrient input, and the provinciality of planktic foraminifera. This might be related to the development of the Equatorial Undercurrent and Countercurrent systems owing to the gradual emergence of the Indonesian archipelago.

Keyword

Western Equatorial Pacific, Planktic foraminifera, Pliocene, Mixed layer, Thermocline

The evolution of Southern Benguela Upwelling System and its impact on southwest African climate during the Late Miocene

RUDRA NARAYAN MOHANTY[1]*, Indian Institute of Technology Kharagpur (rudranarayanmohanty000@gmail.com)
ANIL KUMAR GUPTA[2], Indian Institute of Technology Kharagpur

Abstract

The Benguela Upwelling System (BUS) is marked by intense upwelling making it one of the most productive regions among the Eastern Boundary Upwelling Systems (EBUS). In this study, new planktic foraminiferal relative abundance data from ODP Site 1087 (31°27.9137'S, 15°18.6541'E), situated in the Southern Benguela Upwelling System (SBUS), is employed to comprehend the upwelling dynamics of the BUS and its impact on the continental climate of southwest Africa during the Late Miocene. During the early Late Miocene interval of weak upwelling, there was a notable high relative abundance of tropical Indian Ocean species, possibly indicating a probable connection between the Indian Ocean and the Southeast Atlantic Ocean. Our planktic foraminifera relative abundance data suggest that the BUS perhaps initiated between ~ 10 - 9 Ma, with intensified upwelling occurred only after ~ 8 Ma. Our results corroborate earlier observations on the initiation of BUS. Between ~ 8 and 5 Ma, the Late Miocene Biogenic Bloom period witnessed a high relative abundance of upwelling indicator species, signifying the presence of intense upwelling and increased productivity in the SBUS. Over this period, the warm water species gradually decreased, whereas the cold water species increased. The growth of Antarctic ice sheets and subsequent strengthening of southeast trade winds likely played a crucial role in fueling the Benguela Coastal Current and establishing the upwelling-dominated regime in the SE Atlantic Ocean. Interestingly, the timing of the development of the upwelling in the SBUS at ~ 10 Ma, aligns with the shift in vegetation type in southwest Africa. The cooling effect of the upwelling process and subsequent reduced moisture supply to the adjacent land would have profoundly contributed to the aridification in southwest Africa, leading to the transition from tropical to arid vegetation.

Keyword

Planktic foraminifera, Late Miocene, Benguela Upwelling System, Southwest African climate, Trade winds

Grain size distribution in the Northwest Pacific deep-sea sediments: implication for rare earth elements and Yttrium enrichment

EUIJONG LEE[1]*, Department of Environment and Energy, Jeonbuk National University (euijong98@gmail.com)
KISEONG HYEONG[2], Ocean Georesources Research Department, Korea Institute of Ocean Science & Technology
INAH SEO[3], Department of Earth and Environmental Sciences, Jeonbuk National University

Abstract

Rare earth elements and yttrium (REY) are metallic elements with unique chemical and optical properties which allows their applications across various industries. The global supply is heavily reliant on ion-adsorption deposits primarily located in southern China, with increasing demand due to energy transition trends. Recently, there has been growing interest in REY-rich muds in deep sea as a potential alternative resource, as reports indicate comparable REY concentrations in the Pacific Ocean to those found in terrestrial deposits. Notably, extremely REY-rich mud (>5000 ppm) was reported in Japanese Exclusive Economic Zone (EEZ) near Minamitorishima Island, only at certain stratigraphic levels in specific locations. Such heterogeneity in REY distribution calls for a thorough investigation into its genetic origin and the relevant paleoceanographic factors involving reliable age models for conducting a comprehensive resources assessment and evaluation.

We conducted grain-size analysis on surface sediments from 7 cores in the Northwest Pacific to examine the correlation between grain size distributions (GSD) and REY concentrations. There is a positive relationship between the proportion of coarse-grained (greater than 55 micrometers) sediments and the maximum REY contents at the individual sites, with exceptions observed below ~700 ppm. This suggests that in the regions with high REY concentrations, mineral phases constituting the coarse fraction, presumably including biogenic apatite, serve as the primary host of REY, thereby inducing their regional enrichment. However, below a certain concentration threshold, factors unrelated to GSD seem to exert a greater influence on REY enrichment.

In addition, we employed down-core end-member mixing analysis (EMMA) on the sediment core (WP21GPC04; 20.7657° N, 152.5923° E), which contains an extremely REY-rich mud layer, to isolate the modes identified in GSD spectrum. In most samples, the GSD shows a trimodal distribution, and the peak height of the coarsest component is associated with the REY concentration. However, the position of each peak's mode is not consistent with regard to sampling depth, requiring the integration of 8 end-members to effectively explain GSD variance with R-squared value of 0.68. Such depth-wise variance in the average grain size of each mode indicates temporal changes in the environmental factors, which necessitates further specification of each end-member through optical microscope analyses.

Keyword

Rare Earth Elements and Yttrium, Deep-sea sediments, Grain size analysis, Northwest Pacific

[Keynote] Geohazard assessment from submarine landslides: a multi-stage approach for the Ulleung Basin

Roger URGELES[1]*, Institute of Marine Sciences (CSIC) (urgeles@icm.csic.es)
Jang-Jun Bahk[2], Chungnam National University, Daejeon, 34134, Republic of Korea
Deniz Cukur [3], Korea Institute of Geoscience and Mineral Resources (KIGAM), Gwahak-ro 124, Yuseong-gu, Daejeon 34132, Republic of Korea
Senay Horozal [4], Chungnam National University, Daejeon, 34134, Republic of Korea
Sueng-Won Jeong [5], Korea Institute of Geoscience and Mineral Resources (KIGAM), Gwahak-ro 124, Yuseong-gu, Daejeon 34132, Republic of Korea
Gil Young Kim [6], Korea Institute of Geoscience and Mineral Resources (KIGAM), Gwahak-ro 124, Yuseong-gu, Daejeon 34132, Republic of Korea
Seong-Pil Kim [7], Korea Institute of Geoscience and Mineral Resources (KIGAM), Gwahak-ro 124, Yuseong-gu, Daejeon 34132, Republic of Korea
Gwangsoo Lee [8], Korea Institute of Geoscience and Mineral Resources (KIGAM), Gwahak-ro 124, Yuseong-gu, Daejeon 34132, Republic of Korea
Sang Hoon Lee [9], Korea Institute of Ocean Science and Technology, 385, Haeyangro, Yeongdo-Gu, Busan 49111, Republic of Korea
Dong Geun Yoo[10], Korea Institute of Geoscience and Mineral Resources (KIGAM), Gwahak-ro 124, Yuseong-gu, Daejeon 34132, Republic of Korea

Abstract

Submarine landslides are capable of generating tsunami that threaten coastal communities, infrastructure and global economies. The eastern coast of the Korean Peninsula is also not safe from such geohazard. The Ulleung Basin is the source to more than 100 submarine landslides that occurred in the last 300 kyrs with source areas that may attain 165 km2 and up to 24 km3 in volume. A series of stages characterizes the occurrence of submarine landslides: pre-failure, failure and post-failure; each of which presents distinct hazards. For the pre-failure stage, we assessed the potential occurrence of excess pore pressure based on average sediment compressibility and porosity profiles and 2D basin analysis models. Both analyses point to little overpressure in sediments of the Ulleung Basin. Only the upper range of potential compressibility, or sudden deposition of MTDs in the basin center could reduce the effective stress by ~30 %. For the failure stage, we carried out a regional susceptibility mapping using normalized parameters. We found that the slopes of the basin are quite safe under static conditions and most areas show factors of safety of 3 and above. A pseudo-static analysis (calibrated with dynamic parameters) indicates that maximum potential earthquake loading could involve failure of sectors of the basin's western slope, where gradients exceed 20º and faults provide the most intense ground shaking. Although not analyzed in detail, the depth to the base of the gas hydrate stability zone also seems to play a role in occurrence of slope failures. To characterize post-failure evolution, we set up a series of numerical models to reproduce the main features of a 23,5 +-8.3 km3 debris flow with a runout of 152 km using Herschel-Bulkley rheology in the depth averaged code MassMov2D. The latter was modified to account for buoyancy, remoulding and drag forces. We found no value that actually allows to accurately reproduce the pattern of sediment distribution

within the debris flow, likely indicating the turbiditic nature for the deposit most distal part. The models with the highest yield strengths display limited runout distance, while those with the lowest yield strength lead to large lateral spread and fail to reproduce the pattern of thickness distribution. The simulations imply, however, that significant wetting (i.e., a gradual reduction of yield strength) of the materials involved in the debris flow must occur as deformation proceeds. The yield strength also controls initial velocity history of the failed mass. Coupling the landslide dynamics to a NLSW tsunami model (GeoClaw) shows that the landslide is clearly subcritical and produces trains of 2 km long waves. Instantaneous onset of the landslide compared to more gradual release produced slightly larger waves and more energy focused towards the Korean coast. Bathymetric features such as the Hupo Bank focus tsunami energy. Resulting tsunami waves are up to 0.6 m in 50 mwd considering gradual landslide release and up to 0.8 m considering instantaneous landslide release. These should be translated to runups of a few meters at the coast.

Keyword

Geohazard, Submarine landslide, Tsunami, Pore pressure, Post-failure evolution

Generation and propagation characteristics of submarine-landslide tsunami

Ao SHEN[1]*, China University of Geosciences, 388 Lumo Road, Hongshan District, Wuhan (cugshen@cug.edu.cn)
Qiliang Sun[2], China University of Geosciences, 388 Lumo Road, Hongshan District, Wuhan

Abstract

Tsunamis generated by submarine slope failures have the potential to cause devastating consequences. Quantifying the potential tsunami impact caused by landslides is particularly crucial for geohazard assessment. Separating tsunami wave signals from other influencing factors (e.g., wave refraction and reflection) would be greatly helpful for understanding wave propagation characteristics and improve the accuracy of tsunami prediction. This paper numerically investigated the processes of landslide deformation, tsunami generation and propagation in the Xisha Islands, South China Sea (SCS), and evaluated the impacts of resonance, wave refraction and reflection on the time series characteristics of tsunami waves, and quantified them during wave propagation. The tsunami waves generated by submarine landslides have strong dispersion, which is different from those generated by earthquake. They are mainly concentrated around the Xisha Islands, with the maximum wave height of ~10 m. The landslide process has an obvious influence on the initial tsunami wave. The waves usually have a chirp change in frequency. By decomposing and analyzing the time series of tsunami wave, the wave signals can be reconstructed by two components, characteristic components 1 (CC1) and 2 (CC2). The former (CC1) is characterized by small-amplitude, high-frequency, short-period waves; the latter is characterized by high-amplitude, low-frequency, long-period waves. CC1 represents the normal tsunami wave without influencing by other factors; CC2 represents the tsunami wave influenced by resonance, wave refraction and reflection. This study suggests that morphology could greatly influence the propagation of submarine landslide-generated tsunami. It also indicates that tsunamis generated by submarine slope failure are a significant geohazard to the islands of SCS and should be considered during the assessment of SCS geohazard. The results would improve the understanding of the processes and characteristics of submarine landslide-related tsunami generation, and also improve the hazard assessment in coastal areas.

Keyword

submarine landslide, tsunami wave, wave propagation, time series analysis, signal separation

Factors controlling carbonate slope failures: Insight from stratigraphic forward modelling

Jianliang LIU[1]*, China University of Petroleum (East China) (liujianliang@upc.edu.cn)
Keyu LIU[2], China University of Petroleum (East China)

Abstract

A carbonate slope links platform and basin-floor regions holding crucial information on the carbonate source-sink system of a vast ocean. There is a generally poor understanding of the entire process of carbonate slope deposition, failure, and subsequent transportation and re-deposition etc. due to the lack of field observation and adequate numerical modelling algorithms. Based on a comprehensive literature review on carbonate slope failures, a three-segment carbonate slope depositional model was conceptualized and simulated using a stratigraphic forward modelling (SFM) program. The model is capable of simulating carbonate slope failures in a) subaerial, b) shallow marine, and c) deep marine settings concurrently. The SFM program was employed to simulate the evolution of carbonate slope and the occurrence and distribution of mass transport deposits (MTDs) in a deeply buried upper Ediacaran carbonate succession in the central Sichuan Basin, China. The simulation results show that MTDs were mainly developed at the toe-of-slopes and in the center of the Ediacaran trough, offering a new potential play for future hydrocarbon exploration in the area. Several key factors controlling carbonate slope failures, including carbonate lithologies, carbonate growth rates, and frequencies and amplitudes of sea-level fluctuations, were quantitatively evaluated in both time and space domains. Simulations have confirmed that carbonate lithologies can notably affect the frequency and magnitude of slope failures and the development of MTDs, indicating that the higher the proportions of coarser and cemented sediments, the less frequent slope failures and the less the volume of the MTDs would be. The frequency of slope failures and the volume of the MTDs would increase with carbonate growth rates. Slope failures are more likely to be triggered by high-frequency sea-level fluctuations than by low-frequency sea-level changes. For a given sea-level change frequency, the magnitude of a single slope failure event and the total volume of associated MTDs are more likely to be more significant under a greenhouse climate, with a relatively smaller amplitude of sea-level changes, than under an icehouse climate.

Keyword

Carbonate slope failure, Mass transport deposits, Tectono-sedimentary evolution, Stratigraphic forward modelling, Sichuan Basin, China

Analysing submarine landslide distribution along the Calabrian continental margins, insights from high-resolution morpho-bathymetric data.

Marco BIANCHINI[1]*, Institute of Oceanography and Applied Geophysics (mbianchini@ogs.it)
Silvia Ceramicola[2], Institute of Oceanography and Applied Geophysics
Daniele Casalbore[3], Sapienza, University of Rome
Francesco Latino Chiocci[4], Sapienza, University of Rome

Abstract

Submarine landslides are common geological features occurring on the seafloor and at the same time difficult to characterize, but very important for the assessment of geohazards for a given area.

The geodynamic evolution of the Mediterranean region caused steep continental margins, canyon formation, seismicity, high uplift, and sedimentation rate that played an important role as preconditioning and triggering factors for landslide occurrence. This has led the southern Italy continental margins to be among the most landslide-prone regions of the Mediterranean Sea.
Our work consists in the inventory, mapping, morphometric parametrization, and statistical analyses of about 2000 morphological features related to mass wasting processes occurring in continental slope of the active Calabrian arc (uplift rate up to 1 mm/y). Namely the analysis was performed in two areas, in back arc (Tyrrhenian) and forearc (Ionian) settings, driven by the subduction and roll-back of the Ionian plate under the Calabrian Arc. The research is part of Ph.D. programme in the framework of a PNRR national project “Geoscience IR” and will make use of an extensive high-resolution morphological dataset acquired during the Magic project.
Due to the difficulties in carrying out direct in-situ observations and geotechnical parameterization of landslides in the submarine realm, the morphometric analysis seems to be a useful tool that allow us to analyse the amount of submarine landslide, and therefore, balancing the lack of information using a statistical analysis on the control factors.
For the reason we make use of the extensive high-resolution MaGIC bathymetric dataset (about 15.000 km2) to analyse landslide morphologies (aspect, ratio, length. volumes...) to assess existing relations between landslide occurrence, their shape, and spatial distributions. To do this we will make use of several thematic maps derived by the bathymetry (contour, shaded relief slope, roughness, gradient ...).
The overall aim is to use bathymetric derived information to gain better understanding of the triggers and driving mechanisms causing a slope to fail and recognise spatial correlations between submarine landslide occurrence and other geological factors, as well as being able quantify landslide occurrence. Gaining a better understanding of failure dynamics will allow us to develop an increasingly accurate hazard estimates of the seabed.

Keyword

Submarine landslides, Morphometrical analysis, Submarine Geohazard, Multibeam (MBES)

Multistage submarine landslides and their effects on widespread seeps, shallow gas and gas hydrate occurrences

Xiujuan WANG[1]*, Ocean University of China (wangxiujuan@ouc.edu.cn)

Abstract

Multistage mass transport deposits (MTDs) or submarine landslides have been delineated using three dimensional (3D) seismic data in the sedimentary basins of the world oceans, especially in the deep-water basins. Moreover, widely distributed gas hydrate, shallow gas and numerous paleo-seeps or active seeps are also found from 3D seismic data, in situ detection and multibeam data. Gas hydrates been confirmed by logging-while-drilling and coring with different morphologies and even coexistence with free gas in some areas. Gas hydrates are found below or within MTDs above the base of gas hydrate stability zone (BGHSZ) showing layered or mounded-like structures which is controlled by the internal structure of MTD and the fluid flow. Mostly seeps and the high concentrated gas hydrate are found in the sand-rich reservoir above the shallow gas trapped zones, where the faults and gas chimneys zones root from basement uplift. More than 200 chimney-like and mounded-like structures are identified above MTD near the BGHSZ from 3D seismic data in the Qiongdongnan basins, South China Sea. The thrust faults and fractures are found within the MTD using the geophysical attributes which provide pathways for fluid flow migrations. Detailed studies show that the fluids migrated from the structural faults and the tensile faults directly above the basement uplift which contribute to the accumulated shallow gas, seeps and gas hydrate. However, we found that the long-distance fluid migration along sand-rich below MTD provides the main gas resource for the gas trapped below MTD. We quantitatively reveal that a similar vertical distribution of gas hydrate saturation can be formed around the open faults above the base of hydrate stability zone and the thermogenic gas migration along faults contribute to enrichment of gas hydrate. The integrated studies provide a better understanding how the fluids can pass through the MTD and form seeps, shallow gas and the concentrated gas hydrate.

Keyword

Mass transport deposits, Paleo- and active seeps, mounded-like, gas hydrate, fluid flow

Numerical Assessment of tsunamigenesis from submarine mass movements along the slopes of Ionian Calabrian Margin (South Italy)

Filippo ZANIBONI[1]*, Dipartimento di Fisica e Astronomia "A. Righi" - Università di Bologna, Italy (flippo.zaniboni@unibo.it)
Silvia Ceramicola[2], National Institution of Oceanography and Applied Geophysics, OGS, Trieste, Italy
Nora Markezic[3], Dipartimento di Matematica, Informatica e Geoscienze, Università degli Studi di Trieste, Trieste, Italy
Cesare Angeli[4], Dipartimento di Fisica e Astronomia "A. Righi" - Università di Bologna, Italy
Martina Zanetti[5], Dipartimento di Fisica e Astronomia "A. Righi" - Università di Bologna, Italy
Alberto Armigliato[6], Dipartimento di Fisica e Astronomia "A. Righi" - Università di Bologna, Italy

Abstract

The Ionian Calabrian Margin (ICM, located in south Italy) is deeply incised by submarine canyons and failure scars, testifying an intense mass movement activity, enhanced by the steep slopes and the continuous sediment supply from the dryland, favoured by the rapid uplift (1 mm/a) the margin is undergoing since 1 Ma.

High-resolution bathymetry and 2D seismic surveys acquired by OGS revealed in detail the morphology and the acoustic facies of multiple failure events that occurred along the steep slopes (from 110 to over 1500 m depth, around 9° average incline) of the ICM and only 5 km away from the coast. The analysis and interpretation of geophysical data allowed to reconstruct the failure dynamics, defining in particular three landslide geometries, with their volumes and run out. These pieces of information have been used to simulate failure scenarios and the potential ensuing tsunamis, together with the quantification of the possible effects of the latter on the coastline in terms of maximum tsunami amplitude, inundation depth and penetration distance.

The whole phenomenon is evaluated by means of numerical techniques, developed by the University of Bologna research team: the landslide dynamics is simulated through a numerical code able to reproduce the time evolution of the landslide shape and motion, factors that deeply influence the tsunamigenesis; the generated wave propagation is mimicked by a shallow-water equations solver, able to quantify the impact of the sea level perturbation on the coast.

The simulations produce maximum wave amplitudes of more than 2 m that, though not catastrophic, are certainly able to produce damage to boats and coastal infrastructure. Land flooding is limited, due to the steep slopes characterizing the coasts, but the riverbeds act as preferential direction for onshore penetration of the tsunamis, that can climb inland for hundreds of meters far from the coast. Coastal shelf-indenting canyons located south of the modelled failures and only some hundreds of meters away from the coast also play an important role in the coastal expression of the tsunami. Moreover, these scenarios have been taken as the basis for a sensitivity analysis that explored the influence of landslide parameters on the generation of the tsunami, bringing new light to the hazard analyses of this portion of ICM.

Keyword

landslide-tsunami, submarine margin, numerical simulation, hazard assessment

(Withdrawn) Causes of Mass Transport Complexes (MTCs): Implications for the Guyana Basin

Deron Saul[1]*, Heriot-Watt University (dos2@hw.ac.uk)
Uisdean Nicholson[2], Heriot-Watt University

Abstract

The Guyana Basin, a large sedimentary basin situated off the north-eastern coast of South America holds a repository of stratigraphic data that provides insights into the causes and consequences of submarine landslides. The upper Cenozoic stratigraphic record of the Guyana Basin is dominated by mass transport deposits (MTDs). In this study we seek to understand their distribution in time and space, ultimately to understand their preconditioning and triggering mechanisms and to better mitigate the risks to people and submarine and coastal infrastructures.

Numerous moderate to giant (10^2 to 10^3 km3) MTDs were mapped using 2D seismic lines across the Guyana Basin. They often consist of stacked geometries with individual MTDs which eroded into older deposits forming mass transport complexes (MTCs). In some cases, the MTDs were larger than the 8100 BP Storegga Slide.

The persistent failure of the continental slope of the Guyana Basin is likely related to significant increases in sedimentation rates that began in the Tertiary. This was likely associated with tectonic uplift and paleoclimatic conditions which promoted significant erosion and sediment routing to the basin since that time. Because of the increase in sediment accumulation rates, overpressure generated by disequilibrium compaction since the Miocene may have been the preconditioning mechanism. The triggering mechanisms are likely related to seismicity at the Caribbean and South American Plate Boundary, particularly since the Pliocene.

There was a gentler and extended slope during the Miocene in the southwestern Guyana Basin while there was a steeper slope and more occurrences of frequent MTDs in the southeastern Guyana Basin. However, the modern southwestern slope is steeper, and dominated by MTDs, more than anywhere else in the basin. Thus, this active area of persistent failures which is closer to the ongoing collision between the Caribbean and South American Plate may be more prone to submarine landslides. This may have implications for damages to subsea infrastructure and tsunami hazards for Guyana's coast. The modern continental shelf is most extensive in the southeastern Guyana basin and contains fewer MTDs, indicating more stability and the potential for less frequent but larger submarine landslides in this region.

Keyword

Guyana Basin, submarine landslide, MTD, large, Tsunami

Ground subsidence studies of Mumbai city, India using InSAR

Santhosh Kumar SAKTHIVEL[1]*, CSIR-National Institute of Oceanography
(san.santhos@gmail.com)
Mani Murali R[2], CSIR-National Institute of Oceanography
Deepika Dwivedi[3], CSIR-National Institute of Oceanography

Abstract

Coastal subsidence or uplift is a predominant problem in many coastal cities that are least explored and requires significant attention to know the status of the cities. The sinking land and rising sea levels make the deformation situation alarming. The coastal cities of India experience a rise in sea level, but the effect on the subsidence rate of these cities is still unknown. The coastal megacities of India hold high socio-economic importance as most of them are highly populated and have substantial economic returns to the country. This study explored the subsidence rate of Mumbai city, which is the financial capital of India and is under serious threat due to many coastal disasters. The Mumbai's line of sight (LOS) deformation rate was derived from January 2018 to November 2023 using C-band Sentinel 1 on-demand interferometric synthetic aperture radar (InSAR) data. A time series analysis using Mintpy revealed high subsidence in some regions of Mumbai, such as the Deonar dumping area, Wadala, and the railway track behind the IMC-limited land Sangam Nagar. Overall, the subsidence values in these areas vary between -5 and -2.5 cm from 2018 to 2023. The elements contributing to this deformation revealed changes in land use and land cover (LULC) pattern. Increased urbanization with groundwater exploitation makes the regions subside at a higher rate than expected. These areas also fall into established high flood-prone parts of the city. The predicted inundation regions due to the rising sea level are also closer to these places, showing high subsidence rates. The combined effect of land sinking, groundwater running down, increased urbanization in flood-risk areas, and rising sea level pose a serious threat that needs to be addressed and monitored. Land subsidence and its consequences should be considered for effective coastal planning and management.

Keyword

Coastal Subsidence, InSAR, Mumbai city, Groundwater, Sentinel-1

Tapping into Potential: Unveiling Geological Dynamics and Geohazard Risks in the Potiguar Basin, Brazil

Yasmym Consthance SILVA[1]*, Federal University of Rio Grande do Norte (yasmym.silva.701@ufrn.edu.br)
Helenice VITAL[2], Federal University of Rio Grande do Norte, Postgraduate Program in Geodynamics and Geophysics (PPGG), Brazil

Abstract

The Potiguar Basin, situated in the Brazilian Equatorial Margin, represents an exploratory frontier situated within a complex geological framework. Studies have demonstrated its significance as a crucial reservoir of valuable hydrocarbon reserves, making it a promising area for exploration and potential oil and gas discoveries. Additionally, the Potiguar Basin stands out by possessing one of the largest offshore wind potentials in the region, further enhancing its significance in both the energy and exploration sectors.

Despite the substantial potential inherent in this basin, it remains relatively unexplored and poorly understood, particularly concerning its seabed and subsurface. Recognizing this challenge, the aim of this study is to comprehensively map the seafloor in the slope between the cities of Caiçara do Norte and Guamaré, encompassing depths ranging from 100 to 2000 meters. The data was collected within the scope of the SeabedMap project during the month of June 2022 aboard the Hydro-oceanographic vessel Cruzeiro do Sul, in a partnership between Brazilian educational institutions, the Brazilian Navy and the Brazilian Geological Service. Data from multibeam bathymetry (MBES), high-resolution seismic (CHIRP), measurements of speed of sound along the water column (XBT) were acquired.

In addition to being imaged for the first time with multibeam bathymetry, the results revealed several features, predominantly canyons, on the studied slope. Despite the Potiguar Basin being on a passive margin, the identified canyons exhibit steeper, shorter, and more closely spaced characteristics compared to others in its vicinity, introducing a unique geological dimension to its dynamics. This comprehensive mapping not only enhances our understanding of geological processes but also aids in identifying potential geohazards, such as submarine landslides, with significant implications for seabed stability.

The presence and characteristics of these canyons on the slope offer valuable insights into past or potential submarine landslide activity, contributing to a broader understanding of the geological dynamics and risk factors associated with the Potiguar Basin. This comprehensive approach is pivotal not only for advancing energy exploration but also for safeguarding environmental sustainability in offshore operations. Furthermore, these initiatives in the Potiguar Basin, including mapping the continental slope, align not only with the objectives of SDG 14 - Life Below Water, but also of SDGs 4 – Quality Education, 5 – Gender Equality, and 13 – Climate Action. These efforts also resonate with the goals of the Decade of the Ocean, focusing on enhancing scientific capacity, deepening understanding of ocean interactions, and promoting the utilization of ocean

knowledge for sustainable development. This integrated approach contributes to a more informed and responsible management of marine environments and resources.

Keyword

Potiguar Basin, Seafloor mapping, Multibeam bathymetry, Geoharzards

Investigating the influences of an ecological restoration project to the coastal groundwater system along the South Flank of the Yangtze Delta

Bradley Allen A. WEYMER[1]*, Shanghai Jiao Tong University (bradley.weymer@sjtu.edu.cn)
Zijun WU[2], Tongji University
Xianwei WANG[3], Shanghai Jiao Tong University
Ruifang C. XIE[4], Shanghai Jiao Tong University
Yiqing WANG[5], Tongji University
Qiyue GU[6], Shanghai Jiao Tong University
Qinqin TANG[7], Shanghai Jiao Tong University

Abstract

A large proportion of the world's megacities rely on groundwater resources stored in underlying coastal aquifers. These systems are often geologically heterogeneous and contain both natural and human-engineered structures, for example, in land reclamation areas that make subsurface hydraulic properties unpredictable and challenging to investigate. The interactions of submarine groundwater discharge (SGD) and seawater intrusion (SWI) exert a major control on the onshore-offshore fluxes of organic carbon and nutrients. Characterizing groundwater dynamics in coastal aquifers is fundamental for understanding both processes and their interaction, yet investigating these systems has remained understudied to date due to a scarcity of observational data. Exploring the various spatiotemporal scales of drivers that limit, or enable SGD and SWI especially in land reclamation areas is a knowledge gap in coastal groundwater research. We aim to bridge this gap through a case study along the South Flank of the Yangtze Delta in the Nanhui artificially restored wetland and tidal flat system of the greater Shanghai coastal region. We integrate ground penetrating radar (GPR), drone remote sensing, and borehole groundwater sampling collected over three field campaigns to draw inferences on how the groundwater system is responding to a recent large-scale ecological restoration project. We find that although the land surface (i.e., vegetation cover) changed considerably over a six-month period during restoration activities (November, 2022 – May, 2023), subsurface structures imaged by the GPR show little change over tidal and seasonal cycles. On the other hand, a sharp change in groundwater salinity, pH, and Fe concentrations at a narrow zone near the high-tide line is observed. A localized Fe-enriched signal in the groundwater dissipates and deepens from November, 2022 (beginning of the restoration) to May, 2023 (end of the restoration) that likely reflects a change in the redox conditions within the sampling site. This change in Fe concentrations within the liquid phase is corroborated by a strong and persistent reflector in the GPR data that is more sensitive to Fe in the solid phase. The coincidence in variations between groundwater Fe concentrations and GPR signals suggest a strong interaction between the groundwater and surrounding reclaimed material at the study site. Our study thus offers a unique "before" and "after" view into the response/recovery mechanisms of this complex engineered coastal system.

Keyword

coastal, land reclamation, groundwater, ground penetrating radar, iron (Fe)

Analysis of major Shoreline changes along southern Karnataka coast,India for Five Decades.

Gayathri Nivedha Nivedha R[1]*, Masters student, NITK (gayathrinivedha05@gmail.com)
Ramesh H [2], Professor,NITK

Abstract

Coastal erosion is a natural phenomenon affecting a large number of coastal areas. The coastal zone is an area with immense geological, geomorphological and ecological interest. Monitoring and mitigation of shoreline erosion along populated coastal areas is an important task and remains a difficult goal to achieve.

The coast of Karnataka state extends from Talapadi in south to Sadashivgad in north covering a distance of about 280 km. In this study, an attempt has been made to investigate the shoreline transformation along the Karnataka coast. Fair weather satellite images of CORONA (1965), LANDSAT from 1975 to 2016 with an interval of ten years were used to delineate the shoreline.

The main purpose of the work is to provide a systematic historical information on shoreline change along Karnataka coast using multi resolution satellite data (Landsat (MSS, TM & ETM+) and Geographic Information System (GIS) for past 50 years period i.e. from 1965 to 2016. The six historical shorelines (1965, 1975, 1985, 1995, 2006 and 2016) were used in GIS for computing the shoreline change rate along the coast.

The analysis revealed that about 70% of the coastline was either stable or accreting in nature, whereas remaining 30% region was experiencing varying magnitude of erosion. The change rate was classified in three categories indicating the accretion, low erosion and high erosion locations. The erosion and accretion pattern observed along the coast is influenced mainly by the coastal process and riverine inputs. Area of study is mainly considered to be a part of tourist economy and 75% of the regions occupation is based on the coastal belts of southern Karnataka, India.

Erosion was found in isolated pockets throughout the coast. The variation in river mouth morphology was quite significant. The present study demonstrates that combined use of satellite imagery and statistical method such as weighted linear regression can be a reliable method for shoreline change analysis.

Keyword

Shoreline, Coastal erosion, Coastal accretion, Geographic Information System, Google Earth Engine

Monitoring time-series surface deformation of coastal port area in Busan with space-based radar interferometry

Seongcheon PARK[1]*, Pusan National University (parksc@pusan.ac.kr)
Sanghoon HONG[2], Pusan National University
Jeyun LEE[3], Pusan National University

Abstract

Coastal areas that are adjacent to the sea have been developed continuously because of its advantage of resource transport and accessibility. These regions are suitable for the construction of social infrastructure such as ports, airports and urban areas. Thus reclamation projects have been conducted to expand the coastal areas. Because, however, coastal reclaimed land is vulnerable to several natural hazards like sea levels rise, land subsidence, and soil erosion, it is necessary to monitor continuously for geohazards prevention. For monitoring coastal reclaimed land, Global Navigation Satellite System (GNSS) and traditional leveling surveys are widely used. Although its high accuracy of monitoring displacement, these have limitations in terms of spatial resolution and high cost over large areas. To overcome these limitations, remotely sensed Synthetic Aperture Radar (SAR) dataset from space have been utilized in volcanoes, earthquakes, and land subsidence. The SAR satellite is a useful tool that can acquire high spatial resolution data at a relatively low cost for extensive areas in all-weather conditions by transmitting microwaves to the surface.

In this study, we apply differential interferometric synthetic aperture radar (DInSAR) to observe surface displacements on the new port that is coastal reclaimed land in Busan, South Korea. The DInSAR technique calculates the phase difference between two SAR images acquired at different times and obtains surface displacements by removing the topographic phase using known topographic information from an existed Digital Elevation Model (DEM). We utilize three datasets comprising COSMO-SkyMed X-band data acquired from 2016 to 2019 and Sentinel-1 C-band ascending and descending orbit data from 2016 to 2021. The Small BAseline Subset (SBAS) technique, which is one of fascinated time-series DInSAR analysis method, was used to observe time-series surface deformation occurring in coastal reclaimed land. The results show significant land subsidence in the eastern part of the new port. The subsidence rate in vertical direction at randomly selected point A was approximately –1.55 cm/year and –1.90 cm/year from Sentinel-1 ascending and descending orbits data, respectively, and –2.80 cm/year from COSMO-SkyMed data. In contrast, we also observe slight ground uplift phenomenon in the western part of the new port. The ground uplift rate in vertical direction at randomly selected point B from Sentinel-1 ascending and descending orbits was approximately 0.08 cm/year and 0.20 cm/year, respectively, and COSMO-SkyMed is showing a uplift rate of about 0.28 cm/year. The ground uplift behavior occurred along the region that underwent mountain excavation for development, and it is inferred to be an isostatic rebound resulting from the compensation in regions where the loss of mass

occurred. To verify surface deformation observed by radar interferometry, we compared with bouguer anomaly data caused by changes in density beneath the surface using satellite gravity observations. Our results suggest that the SBAS technique is efficient method for monitoring time-series surface displacements in coastal reclaimed land, representing the necessity for continuous monitoring of coastal reclaimed land using space-borne synthetic aperture radar.

Keyword

Interferometric SAR, Subsidence, Land reclamation, Small BAseline Subset

Earth observation on Asian Mega-deltas environment risk under climate changes and mitigation strategy for sustainable development

Ping YIN[1]*, Qingdao Institute of Marine Geology,China Geological Survey
(yinping@mail.cgs.gov.cn)
Jingpeng LIU[2], Qingdao Institute of Marine Geology,China Geological Survey

Abstract

Delta and estuary are the link between the land and the sea, the early settlements for our ancestors and still embrace most of the megacities today. Delta and estuary also provide important ecosystem combining the terrestrial and marine eco-functions, they are the most dynamic interaction of biosphere-hydrosphere-pedosphere. Delta and estuary locate on low-land region along the world-wide coast and are exposed to threats from both land and sea, such as the catastrophic flooding, storm surges, tsunamis as well as the long term impact of global warming and sea level rise. Land uses through history and urbanization have greatly changed the feature of global deltas and estuaries and lead to reduction of these important ecosystems. Coastal erosion, land subsidence, pollution and wetland degradation in the delta and estuary areas are global challenges which need more earth observation (EO) data to support the stakeholder decision-making via local, regional and global scales for sustainable and resilient coastal social-ecological system. Varieties of remote sensing sensors and spatial resolution of data and their availability make it possible to monitor deltas and estuaries and to understand their evolution processes under natural and anthropogenic impacts with unprecedented spatial and thematic detail information, to better understand the pressures of deltas and estuaries and to provide global reliable information in order to improve sustainability and resilience of social-ecological system in global deltas and estuaries.

Integrated Earth Observation on ecosystem and environment changes were applied on the Asian Mega-deltas and estuaries, including the Yellow River Delta, the Yangtze River Delta, the Red River Delta and the Indus River Delta, varying from different climate zone, development stages and geological conditions. These mega-deltas have experienced dramatic changes under the impacts of global climate changes and anthropogenic impacts in the past century, consequently, these environmental risk are influencing the safety of cities which embanked on the deltas, as well as the economy developments. Geo-information based geo-hazards modeling and future tendency were studied to provide functional delta management strategies for adaptation to climate change, smart spatial planning for risk mitigation.

Keyword

Coastal environment risk, Asian Mega-delta, Earth Observation, Climate changes, Mitigation strategy

Construction of hydrogeological database of coastal reclaimed land considering underground development in industrial area

Juhee KIM[1]*, Korea University (juhee97218@korea.ac.kr)
Soonjae LEE[2], Korea University

Abstract

The development of underground in coastal reclaimed lands typically involves deep excavation resulting groundwater leakage. Various hydrogeological information is required to manage the risk related to groundwater. We constructed a hydrogeological database for coastal reclaimed land considering underground development. The study area is a coastal reclaimed land undergoing industrial area development. The geological and hydrogeological data were collected from open-source database and previous subsurface investigations. For the construction of geological model, stratigraphy modeling was conducted using 590 boreholes, digital elevation model (DEM), and the cross-sections. Regression analysis have been used to determine the distribution of geological material. The groundwater system was defined by the hydrogeological model using MODFLOW simulation. A hydrogeological model was constructed based on the geological model and groundwater model for the watershed. The hydrogeological database constructed using ArcGIS (Esri) and Arc Hydro Ground Water (AQUAVEO) could compile and visualize the multiple dimensional geological and hydrogeological information, such as borehole, cross-section, strata, aquifer, water level and groundwater flow. The integrated hydrogeological model could be compiled into the database along with the input data for preprocessing, such as boundary conditions and hydrogeological properties. Considering the underground development, this hydrogeological information could be used to assess vulnerability of underground development. The database can suggest the distribution of hydraulic head at specific development depths and excavation depth limits for the determination of optimal development depth. The hydrogeological database could serve as a useful tool for planning and implementing underground development projects in specialized environments like coastal reclaimed areas.

Acknowledgements
This work was supported by the National Research Foundation of Korea (NRF) grant funded by Ministry of Science and ICT, South Korea (NRF-2022R1A2C1093405).

Keyword

Coastal reclaimed land, Underground development, Hydrogeological database, Geological model, Groundwater model

Geochemical and mineralogical characteristics of beach sediments along the Bay of Bengal coast, Bangladesh

H. M. Zakir HOSSAIN[1]*, Jashore University of Science and Technology (zakirgsd@yahoo.com)

Abstract

The geochemical composition of sediments from Cox's Bazar and Kuakata Beach sites along the Bay of Bengal coasts, Bangladesh, has been carried out to determine provenance, maturity, and weathering conditions. The mineralogical composition reflects abundant quartz, followed by feldspar and lithic fragments, inferring a quartzose recycled provenance. All samples contained a significant portion of zircon, rutile, magnetite, apatite, epidote, and monazite. The Cox's Bazar Beach sands contained high SiO2 (84-90 wt.%) and low Al2O3 (4.4-6.4 wt.%), while the Kuakata Beach sands have low SiO2 (63-79 wt.%) and high Al2O3 (9.0-11.3 wt.%). Concentrations of the investigated sediments show similar dispersal patterns with high enrichment of Th and SiO2 compared to the UCC. Lead, Rb, Y, Ga, Sr, and Fe contents of the Kuakata Beach sediments are slightly elevated than UCC, and the remaining elements for both sites are strongly depleted, suggesting the destruction of feldspar in the fluvial transportation pathways. The beach sediments of both locations are classified as subarkose and litharenite and compositionally low mature to immature. Chondrite-normalized REE patterns for the beach sandy sediments show high enrichment of LREE and flat HREE (LaN/YbN, 7.6-9.4 and 5.5-8.8, respectively) coupled with marked Eu anomalies (Eu/Eu*, 0.5-0.7 and 0.5-0.8, respectively), indicating felsic source composition. Discriminant function diagrams, elemental ratios, and REE parameters suggest that both beach sediments originated from felsic rocks, with compositions similar to the average rhyolite, granodiorite, granite, and UCC. The ICV, CIA, and PIA proxies, Rb/Sr, and K2O/Rb ratio values show low to moderate chemical weathering intensity in the source. This result suggests that the strength of Himalayan monsoon climates might control the intensity of the chemical weathering patterns in the sediments.

Keyword

Geochemistry, Provenance, Chemical weathering, Beach Sediments, Bay of Bengal

Investigation of coastal dynamics in the Nakdong Estuary using sediment core biogeochemistry

YUNJI KIM[1]*, Korea Institute of Ocean Science & Technology (helena4818@kiost.ac.kr)
JEONGWON KANG[2], Korea Institute of Ocean Science & Technology
JOOBONG JEONG[3], Korea Institute of Ocean Science & Technology

Abstract

For the last century, the Nakdong Estuary has been undergone continuous physicochemical environmental changes including modification of river discharge, tidal prism, salinity, and nutrient ratio (Si:N:P) by various human activities (e.g. damming, reclamation, dredging), which has changed vegetation, phytoplankton community structure, and other related ecological parameters. For example, changes in river discharge and nutrient ratio (Si:N:P) would have modified primary productivity and phytoplankton community structure (i.e. diatom dominance), and enhanced harmful algal blooms in the estuary and adjacent coastal area. These environmental changes could be well recorded in sediments as various biogeochemical parameters including TOC (total organic carbon), TN (total nitrogen), carbon and nitrogen stable isotope (δ13C and δ15N), biogenic silica (BSi). Therefore, this study aims to investigate the influence of human activities on the Nakdong Estuary by reconstruction of spatial and temporal variation of sediment characteristics and productivity using biogeochemical parameters of sediment cores. We plan to investigate the changes in river discharge (TOC/TN ratio, δ13C), primary productivity (TOC), diatom productivity (BSi), phytoplankton community structure (BSi/TOC ratio), and other related biogeochemical environment by human activities during the last century, using the various biogeochemical parameters of sediment cores collected at back-barrier tidal flat of the major barrier islands in the Nakdong Estuary, Korea.

Keyword

Nakdong Estuary, Coastal Dynamics, Biogeochemistry

Lithofacies, Petrographic, SEM-EDX, and Isotope Analyses of Emergent Late Holocene Beachrocks as Sea-Level Indicators along the Negros Trench Forearc, Philippines

Lyndon Jr Nawanao[1]*, Geomorphology and Active Tectonics Research Laboratory, National Institute of Geological Sciences, College of Science, University of the Philippines Diliman, Quezon City, Philippines (lpnawanao@up.edu.ph)
Noelynna Ramos[2], Geomorphology and Active Tectonics Research Laboratory, National Institute of Geological Sciences, College of Science, University of the Philippines Diliman, Quezon City, Philippines
Robelyn Mangahas[3], Geomorphology and Active Tectonics Research Laboratory, National Institute of Geological Sciences, College of Science, University of the Philippines Diliman, Quezon City, Philippines; Department of Science and Technology-Philippine Institute of Volcanology and Seismology, Diliman, Quezon City, Philippines

Abstract

Beachrocks have been widely used as markers of past relative sea-level (RSL) changes. However, a major challenge of beachrocks is constraining their indicative meaning. Different approaches have been proposed to address this uncertainty, from bedding architecture to cement characteristics. Along the forearc of Negros Trench in the Philippines, two parallel, discontinuous northeast-trending strips (BRS1 and BRS2) of emergent beachrocks occur along the coast of southwest Panay Island. In this study, we integrate lithofacies, petrographic, scanning electron microscopy with energy dispersive X-ray spectroscopy (SEM-EDX), and cement oxygen–carbon isotope analyses to better constrain the paleoenvironment of the latest beachrock formation and their indicative meaning. Nine facies were mapped from BRS1 and BRS2, with the topmost units composed of poorly sorted, subrounded coarse sand-to-cobble composed of volcanic lithic fragments with seaward-dipping foreset cross-stratifications. Petrographic analyses of 14 samples collected on the topmost facies in both strips all showed partial to complete isopachous cementation, but the cement type and phases vary laterally, including rims of acicular microcrystalline calcite, acicular aragonite, and micrite envelope. SEM-EDX analysis of cements also revealed a relative abundance of Na, Mg, and Sr of marine affinity compared to Mn and Fe which are of meteoric association. Relatively higher δ13C (-1.15 to +0.55 ‰PDB) and δ18O (-7.57 to +0.15 ‰PDB) also indicate a marine origin, as exemplified by Z values ranging from 123.81 to 127.58. Consistent with lithofacies and isotope analyses, both beachrock strips indicate the latest formation occurring in the subtidal upper shoreface before emergence. This constrained paleoenvironment posits an indicative meaning having an upper (U) and lower (L) limit of mean lower low water (MLLW; -0.61 m amsl) and wave base (-8.91 m amsl), respectively, as well as a reference water level (RWL) of -4.76 m. A maximum RSL of 7.60 m was constrained for BRS1, while 6.43 m for BRS2. Bulk radiocarbon dates of beachrock cement indicate that the BRS1 formed until 5855–4508 cal BP, whereas BRS2 formed until 3128–1825 cal BP. These two beachrock strips imply at least two abrupt RSL fall events after their formation. The absence of

Late Holocene highstands in glacial isostatic adjustment (GIA) RSL models and the anomalously higher maximum RSL elevations of these beachrocks suggest local uplift along the forearc. This study emphasizes the significance of integrating these analyses to establish the indicative meaning of beachrocks.

Keyword

beachrocks, indicative meaning, Late Holocene, Negros Trench forearc, Panay Island

Characteristics of surface topography and sedimentation before and after typhoons Kompasu and Soulik in the Gochang Donghori intertidal flat, Korea

Woo Hun RYANG[1]*, Jeonbuk National University (ryang@jbnu.ac.kr)
Sol Ip Kang[2], Jeonbuk National University

Abstract

In the macro-tide intertidal flat of the Korean western coast, this study has investigated typhoon effects on the variation of topography, surface sediment texture, sedimentary properties, and sedimentary environment, which appeared before and after the typhoons Kompasu in 2010 and Soulik in 2018, respectively. Along the southwestern coasts and across midlands of the Korean Peninsula, the typhoons Kompasu and Soulik moved from 1 to 2 September 2010 and from 23 to 24 August 2018, respectively. Topography and surface sediments before and after the typhoons were measured and sampled along the survey line in the Gochang Donghori intertidal flat. The intertidal area was divided into the upper tidal zone, middle tidal zone, and lower tidal zone based on mean high water level, mean sea level, and mean low water level. Surface sediments of the intertidal flat consist mainly of very fine to medium sands, and the ratio of fine sand is the largest both before and after the typhoons. Surface sediments after both typhoons became finer in mean grain size showing well sorting rather than those before the typhoon. It is interpretative of the strong wave effect, caused by typhoons. The surface sediment texture of the middle tidal zone shows rare variations and band-shaped deposits appeared in some lower tidal zone intervals.

Acknowledgements: This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (NRF-2022R1F1A1063126).

Keyword

macro-tide intertidal flat, typhoon Kompasu, typhoon Soulik, surface sediment texture, Gochang

Analysis of seabed stability spatial distribution for underwater platforms

Joo Bong JEONG[1]*, Korea Institute of Marine Science and Technology (jjbongeo@kiost.ac.kr)
Jeongwon Kang[2], Korea Institute of Marine Science and Technology
EuiYong Jeong[3], Korea Institute of Marine Science and Technology
Euiyoung Jeong[4], Korea Institute of Marine Science and Technology
Sik Huh[5], Korea Institute of Marine Science and Technology
Jun-Yong Park[6], Korea Institute of Marine Science and Technology
Byung-Cheol Kum[7], Korea Institute of Marine Science and Technology
Seok Jang[8], Korea Institute of Marine Science and Technology
Moonsoo Lim[9], Marine research Corp.

Abstract

Selection of a candidate site for a submarine space platform is very important in terms of the stability of the structure and the geographical efficiency of users, and there are factors to be considered such as seafloor topographic information and sediment environment characteristics. In this study, factors for evaluating the ground stability of the candidate site were identified and topographic geological information was analyzed through marine physical exploration (bathymetry, side scan sonar) and sediment investigation methods.

As a result of geophysical exploration, the water depth ranges up to 54.7m and increases from the coastline to the open sea (southeast direction). The average slope is 5.5°, and the water depth changes rapidly below 10m, and the seafloor is mainly covered with exposed rock and conglomerate sediments. Due to the distribution of rock mass, the local slope increases and reaches up to 60°. It is a landform with two waterways formed on the sea floor, and ships frequently move through the waterways. At a depth of about 10m to 20m, the seafloor is curved and sandy and coarse-grained sediments are distributed. The proportion of rock mass has decreased compared to the previous depth zone, making it a relatively stable environment, and the distribution of ripples on the sea floor suggests that it is an environment dominated by wave energy. Above approximately 20m, the water depth increases gently toward the open sea, and the seafloor is flat with sandy or sandy-sized sediments distributed. As a result of analysis of surface sediments, sand was dominant in water depths of 10 m or less, showing sandy and silty sand sedimentary characteristics, and as water depth increased, silt and clay were distributed. The sediment content was 0.00~0.86% gravel, 0.00~99.19% sand, 0.00~47.01% silt, and 0.00~100.00% clay, with almost no gravel appearing. The average particle size is –0.05∼6.14Φ, which corresponds to very coarse sand to medium silt. The classification degree was found to be 0.54 to 2.40, which was found to be a spatially diverse energy environment ranging from moderately well sorted to poorly sorted. As a result of analyzing the spatial distribution factors of seafloor stability, the slope of the seafloor and the boundaries of sediment distribution according to water depth were identified. It is believed that this can be used as basic data for an undersea space platform. In addition, future research will contribute to improving the stability and efficiency of candidate site selection by applying a Benthic terrain modeler based on the results of

this analysis.

Keyword

Geophysical exploration, precise topographic survey, particle size analysis, seafloor stability

Spatio-temporal distribution and migration patterns of microplastics on tourist beaches: A case study in the Beidaihe District, North China

Yutao ZUO[1]*, 488568703@qq.com (488568703@qq.com)
Yawen Ge[2], geyawen@hebtu.edu.cn

Abstract

Coastal zones are generally acknowledged to be significant reservoirs of microplastics, posing substantial threats to coastal ecosystems, and human health. However, the extent to which marine-land interaction and human activities impact the occurrence and migration of microplastics on popular tourist beaches remains unclear. We conducted a comprehensive investigation into the spatial and temporal distribution of microplastics on tourist beaches in northern China. The study focused on the disparities in microplastic abundance between beach sediments and seawater, and migration patterns of microplastics within intertidal zones.Additionally, comparisons were made between microplastic levels on tourist beaches versus natural beaches, along with variations across different years. The findings revealed that the mean microplastic abundance in beach sediments was 2,212.0±895.2 items/kg while it was 30,670.8±15,094.9 items/m3 in seawater at Beidaihe coastal zone. The most common shape observed for microplastics was fibers, followed by films and fragments. Transparent, blue, green and black colors prevail among the microplastics found with cellulose and PET being the most common components. Microplastic abundances decreased from high tide zone to low tide zone, and the abundance in seawater was positively correlated with the high tide zone and negatively correlated with the low tide zone, suggesting that microplastics mainly originated from nearshore transport and were significantly influenced by wave sorting. This also resulted in higher microplastic abundance with more complex compositions found at high tide zones thereby posing greater ecological risks. Compared to wave influence, the impact of human activities such as tourism, aquaculture, and fishing on microplastic abundance was relatively limited. There were no significant differences observed in the abundance and composition characteristics of microplastics between tourist beaches and natural beaches, potentially attributed to the wave disturbance. Watershed precipitation and human activity intensity emerged as primary factors contributing to substantial annual variations in microplastic abundance and characteristic compositions.

Keyword

Microplastic, Migration pattern, Intertidal zone, Human activity, Annual variation

The Neogene delta-front wave-built sand bodies and their petrophysical characteristics in the Enping Sag of the Pearl River Mouth Basin.

YA XUE[1]*, China University of Petroleum (East China) (1587837149@qq.com)
GUANMIN WANG[2], China University of Petroleum (East China)

Abstract

Enping Sag is situated within the western sector of the Zhujiangkou Basin, part of the Pearl River Mouth Basin. During the Neogene period, specifically the deposition phases of the Hanjiang Formation and Zhujiang Formation, Enping Sag witnessed the development of a series of elongated or tabular wave-generated sand bodies along the deltaic front. These formations exhibit rapid variations in both thickness and connectivity, thereby complicating the comprehension of sedimentary dynamics and reservoir properties. This ambiguity significantly hampers the exploration and exploitation endeavors targeting the Neogene deltaic-front sand bodies in the region.This study, grounded on meticulous interpretation of 3D seismic data, endeavors to elucidate the spatial distribution attributes of deltaic-front sand bodies via attribute extraction and fusion techniques. Furthermore, through detailed scrutiny and analysis of core samples, the deltaic-front sand bodies are classified into two microfacies types: wave-generated sand bars and tabular sands. These microfacies are further delineated into secondary categories including nearshore-frontshore, backshore, and mixed shoal microfacies.Employing a suite of analytical methods encompassing thin-section examination, grain size analysis, and well log interpretation, it is ascertained that medium to fine sand grains, particularly within well-sorted nearshore-frontshore sands, exhibit heightened porosity and permeability, indicative of preferential reservoir facies. The favorable depositional milieu, coupled with attenuated compaction and cementation processes, emerge as principal controlling factors facilitating the genesis of high-quality reservoirs in this setting.

Keyword

Enping Sag;Neogene, Deltaic front, Wave-generated sand bars, Porosity and permeability, High-quality reservoir

Paleolimnological analysis of three shallow freshwater lakes in urban development areas around the city of Glasgow, Scotland, UK

Xinchang WANG[1]*, Yonsei University (xinchang@yonsei.ac.kr)
Eunji Byun[2], Yonsei University
Simon Turner[3], University College London
Handong Yang[4], University College London
Ambroise Baker[5], Teesside University
Helen Bennion[6], University College London

Abstract

Paleolimnological analysis of three shallow freshwater lakes in urban development areas around the city of Glasgow, Scotland, UK

Xinchang Wang1*, Eunji Byun1, Simon Turner2, Handong Yang2, Ambroise Baker3, Helen Bennion2

1 Department of Earth System Sciences, Yonsei University, Seoul, Korea
2 Department of Geography, University College London, London, UK
3 School of Health and Life Science, Teesside University, Middlesbrough, UK
*Presenter: Xinchang Wang xinchang@yonsei.ac.kr

Global lacustrine ecosystems are experiencing a variety of anthropogenic stressors. One such stressor is urban development and contaminant inputs through hydrological connections, leading to water quality degradation. Paleolimnology is a useful approach for assessing changes in water quality of urban shallow lakes. We investigated three urban/suburban lakes in and around the city of Glasgow, Central Scotland to assess environmental change in response to historical anthropogenic stressors. Diatom microfossils, supplemented with plant and insect macrofossils, and geochemical elements, were analyzed in a dated sediment core from each lake to determine chemical and ecological changes over the last 150 years. Ordination techniques were used to explore the shifts in the diatom assemblages. The study found that two of the lakes in more heavily industrialized urban catchments experienced eutrophication in recent decades. The third lake had been managed by private landowners but now is under protection as a nature reserve and did not show a clear sign of eutrophication. Our data suggest that local land-use history and degree of connectivity are important considerations in assessing the onset, degree and nature of environmental change and can result in lakes with varying types of anthropogenic stressors and variable impacts, even within the same small geographical region. This variation needs to be taken into account when designing lake-specific eutrophication management strategies. The potential of paleolimnology for better understanding the impacts of industrialization on urban waterbodies is highlighted.

Keyword

paleolimnology, diatom, eutrophication, urban development, shallow lake

Variations in paleovegetation and paleoclimate recorded by plant terpenoids in the sediments from Lake Suwa (central Japan) from the last glacial period to Holocene

Ryosuke FUKUCHI[1]*, Hokkaido Universitry (fukuchirs@eis.hokudai.ac.jp)
Nozomi HATANO[2], Natural Environment Division, Nagano Environmental Conservation Research Institute
Ken SAWADA[3], Department of Earth and Planetary Sciences, Faculty of Science, Hokkaido University

Abstract

Sediments collected from and around lake frequently record the change of various depositional environments such as floodplain and wetland depending on scaling of the lake water areas. Such various and unsteady sediments are important sources to interpret paleoclimatic and paleoenvironmental changes. However, there have been few reports for paleoenvironmental and paleoclimatic reconstructions with the glacial-interglacial time scale in Japanese inland areas, especially mountain areas. Lake Suwa (Nagano Prefecture, central Japan) located in mountain area, has changed its water areas, and the sediment core collected from the shore has various sedimentary facies. The authors have mainly reported the paleoenvironmental changes associated with the scaling of the water area by biomarker analysis of the sediment core (Fukuchi et al., 2023). In this presentation, we will focus paleovegetational reconstructions using plant terpenoids in the sediment core from Lake Suwa, especially the changes with the glacial-interglacial climate changes, comparing with previous pollen research.

In our study, we used a sediment core (ST2020) collected from the shore of Lake Suwa. The ages were determined by AMS 14C dating, and the lowermost horizon was estimated to be about 27 cal kyrs BP. The sediments (1-2 cm thick) were extracted by solvents and then separated into fractions by silicagel column. The apolar and polar fractions were analyzed by GC-MS. Sedimentary facies evaluated by sedimentary investigation indicated that the depositional environments changed from meandering fluvial, lacustrine, and delta in the ST2020 (Hatano et al., 2023).

In the ST2020 sediment core samples, gymnosperm-derived diterpenoids (DTs) and angiosperm-derived triterpenoids (TTs) were mainly identified. We established the ratios of sugiol/ΣDTs, totarol/ΣDTs and dehydroabietic acid (DAA)/ΣDTs as vegetation proxies. Considering the DTs such as totarol and sugiol are mainly derived from the Cupressaceae, the sugiol/ΣDTs and totarol/ΣDTs indicate the contributions of the Cupressaceae to the total gymnosperm vegetations. Although the DAA is thought to be widely distributed among various gymnosperm, the DAA/ΣDTs indicates mainly the Pinaceae contribution in the core. This is because the pollen records in the sediments from Lake Suwa suggested that Pinaceae was dominant in coniferous vegetation (Anma et al., 1990). The DAA/ΣDTs were higher in the glacial period, but the totarol/ΣDTs and sugiol/ΣDTs were higher in the deglacial stage. These results suggest that the

vegetation around Lake Suwa converted from subalpine coniferous forest to temperate coniferous forest with deglacial warming. Noticeably, Pinaceae vegetation in DT indicators rapidly decreased but Cupressaceae vegetation indicators showed increasing spikes during the cooling events such as Heinrich Event 1 and 9.3 ka event. Thus, the coniferous vegetation in the mountain areas around Lake Suwa might vary affected by global climatic events, although the detailed mechanism(s) for the linkages need to be examined.

Keyword

biomarker, plant terpenoid, paleovegetation, mountain lake, the last glacier

Paleo-oceanographic reconstruction using geochemical and mineralogical proxies from sediment core off Lakshadweep Islands, Arabian Sea

SAINABA N N.K[1]*, GEOLOGICAL SURVEY OF INDIA (sainus@gmail.com)
REMYA C[2], GEOLOGICAL SURVEY OF INDIA
SELVASUNDARAM S[3], GEOLOGICAL SURVEY OF INDIA
PRIYA T N[4], GEOLOGICAL SURVEY OF INDIA
BHUSHAN R[5], PHYSICAL RESEARCH LABORATORY

Abstract

The gravity core of 4.6 m recovered at a depth of 4492m from the Arabian Sea off Lakshadweep Islands was studied to reconstruct/unravel the paleoceanography/ paleoclimatology through detailed and integrated multiproxy analysis of isotopic, geochemical, sedimentological, and micro-paleontological studies. The dominant sediment size of the core sample is mainly silt with subordinate clay and sand. Around 40 kyrs data could be traced through AMS dating. This data was compared with oxygen isotope data for fixing Marine Isotope Stages (MIS) boundaries. MIS-1 represents Holocene and MIS-2 is the Last Glacial Maximum (LGM) and MIS-3 warmer period between 24 and 60 ka. High values for the CaCO3 were observed during LGM with a gradually declining trend during the early Holocene and subsequently marginal increase during the late Holocene. Two conspicuous peaks of OC during ~12 ka years BP at 9 to 10 cm bsf and 24 to 25 cm bsf have been observed. This peak corresponding to the LGM period, however, resulted due to high productivity and better OC preservation because of strong NE monsoonal winds that enhanced nutrient levels in the photic zone. In MIS-3, the negative and positive per mil values of δ18O at various levels down the core. In the alternating warmer episodes of MIS-3, the clay content decreases with a corresponding increase in coarse silt. The higher ratios of Si/Al and low TOC at this climatic event indicate the increased influx of silt-sized terrigenous sediments to the basin. The incidence of more quartz grains in the sediments at these levels also supports this. Ten species of Planktonic foraminifera are most abundantly present in this core, among which *Pulleniatina obliquiloculata*, *Globorotalia menardii*, *Neogloboquadrina dutertrei*, *Globigerinoides conglobatus*, *Globorotalia tumida* reflects tropical warm water climate. The sedimentation rate is calculated in comparison with AMS age data as 0.016 cm/yr (0.16 mm/yr). Within a time span of 39960 years, 4.6 m thick sediments were deposited and Marine Isotopic Stage up to MIS-3 could be traced. In the top 118 cm of the sediment column covering late phases of MIS –3, LGM (MIS-2), and Holocene (MIS-1), the sedimentation rate is comparatively low in the order of 0.005 cm/yr to 0.001 cm/yr. From 118 cm bsf to 350 cm bsf, the sedimentation rate is higher in the order of 0.049 cm/yr, which may be due to the high intensity of monsoon or prominent warmer climatic conditions at the mid of MIS-3. It implies that, there is a decreasing trend in sedimentation rate from MIS-3 to LGM followed by Holocene.

Keyword

Paleo-oceanography, AMS Dating, Oxygen Isotope, LGM, Sedimentation

Hydroclimatic Variability during the 4.2 ka Event: Insights from a High-Resolution Diatom Record in Korea

Ara CHO[1]*, Korea Institute of Geoscience and Mineral Resources (joara5813@kigam.re.kr)

Abstract

Understanding the East Asian monsoon holds significant importance within the realm of climate change, given its far-reaching impacts on society, culture, and the environment. While previous research has generally depicted the 4.2 ka event as a widespread abrupt cooling episode in the Northern Hemisphere, its hydroclimatic effects have displayed regional variations. Currently, the weather dynamics on Jeju Island diverge notably from those on the mainland, with precipitation levels showing altitude-dependent variability. Our study, which draws upon diatom assemblage data collected from Sara-oreum and Muljangori wetland, volcanic cones located on Jeju Island in South Korea, highlights the prevalence of tychoplanktonic species during this period. Through meticulous monthly analysis, we found that during the 4.2 ka event, tychoplanktonic species like *Aulacosiera alpigena* were notably abundant in July, whereas a similar species, *Aulacoseira nygaardii*, reached peak abundance at Muljangori wetland. These observations suggest a humid climate prevailing during this timeframe. Moreover, the abundance of tychoplanktonic species such as *Aulacosiera alpigena* correlates with the westerly effect index during the Holocene. Although precipitation patterns between Sara-oreum and Muljangori wetland exhibit notable similarities, the results from Sara-oreum appear to be more influenced by the westerly jet due to its higher altitude. The reinforcement and southward shift of the westerly jet might have prolonged the rainy season over Jeju Island and central China.

Keyword

Holcene, wetland, 4.2 ka event, Westerly, East Asia

Lake-floor signatures revealed by a post-earthquake follow-up geophysical survey

Seong-Pil . Kim[1]*, Korea Insitute of Geoscience and Mineral Resources (spkim@kigam.re.kr)
Deniz CUKUR[2], Korea Insitute of Geoscience and Mineral Resources
Denizhan VARDAR[3], Istanbul University
Murat ÖZKAPTAN[4], Karadeniz Technical University
Aysegul Feray MEYDAN[5], Yuzuncu Yil University
Ho-Bin LIM[6], Korea Insitute of Geoscience and Mineral Resources

Abstract

A ten-day geophysical survey was conducted in the largest saline lake, Lake Van (<450 m in depth) by a Turkiye-KIGAM joint research team. The study area is located in the eastern part of Turkiye near the borders to Syria and Iraq. The main purpose of the survey was to search and identify any earthquake-induced change in the lake floor sediments, which were possibly resulted from the 2011 Van earthquake (up to 7.2 in magnitude). More than 650 line-km-long records of a chirp-type acoustic profiler were achieved along previous survey tracks made before the 2011 earthquake. Six cored samples were also recovered in the eastern part of the lake floor using a handheld gravity corer. Several signatures in the acoustic images indicating syn- or post-earthquake deformation, movement or redeposition of the lake floor sediments could be recognized along with subaqueous slope failures and shallow gas anomalies. In some records new acoustic turbid zones were found, which were invisible in the previous survey records acquired before the 2011 Van earthquake and possibly be formed during the period of ground movement. This study shows a good example of repetitive surveys applicable to investigate and monitor subaqueous hazardous elements and their characteristics in earthquake-prone areas.

Keyword

Lake Van, Turkiye, lake floor, earthquake, hazard

Late Holocene hydroclimate changes in Tsushima Island, Japan

Jaesoo LIM[1]*, Korea Institute of Geoscience and Mineral Resources (limjs@kigam.re.kr)
Kota KATSUKI[2], Shimane University

Abstract

To predict future water availability in a small island in response to anticipating global warming, it is essential to understand past behavior of hydrological changes in terms of its frequency and controlling factors. Based on the geochemical analyses (carbon isotope, C/N ratios), we investigated past hydroclimate variability using coastal sediments in Tsushima Island where freshwater input has been constrained by limited catchment area, suggesting high sensitivity to small precipitation. The time series of C/N ratios in a bay clearly indicate decreasing trend during the last 3000 years, suggesting decrease in the influence of terrestrial plant. And this can be supported by increasing trend in the time series of the δ13CTOC values. This long-term trend is superimposed by low-amplitude fluctuations at multi-decadal to millennial variability. Significant peaks are found at 700 and 2000 cal yr BP, and troughs are found at 400 and 1700, and 2700 cal yr BP, suggesting remarkable shifts in the hydroclimate change over study area. To test more high-frequency variability in the time series of the C/N ratios, we subtracted its long-term trend described by three-order polynomial (dashed line) and their detrended values were achieved. Using this detrended C/N ratios, spectral analysis was performed. The result reveals prominent three periodicities (1300, 645, and 134 years), indicating significant centennial to millennial fluctuation in hydroclimate changes in the island.

Keyword

C/N ratios, carbon isotope, late Holocene, hydroclimate

High-resolution paleolake records of late Holocene hydroclimate change in central South Korea and its controlling factors

Arum JUNG[1]*, 1. Quaternary Environment Research Center, Korea Institute of Geoscience and Mineral Resources / 2. Department of Geological Science, University of Science and Technology (UST) (arum@kigam.re.kr)
Jaesoo LIM[2], 1. Quaternary Environment Research Center, Korea Institute of Geoscience and Mineral Resources / 2. Department of Geological Science, University of Science and Technology (UST)
Sujeong PARK[3], Quaternary Environment Research Center, Korea Institute of Geoscience and Mineral Resources

Abstract

Recently extreme climate events have been increasing due to global warming, accordingly the importance of research on the climate event is increasing and such information is considered very important to prepare for future climate prediction. To trace past extreme climate changes, paleo-hydrological fluctuations were reconstructed using 10 m-long sedimentary cores (20CR-02) from Yongho paleo-lake located in Changnyeong area, south korea. Radiocarbon dating was performed using plant fragments in the lake sediments. Particle size analysis and XRF core scanning were performed to determine the physical and chemical characteristics of the sediment layers. Radiocarbon dating results indicate modern age at about 1.5 m and 4500 cal yr BP at about 8.5 m in depth, suggesting that the paleolake sediments were deposited over the past 4500. The time series of the median grain size and elemental ratios (e.g., Zr/Ti and Zr/Rb ratios) showed similar variability. For example, the Zr/Ti ratios significantly increased at 800, 1200, 2000, 2400, 4400, 5000 cal yr BP, suggesting increased heavy rainfall events. Dry periods based on the Zr/Ti and Zr/Rb ratios were found at 1000, 1600, 3000-3800 cal yr BP. These multi-centennial hydroclimate fluctuations in the study area seem to have been influenced by regional summer monsoon changes coupled to sea surface temperature in Western Pacific.

Keyword

extreme climate event, future climate prediction, Particle size analysis, Radiocarbon dating, XRF core scanning

Historical hydroclimate events recorded in paleo-Gaho lake sediments over the past 7ka

Sujeong PARK[1]*, Korea Institute of Geoscience and Mineral resources (sujeongp@kigam.re.kr)
Jaesoo LIM[2], Korean Institute of Geoscience and Mineral Resources
Hyoun soo LIM[3], Pusan national university

Abstract

Understanding the determinants of extreme hydrological climate change is critical to mitigating the impacts of floods and droughts causing by global warming. Historical records can provide useful parallels to the past, but continuity must be tested and gaps filled based on data from reliable long-term climate records. This study delves into reconstructing the intensity of summertime extreme rainfall during the middle to late Holocene period by analyzing median grain size, strontium/titanium (Sr/Ti), and zircon/titanium (Zr/Ti) ratios of sediments from the Gaho Paleolake core in the southern Korean Peninsula. Centennial-scale variations, evidenced by concurrent decreases or increases in grain size, Sr/Ti, and Zr/Ti ratios in lake sediments, exhibit strong correlations with historical droughts or floods, such as the megadrought period (AD 1593–1698), and fluctuations in sea surface temperature in the western North Pacific region. Notably, pronounced declines in grain size and Zr/Ti ratios around AD 900–1000 and 1300–1400, as observed in the lake sediment records, suggest a direct association between extreme drought events and the downfall of ancient civilizations—namely, the Unified Silla and Goryeo kingdoms on the Korean Peninsula. This research underscores the Sr/Ti and Zr/Ti variations in Gaho Paleolake sediments as proxies for historical flooding and drought events, aiding in bridging gaps within incomplete historical records. Furthermore, also provides a deeper understanding of how historical disasters

Keyword

paleolake, historical era, Little ice age, East Asian summer monsoon, XRF core scanning

Sedimentary diatom records and climate and environment changes of Yazihai Lake, Ningwu County, Shanxi Province before and after the 4.2 ka event

Huiyuan JIA[1]*, Hebei Normal University (1300987550@qq.com)
Yawen Ge[2], Hebei Normal University

Abstract

The 4.2 ka event was an important extreme climate event in the mid-late Holocene, which had a significant impact on environmental changes in different regions of the world. However, there were still limited studies on the response of alpine lake ecosystems to 4.2 ka event in the East Asian monsoon region, which limited the understanding of the relationship between Holocene extreme climatic events and lake environmental evolution. In this project, the Yazihai Lake, an alpine, enclosed freshwater lake in Ningwu County, Shanxi Province, North China, was selected as the research target, and YZH-2022-B core with a length of 1.91m was obtained. A high-resolution sedimentary dating model was established by using AMS 14C and 210Pb/137Cs technique. Using environmental proxies such as diatoms, geochemical elements and grain size in sediments, the aim was to reconstruct the succession of diatom community and the environmental changes of lake before and after the 4.2 ka event. The results showed that during 4,490-3,190 cal yr BP, the dominant diatom genera of the Yazihai Lake mainly included Anomoeoneis, Amphora, Aulacoseira, Gomphonema, Fragilaria, Navicula, Neidium, etc. The succession of diatom community was obvious in different stages. On the basis of clarifying the changes of diatom composition and combining the methods of transformation function, this study quantitatively reconstructed the changes of lake water level and lake temperature before and after the 4.2 ka event, providing more accurate evidence for revealing the evolution of mountain lake ecosystems, and more clearly defining the characteristics and potential mechanisms of the sensitive response of lakes in the East Asian monsoon region to the 4.2 ka event.

Keyword

diatoms, Yazihai Lake, 4.2 ka event, Environmental change, Quantitative reconstruction

Geological and climatic conditions during the Miocene evolution of the North Patagonian Andes, South America: Insights from ancient lake deposits of the Ñirihuau Basin, Argentina

Camila SANTONJA[1]*, Instituto de Geociencias Básicas Aplicadas y Ambientales de Buenos Aires , UBA-CONICET (cs.santonja@gmail.com)
Cecilia Andrea Benavente[2], Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, CONICET
Julieta Suriano[3], Instituto Argentino de Nivología, Glaciología y Ciencias Ambientales, CONICET
Arturo Miguel Heredia[4], Instituto de Investigación en Paleobiología y Geología, CONICET-UNRN
Natalia Fortunatti[5], Departamento de Geología, Universidad Nacional del Sur
Ana Laura Rainoldi[6], Instituto Geológico del Sur, UNS-CONICET
Diego Alejandro Kietzmann[7], Instituto de Geociencias Básicas Aplicadas y Ambientales de Buenos Aires , UBA-CONICET
Florencia Bechis[8], Instituto de Investigaciones en Diversidad Cultural y Procesos de Cambio, CONICET-UNRN

Abstract

The Ñirihuau basin, located between 41° and 43° S, on the eastern side of the Patagonian Andes, Argentina is filled by a thick sequence of Oligo-Miocene volcanic rocks (Ventana Formation) followed by Miocene volcaniclastic, clastic, and carbonatic, mainly continental rocks (Ñirihuau and Collón Curá Formations). The Ñirihuau Formation was interpreted to be deposited on alluvial, fluvial, deltaic, and lacustrine environments and based on available U-Pb geochronological data, was constrained to the early to late Miocene (22–11 Ma). The lacustrine system was established between ~15–13 Ma (Langhian–Serravallian) and holds significance because it was deposited during a transition from an extensional to a compressional tectonic regime, which led to the initiation of the last stage of mountain building in this Andean segment; and it registers the Middle Miocene Climatic Optimum and the beginning of the subsequent Middle Miocene Climatic Transition. Therefore, this contribution aims to document and constrain the past hydrological and sedimentation dynamics and the climatic conditions that prevailed during its deposition by analyzing the limestone beds that are interbedded among the fine-grained deposits. Two detailed sedimentary logs 48 m and 15 m thick were surveyed along the Arroyo Las Bayas, both at the western and eastern flank of the David Syncline, representing similar intervals of the unit. Limestone bed sampling was carried out on both stratigraphic sections, as well as on isolated limestone beds from the Ñirihuau Formation of two other sites. For the sedimentary successions analyzed, one facies association was defined (FA1), which was interpreted as a perennial lake associated with a deltaic system and dominated by detrital clastic material from a fluvial input. It is constituted by Facies 1 (Marginal lacustrine) and Facies 2 (Lower delta plain); on both facies the presence of grainstones and calcimudstones stands out. Through the study of the petrography and cathodoluminescence of these continental carbonates, nine microfacies were identified which point to mainly bio-induced subaqueous carbonate precipitation and subordinated deposition by tractive flows with low transport on a littoral lacustrine environment. Many of them exhibit

subaerial exposure and very early diagenesis (eogenesis) with minor mesogenesis (such as cementation or chemical compaction) effects. The C and O isotope values are consistent with those recorded in the global deep-sea curve during the Middle Miocene Climatic Optimum (17-15 Ma) when most of the limestone beds were deposited. Then, based on the observed features of the limestone beds and the results obtained, it is suggested that they were deposited in a paleolake system under temperate to warm and humid conditions. These conditions are thought to have prevailed until the final Andean uplift in the Miocene, which led to an aridification due to the rain shadow effect.

Keyword

Patagonia, Andean building, Petrography, Cathodoluminescence, δ13C and δ18O stable isotopes

Mechanism of Salinization in Lacustrine Basins and Organic Matter Enrichment Patterns in Paleolake Water with Different Salinities—A Case Study of the Bohai Bay Basin

Zhenguo QI[1]*, China University of Petroleum - Beijing (qizhg7@126.com)
Fujie Jiang[2], China University of Petroleum - Beijing
Zhou Fang[3], China University of Petroleum - Beijing
Tao Hu[4], China University of Petroleum - Beijing
Di Chen[5], China University of Petroleum - Beijing

Abstract

Compared to oceans, lacustrine basins, due to their relatively smaller scale, exhibit greater sensitivity to climate and geological events, leading to frequent changes in their aquatic environments. These changes significantly impact organic matter enrichment and the formation of high-quality source rocks. Notably, variations in paleosalinity can alter paleontological groups, causing water stratification and influencing paleoproductivity and paleoredox conditions. These factors determine the quality of source rocks.

The Bohai Bay Basin is the only Cenozoic super basin globally, with multiple sets of hydrocarbon source rocks. Previous studies have indicated significant variations in paleosalinity among different intervals. This study, through the analysis of total organic carbon content, major and trace elements content, sulfur isotopes, biomarkers information, and identification of microalgal fossils, elucidates the abundance of organic matter (TOC), terrigenous detrital input intensity (P/Ti), hydrothermal influence degree (δEu), paleoclimatic evolution (Sr/Cu, CIA), paleosalinity (Sr/Ba, Gam/C30H), paleoproductivity (P/Ti, CaO), and paleoredox conditions (Pr/Ph, V/Cr) of the source rocks in the Kongdian Formation(E2k), Shahejie Formation(E2-3s), and Dongying Formation(E3d) in the Bohai Bay Basin.

According to the research, paleolake water salinization in different intervals is attributed to marine transgression and climatic aridity: the E2s3 and E3s1 are influenced by marine transgression, leading to water salinization, while the E2k and the E2s4 experience salinization due to hot and arid climatic conditions. Locally, paleosalinity is influenced by deep hydrothermal activity and the intensity of terrigenous detrital inputs. the southern subsag of the Laizhou Bay Depression and the Miaoxi Depression, characterized by well-developed faults, are affected by hydrothermal activity. This results in higher paleosalinity in the E2s4 and E2s3 compared to other areas. In contrast, the northern subsag of the Laizhou Bay Depression, being closer to the sub-uplift, experiences a stronger dilution effect due to the abundance of terrigenous detrital inputs, leading to significantly lower salinity compared to other areas within the same stratigraphic interval.

Based on this study, three organic matter enrichment patterns are identified under different paleosalinity conditions: when paleosalinity ranges from 0‰ to 7‰, increasing paleosalinity leads to elevated nutrient elements in the water, causing water stratification and enhancing paleoproductivity and reducing conditions, favoring the formation and preservation of organic matter. This is considered a productivity-preservation co-control pattern. When salinity ranges

from 7‰ to 14‰, higher salinity causes some freshwater organisms in the lacustrine basin to be unable to adapt, resulting in decreased paleoproductivity but continued enhancement of reducing conditions, leading to better preservation conditions than the previous stage. This is also characterized by an increase in TOC with rising paleosalinity. This is considered a preservation control pattern. When salinity exceeds 14‰, the inability of more freshwater organisms to adapt leads to mass mortality, reducing paleoproductivity and increasing reducing conditions. However, due to extremely low paleoproductivity at this stage, characterized by a decrease in TOC with increasing paleosalinity, indicating a productivity control pattern.

Keyword

Mechanism of Salinization, Organic Matter Enrichment, Lacustrine Basins, Bohai Bay Basin

Isotopic composition (δ13C, δ15N) and Elemental (C/N ratios) of sedimentary organic matter from a high-altitude mountain lake, western Himalaya: Implications to lacustrine productivity

Aasif Mohmad LONE[1]*, Department of Earth Sciences, Indian Institute of Technology Kanpur India (geoaasif@gmail.com)
Debajyoti Paul[2], Department of Earth Sciences, Indian Institute of Technology Kanpur India
Elodie Brisset[3], Institut Méditerranéen de Biodiversité et d'Ecologie
Anchana P[4], Department of Earth Sciences, Indian Institute of Technology Kanpur India
Hema Achyuthan[5], Anna University Chennai

Abstract

The lacustrine ecosystems are dynamic landscapes sensitive to terrestrial, insitu and atmospheric changes and hence considered as important archives of past environments. The δ13C and δ15N isotope composition along with geochemical proxies have been utilized widely in lacustrine systems to infer past fluctuations in lake productivity and terrestrial inputs linked to climate-induced environmental changes. In the present study, we investigate changes in the organic geochemical data including δ13C, δ15N isotope and C/N ratios of sedimentary organic matter (OM) from a small, hydrologically closed lake (Ahansar) in Kashmir Himalaya to investigate changes in aquatic productivity and nutrient source variations through time with respect to climate-induced environmental changes. The lake is idealistically located at the intercept between the mid-latitude westerlies (WD) and the Indian Summer Monsoon (ISM). Our organic geochemical parameters clearly excluded a significant contribution of terrestrially derived OM to the sediments, but rather evidenced the strong contribution of aquatic primary productivity to the lake. However, the records also show phases of reduced δ13C values with enhanced TOC and C/N ratios attested to wetter phases and development of vegetated catchment landscape/soil development. The records therefore demonstrate that climate-induced environmental changes influenced OM and lake productivity in this high-mountain lake throughout the sedimentary record.

Keyword

Lake sediments, Himalaya, Productivity, Organic matter

Study on atmospheric CO2 concentration and climate change since the Holocene recorded in lake sediments on the Tibetan Plateau

Yongli Wang[1], Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences; CAS Center for Excellence in Life and Paleoenvironment, Beijing 100029, PR China;
Zhifu Wei[2], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China
Gen Wang[3], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China
Ting Zhang[4], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China
Xueyun MA[5]*, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences (maxueyun@nieer.ac.cn)
Zengguang Guo[6], Key Laboratory of Cenozoic Geology and Environment, Institute of Geology and Geophysics, Chinese Academy of Sciences; CAS Center for Excellence in Life and Paleoenvironment, Beijing 100029, PR China;
Kaikang Liang[7], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China.
Xiaomei Zhang[8], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China.
Shangkun Li[9], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China.
Jianzhen Chen[10], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China.
Zelong Li[11], Key Laboratory of Petroleum Resources Exploration and Evaluation, Gansu Province, Northwest Institute of Eco-Environment and Resources, Chinese Academy of Sciences, Lanzhou 730000, PR China.

Abstract

This study focused on the sediment core and surface sediments of the Hurleg Lake, Qaidam Basin, northeastern margin of the Tibetan Plateau. Based on the comprehensive analyses of the geochemical characteristics of the lake sediment sequences, the compositions of long-chain alkenone, mid-chain ketone in the sediments, and the characteristics of the paleo-DNA, paleoclimate and paleoenvironment since the Holocene in the Qaidam Basin were systematically studied. The results showed that changes in the content of mid-chain ketone series compounds revealed two typical cold events (4.2 ka and 8.0 ka), which possibly corresponded to the phase of low atmospheric CO2 concentration (Fig. 1). A comparative study of long-chain alkenones from

lakes in different regions revealed that lake alkenones in the Qaidam Basin were influenced by the species and biomass of the alkenone parent source, and further research is needed. In addition, in terms of atmospheric CO2 reconstruction, the study of original organic carbon recovery and carbonaceous gas emissions in the Xiejia profile on the northeastern margin of the Tibetan Plateau showed that the magnitude of original organic carbon burial fluxes was positively correlated with the typical warm and cold climatic environments in the geological period, where warmer/arid climatic conditions corresponded to a higher rate of original organic carbon burial, and a lower rate was found in colder climatic environments. Further attention was paid to the thermal evolution of organic matter deposited during geologic history, which was converted into carbon-containing gases (including CO2 and CH4, etc.) and released to the atmosphere. We firstly estimated the amount of CO2 emitted from Cenozoic sediments in the Xiejia section of Xining Basin, during the shallow burial stage, the amounts of CO2 emissions were 60~13910 ml/g TOC, and CH4 emissions were 2~24 ml/g TOC, which provided an important reference for calibrated values of atmospheric CO2 reconstruction. Meanwhile, the combination of the multi-proxies indicated that the climate of Hurleg Lake was warm and humid during the Last Deglacial period, cold and humid in the early Holocene, warm and humid occurred in the middle Holocene, finally, gradually cold and dry in the late Holocene. During the Holocene, the water vapor evolution in the Hurleg Lake area was controlled by the Asian Summer monsoon, showing a typical "monsoon pattern", while the long-term decline in temperature and precipitation since the late Holocene may have led to the degradation of vegetation, the advance of glaciers, and the intensification of wind-induced activities, thus affecting the ecological landscape of the region.

Keyword

CO2 atmosphericconcentration, Ancient microorganism, Total organic matter

Reconstructing Holocene Indian Summer Monsoon Variability Using Multi-proxy Records from Eastern Indian Lake Sediments

ARPITA PARHI[1]*, INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR
(arpitaparhiak418@gmail.com)
ANIL KUMAR GUPTA[2], INDIAN INSTITUTE OF TECHNOLOGY
SUBHASISH TRIPATHY[3], INDIAN INSTITUTE OF TECHNOLOGY KHARAGPUR

Abstract

The Indian summer monsoon (ISM) is an essential component of the global climate system. Its variability directly impacts agricultural productivity and water availability, significantly shaping the livelihoods of the South Asian population. Moreover, the intensity of the ISM has also exhibited notable fluctuations in the past. To comprehend this variability, our research focuses on two lakes situated in eastern India. Hansadanga lake (in West Bengal) is an oxbow lake located on the Lower Ganga plain and Tampara lake (in Odisha) is a coastal lake adjacent to the Bay of Bengal. Sediment core samples having length of ~ 5 m from Hansadanga lake and ~ 2.5 meters from Tampara lake were collected. The sediment cores of Hansadanga lake covers an age range from 11,000 cal yr BP to the present and Tampara lake covers an age range from 13,000 cal yr BP to the present, using radiocarbon dating method. Our multiproxy dataset from both lakes includes the parameters like grain size, major and trace element ratios (K/Al, Mg/Al, Zr/Al, Mg/Ca, Rb/Sr, Al/Ca and Chemical index of alteration), Total Organic Carbon (TOC, wt%), δ13Corg and environmental magnetism (χlf, SIRM). The records obtained from Hansadanga lake reveal distinct climate phases: a stable dry phase between 11000 to 8400 cal yr BP, succeeded by a relatively intensive dry phase extending from 8400 to 7500 cal yr BP. Afterwards, a brief wet phase is evident during 7200 to 6700 cal yr BP, followed by a moderate phase of precipitation from 6700 to 4500 cal yr BP. Subsequently, an intensified dry phase is prevailed between 4500 to 3800 cal yr BP, preceeded by an increased precipitation phase during 900 to 400 cal yr BP. Furthermore, the sediment records obtained from Tampara lake indicate three alternate phases: a strengthening of monsoonal precipitation is observed from 10600 to 8700 cal yr BP, followed by a pronounced weakening between 8400 to 3500 cal yr BP and again by strengthening from 3400 to 600 cal yr BP. Remarkably, our data from the lakes of eastern India display evidence of the 8.2 ka and 4.2 ka arid events and exhibit noteworthy correlation with each other, as well as with marine and continental records globally.

Keyword

Indian Summer Monsoon, Lake sediments, 4.2 ka event, 8.2 ka event

Paleoclimate and Paleoenvironments of Chegarman Lake according to sedimentological and geochemical studies during Late Holocene in SW Iran

Javad DARVISHI KHATOONI[1]*, Geological Survey of Iran (Darvishi.khatooni@gmail.com)
Elnaz Aghaali[2], MSc. in Petrology, Geological survey of Iran, Tehran, Iran
hamideh noroozpour[3], Assistant Professor, Payame Noor Unvierstiy, Tehran, Iran
Sara Narimisa[4], Ph.D. in Environmental science, Iran University of Medical Sciences, Tehran, Iran

Abstract

Introduction

Chegarman Lake formed in the northeast of Khuzestan province on the hillsides of folded Zagros and under the Izeh unit in a pit. This study has been tried to by Sedimentary geochemistry analyze, Elemental ratios, identification of sedimentary facies, and identification of sedimentary environments and changes of these environments set to the reformation the climatic and environmental conditions of Chegarman wetland in the Late Holocene.

Methods and Findings

To investigate the paleoclimate and conditions of the sedimentary environment, one intact sediment cores with depth of 7.2 m collected with using Auger corer. 21sediment samples were selected for elemental analysis with ICP-OES and XRF (X-Ray fluorescence). In this study, elemental ratios of V/Cr, Mn/Al, K/Al, Rb/Al, Si/Fe, Ti/K were used to reconstruction of the paleo climatic and environmental conditions.

Results and discussion

In the studied core, 5 major sedimentary facies identified. Two wetland sedimentary and alluvial environments identified. According to the Chronology, the average sedimentation rate in the Chegarman wetland is 1.4 mm / year, which this amount is different for various depths (Darvishi et al., 2022). Due to the type of sediments, the high level water period of the Chegarman wetland has been established between 1250 and 150 years ago. The study of the facies sediments of the wetland bed shows that climate change occurred gradually (not suddenly) about 1250 years ago and this trend has taken at least 300 years. The relatively dry and cold period lasted about 1850 years from 3100 years to 1250 years ago and is confirmed with the reported dry periods in the Maharlou Lake about 1800 years ago, in the Mir Abad Lake about 1500 years ago and in the Urmia Lake between 2500 and 1500 years ago. From 4000 years ago to about 3100 years ago, stable and slow wetland conditions was prevailed. The conditions for creating a peatland environment have been provided in the wetland and were associated with increasing the amount of organic matter, vegetation and shell fossils and consequently increasing sedimentation rate. This period which lasted for about 900 years, has been accompanied by extremely humid conditions, high groundwater level and activity of springs in the region. The existence of light brown mud which has the age ranges from 4900 to 4000 years ago, indicates a dry period (900 years). This dry

period shows suitable approximate conformity with a dry event of 4200 years ago in the northern hemisphere. This period in the studied region appeared with at least 100 years of temporal delay. After this dry period, we see again a gray sequence with plant and shell fossils that continue to a depth of 7 meters (about 5000 years ago).

Conclusion

In the Chegarman wetland, at least 2 high water periods with humid climate and at least 2 dry periods during the Late Holocene were identified. Dry periods appear more suddenly and with more intensity and shorter duration than humid periods

Keyword

Paleoclimate, Sedimentary Geochemistry, Sedimentary Core, Late Holocene, Zagros lake

Monitoring of the land-sea interface: Analysis of high-resolution time series from 1950 to the present-day illustrating erosion, transport, and coastal sedimentation processes on the west Atlantic coast of France.

David MENIER[1]*, University of South Brittany (david.menier@univ-ubs.fr)
Romain LE GALL[2], Geo-Ocean UMR CNRS 6538, Université Bretagne Sud, 56017 Vannes Cedex, France
Manoj Mathew[3], Department of Geography, Geology and the Environment; London, United Kingdom
Benjamin SAUTTER[4], Geo-Ocean UMR CNRS 6538, Université Bretagne Sud, 56017 Vannes Cedex, France
Glen BULOT[5], Geo-Ocean UMR CNRS 6538, Université Bretagne Sud, 56017 Vannes Cedex, France

Abstract

The analysis of the coastline can be systematically carried out through field observation campaigns, analysis of aerial and/or satellite photographs, as well as by utilizing LIDAR data or drone surveys. Although these tools provide measurements of coastal erosion and accretion at different spatial and temporal resolutions, there is still too little scientific synthesis at the regional scale.

Thanks to recent advances in LIDAR data acquisition and drone surveys, it is now possible to obtain high-resolution time series, thus enabling fine-scale monitoring of the coastline at decimeter to centimeter scales.

Our study focuses on two study areas: the first involves monitoring over a 50-year period of the retreat of a 2km-long cliff, which exhibits a high propensity for erosion over a relatively short distance (less than 1 km), and the second sector is located on the southern shore of the Vilaine estuary, characterized by a coastline undergoing constant morphodynamic evolution. The aim here is to discuss the importance of high-resolution and high-frequency monitoring in these two study areas where erosion and sediment transport processes are observed.

The analysis results of the cliff attest to a substantial retreat of up to 60cm/year from the cliff top, with notable variations along the studied area. The eroded materials are deposited downstream, contributing to a beach with coarse to fine sediment grain sizes. The relatively strong tidal currents in this sector, combined with wave action, result in the clearance of rockfalls at the base of cliffs. These materials are then redistributed towards the second study area. The analysis of time series data from this second area between 1952 and 2020 highlights significant morphological changes, including the migration of sand spits, areas of progradation/accretion, and sectors undergoing erosion, providing a dynamic perspective of the land-sea interface. Clear retreats of over 50 meters are observed, as well as lateral shifts along the coast, consequences of littoral drift and tidal currents.

The results obtained provide crucial data for the sustainable management of coastlines and underscore the need for long-term observation measures to provide public decision-making tools

and protective measures tailored to the specific characteristics of each studied area.

Keyword

Erosion, Cliff, Lidar, Drone, Coast

Human-controlled discharge effect on hydrodynamic and benthic sedimentary processes in the tide-dominant estuary

Seong Woon JEONG[1]*, Inha University (idiq1922@gmail.com)
Ho Kyung Ha[2], Inha University

Abstract

The estuarine environment is a representative coastal system of densely-populated areas since industrialization. Accordingly, various artificial structures such as dam, harbor, and dyke were built along an estuary. The Geum River Estuary (GRE), which is located on the west coast of Korea, is no exception for the severe effect of estuarine dam on the hydrodynamic and benthic sedimentary environments. To estimate the spatial differences of human-controlled discharge and tidal effects on the GRE, three up-looking acoustic Doppler current profilers (ADCPs, Teledyne RD Instrument, Workhorse 600 kHz) were installed at upper (PC1), middle (PC5), and lower part (PC6) of the GRE during September 8–25, 2020. The primary forcing which controls high current velocity and benthic sediment resuspension was different at each mooring site. At the PC1, spring tide flood (VB: 1.12 m/s; SSCB: 261.61 mg/l) and the discharge (VB: 1.11 m/s; SSCB: 247.21 mg/l) caused almost a same level of benthic current velocity (VB) and suspended sediment concentration (SSCB). At the PC5, the effect of spring tide flood (VB: 2.05 m/s; SSCB: 649.37 mg/l) was stronger than the discharge (VB: 1.39 m/s; SSCB: 611.63 mg/l) on VB, however, the effect on SSCB was similar. At the PC6, where was farther from the GRE dam, the effect of discharge on the hydrodynamic environment was weak compared to other mooring sites. Although the discharge reinforced VB (0.91 m/s) and SSCB (158.93 mg/l), it was almost negligible compared to other mooring sites. During the neap tide, a relatively high level of SSC was observed only during the discharge (SSCB: 156.60 mg/l), which was speculated by dispersed suspended sediments from the PC1 and PC5. The results from this study indicate that the main reason for the benthic sediment resuspension could be spatially different at the GRE. The effect of the discharge from the GRE dam gradually decreased from upper to lower part of the estuary. SSCB at PC5, which was highest among the mooring sites, implies that severe sediment accumulation might have been occurred at the middle of GRE. Further analysis on suspended sediment fluxes at each mooring site will be explained during the presentation.

Keyword

Estuary, Human-controlled discharge, Tide, Sediment, Resuspension

Seasonal controls on the channel morphodynamics in an open coast macrotidal flat, west coast of Korea

Seolhui BANG[1]*, Seoul National University (shbang@snu.ac.kr)
Seungyeon Sohn[2], Seoul National University
Luke Stefan Bisson[3], Seoul National University
Joohee Jo[4], Seoul National University
Kyungsik Choi[5], Seoul National University

Abstract

The morphodynamics of tidal channels is crucial in understanding the evolution of tidal flats, as they exert as a conduit for sediment transport and drive the geomorphic changes. However, the characterization of the channel morphodynamics remains a challenge due to the difficulties in differentiating many natural and anthropogenic factors involved in the process. The present study aims to unravel the spatiotemporal variation of the channel morphodynamics in an open-coast macrotidal flat in southern Ganghwa island by conducting a repeated survey over the two decades using an unmanned aerial vehicle (UAV) and high-precision profiling. The results showed that the channel morphodynamics tend to be more pronounced in the lower intertidal zone and during summertime rainy season when heavy rainfall coincided with spring low tides. In case the channel is linked to a sluice gate, seasonal influence on the channel morphodynamics is even accentuated in the upper to middle intertidal zone. Channels are landward-skewed and shift downstream with frequent chute cut-off and subsequent abandonment of the channel, highlighting ebb tidal currents seasonally reinforced by runoff discharge drive the long-term morphologic change. The channel morphodynamics accounts for the facies heterogeneity in the middle to lower intertidal zone of the channelized open-coast macrotidal flat.

Keyword

morphodynamic, tidal channel, open-coast tidal flat, rainfall

Variations in flocs related to wind-induced turbulent shear in macrotidal flat, Asan Bay

Sun Min CHOI[1]*, Inha University (choism124@gmail.com)
Ho Kyung Ha[2], Inha University

Abstract

In the intertidal flats with macrotidal regime, in-situ mooring was conducted to reveal the variations in floc properties (e.g., floc size (davg) and density (rho_e)) under tide and wind-dominant conditions. The floc property, current, and turbulence were simultaneously measured by using a laser particle sizer, acoustic Doppler current profiler, and acoustic Doppler velocimeter, respectively. During two weeks of field campaign (October 17–31, 2021) in Asan intertidal flats, the spring-neap variations in floc was dominant, showing a continuous decrease of current velocity and water level from 5 to 2 m. The continuous decrease in davg from 275 /mum (spring) to 70 /mum (neap) was superimposed by the flood-ebb variations in davg. At each tidal cycle, the davg grew by approximately 1.6 times during the flood, and decreased during the ebb. The turbulence enhanced by winds caused changes in davg and rho_e. The floc structures during flood and ebb under strong winds (wind speed > 6 m s-1) changed depending on the sources of suspended sediments in intertidal flats. For advected floc during the early flood, the strong winds formed the floc having a similar relationship between rho_e and davg to those under weak winds (wind speed < 6 m s-1). For eroded flocs during the ebb, meanwhile, the floc supplied by bed erosion had a different relationship between rho_e and davg, showing much smaller size and denser structure compared to those under weak winds.

Keyword

Flocculation, Wind, Floc density, Intertidal flat, Erosion

Tidal and seasonal influences on the morphodynamic evolution of the tidal channels in a macrotidal embayment: Garolim Bay, west coast of Korea

Seungyeon SOHN[1]*, Seoul National University (ssyhhhh@snu.ac.kr)
Seolhui Bang[2], Seoul National University
Joohee Jo[3], Seoul National University
Kyungsik Choi[4], Seoul National University

Abstract

The seasonal variation of rainfall-induced discharge is a crucial factor that affects sediment transport and morphological changes of tidal channels. This is particularly the case in macrotidal settings that are influenced by monsoons. However, our understanding of how seasonal changes affect the channel morphology and related facies architecture is still limited. To improve our knowledge, we conducted a series of field survey in Garolim Bay, located on the west coast of Korea. We used sedimentological, morphological and hydrodynamic data to investigate the seasonal influence on the geomorphic evolution of tidal channels and their stratigraphic record in a semi-enclosed macrotidal embayment with insignificant fluvial input.

During the rainy season, tidal channels actively migrate and become more sinuous. Heavy rainfalls intensify ebb currents and induce seaward flow even during flood tide, leading to frequent chute cutoff and subsequent infilling of abandoned channels. Landward-skewed tidal channels that shift downstream and inclined heterolithic stratification (IHS) dipping ebbward support overall ebb dominance. Seasonality in the IHS is cryptic but manifested by the alternation of thickly bedded, unidirectional ripple cross-laminated sand with a lack of mud drapes, representing high-energy conditions during the rainy season, and relatively thinly bedded, bidirectional ripple cross-laminated sand and interlaminated sand and mud formed during the dry season. Digital elevation models of difference (DoD) and repeated high-precision profiling indicate the tidal flats experience summertime erosion and wintertime deposition, implying net sediment export occurs during the rainy season.

Keyword

tidal channel, inclined heterolithic stratification, channel migration, rainy season

Chronology of raised marine terraces at the coasts of Tamil Nadu, South India- Implications on palaeotsunmi and higher sea-level

LINTO ALAPPAT[1]*, Christ College Autonomous, Irinjalakuda, Thrissur, Kerala, India (alappatlinto@christcollegeijk.edu.in)
Monika Devi[2], Physical Research Laboratory, Ahmedabad, India, 3800093
Devapriya Chattopadhyay[3], Earth and Climate Science, IISER Pune, 411008, India
Yadava M.G. [4], Physical Research Laboratory, Ahmedabad, India, 3800093
Naveen Chauhan[5], Physical Research Laboratory, Ahmedabad, India, 3800093

Abstract

Late Pleistocene- Holocene beach deposits have been identified at the coasts of Tamil Nadu, South India. The outcrops are located between Thoothukudi and Rameswaram at 2-3 meters above sea level. The study aims to determine the sediment depositional history, palaeo sea-level and tectonics of the area, and constrain chronology using optically stimulated luminescence (OSL) as well as 14C dating. The deposits represent medium to coarse moderately sorted sand with sub-horizontal or gently sea-ward dipping stratification. The outcrop consists of a total ~7.0 m thick succession of alternating cross laminated fossiliferous, quartzitic conglomerate with intervening sandy lenses, which are capped by aeolian sand deposits. The samples were collected from four sections in the area. An intermediate layer and a basal layer contain cemented coarse sand, gravel with abundant fossils of marine molluskan fauna. The molluscan fauna are dominated by gastropoda (families: Turritellida, Conidae, Cypridae, Naticidae, Strombidae) and Bivalvia (families: Arcidae, Ostreidae, Pectinidae, Veneridae). A poorly sorted consolidated unit of medium to coarse grained sand with gravel unit along with cross stratified troughs and hummocky stratification shows that this may have formed by high energy conditions. The remnants of former sea-level high stands at the coasts of south India are generally scarce, usually represents either last interglacial (~120 ka) or mid Holocene eustatic maximum. The samples collected at distinct sedimentary units have shown OSL ages of 6±1 ka for the upper aeolian unit, followed by 24 ± 1ka for the marine sequence and 53 ± 4ka for the basal gravel layer. The third section had given an age of deposition during 59 ± 3ka and 102 ± 8ka. The shell samples collected shows that their deposition has occurred in a marine- marginal marine conditions and the OSL ages of sediments from this units shows that their deposition has occurred during 28 ± 1ka and 59 ± 3ka. The evidences point to a high energy event, possibly a potential palaeo-tsunami, which caused deposition of marine shells within the clastic sedimentary unit. The emergence of the coast may be attributed to a higher sea-level stand that had occurred in the area during this time.

Keyword

Late Quaternary, Palaeo-tsunami, Sea-level changes, OSL dating, Marine terraces

Distribution Characteristics and Accumulation Mechanism of High Saturation Gas Hydrates in the Makran Accretionary Prism offshore Pakistan

JING LIAO[1]*, Qingdao Institute of Marine Geology, CGS (qdliaojing@gmail.com)
Jianming Gong[2], Qingdao Institute of Marine, CGS

Abstract

The Makran Accretionary Prism, located in the southern maritime area of Pakistan, is the result of the Arabian Plate subducting towards the Eurasian Plate. It features a low subduction angle (3-4°), high convergence rate (40mm/year), thick sedimentation (over 7000m), and abundant gas supply, making it an ideal location for gas hydrate accumulation. To delineate the spatial distribution of high saturation gas hydrate reservoirs in this area, we interpreted the seismic data and compared it with drilling results from the Nankai Trough in Japan and the ODP204 expedition. The results reveal a clear and continuous bottom simulating reflector (BSR). Hydrates are mainly distributed in three areas: first, strong reflections located above the BSR indicating high saturation hydrates with a thickness of about 100m; second, regions related to submarine cold seep leaks where cold seep biota have been found distributed along the anticlinal ridges; third, weak reflection layers located above the BSR and beneath the seabed, which cover a relatively larger area with greater thickness but lower saturation. Additionally, strong reflections below the BSR, identified as free gas according to drilling results, are considered part of the hydrate accumulation system, with the thickness up to 1000m. The fluid migration system in the study area comprises a developed "large thrust fault-high permeability turbidite sand layers" composite migration system. High saturation gas hydrates are primarily formed by the upward migration of free methane gas along the inclined turbidite sand layers, capped below the BSR to form gas columns.

Keyword

Makran Accretionary Prism, BSR, strong reflections, high saturation gas hydrate, fluid migration system

Analysis of characteristics of seaweed forest distribution area using acoustic exploration method (multi-beam echo sounder)

SoonYoung CHOI[1]*, Korea Institute of Ocean Science and Technology, Kangwon National University (sychoi@kiost.ac.kr)
ChangHwan KIM[2], Korea Institute of Ocean Science and Technology
WonHyuck KIM[3], Korea Institute of Ocean Science and Technology
ChanHong PARK[4], Korea Institute of Ocean Science and Technology

Abstract

This study performed habitat environment mapping analysis using acoustic exploration to determine the distribution of seaweed forests. The study area, inhabited by seaweed, is located around Uljin Huam Beach, which has an underwater observatory and an underwater breakwater. In April 2022, a detailed seafloor topographic survey was conducted using multibeam in the study area to obtain water depth data. The water depth in the study area ranges from approximately 3 to 25 m. The water depth gradient gradually deepens from the southwest (near the coast) to the northeast. The distribution of seafloor in the study area has sandy sediments widely distributed in all areas. Rocky areas are concentrated in shallow coastal areas and areas close to underwater breakwaters. The overall shape of the rocks is irregular, but the direction of cracks is predominantly N-S or NE-SW. In the backscattered images the difference in shade and relief between the rocky area and the sandy sediment layer is clearly distinguished. The habitat environment was classified by integrating slope, surface roughness, bathymetry, and backscatter images derived from water depth data. The habitat environment of the study area is divided into rocky bottom, gravelly sand, sand and silty sand sediments. The seaweed distribution area was identified as the location where seaweed was detected using water depth and water column data. Most of the seaweed growing in the study area are distributed in rocky areas with shallow water depths (<10 m), and are relatively rare in sandy sediments. The type of seaweed is expected to be Sargassum fulvellum, and the length of seaweed is 2 to 4 m or more. As a result of comparing the predicted location of seaweed distribution based on multibeam data and the location of seaweed confirmed by underwater camera images, the two data match well. The habitat environment of the seaweed distribution area is mainly concentrated in rocky areas and gravelly sand sediment areas.

Keyword

habitat map, seaweed, multibeam, water-column, seabed classification

Sediment Dynamics in the Nakdong River Estuary, South Korea: Insights from the Nakdong Estuary Information Service System (NEISS)

Junho Lee[1]*, Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology (leejh@kiost.ac.kr)
Hoi-Soo JUNG[2], Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology
Huigyeong RYU[3], Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology
Han Jun WOO[4], Peru-Korea Joint Ocean Research Center, Korea Institute of Ocean Science & Technology
Joo-Hyung RYU[5], Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology
Hee Cheol YANG[6], Ocean Law and Policy Institute, Korea Institute of Ocean Science & Technology

Abstract

This research explores the sedimentary dynamics within the Nakdong River Estuary (NRE), Busan, South Korea, influenced by both natural processes, such as erosion and sedimentation, and human activities, notably the construction of the NRE Dam in November 1987. Utilizing data from the Nakdong Estuary Information Service System (NEISS) from 2015 to 2021, our study aims to elucidate the terrestrial and marine interaction and detail the sedimentary characteristics of the estuarine transition zone near the NRE barrier islands. Analysis of NEISS-provided sediment distribution data reveals a predominance of sand on the ocean-facing sides of the barrier islands and muddy sand on the lagoon sides. Based on the depth-integrated net suspended sediment load during a tidal cycle, sediment transport analysis identified a seaward sediment movement of 1698 kg per meter. Net suspended sediment fluxes were calculated for the surface, mid-water, and bottom layers, showing values of -2.1 × 10 to the negative third power, -2.0 × 10 to the negative third power, and +3.3 × 10 to the negative third power kg per square meter per second, respectively. A stratification index (SI) analysis underscored a pronounced saltwater intrusion and significant stratification within the estuary, affecting both the ebb and flood tide phases. The study highlights the NEISS's role in documenting sedimentary environment alterations in the NRE through the period under review, with post-May 2015 data informing Marine Spatial Planning (MSP) efforts in the area. Furthermore, this system underscores the potential of the NEISS for ongoing monitoring of NRE sedimentary dynamics, especially in anticipation of ecological shifts after the dam's partial opening on February 18, 2022.

Keyword

Barrier islands, Nakdong River estuary, Salinity, Sediments, Suspended sediments

Deciphering Dokdo Seamount's Submarine Topography: Generation and preservation of submarine terrace structure

Duhwan KEUM[1]*, Department of Earth System Sciences, Yonsei University
(2022321202@yonsei.ac.kr)
Wonsuck KIM[2], Department of Earth System Sciences, Yonsei University

Abstract

Marine terraces, characterized by flat surfaces of marine origin bordered by steeper ascending and descending slopes on the up and down-slope sides, respectively, are products of wave erosion (IHO, 2019). Their elevation is generally accepted as a potent indicator of paleo-relative sea. Here, we aim to identify the primary contributor shaping the distribution of marine terrace elevations in Dokdo, a volcanic island in the East Sea, South Korea over geologic time.

Using a simplified one-dimensional model, we simulate the evolution of rocky coastline through the horizontal and vertical wave erosion processes. Our model considers various scenarios involving sea-level changes, tectonic movements, and wave conditions to unveil the mechanisms governing the generation and preservation of marine terrace structures.

Our findings indicate that the depth of terrace formation often correlates well with periods of prolonged sea level duration. However, the distribution of terrace elevations does not precisely align with the distribution of sea level occupation time due to the destruction of previous topography by subsequent erosional events. The influence of younger and lower erosion can erase topographic features carved earlier, leaving only the most recent features. Additionally, we identify the slope of the initial topography and wave energy conditions as crucial factors controlling the preservation of marine terrace structures. Applying our understanding through modeling, we found possibility of a very recent substantial reset of topography on Dokdo seamount, possibly within the last 300,000 years.

In conclusion, sea level occupation time, initial slope of the surface, and wave energy are crucial factors influencing terrace formation and preservation. These findings contribute to our understanding of coastal morphodynamics and offer insights into reconstructing relative sea-level history of specific regions. Applying our model to Dokdo reveals the potential for recent significant topographic events, showcasing the broader implications of our research for understanding geological history of the East Sea.

Keyword

Dokdo, Marine terrace, Numerical modeling

Multiscale Sea-Level Variability and Predictive Modeling in the Northern South China Sea Under Climate Change

Yilin YANG[1]*, Sun Yat-sen University (yilinyang12@foxmail.com)
Qiuming Cheng[2], Sun Yat-sen University
Yuanzhi Zhang[3], City University of Hong Kong

Abstract

Global warming has escalated sea-level rise, posing significant threats to coastal regions worldwide. This is particularly true for the northern South China Sea (SCS), where low elevation, rapid economic growth, and high population density converge, heightening the vulnerability to the ramifications of rising seas. Our research focuses on understanding the sea-level trends in this critical area and assessing the potential inundation threats to its low-lying locales.

Employing the Ensemble Empirical Mode Decomposition (EEMD) methodology, we dissected time series data from trio of tide gauges stationed along Hong Kong's coastline. This approach unraveled the complex, multidimensional nature of sea-level fluctuations within the SCS and their underlying response mechanisms. The adoption of Multifractal Detrended Fluctuation Analysis (MF-DFA) shed light on persistent correlations and multifractal features within the sea-level time series. Our study revealed distinct seasonal, interannual, decadal, and interdecadal variations, offering detailed insights into the fluctuating patterns of sea-level change.

Furthermore, the investigation into the El Niño-Southern Oscillation (ENSO) phenomena revealed a 6-month delayed correlation with local sea levels, offering insights into the regional impact of global climatic events. Spatial analysis indicated accelerated sea-level rise in proximal coastal zones and a discernible disparity between northern and southern sectors.

Advancing beyond traditional models, we introduced a novel sea-level forecasting approach by fusing EEMD with Long Short-Term Memory (LSTM) neural networks. This hybrid model underwent empirical testing in the northern SCS context, demonstrating superior predictive prowess over conventional LSTM models. By effectively filtering noise and enhancing signal fidelity, the EEMD-LSTM model offers a robust forecasting tool.

In essence, this work delves deep into the multiscale dynamics of sea-level variations in the northern SCS, and proposing an innovative predictive model that marries EEMD with LSTM. Our findings lay a solid foundation for evaluating sea-level rise risks and crafting adaptive strategies for at-risk low-lying communities.

Keyword

Sea-Level Rise, South China Sea, Marginal sea, Coastal environment, Multifractal Analysis

Characteristics of surface sedimentary facies in the Watan Estuary intertidal flat, western Korea

Woo Hun RYANG[1]*, Jeonbuk National University (ryang@jbnu.ac.kr)
Jae Rin Yoon[2], Jeonbuk National University
Sol Ip Kang[3], Jeonbuk National University

Abstract

On the western coast of Korea, the Watan estuary intertidal flat is characterized by macro-tide and semi-enclosed coastal geomorphology. Variations in sediment texture and sedimentary facies of surface sediments and geomorphic topography in August 2016 and February 2017 were investigated along three transect lines to the shoreline in the Watan estuary. Surface sediments and topography were sampled and measured at 45 sites with 50 m intervals along the three survey lines in the Moraemi, Mokmaek, and Flower Garden areas. The surface sediments of the Watan estuary intertidal flat consist mainly of sand and silt sediments. In summer, terrestrial suspended clay sediments were deposited from downstream Flower Garden, Mokmaek extending to the Moraemi area of the Watan estuary. However, in winter, suspended clay sediments accumulated at the Flower Garden and Mokmaek areas in the lower reaches of the Watan stream, not extending to the Moraemi area of the Watan estuary mouth. In summer, the Watan estuary has characteristics of increases in the Watan stream discharge due to an increase in precipitation and relatively weak wave effects within the estuary. In contrast, winter shows decreases in the stream discharge and relatively strong waves. This variation may affect the seasonal sedimentation of intertidal sediments in the estuary.

Acknowledgments: This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (NRF-2022R1F1A1063126).

Keyword

Watan estuary, intertidal flat, surface sediment, sedimentary facies

Coastal Topography Monitoring utilizing CubeSat Constellation, in Hujeong Beach, South Korea

byunggil LEE[1]*, kangwon national university; KIOST (bglee@kiost.ac.kr)
Jae-Youll Jin[2], KIOST
Yeon S Chang[3], KIOST
Jae Ho Choi[4], KIOST
Won-Dae Back[5], KIOST
Chang Han KIM[6], KIOST
Soon Young Choi[7], Kangwon National University; KIOST
Won Hyuck KIM[8], KIOST
Jong Dae Do[9], KIOST

Abstract

Studying shoreface topography in coastal areas within a depth of 10 meters, where active sand movement occurs, often involves direct surveys with small boats. However, this method faces limitations in periodic monitoring due to susceptibility to weather conditions such as wave in surfzone

To address these limitations, algorithms based on satellite imagery have recently been developed for water depth estimation. Utilizing the Cubesat constellation (Planet Scope) with a daily revisit cycle and high spatial resolution enables more extensive depth estimation. However, to effectively utilize data from different satellites within the constellations, it is crucial to employ methods for cross-calibrating and fusing images from other satellite sources (Sentinel2).

This study utilized 2022 data from the coastal area of Hujeong in Uljin-gun, South Korea. An algorithm fused 25 Sentinel-2 images and 127 Planet Scope images, providing a spectrally consistent water depth estimation at a 3-meter resolution. Field depth measurements were obtained three times in May, August, and October 2022, serving as ground truth for validating the estimated values derived from satellite imagery.

Compared to traditional on-site depth measurements, which are challenging to perform multiple times within a short period, utilizing Planetscope satellite Constellation for depth estimation offers advantages in terms of cost-effectiveness, high resolution, and coverage of wide areas. This approach also facilitates daily monitoring of rapidly changing coastal topography caused by adverse weather conditions like storm wave, typhoons, and heavy rainfall.

Keyword

Satellite-Derived Bathymetry (SDB), remote sensing, Cubesat, Planetscope, Semtinel2

Exploring spatiotemporal variations in sediment retention in delta evolution: A numerical experiment with Delft3D

Minsik KIM[1]*, yonsei univerisity (yukms6601@yonsei.ac.kr)
Wonsuck Kim[2], Yonsei University
Jaap Nienhuis[3], Utrecht Univeristy

Abstract

Deltas are dynamic landscapes influenced by the interplay of various factors, with their mass balance largely represented by the accommodation creation and sedimentation. Thus, the sediment retention fraction, the proportion of sediment retained on a delta compared to supplied sediment, plays a crucial role in this mass balance. While external factors such as river flux, waves, tides, and sediment type have been extensively studied on their influence on the sediment retention fraction, there remains a significant knowledge gap for understanding the impact of autogenic spatiotemporal evolution within delta morphology and growth on the sediment retention. We propose that sediment retention fraction spatiotemporally varies across delta evolution mainly due to variations in accommodation. Leveraging numerical experiments with Delft3D, we analyze the relationship between sediment retention fractions of sand and mud, along with the changes in sediment accommodation, throughout the evolutionary process of deltas from initiation to matured delta stage. Our simulation results reveal contrasting behavior between sand and mud retention: sand retention initially increases and then stops increasing, while mud retention continues to rise. Both sand and mud retention are closely tied to their accommodation, i.e., a channel for sand and an interdistributary for mud. This finding underscores the inherent difference in the depositional ratio of sand and mud throughout the delta evolution. By elucidating this relationship, we emphasize the importance of considering spatiotemporally varying sediment retention fractions in delta studies, which provides valuable guidance for delta management and conservation efforts.

Keyword

Delta, Sediment retention, Delft3D

Investigating and quantifying tidal effects on the formation of bifurcated channel networks in modern river deltas

Jiyoung LEE[1]*, Yonsei University (easyoung1442@yonsei.ac.kr)
Wonsuck Kim[2], Yonsei University

Abstract

Deltas have intricate networks of interconnected channels and evolve along with dynamic changes in response to natural and anthropogenic factors, such as sediment particle size, sediment supply, precipitation, vegetation growth, human activities, waves, tides, and climate change.

Especially, tide currents, one of the factors influencing sediment transport within distributary channels, continually modify the morphological and dynamic characteristics of deltas. However, quantitative measures for assessing tidal influence on delta morphology are still challenging.

Here we conducted morphodynamic simulations using Delft3D by varying the tidal amplitude and the ratio of mud and sand supply, while holding all other factors constant. Furthermore, we measured the bifurcation length, the distance between two bifurcation points along the channel centerline in natural deltas, and utilized the record of spatial pattern in bifurcation length. The results show that a higher tidal amplitude causes an increase in bifurcation length spatially when comparing channels of similar bifurcation orders, and a higher proportion of muddy composition responds more sensitively to the tidal effect.

Channel geometry, which is influenced by factors such as flow characteristics and sediment composition, can explain the observations made in this study. We propose that due to strong tidal currents and a more cohesive sediment composition, channel deepening and narrowing facilitate increasing in the advection length and thereby bifurcation length. Our study aims to analyze the spatial pattern of the branching channel network as a quantitative measure of tidal influence on delta morphology. Based on these research findings, we can enhance our understanding of the evolving shape of channel networks across different regions under varying conditions.

Keyword

bifurcation, bifurcation length, tidal currents, channel network, Delft3D

Effect of coastal seiches on sediment transport in a Masan Bay

JUN YOUNG SEO[1]*, Chonnam National University (eric00518@gmail.com)
Byoung-Ju Choi[2], Chonnam National University
Sun Min Choi[3], Inha University
Jongseong Ryu[4], Anyang University
Ho Kyung Ha[5], Inha University

Abstract

In-situ moorings and axial survey using acoustic Doppler current profilers in a microtidal Masan Bay were conducted to reveal the impacts of coastal seiches on sediment resuspension behaviors. The hydrodynamic circulation in the bay was dominated by sluggish tidal and residual currents, with which the coastal seiches with 1-h period were also detected. The velocity of coastal seiches (u_seiche) accounted for 30% of total current velocities, causing back-and-forth motions of water along the main channel as a barotropic structure. The useiche was insufficient to directly resuspend bed sediments without external forcings. Nonetheless, it influenced a variability of suspended sediment concentration (SSC) of turbidity maximum (SSC: ~40 mg l^-1) at central part of the bay, showing an SSC anomaly of 8 mg l^-1. Although the seiche-induced sediment fluxes were only 1% of total fluxes due to offsetting effect of bidirectional flows, they could reach up to 0.040×10^-3 kg m^-2 s^-1 at each pulse of coastal seiches. Repetitive coastal seiches lifted the sediment particles by > 4 m to the upper layer where they would not have risen if not for the vertical motion of coastal seiches. Unlike the tidal or residual currents, however, the distance that the coastal seiches can transport the suspended sediments was too short (< 57 m) compared to their transportable amounts. Even if the sediment particles within the turbidity maximum were advected by the coastal seiches, they could not leave its region, showing only redistribution within an immediate vicinity. This process was intensified toward the land as the useiche slowed down the further it moved away from the node. As long as the bed sediments were resuspended, the coastal seiches were expected to further enhance the potential for water pollution by causing repetitive sediment redistribution. This study highlights that the coastal seiches can have a significant impact on sediment behavior in microtidal bay although they are often masked by tidal and residual currents.

Keyword

Coastal seiches, Suspended sediments, Resuspension, Turbidity maximum, Semi-enclosed bay

Impact of dike construction on sedimentary facies and morphological evolution of semienclosed macrotidal flats in the western coast of Korea

Joohee JO[1]*, Seoul National University (joohe1218@snu.ac.kr)
Dohyeong KIM[2], Korea Environment Institute
Seungyeon SOHN[3], Seoul National University
Seolhui BANG[4], Seoul National University
Kyungsik CHOI[5], Seoul National University

Abstract

Man-made structures like groins, jetties, and dikes are built to prevent storm surges and tidal waves. However, these structures can alter the natural coastal environments by interfering with the natural processes of tides, waves, and rivers. For example, the construction of dikes can cause wave reflection and lead to the formation of wave-built shelly ridges and steep-sloped tidal flat morphology on semienclosed macrotidal flats. The impact of dike construction on sedimentary successions is not yet fully understood, as it is difficult to separate the effects of human intervention from natural processes. The purpose of this study is to examine the sedimentary facies in the macrotidal flats that are affected by dikes, and to distinguish between natural processes and man-made impacts. This will help us better understand how the depositional environment has evolved over time. We collected undisturbed cores from ten locations in the Shinsi tidal flats, annually for six years. This helped us to demonstrate the spatial distribution of the sedimentary facies. We also estimated the sedimentation rate using 210Pb activities from a 2.45 m long auger core in the Wido tidal flats to detect changes in sedimentation rate before and after dike construction. The basal bioturbated muddy sands with shell fragments are interpreted to have been formed before the Saemangeum dike construction under a macrotidal regime. The basal bioturbated muddy sands are overlain by wave-built shelly ridges after the dike construction. The shelly ridges consist of alternating two beds of flood-oriented cross bedded gravels and muddy sands. The gravelly beds and muddy sands are formed during the storm and calm periods, respectively, indicating that the shelly ridges move landward in response to seasonal wave and tidal action. Rill channels formed during summertime preserve the impact of rainfall, which are developed by stronger ebb tidal currents resulting from increased surface runoff discharge. These channels exhibit channel lags overlain by thick, massive silt beds that transition upwards into parallel lamination and bidirectional ripple cross lamination. During summer rainfall, the artificial beach is eroded due to runoff discharge, leading to gravel deposition even in the upper intertidal zone. From 1890 to 2022, the sedimentation rates averaged 4.84 cm year-1. This rate has increased from 0.049 cm year-1 from 1974 to 1986, before the Wido dike construction, to 0.682 cm year-1 from 2010 to 2022. This study emphasizes that human interference complicates the regular sedimentological changes on coastal depositional environments, leading to unpredictable morphological evolution that cannot be explained solely by natural processes.

Keyword

Man-made impact, Sedimentation, Sedimentary facies, Wave reflection, Rainfall

Volatile geochemistry of inorganic gases emitted from the Central Indian Ridge 9°44' - 15°33'S using H_2, He, CO_2, and CH_4

Heejun KIM[1]*, Korea Institute of Ocean Science Technology (sooneeujuro@gmail.com)
Wonhee Lee[2], Seoul National University
Jeongyeon Yu[3], Seoul National University
Junghoon Song[4], Seoul National University
Hyunwoo Lee[5], Seoul National University
Jaewoo Jung[6], Korea Institute of Ocean Science Technology
Wonnyon Kim[7], Korea Institute of Ocean Science Technology
Jonguk Kim[8], Korea Institute of Ocean Science Technology
Urumu Tsunogai[9], Nagoya University
Naoto Takahata[10], University of Tokyo
Yuji Sano[11], Kochi University

Abstract

In this study, we report volatile geochemistry data from hydrothermal fluid emitted from the 9°44'S - 15°33'S region of Central Indian Ridge (CIR), surveyed by R/V ISABU by Korea Institute of Ocean Science & Technology (KIOST) on March 2023. Through this study, we aim to enhance the understanding of hydrothermal systems generated by seawater-crust-mantle interaction and elucidate the emitting volatiles' source. From 8 vent field sites, including 7 active vent sites, we collected hydrothermal fluid samples with a Remotely Operated Vehicle (ROV) of ROPOS and buoyant plume water samples from different depths with CTD Rosette. The compositions of dissolved gases (e.g. H_2, He, CH_4, and CO_2) and their stable isotopic compositions ($^3He/^4He$, $\delta^{13}C$-CH_4, δD-CH_4, and $\delta^{13}C$-CO_2) were measured from samples. As a result, the measured helium isotope compositions were 4.60 ~ 10.23 R/Ra (7.79 ~ 10.29 Rc/Ra), indicating contributions of both upper mantle (8 Ra) and mantle plume (>9 Ra) on helium, supported by mantle tomography image. $\delta^{13}C$-CO_2 (-12.8 ~ -7.4‰ vs.PDB) also showed the presence of mantle-derived CO_2 ($\delta^{13}C$ = -6.5 ± 2.5‰). The CH_4 concentrations of hydrothermal fluid were 526 ~ 190,323 nmol/kg, which suggests severe methane generation in the hydrothermal system regarding <30 nmol/kg of ambient seawater CH_4 concentration. The $\delta^{13}C$-CH_4 (-21.6 ~ -8.1‰) and δD-CH_4 (-196.0 ~-87.0‰) of vent fluid were overlapped with abiotic CH_4 from MAR or EPR. A high concentration of H_2 (1 ~ 86 mol.%) also supports the reduction of CH_4 under a reductive hydrothermal system. Eventually, this study suggests that interactions between the upper mantle, lower mantle, and altered oceanic crust are the source of inorganic gases in the CIR hydrothermal system.

Keyword

Hydrothermal system, Volatile geochemistry, Inorganic gases, Isotope geochemistry

Evolution of the Eastern Gulf of Finland area through Holocene

Olga KOVALEVA[1]*, A.P. Karpinsky Russian Geological Research Institute
(olya_pavlikova@mail.ru)
Daria Ryabchuk[2], A.P. Karpinsky Russian Geological Research Institute
Alexander Sergeev[3], A.P. Karpinsky Russian Geological Research Institute
Leonid Budanov[4], A.P. Karpinsky Russian Geological Research Institute
Vladimir Zhamoida[5], A.P. Karpinsky Russian Geological Research Institute
Igor Neevin[6], A.P. Karpinsky Russian Geological Research Institute

Abstract

Evolution of the Eastern Gulf of Finland coasts (the easternmost part of the Baltic Sea) is governed by different stages of the Baltic Sea level fluctuations during Holocene and external geological processes such as a glacioisostatic movement. Series of coastal palaeo geomorphological structures marking sea-standing levels are traced onland at different altitudes. System of coastal bars forms an irregular belt mostly around the northern coast of the Gulf, their morphometry parameters are far in excess of the modern underwater bars. In areas where abundance of material existed systems of coastal accumulative forms are included palaeo dunes (height up to 10 m) and palaeo spits (length varies from 2 to 10 km) at Sestroretsk, Narva-Luga Bay, Vysokinskoe Lake. Analysis of ground penetration radar profiling showed the presence of coarse material inside some objects what indicate their glacio-fluvial origin (example, fluvial delta at Narva-Luga). Nowadays coasts of the Eastern Gulf of Finland can not replicate the same pattern of accumulative bodies development due to strong deficit of material but short-term spits are formed in the coastal zone nowadays. Postglacial development of the area are reflected off-shore – detailed marine geophysical researched revealed a complex of glacial relief features (elongated glacial till ridges, end-moraine ridges, De Geer moraine). Ananlysis of underwater sediments cores revealed erosional layers as an evidence of sea-level fluctuation. Submerged underwater terraces are indicated a deep regression during early Holocene.

Keyword

coastal processes, coastal evolution, Eastern Gulf of Finland, Baltic sea

Pockmark Seafloor in Hupo Basin, East Sea

Chang Hwan KIM[1]*, Korea Institute of Ocean Science & Technology (KIOST)
(kimch@kiost.ac.kr)
Soon Young CHOI[2], Korea Institute of Ocean Science & Technology
Won Hyuck KIM[3], Korea Institute of Ocean Science & Technology
Chan Hong PARK[4], Korea Institute of Ocean Science & Technology

Abstract

The Hupo Basin, continental marginal basin, of the East Sea extends to Uljin-gun and Yeongdeok-gun. The Hupo Bank, a terrain that is higher than the surrounding seabed, is located at the eastern boundary of the Hupo Basin. KIOST(Korea Institute of Ocean Science and Technology) conducted detailed bathymetry surveys in the northern, central and southern areas of the Hupo Basin from 2011 to 2013. The Hupo Basin, bounded by steep slopes of the Hupo Bank, is deepened from the west coast to the east and deepest to a maximum depth of about 250 m. A narrow seafloor channel appears in the northern, central, and southern areas with the deepest depths. Numerous pockmarks appear on the seafloor at depths of about 150 ~ 250 m in all the three areas of the detailed bathymetry surveys. These pockmarks generally have diameters of about 20 to 50 m and depths of about 4 to 6 m, with crater-like submarine topography of various sizes. Seafloor sediments in the pockmark areas consist of fine silt. Comparing the shape and size of the pockmark of the Hupo Basin with that of other regions of the world, it is considered to be classified as a normal pockmark. There are about 7 pockmarks/1 km square in the northern part of the three areas and about 8 pockmarks/1 km square in the central part. The southern part has about 5 pockmarks/1 km square. If the area with the possibility of pockmarks is extended to the depth area of about 150 ~ 250 m in the entire Hupo Basin, the number of pockmarks is estimated to be more than about 4800. The pockmark of the Hupo Basin is more likely to be generated by a fluid such as a liquid than a gas. In the future, it is necessary to study the cause of the formation and the specific marine ecosystem and environment related to the Pockmark.

Keyword

Hupo Basin, detailed bathymetry survey, pockmark, crater-like, fluid

Progress on Geoscientific Map Series of China-ASEAN Seas and Adjacent Areas

Baojun WANG[1]*, Qingdao Institute of Marine Geology (6469429@qq.com)
Jie Li[2], Qingdao Institute of Marine Geology,China Geological Survey
Fanghui Hou[3], Qingdao Institute of Marine Geology,China Geological Survey
Zhongbo Wang[4], College of Science, Shantou University
Jianghao Qi[5], Qingdao Institute of Marine Geology,China Geological Survey

Abstract

Southeast Asia located in an important regional geodynamic intersection zone surrounded by curved subduction system (Li JB et al., 2021), is a natural laboratory for marine geoscientific research. Due to the complex tectonic settings, frequent and intense geohazards severely impact on the expansive and densely populated coasts of Southeast Asian countries. However, in this region marine geological survey is limited, and early basic geological-geophysical data lacks systematic analysis and in-depth interpretation. In this program, we firstly collected and sorted out the geological and geophysical data of gravity, magnetic anomaly, natural earthquake, terrestrial heat flow, crustal structure, seabed surface sediment and sedimentary rocks in the study area. Then carried out data processing and standardization for comprehensive geoscientific research. Lastly, guided by the theory of "block tectonics", nine free-air gravity anomaly divisions, seven magnetic anomaly divisions, seven geodynamic divisions, five primary tectonic plates and plate boundaries, and forty-five secondary tectonic units were displayed in the mapping area. Meanwhile, the types and distribution characteristics of surface sediments in the China-ASEAN seas and adjacent areas were systematically summarized. The results of this program are shown as "Geoscientific Map Series of China-ASEAN Seas and Adjacent Areas(1:5 million)", which not only establish a database for scientific and technological innovation in the marine geological field, but also provide an important basis and guidance for marine management, disaster prevention and reduction in Southeast Asia.

Keyword

geological and geophysical, Map Series, Disaster prevention and reduction

Influence of meteorological events on the sediment and microphytobenthos resuspension in intertidal flats

Hun Jun HA[1]*, Chonnam National UniversityY (hahunjun86@gmail.com)
Ho Kyung HA[2], Inha University
Tae Soo CHANG[3], Chonnam National University

Abstract

Intertidal flats are found throughout the world's coasts, which can provide important ecological and economic functions. Microphytobenthos (MPB), which is one of the major primary producers in coastal environments, could be resuspended by external forcings (e.g., tides and wind-induced waves) and considered as food sources for upper trophic level consumers. To better understand dynamic behaviors of suspended sediment and microphytobenthic chlorophyll-a (chl-a) under both fair-weather (i.e., tide-dominated) and episodic meteorological conditions, in-situ mooring systems were deployed in the Jeungdo tidal flat, South Korea. During fair-weather conditions, sediment and chl-a were simultaneously resuspended at flood tide, and advected to the tidal channel at ebb tide. The coupling and segregation between suspended sediment concentration (SSC) and chl-a were prevailed in spring and neap tides, respectively. The maxima of SSC and chl-a during storm event were about 9 and 2 times higher than those during fair-weather conditions, respectively. During rainfall event, they were about 7 and 1.2 times higher compared to fair-weather conditions, indicating that the sediment and MPB were highly resuspended by storm and rainfall events. After rainfall event, SSC and chl-a significantly increased with positive relation of the current velocity, suggesting that rainfall was associated with reduction in stabilization of sediment and MPB. Aforementioned outcomes suggest that the tides and storms are important in the dynamic behaviors of sediment and MPB in intertidal flats.

Keyword

Suspended sediment, Microphytobenthos, Resuspension, Meteorological events, Intertidal flats

Exploring Novel Bioactive Compounds from Deep-Sea Microorganisms Originating in Marine Sediments

Ji Young LEE[1]*, Institute of Sustainable Earth and Environmental Dynamics (SEED), Pukyong National University, 365 Sinseon-ro, Nam-gu, Busan 48547, South Korea (jji123789@naver.com)
Sang-Jip Nam[2], Department of Chemistry and Nanoscience, Ewha Womans University, Seoul 03760, Republic of Korea
Songyi Lee[3], Institute of Sustainable Earth and Environmental Dynamics (SEED), Pukyong National University, 365 Sinseon-ro, Nam-gu, Busan 48547, South Korea

Abstract

New natural compounds were discovered from two types of microorganisms originating from deep-sea marine sediments. From the crude extract of Streptomyces sp. CNP-944, two new pyrazine alkaloids, actinopolymorphols E and F (1 and 2), were identified, along with previously reported compounds, actinopolymorphol G (3), and actinopolymorphol D (4). Additionally, from the culture broth of Saccharomonospora sp. CNQ-490, four new natural products, lodopyridones D - G (5 - 8), were discovered, alongside previously reported compounds, lodopyridones A - C (9 - 11), and cotteslosin A (12). The thorough investigation of these compounds' chemical constituents utilized HPLC-UV-guided fractionation. The determination of these compound's chemical structures was achieved by interpreting 1D, 2D NMR, and MS spectroscopic data. Confirmation of the weak antibacterial activity of the new natural compound, actinopolymorphol F, was attained through antimicrobial activity testing, revealing minimum inhibitory concentration (MIC) values of 16, 64, and 64 μg/ml against Kocuria rhizophila, Bacillus subtilis, and Staphylococcus aureus, respectively. These findings underscore the wealth of bioactive compounds harbored within marine bacterial sources. The discovery and structural elucidation of these novel metabolites provide valuable insights into the potential pharmacological applications of marine-derived compounds. Continued exploration of the biological activities and synthetic potential of these compounds holds significant promise for advancing drug discovery and development endeavors.

Keyword

marine sediment-derived bacterium, lodopyridones D-G, actinopolymorphols E and F

Analysis of benthic environment characteristics and microbial community structure in Suyeong River, South Korea

Hee Eun WOO[1]*, Institute of Sustainable Earth and Environmental Dynamics (SEED), Pukyong National University (hew119@pknu.ac.kr)
Kyunghoi KIM[2], Department of Ocean Engineering, Pukyong National University
Jong-Oh KIM[3], Institute of Sustainable Earth and Environmental Dynamics (SEED), Pukyong National University

Abstract

The Suyeong River Estuary, located in Busan, South Korea, serves as a vital ecosystem supporting diverse residential, commercial, and industrial activities. However, concerns regarding contamination from industrial and domestic wastewater persist due to a relatively low sewage pipe penetration rate compared to the national average. This study aims to evaluate sediment pollution levels and their environmental ramifications in this estuarine ecosystem. To evaluate the pollution levels and environmental implications, sediment samples were collected from seven stations along the estuary, spanning from the vicinity of the Dongbu Sewage Treatment Plant to the Minrak Port. These stations were categorized into three zones; SY river, Inner Bay, and Outer Bay. Analyses were conducted on various parameters including pH, oxidation-reduction potential (ORP), and nutrient concentrations (dissolved inorganic phosphate, DIP, and ammonia nitrogen, NH3-N). Metagenomic analysis was performed to characterize microbial community composition. Results reveal a notable variation in pH across stations, with higher values observed closer to the oceanic influence. Elevated concentrations of DIP and NH3-N were observed in the SY river and inner bay areas, signifying significant pollution levels. Microbial community analysis revealed varying trends across the zones, with the phylum Firmicutes exhibiting distinct abundance patterns correlating with total phosphorus concentration. It is clear from these findings that there is considerable sediment pollution in the Suyeong River Estuary, particularly in the inner bay. To ensure the ecological integrity of this important estuarine ecosystem and to maintain the sustainable coexistence of humans and nature in the region, effective management strategies are essential.

Keyword

Sediment pollution, Estuary, Nutrients, Microbial community

Mapping the sedimentation rates in the continental shelf – an European view to the seabed change

Aarno Tapio Kotilainen[1]*, Geological Survey of Finland (GTK) (aarno.kotilainen@gtk.fi)
Ulla Alanen[2], Geological Survey of Finland (GTK)
Anu Marii Kaskela[3], Geological Survey of Finland (GTK)
Susanna Kihlman[4], Geological Survey of Finland (GTK)
EMODnet Geology Partners[5], The European Marine Observation and Data Network (EMODnet)

Abstract

Sediment deposition and resuspension in marine environment are key processes shaping the seabed environment. Information on sedimentation rates is needed in several fields. For example, data on the location and rate of sediment accumulation is important for carbon cycle and carbon budget studies, monitoring pollutants and microplastics, and understanding changes in erosion and deposition of sediments.

EMODnet (The European Marine Observation and Data Network) Geology project is collecting and delivering harmonized data showing sedimentation rates at the seabed. The data is compiled from all available information on the rate of sedimentation in European maritime areas, provided by EMODnet Geology project partners from their national waters (including EEZ).

The focus is on the present-day sedimentation rates. That means sediment accumulations to the seabed over the past decades, since AD 1900 or so. Estimations of modern sedimentation rates can be based e.g., on established historical records of anthropogenic radionuclides (e.g., 137Cs and 241Am), lead (Pb) and stable lead isotope (206/207Pb ratios). Sedimentation rate estimations can be based also on varve/laminae counting, radionuclide 210Pb and 14C decay dating methods. In addition, local stratigraphic marker horizons, like in the Baltic Sea, horizons formed by documented Major Baltic Inflow (MBIs) events, can be used in the estimations.

Here, the information on sedimentation rates for recent sediments is presented as point-source information. This data product, sedimentation rates data, consists of more than 1600 data points at this moment.

According to data, the rate at which sediments accumulate to seabed differs greatly from place to place. Accumulation does not occur everywhere, e.g., in the Baltic Sea Basin it has been estimated that sediment accumulation areas cover approximately one-third of the seafloor. Generally, sedimentation rates in the accumulation areas of the European Seas varies from some mm/year up to some cm/year. Sedimentation rates are highest in the river estuaries and near the mouths of rivers, as well as in some deep(er) basins/depocenters. In some estuaries the sedimentation rates can be up to several cm/yr.

The current EMODnet Geology project phase is executed by a consortium of 40 partners and subcontractors from 30 countries, which core is made up by members of EuroGeoSurveys (EGS) backed up by other partner organizations with valuable expertise and data. The EMODnet Geology project is funded by The European Climate, Environment, and Infrastructure Executive Agency (CINEA) through contract EASME/EMFF/2020/3.1.11 - Lot 2/SI2.853812_EMODnet – Geology.

Discover Europe’s seabed geology at: https://emodnet.ec.europa.eu/en/geology

Keyword

Marine, Sediment, Sedimentation rate, Seabed, EMODnet

Cross-EEZ Cooperation, Standards and Harmonization: Compiling Spatial Data of the European Seafloor Geology and Geomorphology within the EMODnet Geology Project

Kristine E.C. ASCH[1]*, Federal Institute for Geosciences and Natural Resources (BGR)
(Kristine.Asch@bgr.de)
EMODnet Geology Team[2], Europe

Abstract

The EMODnet Geology project (European Marine Observation and Data Network) is now in its 5th phase and is encompassing more than 30 partner organizations. It focusses on producing open, high quality, harmonized marine data, interoperable and available free of charge.

Within EMODnet Geology, the German Federal Institute for Geosciences and Natural Resources (BGR) is leading the Workpackage Seafloor geology (WP4). The aims are to compile and harmonize spatial (map) data within Exclusive Economic Zones (EEZ) in Europe and beyond. The data comprise of pre-Quaternary and Quaternary off-shore geology, geomorphology and general physiographic features of the European Seas. BGR is compiling the data centrally, is processing and publishing them centrally on both, the EMODnet web portal (EMODnet Map Viewer (europa.eu)) and the BGR Geoviewer (https://geoportal.bgr.de) according to FAIR data principles. BGR collates seafloor data of the following geological properties: lithology, age, genesis (event environment/process) and faults. The geomorphology data layer comprises of features that represent the submarine landscape (“seascape”).

Because of participation of numerous partner organisations from different countries, common standards needed to be set up to create interoperable data and harmonized spatial (map) layers.

The project is financed by the European Commission, thus it is self-evident to use European Union standards, i.e. the European INSPIRE Directive Data Specifications, the INSPIRE geology data model and portrayal rules for geology wherever applicable. Where this would not suffice, standards of the global International Union of Geosciences (IUGS) Commission of Geoscience Information (CGI) are being used. In addition, supplementary vocabularies are in development to take into account specific marine seafloor features, in particular in reference to the geomorphological features.

The European Environmental Agency (EEA) provides the standard coastline used by all EMODnet geology partners and work packages.

This presentation will outline the EMODnet geology approach to compile heterogeneous map data of the European seafloor geology, describe the challenges posed to harmonize the semantically geometrically and conceptually varying data sets and show the resulting map data that are the product of a fruitful cooperation with the partner organisations.

Keyword

EMODnet, off-shore, harmonisation, geology, geomorphology

Advancing the Understanding of Seabed Substrate Characteristics: Insights from EMODnet Geology

Susanna KIHLMAN[1]*, Geological Survey of Finland (susanna.kihlman@gtk.fi)
Anu Marii Kaskela[2], Geological Survey of Finland
Aarno Tapio Kotilainen[3], Geological Survey of Finland
Ulla Alanen[4], Geological Survey of Finland
Henry Vallius[5], Geological Survey of Finland
EMODnet Geology partners [6],

Abstract

Increasing activities and pressure on marine and coastal environments have made the easily accessible, reliable, and suitable information on marine environment essential to support overall sustainable marine management decisions, conservation, and research. The EMODnet (European Marine Observation and Data network) Geology project has been aiming to address this demand by collecting and harmonizing geological data at different scales from all the European sea areas since 2009, at present with a collaboration of about 40 partners and subcontractors.

Seabed substrate is one of the key elements in describing the marine environment. In the project, national, highly heterogeneous seabed substrate datasets are harmonized into a shared translation schema, based on the sediment grain size distribution. Currently, harmonized seafloor substrate data are available at a variety of scales, from extensive 1:1 000 000 dataset, to more localized, high-resolution datasets from 1:100 000 to as fine as 1:1 500 scale. The datasets cover all European marine areas, as well as the Caspian Sea and the Caribbean Sea, the latest regional addition to the dataset.

However, grain size alone does not define all seabed characteristics that have significance for the marine environment. As a part of the seabed substrate data, the project has also collected additional information on a variety of surface features that may have ecological, geological, or economic value, and the project partners have considered relevant, such as seagrass meadows, FeMn concretion fields, moving and bioclastic sediments. Further, the project group have recently shifted towards collecting the information on seabed dynamics, especially seabed erosion. Sedimentation rates data have been collected since the beginning of the project.

Besides collecting and harmonizing the existing data, case studies in which tools for substrate modelling and sedimentation rates have been developed. A close connection and collaboration with EMODnet Seabed habitat have been established from the beginning and the methods have been shared with the EMODnet PArtnership for China and Europe (EMOD-PACE) project (2019-2022).

A lot of work has been done to create the foundation to build on, and the work continues. The development of usable and valuable data products requires a collaboration with different stakeholders and end users, and future work should be planned with possible applications and interests in mind. At its best, this kind of data not just helps to define the seabed but provides essential tools for better understanding about the marine environment.

The EMODnet Geology project is funded by The European Climate, Environment, and Infrastructure Executive Agency (CINEA) through contract EASME/EMFF/2020/3.1.11 - Lot 2/SI2.853812_EMODnet – Geology.

Keyword

Marine geology, Seafloor mapping, Seabed substrate, data harmonization, EMODnet

Brazilian research in the Atlantic Ocean

Luciana Felicio PEREIRA[1]*, Geological Survey of Brazil (luciana.pereira@sgb.gov.br)
Patricia Reis Oliveira[2], Geological Survey of Brasil
Hortência Barbosa Assis[3], Geological Survey of Brasil
Ronaldo Gomes Bezerra[4], Geological Survey of Brasil
Vadim Harlamov[5], Geological Survey of Brasil

Abstract

In recent years, the Geological Survey of Brazil (SGB-CPRM) has been developing several activities aimed at research and exploration of marine mineral resources. The growing demands for the use of sea resources force the recognition and mapping of the submerged national territory with the aim of inventorying and directing studies, research and public policies for the adequate use and protection of wealth in a sustainable way. The technologies used to survey these underwater areas are high-resolution shallow seismic, the Light Detection and Ranging system, interferometric sonars, modern collectors, and Remotely Operated Vehicles and Autonomous Underwater Vehicles. In addition it can be used others instruments such as magnetometric sonars, underwater cameras, manipulator arm, cutter and sample collector and various sensors capable of carrying out fundamental measurements for mineral research. The Brazilian government promotes knowledge of the mineral resources of the brazilian continental shelf with two larger projects: Systematic basic geological-geophysical survey of the Brazilian Legal Continental Platform, on a scale of 1:1,000,000; and Thematic projects involving geological-geophysical surveys of sites of geo-economic-environmental interest, with detailed (1:100,000) and semi-detailed (1:300,000) research. This research covers: lithoclastics (sands and gravels), bioclastics (calcareous algae and shells), heavy mineral deposits, phosphorites and metalliferous crusts and polymetallic sulfides. Around 30,000 km2 of area on the shallow platform in the equatorial region and in the south of the country have already been mapped by the project. In the International Atlantic AREA there are two main projects: mapping the occurrence of minerals from the Rio Grande Rise, especially the ferromanganesiferous crusts rich in cobalt, and obtaining information to reveal their geological and paleoceanographic evolution, and mapping stretches of the Mid-Atlantic Mountain Range identifying possible occurrences of polymetallic sulfides. The economic exploration of bioclastic marine aggregates in shallow waters is already a reality in Brazil, even with few deposits being explored. Further, many areas are required for research into heavy minerals, phosphorites and offshore wind energy. In deep waters, many occurrences of cobalt-rich ferromanganesiferous crust have already been identified and are in the evaluation phase.

Keyword

Brazilian continental shelf, geological research, mineral resources

Collating and harmonizing data on geological events in European seas

Andrea FIORENTINO[1]*, Geological Survey of Italy - ISPRA (andrea.fiorentino@isprambiente.it)
Loredana Battaglini[2], Geological Survey of Italy - ISPRA
Simone Orefice[3], Geological Survey of Italy - ISPRA
Alessandra Pensa[4], Geological Survey of Italy - ISPRA

Abstract

EMODnet Geology Work Package (WP) 'Geological events and probabilities' gathers information concerning submarine landslides, earthquakes, volcanic centres, tsunamis, fluid emissions and Quaternary tectonics. The WP aim is the production of harmonized digital maps at multiple scales of events occurrences in European seas.

Each type of geological event occurrence is represented by features organized according to their geometries (polygons, lines and points). Each occurrence is complemented by a comprehensive pattern of attributes.

The elaboration of guidelines to compile the shapefiles and attribute tables, which constitute the WP layers, was aimed at identifying parameters to be used to thoroughly characterize each type of event and any additional relevant information.

Due to the different geological settings of European seas, it was necessary to elaborate a detailed pattern of attributes for the different features, in order to represent the diverse characteristics of each occurrence. Particular attention has been devoted to the definition of such attributes to achieve the best degree of harmonization and standardization complying with the European INSPIRE Directive.

The huge amount of data collated has been processed, validated and standardized. They include data deriving from national and international Projects held by Partners or by third parties. The elaboration of national contributions also promoted systematic inventories of the wealth of published data collected in the last thirty years, thanks to the significant improvement in techniques of acquisition. Collaboration and sharing of data, practices and experiences among Project Partners, which are mainly National Geological Surveys, allowed to increase the quality and detail of the information gathered.

Besides the collection of events occurrences, events probabilities were also considered. However, it is not easy to evaluate probabilities for all of the different events gathered within WP6. Probabilities are generally evaluated concerning single events and are assessed by different methods and parameters. The evaluation of "likelihood of occurrence" seemed to be the best way to obtain indications on probabilities, at least for some events. The submarine landslides layer appeared as the more suitable case for such an attempt. Based on data gathered by WP6 and on parameters obtained from EMODnet Bathymetry (such as depth, slope, curvature, etc.) a "Landslides susceptibility map" was elaborated.

Data, metadata and complementary information are displayed on the EMODnet Central Portal (http://www.emodnet.ec.europa.eu/) subdivided into layers at 1:250.000 scale, which include data

at lower resolutions, and layers at 1:100.000 scale, which include also data more detailed than 1:100.000. The Portal provides access and free download to a reliable and complete interoperable database facilitating exchange and re-use of data which may represent a baseline to elaborate additional thematic maps or support further research as well as land planning and management.

Keyword

EMODnet Geology, geological events, digital maps, database

Paleobotanical zoning of exposed continental shelves as a tool to overcame geographical discontinuity of scattered paleolandscape data

Francesco Latino CHIOCCI[1]*, Sapienza, University of Rome (francesco.chiocci@uniroma1.it)
Elisa De Luca[2], Sapienza, University of Rome
Daniele Casalbore[3], Sapienza, University of Rome
Federico Di rita[4], Sapienza, University of Rome
Donatella Magri[5], Sapienza, University of Rome
Daniele Spatola[6], Sapienza, University of Rome
Heater Stewart[7], British Geological Survey

Abstract

In the EmodNet-Submerged Landscapes initiative, a significant challenge has arisen, which is particular to this domain but holds relevance across various disciplines whose cartography relies on spatially sparse data. EmodNet-Submerged Landscapes aims to to compile a comprehensive data repository encompassing proxies of environments characterizing the European continental shelves during the last eustatic hemicycle.

Around 20,000 years ago, during the last glacial maximum, the sea level reached the continental shelf's edge, exposing the shelf that was harboring diverse fauna and early human populations. Subsequently, over the following 10,000 years (from 18 to 8 thousand years ago), the sea level rose to its present position, inducing landward migration of the shoreline and forming a transgressive erosional surface (ravinement surface). This erosional activity obliterated paleontological remnants, prehistoric artifacts, and reshaped the landscape.

Identifying environmental indicators such as springs, lagoons, eolian dunes, paleo valleys, and other features in presently submerged landscapes relies on seafloor and subsurface sampling, dating of paleontological finds, and reconstructing paleomorphology through techniques like seismic imaging or, in absence of highstand shelf mud, utilizing high-resolution bathymorphological data.

The objective of EmodNet-Submerged Landscapes is to establish a data repository where paleoenvironmental data can be collated, standardized, or generated following uniform standards. This repository aims for easy accessibility in cartographic formats, catering not only to the scientific research community but also to the broader public. Nevertheless, creating legible maps poses challenges due to the limited, inherently uneven, dispersed, and geographically discontinuous nature of the available data.

To contextualize these site-specific data, a significant approach involves considering paleobotanical (and consequently paleoenvironmental) studies of continental shelves across various phases of sea level rise, taking into account the diverse paleoclimate and paleogeography conditions at different temporal stages.

Pollen data from continental shelves have been gathered, to establish a database where modeling techniques have been applied. These data furnish detailed insights into depositional environments, climate, and soil characteristics.

Palaeobotanical zoning (based on pollen records) offers extensive spatial data for reconstructing past land cover changes as well as for evaluating current vegetation composition trends and drivers. The objective is to integrate paleobotanical data with geological and geomorphological data to generate paleoenvironmental maps based on this information.
It is however crucial to communicate the speculative nature and interpretative limitations of the resultant cartography. Nonetheless, adopting such an approach serves to enhance map readability and offer a broader context to the site-specific, scientifically rigorous data.

Keyword

data gaps, cartography, paleo sea level, vegetation, paleoenvironmental reconstruction

Europe's marine minerals: EMODnet geology

Xavier MONTEYS[1]*, geological Survey Ireland (xmonteysv@gmail.com)
Charise McKeon[2], geological Survey Ireland
Koen Verbruggen[3], geological Survey Ireland

Abstract

Minerals are major geopolitical actors in the present world. Supply chains of strategic and critical raw materials like cobalt, copper, lithium, nickel and rare earth elements are highly concentrated, generating risks. The European Marine Observation and Data Network (EMODnet) is a long-term marine data initiative funded by the European Maritime, Fisheries and Aquaculture Fund (EMFAF) and supported by the EU's integrated maritime policy. The EMODnet Geology team released in 2023 a series of pan-European products related to marine themes including Marine Minerals. Data products are available through the integrated EMODnet Central Portal: https://emodnet.ec.europa.eu/en. Collated harmonised and standardised marine mineral types and energy resources can be grouped in 4 main categories: Marine Aggregates, Marine Critical Minerals, Marine Hydrocarbons and Hydrates, Marine non-critical Minerals. The twelve types mapped are aggregates; hydrocarbons; gas hydrates; sapropel, marine placers; phosphorites; evaporites; polymetallic sulphides; polymetallic nodules; cobalt-rich ferromanganese crust; metal-rich sediments; rock, pegmatite and vein hosted mineralisation. With Earth's population growth, efforts to meet our needs for resources with indigenous supplies continue. Many minerals and critical raw materials form important components in low-carbon and resource-efficient technologies such as electric car batteries, wind turbines and solar panels. Information on the types of minerals has relevance to engineering disciplines including extractive industries, beach nourishment and reclamation projects, and more general in Marine Spatial Planning. Environmental and marine EU policies are benefiting from the project's outcomes. The program's study area has been recently extended to include the Caspian and the Caribbean Sea demonstrating a determination to grow beyond the European waters.

Keyword

Critical Raw Materials, Marine Minerals, EMODnet

EMODnet-Geology's new standards revealing Earth's seabed geology

Henry T. V. VALLIUS[1]*, Geological Survey of Finland (henry.vallius@gtk.fi)

Abstract

High-quality maritime spatial planning, coastal zone management, management of marine resources, environmental assessments and forecasting require comprehensive understanding of the seabed. Numerous national seabed mapping programmes worldwide have also demonstrated the necessity for proper knowledge of the seafloor. In response to the obvious needs already in 2008, the European Commission established the European Marine Observation and Data Network (EMODnet), which is a long-term marine data initiative funded by the European Maritime, Fisheries and Aquaculture Fund (EMFAF). It consists of more than 140 organisations assembling marine data, products and metadata to make these fragmented resources more accessible to public and private users, relying on quality-assured, standardised and harmonised marine data which are interoperable and free of restrictions on use. Becoming a new global standard EMODnet strengthened its position when it had its services fully centralised in EMODnet Central Portal in January 2023. It provides now easy and free central access to FAIR marine data, metadata, data products and services spanning seven broad disciplinary themes (lots): bathymetry, geology, physics, chemistry, biology, seabed habitats and human activities. The EMODnet Geology thematic lot, initiated as a pilot project already in 2009, is now 15 years old and is coordinated by Geological Survey of Finland (GTK). With participation of 40 partners and subcontractors from 30 countries it is providing full areal coverage of all European regional seas and is expanding to new areas, already now including data from the Caspian and the Caribbean Seas. EMODnet Geology aims at delivering the various maps at a 1:100,000 scale or finer, but also at coarser scales to ensure maximum areal coverage. Regarding presentation of the web maps a multi-scale approach is adopted where possible. The geology data compiled in the frame of the project, are available through the EMODnet Central Portal: https://emodnet.ec.europa.eu/en. It comprises a) Sea-bed substrate (sediment/rock layer at the sea floor), data on sediment accumulation rates and a sediment erosion database b) Sea-floor geology - lithology and age (bedrock geology beneath the surficial sediment: Quaternary units and pre-Quaternary) c) Geomorphological features of the sea-floor d) Coastal behaviour (migration, type and vulnerability) e) Geological events and probabilities (e.g. submarine landslides, volcanic centres, earthquakes), f) Mineral occurrences (e.g. oil and gas, aggregates, metallic minerals), and g) Submerged landscapes. The EMODnet Geology data products are also available through the European Geological Data Infrastructure (EGDI - www.europe-geology.eu), where they can be viewed in conjunction with terrestrial geological data from onshore Europe. EMODnet Geology is an ongoing dynamic project, where existing datasets are continuously updated and completed with new data. But also new types of data products in frame of marine geology are evaluated in order to be included in the project in the future. EMODnet Geology thus welcomes suggestions of improvement of the available products or addition of completely new products. Third party data submission to EMODnet Geology is

encouraged. The data can simply be submitted straight to EMODnet Geology, but also through EMODnet Data Ingestion (www.emodnet-ingestion.eu) which is reaching out to potential data providers from the public.

Keyword

marine geology, mapping, harmonisation, EMODnet

Hadal Trenches: highly variable geological environments on the Earth

Hiroshi KITAZATO[1]*, Tokyo University of Marine Science and Technology
(kitazatohiroshi2@gmail.com)
Katsuyoshi Michibayashi[2], Nagoya University
Hayato Ueda[3], Niigata University
Alan J Jamieson[4], Univ. Western Australia
Jaya Roperez[5], Ink.Fish LLC

Abstract

Hadal Trenches beyond 6,500 m deep occupy only 0.1 % of the oceanic areas of the Earth. The areas are distributed in a plate subduction zone where oceanic plate subsides under the continental plate. In the western Pacific, two third of oceanic trenches are concentrated. Certainly, seven trenches are recognized around the Japanese Islands facing to the Pacific.

Tectonic activities are actively occurred along the trenches. We should investigate hadal trenches what kinds of tectonic activities are taken place for monitoring and reducing disaster risks. As hadal trenches are quite deep, there are limit to use regular oceanic research gears. Multi Beam Echo Sounding System (MBES) are commonly used for figuring out precise submarine topography. It is good to use AUVs, ROVs or HOV's for precise observations, measurements, and sample collections. In parallel to operations of these underwater vehicles, it is effective to use lander deployments for long term measurements or observations.

On 2022, we had a chance to have a research cruise along the Japanese Island arcs by DSSV Pressure Drop with full depth HOV Limiting Factor and three hadal landers of Caladan Oceanic / Inkfish LLC. Even though the Japanese Trenches have long been investigated by different HOVs such as French Bathyscaphe, Nautiles, Japanese Shinkai 2000 and 6500, any scientists have never visited hadal depth beyond 6,500m.

We dived at 7 localities of Ryukyu, Ogasawara, off Boso, Japan Trench deepest points and Great East Japan Earthquake Epicenter areas by MBES, full depth landers and full depth HOV Limiting Factor. By using with different gears and instruments, we succeeded to figure out vivid seascapes of hadal trenches in detail. Hadal trenches along the Japanese Islands are extremely variable geological and biological features in comparison to other deep-sea areas.

Keyword

western Pacific, subduction, collision, trench evolution, hadal biology

Need for the uniform information in multinational marine areas - Experiences from the harmonization within seabed substrate data

Susanna KIHLMAN[1]*, Geological Survey of Finland (susanna.kihlman@gtk.fi)
Anu Marii Kaskela[2], Geological Survey of Finland
Aarno Tapio Kotilainen[3], Geological Survey of Finland
Ulla Alanen[4], Geological Survey of Finland
Henry Vallius[5], Geological Survey of Finland
EMODnet Geology partners [6],

Abstract

Efficient and sustainable management of large sea areas, research and conservation require multidisciplinary information on the marine environment though it is commonly hampered by lack of data, or comprehensive information on the sea areas. Seabed substrate is one of the key elements in forming the marine environment and EMODnet Geology project has produced harmonized seabed substrate data products for the European marine areas since 2009. The work started with the seabed substrate data products at scales of 1:250 000 and 1:1 million. Currently, the project offers harmonized seafloor substrate data at a variety of scales, from 1:1 000 000, to high-resolution datasets as fine as 1:1 500 scale covering all European marine areas, the Caspian Sea and the Caribbean Sea. To reach this point, plenty of work has been done, especially at the beginning of the project when the foundations for the future work were laid.

The harmonization process includes the translation of the original national seabed substrate data, conforming to various standards into a shared, uniform EMODnet substrate classification schema (i.e., the Folk sediment classification) describing the uppermost part of the seabed (30 cm). The Folk classification was chosen because it is internationally prevalent, especially in sedimentological studies, serves the needs of habitat mappers and could be delivered by all partners, facilitating the harmonization process across national borders.

The modified Folk sediment classification with three granularities of 15, 6 and 4 classes, each supplemented with an additional class of “rock and boulders”, forms a simple hierarchy of the straightforward union of 16 classes into 7 or 5 classes. If national datasets were classified using the Folk sediment triangle, no conversion was needed. However, if the original data was not initially in the Folk classification, data points could be reclassified based on sample analysis or description, or mapped units could be translated into the most likely Folk class using expert-based prediction. To preserve the data origin, these details about the original substrate and possible reclassification are included as a metadata in the attribute table of the data. A confidence assessment, based on sampling amount, remote sensing coverage and distinctness of substrate boundaries, was applied to characterize the information that underpins the geological interpretations.

Over fifteen years since the beginning of the project, EMODnet Geology has become a key producer of publicly available, harmonized datasets covering broad areas. The methodology is widely recognized, and close collaboration with other EMODnet themes, have contributed the spread to new areas such as Beibu Gulf in South China Sea. Ongoing data collection as a part of EMODnet Geology and European wide consortium with well-established co-operation and the development of the data products within the project, e.g., adding new scales and geographical areas, including new useful attributes to complete the data, will sustain its relevancy in the future.

The EMODnet Geology project is funded by The European Climate, Environment and Infrastructure Executive Agency (CINEA) through contract EASME/EMFF/2020/3.1.11 - Lot 2/SI2.853812_EMODnet – Geology.

Keyword

Marine geology, Seabed substrate, Data harmonization, Sediment classification, EMODnet

Harmonizing marine geological data to support the sustainable use of the maritime areas and their resources - EMODnet Geology as an example

Anu Marii KASKELA[1]*, Geological Survey of Finland (anu.kaskela@gtk.fi)
Henry Vallius[2], Geological Survey of Finland
Susanna Kihlman[3], Geological Survey of Finland
Aarno Tapio Kotilainen[4], Geological Survey of Finland
Ulla Alanen[5], Geological Survey of Finland
EMODnet Geology Partners [6],

Abstract

The European Marine Observation and Data Network (EMODnet) is a network of more than 120 organizations supported by the EU's integrated maritime policy. Since 2009, it has been assembling fragmented and partly inaccessible marine data into coherent, interoperable, and freely available data products covering European marine areas. As the resulting data products are open to use, the program supports European maritime activities contributing to the sustainable use and management of the European seas, including e.g., Blue Economy, Maritime Spatial Planning, Green Deal, and European Critical Raw Materials Act. Today, the EMODnet Central Portal (https://emodnet.ec.europa.eu/en) provides free access to collected marine data, metadata and data products and services spanning seven broad disciplinary themes (lots): bathymetry, geology, physics, chemistry, biology, seabed habitats and human activities.

The EMODnet Geology thematic lot is delivering integrated and harmonized marine geological data products containing seabed substrate, sediment accumulation rates and seabed erosion index database, sea floor geology including lithology and stratigraphy, Quaternary geology and geomorphology, coastal behaviour, geological events such as submarine landslides and earthquakes, marine mineral resources, as well as submerged landscapes of the European continental shelf at various time frames. It focuses on delivering harmonized interpreted data layers (i.e., maps) rather than the underlying data. The metadata provides information on the data holder in case user needs to access the raw data. The aim is to produce data products at 1:100,000 scale or finer, but also at coarser scales to ensure maximum areal coverage. The EMODnet Geology thematic lot is providing the full areal coverage of European seas and is expanding to new areas, as also the Caspian and the Caribbean Seas are included in the geographical scope of the project. It is a dynamic project, where existing datasets are continuously updated with new data.

The current EMODnet Geology project phase (2023-2025) is coordinated by the Geological Survey of Finland (GTK), and it is executed by a consortium of 40 partners and subcontractors. The core of the partnership is formed by members of the EuroGeoSurveys network, supported by other partner organizations with valuable expertise and data. EMODnet Geology also supports third-party data submission. Third party data can be submitted either straight to EMODnet

Geology or through EMODnet Data Ingestion (www.emodnet-ingestion.eu), which is reaching out to potential data providers from private bodies and public.

The EMODnet Geology project is funded by The European Climate, Environment and Infrastructure Executive Agency (CINEA) through contract EASME/EMFF/2020/3.1.11 - Lot 2/SI2.853812_EMODnet – Geology.

Keyword

Marine geology, Data harmonization, Blue economy, Open access, EMODnet

MAPPING THE MARINE GEOLOGICAL RESOURCES OF THE CARIBBEAN SEA IN THE EMODnet-GEOLOGY PROJECT

Teresa MEDIALDEA[1]*, Instituto Geológico y Minero de España (t.medialdea@igme.es)
Francisco Javier González[2], Instituto Geológico y Minero de España, CSIC, Ríos Rosas 23, Madrid 28003, Spain
Edward Salazar[3], Servicio Geológico Colombiano, Diagonal 53# 34-53-Bogotá, CP 111321, Colombia
Ismael Moyano[4], Servicio Geológico Colombiano, Diagonal 53# 34-53-Bogotá, CP 111321, Colombia
Carlos Andrés Ramirez[5], Servicio Geológico Colombiano, Diagonal 53# 34-53-Bogotá, CP 111321, Colombia
Martín Rojas[6], Dirección de Geología y Minas, Avda. 21, Calles 9 y 11, San José, San Francisco de Goicoechea, Costa Rica
Miguel Cabrera[7], Servicio Geológico de Cuba, Vía Blanca 1002, San Miguel del Padrón, La Habana, CP11000, Cuba
Berenice Matías[8], Servicio Geológico Nacional, Avda. Winston Churchill No. 75, Santo Domingo, Dominican Republic
carolina Hericelda Maldonado[9], Ministerio de Geología y Minas, Diagonal 17,29-78 zona11, Las Charcas 01011, Guatemala
Josiela Sahari Sánchez Barahora[10], Instituto Hondureño de Geología y Minas, Avda. La FAO, Blvd Centroamérica, Tegucigalpa, Honduras
Sofía Mendoza[11], Servicio Geológico Mexicano, Blvd. Felipe Angeles km 93 50-4, 42083, Pachuca, Hidalgo, Mexico
Ana Lobato[12], Instituto Geológico y Minero de España, CSIC, Ríos Rosas 23, Madrid 28003, Spain
Luis Somoza[13], Instituto Geológico y Minero de España, CSIC, Ríos Rosas 23, Madrid 28003, Spain
Xavier Monteys[14], Geological Survey of Ireland, Booterstown Hall, Booterstown, Blackrock, Dublin A94 N2R6, Ireland

Abstract

The EMODnet-Geology project, funded by the European Union, is assembling marine geological data and producing harmonised maps of the European regional seas for public and private users. The project has recently expanded to new areas as the Caribbean Sea and since 2023 some geological maps of this region are available at the website of the project (https://emodnet.ec.europa.eu/en/geology). In order to improve the coverage and quality of the map products in this region, a working group comprising geological surveys of Caribbean countries (Colombia, Costa Rica, Cuba, Dominican Republic, Guatemala, Honduras, Mexico) and Spain was promoted by the project and has been set up with the support of the Association of Iberoamerican Geological and Mining Surveys (ASGMI). Considering the increasing interest for marine geological resources, the first aim of the group has been to collate data from different sources regarding mineral deposits and hydrocarbons in the Caribbean Sea. A map of occurrences is presented revealing a considerable lack of information in the region on metalliferous mineral deposits, which contrasts with the growing interest aroused by the global increasing demand for

strategic and critical raw materials. In order to overcome the observed gaps, a second map of potential mineral deposits distribution (cobalt-rich ferromanganese crusts, polymetallic nodules and sulfides, phosphorites, marine placers) has been developed, on the basis of several bathymetric and geomorphological criteria and the age of the oceanic crust. Recognition of knowledge gaps and determination of potential areas for marine mineral occurrences is a useful and key issue to address strategically exploration and scientific research studies in the next future, considering the large investments and efforts required in the framework of the geologic and tectonic evolution of the Caribbean plate.

Keyword

marine resources, critical raw materials, EMODnet-Geology, Caribbean Sea

First comprehensive assessment of pockmarks and debut of susceptibility mapping along the Italian Continental Margins

Francesco Latino CHIOCCI[1]*, Sapienza, University of Rome (francesco.chiocci@uniroma1.it)
Daniele Spatola[2], Department of Earth Sciences, Sapienza University, Rome, Italy
Daniele Casalbore[3], Department of Earth Sciences, Sapienza University, Rome, Italy
Ashok Dahal[4], University of Twente, Faculty of Geo-Information Science and Earth Observation (ITC), PO Box 217, Enschede, AE 7500, Netherlands
Stéphanie Dupré[5], Ifremer, UMR Geo-Ocean, Centre Bretagne
Gemma Ercilla[6], Instituto de Ciencias del Mar, ICM-CSIC, GMC, Barcelona, Spain.
Martin Hovland[7], Magma Chem Research Institute, Sola, 4055, Norway
Luigi Lombardo[8], University of Twente, Faculty of Geo-Information Science and Earth Observation (ITC), PO Box 217, Enschede, AE 7500, Netherlands
Marzia Rovere[9], Institute of Marine Sciences (ISMAR), Consiglio Nazionale delle Ricerche (CNR), Bologna, Italy
Attilio Sulli[10], 8. Earth and marine Sciences, University of Palermo, Italy
Juan Tomás Vázquez[11], Instituto Español de Oceanografía, Centro Oceanográfico de Málaga, Fuengirola (Málaga), Spain

Abstract

Pockmarks, characterized by a negative relief resulting from fluid escaping the seafloor, are prominent features discovered for the first time in the Nova Scotian shelf by using echo-sounder records. They have diverse shapes, including U- and V- cross sections, with diameters up to several kilometers and internal depths exceeding 100 meters. These submarine morphologies vary in planform shape from circular to elongated, and in vertical shape profile from flat-bottomed to conical. Despite numerous hypotheses, the mechanisms driving pockmark formation and growth in marine environments remain poorly understood. To address this gap, studies have collected geophysical, morphological, sedimentological, and geochemical data from marine areas hosting pockmarks, offering valuable insights into their genesis and evolution.

In this study, we conduct a comprehensive review of pockmark distribution along the Italian continental margins, selecting 5,932 pockmarks to investigate their relationship with environmental and geological factors. Our analysis considers physical parameters such as morphology, slope gradients, water depth, and sea-level changes, as well as geological features/processes like fractures, fault systems, and seafloor sediment distribution. To enhance understanding and prediction, we employ a deep learning model incorporating geological information such as morphology, distance to faults, sediment type, slope gradients, sedimentary thickness, and water depth. The model generates the first "Predicted Pockmark Susceptibility Map" for the Italian continental margin, identifying the upper continental slope as particularly susceptible.

Our findings highlight the higher number of pockmarks are mainly located in flatter seafloor areas (less than 4°), composed mainly of sandy mud, with a Plio-Quaternary sedimentary layer up to 400 meters thick, and in close proximity to fault systems. We also observe the influence of salt

tectonics, notably related to the Messinian Salinity Crisis, although the retrieval of the thickness of Messinian evaporites poses challenges.
Beyond enhancing our understanding of pockmark formation, our study underscores the broader implications for climate change dynamics, marine biodiversity, and economic considerations. Pockmarks release significant gases, impacting the greenhouse effect and affecting the biosphere, hydrosphere, and atmosphere. Additionally, they hold economic significance due to their association with hydrocarbon deposits but pose threats to offshore installations and navigation safety. Our investigation also addresses the impact on marine biodiversity, emphasizing the conservation importance of deep-sea habitats. The susceptibility map generated can aid in delineating regions suitable for submarine infrastructures and identifying areas requiring reinforcement with safety measures, thereby contributing to marine spatial planning and conservation efforts.

Keyword

Pockmarks, Italian Continental Margin, Fluid Flow, Hazard, Susceptibility map

Ground ice formation mechanisms constrained by stable water isotope ratios and occluded gas compositions

Nikolai FEDOROV[1]*, Seoul National University, Seoul, South Korea (nfeda96@snu.ac.kr)
Nayeon Ko[2], Seoul National University, Seoul, South Korea
Jinho Ahn[3], Seoul National University, Seoul, South Korea
Hyejung Jung[4], Ewha Womans University. Seoul, South Korea
Yalalt Nyamgerel[5], Ewha Womans University. Seoul, South Korea
Jeonghoon Lee[6], Ewha Womans University. Seoul, South Korea

Abstract

Ice wedges, unique underground V-shaped ice formations, result from the infiltration of atmospheric moisture or precipitation through frost cracks in permafrost. They are valuable in reconstructing past winter temperatures, much like how scientists analyze ice cores from polar ice regions. However, there has not been sufficient research into understanding how ice wedges form and where they come from. This lack of understanding could pose significant challenges in interpreting the isotopic composition of meltwater and, consequently, in reconstructing paleotemperatures. The way moisture isotopes are fractionated can vary depending on whether the ice forms from compacted snow or hoarfrost, or from water freezing in frost cracks.

To better understand how ground ice forms, we can use a geochemical indicator called the δ(N2/Ar) molar ratio of occluded gas. This can help distinguish between ground ice formed by the compaction of hoarfrost or snow (where δ(N2/Ar) is ~ 0%) and ice formed by freezing water (where δ(N2/Ar) is ~ -60%). To analyze this, we used a system that melts and refreezes the ice and extracts occluded gas along with Gas Chromatography equipped with a Thermal Conductivity Detector to determine the gas molar ratios.

Our study examined various types of ground ice from East Siberia and Alaska. The δ(N2/Ar) molar ratio of open-cavity ice, formed from vapor sublimation in void spaces, was close to those of the atmospheric, ranging from -8.53% to 1.93%. In contrast, intrusive ground ice, created by the freezing of groundwater due to gravity, had δ(N2/Ar) molar ratios ranging from -63.25% to -27.82%, indicating that the gas originated from dissolved gases. Ice wedges displayed a range of values falling between two extremes, suggesting that they formed in mixed conditions involving various sources such as snow, hoar, and liquid water, depending on the δ(N2/Ar) signal.

Our study may reveal valuable chemical characteristics of ground ice that help identify how it forms. By linking δ(N2/Ar) with stable water isotopes, we might gain insights into paleoclimatic interpretations, particularly when analyzing ice wedges from regions in the permafrost zone.

Keyword

Ground ice, Permafrost, Geochemistry, gas chromatography, water stable isotopes

A comparison of the geochemistry between the Chokurdakh ice wedge and the central Yakutian ice wedges formed during the Last Glacial Maximum (LGM)

Nayeon KO[1]*, Seoul National University (rhskdus88@naver.com)
Jinho Ahn[2], Seoul National University
Go Iwahana[3], International Arctic Research Center (IARC)
Hyejung Jung[4], Ewha Womans University
Jeonghoon Lee[5], Ewha Womans University

Abstract

In this study, we examined the geochemistry of the Chokurdakh ice wedge near the Northeast Siberian Sea and compared it with that of ice wedges from the inland Siberian region, especially in the Yakutsk area (referred to as central Yakutian ice wedges hereinafter). The ages of the central Yakutian ice wedges correspond to the Last Glacial Maximum (LGM; with a mean of 20300 years before present [BP], present = 1950 CE), and the Chokurdakh ice wedge also corresponds to the LGM, with an age of 24710 ± 150 years BP. Regarding the δ(N2/Ar) ratios, Chokurdakh ice wedge exhibits a range from -3.53 to 2.39 %, with a mean of -1.20 % (n=6), which is similar to the range observed in the central Yakutian ice wedges (-0.17 to 5.73 %, with a mean of 2.45 %, n=11).The δ(N2/Ar) ratios close to 0% indicate that these ice wedges primarily formed through hoarfrost accretion or dry snow compaction. Most of the ice wedges show δ(O2/Ar) ratios of -80 to -100%, indicating that oxygen gas was largely consumed by microorganisms within the ice wedge. In terms of the co-water isotope relationship (δ18O- δD). Both the Chokurdakh (δD= 5.93*δ18O-61.48, R2= 0.41) and Cyuie ice wedges in central Yakutia (δD= 6.90*δ18O-29.93, R2= 0.85) follow similar regression lines, with average d-excess values of 1.06 ±1.33 and 3.45 ± 1.53 ‰ for Chokurdakh and Cyuie ice wedge, respectively. Regarding greenhouse gas (GHG) composition, the Chokurdakh ice wedge exhibits an average CO2 mixing ratio of 5.0%, roughly half the value of 10.4 % observed in the central Yakutian ice wedges. Conversely, the average CH4 mixing ratio for Chokurdakh is 913.5 ppm, nearly 60 times higher than the value observed in central Yakutian ice wedges, which is 16.2 ppm. However, the N2O mixing ratio of both ice wedges is comparable, with averages of 27.9 ppm for Chokurdakh and 25.6 ppm for central Yakutian ice wedges. The central Yakutian ice wedges show a broader range of N2O values, with a standard error of 34.92, compared to the Chokurdakh ice wedge's standard error of 12.98. In future studies, a more detailed geochemical comparison will be undertaken, taking into account the distinct environmental conditions during the formation of the Chokurdakh and central Yakutian ice wedges. This will offer further insights into the interpretating paleoclimate conditions in the Siberian region during the LGM period.

Keyword

ice wedge, stable water isotope, greenhouse gas, paleoclimate, Siberia

Characterization of the electrical response of subglacial bedrock in Antarctica considering free pore water and film water

Yuanyuan ZHANG[1]*, China University of Geosciences (Beijing) (yyzhang@email.cugb.edu.cn)
Changchun ZOU[2], China University of Geosciences (Beijing)
Cheng PENG[3], China University of Geosciences (Beijing)
Alexey Markov[4], China University of Geosciences (Beijing)
Sergei Popov[5], Saint Petersburg State University
Pavel Yu Pushkarev[6], Moscow State University

Abstract

Geologically, Antarctica is the least explored place on earth. A thick ice sheet covers 98% of the continent, and the harsh environment has slowed the exploration of the interior of the Antarctic ice sheet and its beds for decades. Currently, electrical and electromagnetic methods including Magnetotelluric(MT) and transient electromagnetic (TEM) et al., methods are being used for experimental measurements in Antarctica, which can provide 2D or 3D tomography/images of the subsurface in a fast and non-invasive manner. However, subglacial rocks in Antarctica differ significantly from those in other regions. Using available core data, it is possible to find that the subglacial rocks are composed of materials in four different phases: two solid phases (rock/soil matrix and ice), a liquid phase (unfrozen pore water with some ions), and air-filled pore spaces and cavities in Antarctica. Unlike the freezing of bulk water, liquid water in porous media doesn't completely change phase to solid ice below the freezing temperature. The primary reason for this is the decrease in the melting point of water induced by adsorption on the surface of the skeleton particles and the curvature These unfrozen waters provide channels for the migration of ions, which is directly responsible for the conductivity of subglacial rock and key to the evaluation of electrical conductivity. Hence, applying electrical and electromagnetic methods for geo-environmental studies in cold regions requires more experimental and modeling studies of the electrical conductivity of subglacial rock.

In this study, the unfrozen water was categorized as free pore water and film water. The conductivity of pore water is affected by a combination of concentration and temperature. When the temperature decreases, a salting effect occurs, resulting in a decrease in conductivity. The electrical conductivity of thin-film water is determined by the Gibbs-Thomson equation and the specific surface conductance between the solid surface-liquid water and bulk ice-liquid water interfaces. Subsequently, two microscopic models were developed: a skeleton model and a pore network model using the FEM method to simulate the electrical response characteristics of subglacial rock. By comparing the electrical response characteristics of the two models, the characteristics of the effects of the unfrozen water content, initial water content, temperature, mineralization, and porosity on the electrical resistivity of subglacial rock were analyzed. In addition, the specific contribution of free pore water and film water to resistivity under different conditions is discussed, revealing further the importance of free pore water and film water in the conductivity process. These studies contribute to a deeper understanding of frozen porous media's

electrical properties and open new possibilities for characterizing the distribution and dynamics of liquid water in frozen environments using geoelectric and electromagnetic techniques.

Keyword

Antarctica, frozen porous media, Numerical simulation, Electrical characterization

Time-series deformation monitoring of post-glacial rebound using space-based synthetic aperture radar observations

Seong-Woo JUNG[1]*, Pusan National University (swjung@pusan.ac.kr)
Sang-Hoon HONG[2], Pusan National University

Abstract

Glaciers worldwide have been melting steadily for approximately 20,000 years since the last glacial maximum, and recent global warming has accelerated this trend. Post-glacial rebound, also known as glacial isostatic adjustment (GIA), occurs as glaciers melt and thin, causing a decrease in the load on the Earth's surface and resulting in ongoing deformation. Greenland significantly contributes to global sea-level rise, with substantial mass loss annually. Despite being seismically quiet and structurally stable, Greenland undergoes continuous deformation due to mass loss and glacial isostatic adjustment following glacier retreat. Iceland, where approximately 11% of the land is covered by glaciers, also undergoes deformation due to various processes such as plate spreading, post-glacial rebound, and localized volcanic activity. Global Navigation Satellite System (GNSS) data is available even in polar regions, however its sparse distribution poses challenges in observing large areas comprehensively.. Synthetic aperture radar (SAR) satellites offer advantages for continuous observation, as they can acquire surface images regardless of weather conditions and day-night cycles, even in geographically inaccessible regions. SAR interferometry provides a technique to measure displacements with high accuracy ranging from a few millimeters to centimeters over large areas. In this study, we observed post-glacial rebound deformation in Greenland and Iceland using Sentinel-1 and ALOS-2 PALSAR-2 data acquired over several years, employing the Small Baseline Subset technique (SBAS) and compared the results with GNSS measurements.

Keyword

Post-glacial rebound, Glacial isostatic adjustment, SAR, SBAS, InSAR

Understanding Intra/inter-regional Heterogeneous Glacier Retreat and Glacier-Climate Synthesis over the Himalayas

Parvendra KUMAR[1]*, Department of General and Applied Geography, Dr. Harisingh Gour University, Sagar, Madhya Pradesh, India (parvendra.jnu@gmail.com)
Milap Chand Sharma[2], Centre for the Study of Regional Development, Jawaharlal Nehru University, New Delhi

Abstract

Himalayan glaciers support the most populous region of the world as well as provide an opportunity to understand the climate change in the region. Glaciers in the Himalayas are reported in a general state of retreat from the 19th century. However, glaciers have recorded a heterogeneous pattern of retreat over the Himalayas. Consequently, a glacier-climate synthesis has not been developed yet. Therefore, the present study aims to understand intra-regional and inter-regional diverse patterns of glacier retreat caused by topographical and climatic factors to develop Glacier-Climate synthesis over the Himalayas. To understand the intra-regional heterogeneity in retreat patterns, the study assesses the terminus retreat of medium-sized glaciers (1988 to 2018) using geospatial dataset and inputs from fieldwork in Sikkim Himalaya which is under the direct influence of the Indian Monsoon. Glaciers have retreated at a diverse rate in a range from 63.9 m yr-1 to 3.9 m yr-1 and lost a total area of ~3.95 (±0.35) km2 (~2.53%, 0.08% yr -1) during 1988-2018 in Sikkim. Being located in similar climatic conditions, the intra-regional heterogeneity in glacier retreat in Sikkim seems to be caused by topographical factors as glaciers with a shorter length, smaller area, higher terminus altitude, lesser slope gradient, possessing a simple form, having lakes and oriented in E, SE and S have retreated the most over the entire observation period. A comparison of glacier retreat in Sikkim with other parts of the Himalayas reveals a declining gradient of retreat from the northwest to the eastern Himalayas with a lower rate of glacier retreat in Sikkim, broadly. This inter-regional disparity in the retreat rate of glaciers seems to be caused by existing climatic regimes over the different parts of the Himalayas. The results are helpful in comprehending the Glacier-Climate synthesis over the Himalayan region.

Keyword

Glacier, Climate, Synthesis, Himalaya, Sikkim

Effect of varying the fluidity parameter in Glen's Law on ice sheet dynamics using 2D finite element software, Elmer/ice.

Su-Jeong LIM[1]*, Kangwon National University (aa049600@kangwon.ac.kr)
Byung-Dal So[2], Kangwon National University

Abstract

The dynamics of ice mass change are closely linked to the movement of the grounding line in the transition zone between ice sheets and ice shelves. These dynamics are controlled by external factors such as ice discharge, accumulation and ablation, and gravity-driven ice flow. The position and movement of the grounding line, as well as ice discharge and flow, depend critically on the viscosity of the ice. Viscosity is a function of several factors, including bed topography, ice geometry, and hydrostatic pressure, due to the nonlinear relationship between ice viscosity and both stress and temperature. Ice viscosity parameterizes the rheological behavior of ice through Glen's law, a power law relationship where strain rate is proportional to the Glen exponent (n) squared of the deviatoric stress. The fluidity parameter (A), typically a parameter of Glen's law, depends on temperature, interstitial water content, and hydrostatic pressure in modeling ice sheet dynamics. Traditionally, ice sheet dynamics modeling has used a Glen exponent value of n=3, which has been effective in reproducing observed ice flows. However, recent analyses suggest that a more accurate exponent may be n=4, based on correlations with ice velocity and sea level rise data. Laboratory experiments suggest a wide range of A for n = 4. We constrain the wide range of fluidity parameters to identify the appropriate ice viscosity for modeling ice sheet dynamics when n = 4. We performed the numerical simulations solving the full Stokes equations (Elmer/Ice) to calculate the flow across the ice sheet and ice shelf. We developed two-dimensional models with simple slope and actual Antarctic ice topography. Variation of the fluidity parameter controls ice velocity, ice area, and ice thickness. Identifying the fluidity parameter, a parameter of Glen's Law, to accurately estimate ice viscosity is necessary to predict ice mass change and future sea level change.

Keyword

ice sheet dynamics, glen's law, fluidity parameter, ice velocity, viscosity

Exploring the Soft-Sediment Deformation Structures (SSDS) in Glacial Environments: Insights from Physical Dropstone Deposition's Simulations

Ana Beatriz Dias JARDIM[1]*, Universidade de Brasília (abjardim97@gmail.com)
Elder YOKOYAMA[2], Universidade de Brasília
Ingrid de Souza HOYER[3], Universidade de Brasília

Abstract

Anthropogenic activities have exacerbated global climate change. The impacts of rising global temperatures are noticeable globally, with polar regions experiencing significant effects, as seen in the diminishing ice caps. Melting ice reduces marine salinity in affected areas and increases the deposition of terrigenous sediments. Within these sediments, extrabasinal clasts, known as dropstones, are deposited. Dropstones are rock fragments dislodged from ice rafts and icebergs as water temperatures increase. Upon reaching the bottom sediments, they trigger the formation of structures called soft-sediment deformation structures (SSDS). The morphology of these deformations is influenced by factors, such as water column thickness, density, and salinity. SSDS has the potential to be a new paleoenvironmental proxy, helping with paleoclimatic interpretations. Recent studies using numerical simulations have clarified dropstone deposition and SSDS formation processes. These studies had limited variation in physical parameters, like water salinity, leading to outcomes that differed from geological reality. The current study uses physical simulations to provide new insights into the formation and implications of SSDS in the paleoenvironmental context. Lead ellipsoids (LE) with an average long axis of 2 cm and weighing 17.5 g were used as dropstones. The water column was simulated using a one-meter-high acrylic tube with a 10 cm diameter. Deformation test specimens comprised alternating layers of kaolin sheets dyed with hematite and kaolin, each layer averaging 0.4 cm in thickness. The specimens underwent LE dispersion based on water column thickness, replicated for both fresh and saltwater. Recordings during the experiment were analyzed using ImageJ software to determine the path and speed of the LE throughout the trajectory. This analysis, conducted for various water column thicknesses, showed a final deformation rate of 75% and 96% in the top layer for a 30 cm water column thickness with fresh and saltwater, respectively. At 60 cm, the deformation rate increased to 89% for fresh water and 96% for saline water. In a 90 cm freshwater column, a final deformation rate of 97% was observed. High deformation values were observed in deeper layers for all three water column thicknesses when only fresh water was present, suggesting penetration and ruptures in the sediment layers. The thickness of the water column with saline water resulted in a smoother penetration pattern and fold formation in the layers, showing the impact of environmental salinity and creating more distinct features in the initial sediment layers. To assess the impact of the water column on sediment deformation, an experiment without water showed only a 2% deformation rate in the top sediment layer, showing that water plays a direct role in SSDS formation. This study highlights the significance of comprehending the connections among melting processes, dropstone deposition, and SSDS structure formation in glacial environments,

enhancing our understanding of the effects of future global climate change.

Keyword

Dropstones, Water column, SSDS, Climate Change, Ice cap

Elevation changes of the ice sheet above subglacial lakes around David Glacier in East Antarctica measured using Sentinel-1 DDInSAR

Taewook Kim[1]*, Kangwon National Univercity (tw960215@kangwon.ac.kr)
Hyangsun Han[2], Kangwon National University

Abstract

The change in water level of a subglacial lake, driven by water filling and draining activities, results in the elevation change of the overlying ice sheet. The ice sheet elevation change due to the subglacial lake activities has been widely analyzed through time-series observations from satellite altimeters. However, the revisit times of satellite altimeters, spanning a few tens to hundreds of days, are insufficient for capturing small changes in ice sheet elevation over short periods due to lake activity. Differential Interferometric Synthetic Aperture Radar (DInSAR) with shorter temporal baseline offers a valuable tool for observing precise surface displacements of the ice sheet above a subglacial lake. In this study, we generated time-series DInSAR images using Sentinel-1 SAR imagery at ascending and descending nodes from March 2016 to December 2023 around David Glacier in East Antarctica, where subglacial lakes named David 2 (D2), David 3 (D3), and an uncharted subglacial lake (hereafter referred to as K1) are located. DInSAR-derived displacement contains both horizontal ice flow and vertical elevation change due to subglacial lake activity. To observe the vertical displacement due to subglacial lake activity, we applied the Double Differential InSAR (DDInSAR) technique, which differentiates between two DInSAR images assuming constant ice flow, to the DInSAR images. First, for each subglacial lake, we identified a reference DInSAR reflecting no elevation change due to stable water levels in the subglacial lake, guided by ICEsat-2 altimeter observations. We then generated DDInSAR images by subtracting the remaining DInSAR images from the reference one. The DDInSAR images effectively reveal the temporal variations in vertical displacement due to variations in subglacial lake activities, with minimal ice flow variations. Integrating the time-series DDInSAR-derived displacements, we found that the ice sheet elevations changes over the subglacial lakes, as measured by integrating DDInSAR-derived displacements, although some discrepancies were possibly attributed to uncertainties in the ICEsat-2 observations and residual ice flow effects in the DDInSAR. The ice surface over D2 and D3 uplifted approximately 8 m and 3.5 m, respectively, from March 2016 to May 2020. The uplift of the ice surface over D2 and D3 continued, but it was only by an additional 0.5 m and 0.2 m, respectively, over the three years following May 2020. The ice surface over K1 was uplifted by about 0.5 m from March to July 2016 and experienced repeated cycles of uplift and subsidence of approximately 0.2 m until May 2020. Subsequently, it subsided by about 1.5 m from May 2020 to March 2021. After that period, the ice surface over K1 was uplifted by about 0.4 m. The analysis of DDInSAR-derived surface displacements enables precise observations of ice sheet elevation change caused by subglacial lake activity in short period, which can help better understand the subglacial water filling-draining system.

Keyword

Sentinel-1, DDInSAR, elevation change, subglacial lake, David Glacier

An Innovative Experiment of Geophysical Measurements with Low-Altitude UAV in the Ingrid Christensen Coastal Ice Sheet

Changchun ZOU[1]*, China University of Geosciences (Beijing) (Zoucc@cugb.edu.cn)
Yuanyuan Zhang[2], China University of Geosciences (Beijing)
Chang Peng[3], China University of Geosciences (Beijing)
Hongjie Zhang[4], China University of Geosciences (Beijing)

Abstract

99.82% of the Antarctic continent is covered by ice, resulting in a limited understanding of the underlying geology. Aimed at the extremely poor climatic environment and complex geologic conditions, the research carried out polar geophysical studies and independently developed key technologies and equipment for integrated geophysical Measurements with UAVs, which have become a favorable tool to unveil the mysteries of the bedrock beneath the Antarctic ice.

During the 40th China's 40th Antarctic Expedition, the study conducted ground-breaking under-ice electromagnetic detection using unmanned aerial vehicles in the Larsemann Hills region of East Antarctica. The exposed bedrock test area at Law Base and the ice cap test area off the coast of Ingrid Christensen were selected as detection targets, and seven flights were efficiently completed at a flight speed of 5 m/s, collecting electromagnetic detection data for 16 lines totaling 4.19 km. Additionally, ground magnetic surveys were also used to complement the investigation, providing lithologic features and magnetic anomaly data, which assisted in the interpretation of electrical anomalies. After data processing, the electrical parameters of the subglacial bedrock were successfully calculated and a high-resolution 3D resistivity image of the subglacial bedrock was reconstructed. The results show that the subsurface resistivity values in the exposed bedrock sounding area of Law Base are relatively low, indicating an overall low resistivity character, which is also exhibited in the deeper parts. In the Ingrid Christensen Coastal Ice Sheet Test Area, the resistivity is relatively high at shallow depths and relatively low at deeper depths, consistent with the distribution of seawater beneath the test area.

The successful application of this detection technology has provided an unprecedented "CT" scan of the bedrock beneath the ice. In the future, with further improvements and applications of the technology, more breakthroughs and discoveries will be made in the field of Antarctic scientific research, which will contribute more to global climate change and other scientific subjects.

Keyword

East Antarctica, Geophysical Measurements, Experiment, UAV, Resistivity Imaging

Diel variations in isotopic and chemical compositions of stream water in Antarctica

Hyejung JUNG[1]*, Ewha Womans University (hyejeong.chung@gmail.com)
Hyoungseok LEE[2], Korea Polar Research Institute
Chaeyoung KIM[3], Ewha Womans University
Jeonghoon LEE[4], Ewha Womans University

Abstract

Global warming is accelerating the thawing of permafrost in high latitudes, leading to alterations in hydrological pathways. An important implication of the increased active layer thickness is that groundwater is likely to play an increasingly important role in polar terrestrial freshwater systems. These changes have a significant influence on predicting chemical weathering and hydrologic pathways in river systems. A study conducted in 2022 documented diel (24-h) variations of δ18O and chemical species observed in a stream on King George Island in Antarctica. The purpose of this study was to expand on these earlier findings by conducting high resolution monitoring for chemical components. The most important findings of this study include: (1) diel δ18O decreased during the night and increased during the day, in agreement with previous work; (2) these changes were negatively correlated to diel changes in Cl- and NO3- concentrations (r = -0.6); (3) diel pH decreased during the night and increased during the day due to aquatic plants and microbes; and (4) pH was positively correlated to diel variation in Cl- and NO3- concentrations (r = 0.4). Additional interpretation is required to better understand how future climate change could impact river systems aspects for chemical weathering and hydrologic pathways in this region.

Keyword

Climate change, Permafrost hydrology, Isotope hydrology, Diel variation, Antarctica

Development and benchmarking of ice sheet dynamics model using COMSOL Multiphysics® compared to Ice Sheet System Model (ISSM)

Yi-Jeong BAEK[1]*, Kangwon National University (yijung0320@kangwon.ac.kr)
Byung-Dal So[2], Kangwon National University

Abstract

Numerical simulation of ice sheet dynamics is essential for assessing glacier mass balance and sea level rise. Ice flow is attributed to the complicated interaction between grounding line migration, calving, basal friction, and topography. Previous studies using massive geophysical observation, including IPR (Ice Penetrating Radar), InSAR (Interferometric Synthetic Aperture Rada), and heat flow exploration, highlight the need to develop a sophisticated numerical model. For quantitative simulations of continental-scale ice sheets, such as Antarctica and Greenland, ice-flow models rely on the Shallow Shelf Approximation (SSA). We have developed an SSA module using COMSOL Multiphysics®, named COM-SSA. To verify the applicability of COM-SSA as software for ice sheet dynamics, five subdivided cases are compared with ISSM. In Cases 1 and 2, which dealt with nonlinearity problems, we confirmed that the convergence of viscosity and basal friction was successfully handled. Case 3 tested the ice thickness evolution calculated by the conservation of mass equation. Case 4 investigated the grounding line migration with time-dependent ice thickness changes. In both cases, a pattern similar to ISSM was shown. This indicates that COM-SSA could precisely implement ice sheet dynamics. After the validation of COM-SSA by comparison with ISSM, we have demonstrated its capabilities in the case of the application to the Pine Island Glacier, Antarctica. COM-SSA successfully performs 300 years of velocity, ice thickness evolution, and grounding migration for the PIG.

Keyword

Ice sheet dynamics, COMSOL Multiphysics®, Shallow Shelf Approximation (SSA), grounding line, Ice Sheet System Model (ISSM)

Meltwater influence on sulfur isotope composition of sulfate in ice wedge

Hyeonjeong JEONG[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea (hyeonwjd@snu.ac.kr)
Nikolai FEDOROV[2], School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea
Jinho AHN[3], School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea
Min Sub SIM[4], School of Earth and Environmental Sciences, Seoul National University, Seoul, Korea

Abstract

Ice wedges, formed through repeated crack and infilling processes, serve as valuable archives complementing the limitations of traditional ice cores, offering insights into paleoenvironmental and paleoclimate reconstruction. Like other ice archives, ice wedges are effective proxies for preserving past atmospheric aerosols, including sulfate. Since sulfate behaves as a conservative component in oxic conditions — atmosphere and Earth's surface environment — sulfur isotope ratios of sulfate have provided understanding of atmospheric sulfate origins and further enabled deductions about past changes in atmospheric circulation. However, uncertainties remain regarding the ice wedge infilling process, leading us to consider the case that snow meltwater, having interacted with vegetation and sediments, infiltrates cracks. Therefore, evaluating whether the snowmelt infilling of ice wedges can reflect their past sulfur isotopic composition without alteration, as it passes through the surface and active layer, becomes important for applying sulfur isotopes geochemistry as a proxy for ice wedges. In this study, we aim to analyze the sulfur isotopic composition of dissolved sulfate in ice wedges collected from the Sulgachchy region in Central Yakutia, Northeast Siberia, with a focus on identifying differences influenced by the degree of contribution of liquid water. In the Sulgachchy ice wedges, the depleted $\delta(N_2/Ar)$ values, which vary between -13% and -15%, indicate the contribution of meltwater during ice formation, and the sulfur isotope compositions of sulfate show a range of approximately 8‰. However, there is no apparent correlation between $\delta(N_2/Ar)$ and $\delta^{34}S_{SO_4}$. In addition, ice wedges of similar age in the nearby Myndagay region have near-zero $\delta(N_2/Ar)$ values, suggesting minimal meltwater influence, but their sulfate sulfur isotope compositions are largely consistent with those of the Sulgachychy ice wedges. This preliminary study demonstrates that the $\delta^{34}S_{SO_4}$ values in ice wedges preserve past sulfate aerosol independently of the infilling process, thus confirming the potential of sulfur isotopes as proxies in ice wedges, which can contribute to the reconstruction of paleoenvironments.

Keyword

Ice wedge, sulfur isotope, sulfate aerosol, meltwater

Glacier-induced provenance changes in Bellsund, Svalbard, during the Holocene

Young Jin Joe[1]*, Korea Polar Research Institute (yjjoe@kopri.re.kr)
Kwangchul Jang[2], Yonsei University
Youngkyu Ahn[3], Korea Polar Research Institute
Jung-Hyun Kim[4], Korea Polar Research Institute
Xia Wan[5], Ministry of Education Ocean University of China
Yeongju Son[6], Korea Polar Research Institute
Matthias Forwick[7], UiT The Arctic University of Norway, Tromsø
Jan Sverre Laberg[8], UiT The Arctic University of Norway, Tromsø
Xiaotong Xiao[9], Ministry of Education Ocean University of China
Seung-Il Nam[10], Korea Polar Research Institute

Abstract

Bellsund is a fjord system connected to the van Mijenfjorden (northeastern), van Keulenfjorden (eastern), and Recherchefjorden (southern) in southern Spitsbergen, Svalbard. This study investigates changes in provenance in response to the past behavior of fjord glaciers by analyzing lithology and mineralogy in a sediment core (HH19-877-GC) from Bellsund. Our results reveal variability in depositional environments and terrestrial sediment input after ca. 12,000 years BP. From 12,400 to 9,500 years BP, turbidity currents and meltwater discharges dominated Bellsund, with strong variations in plagioclase and dolomite. This depositional pattern suggests terrestrial inputs to Bellsund from its tributaries in a rapid phase of glacial retreat. The early to middle Holocene (9,500 to 3,500 years BP) has been identified as a sediment deficit with increased sand content under open marine conditions. The late Holocene (after 3,500 years BP) was characterized by hemipelagic deposition with tidewater glacial influences in the tributaries, with relatively low and constant plagioclase and a gradual increase in dolomite. Plagioclase and dolomite may have been derived from siliciclastic rocks of van Mijenfjorden/van Keulenfjorden and various carbonate rocks of Bellsund/Recherchefjorden, respectively. In this context, the terrestrial input to Bellsund during the late Holocene was likely mainly from the Bellsund coasts and Recherchefjorden. Furthermore, we expect that the ratio of plagioclase to dolomite can serve as a geological proxy for estimating provenance changes in southern Spitsbergen based on the regional distribution of bedrock geology.

Keyword

Bellsund, Holocene, Provenance, Lithology, Mineralogy

[Keynote] Arctic Ocean pH and CO2 history of the last glacial cycle

Jannik Martens[1]*, Lamont-Doherty Earth Observatory, Columbia University, USA (jmartens@ldeo.columbia.edu)
Sarah Hurley[2], Lamont-Doherty Earth Observatory, Columbia University
Helen K Coxall[3], Department of Geological Sciences, Stockholm University
Matt O'Regan[4], Department of Geological Sciences, Stockholm University
Flor Vermassen[5], Department of Geological Sciences, Stockholm University
Jesse Farmer[6], School for the Environment, University of Massachusetts Boston
Laura Gemery[7], U.S. Geological Survey, Florence Bascom Geoscience Center
Martin Jakobsson[8], Department of Geological Sciences, Stockholm University
Bärbel Hönisch[9], Department of Earth and Environmental Sciences, Columbia University

Abstract

The cold Arctic Ocean allows CO2 to dissolve more readily than in other regions, leading to accelerated ocean acidification with profound environmental and socio-economic impacts. For instance, decreasing pH reduces the saturation states of aragonite and calcite in seawater, compromising biogenic calcification. Accurately predicting future carbonate system states remains challenging due to a limited observational record of Arctic seawater history and poorly-constrained processes that impact local ocean biogeochemistry.

The boron isotopic composition (δ11B) of marine carbonates provides a way to assess past Arctic Ocean seawater pH in response to natural climate changes and varying atmospheric CO2 levels. Here, we present δ11B measurements of the planktic Arctic foraminifer *Neogloboquadrina pachyderma* from central Arctic Ocean sediments. We present a new Arctic-specific calibration of the δ11B proxy and reconstruct central Arctic carbonate chemistry over the last glacial-interglacial transition (i.e., the past 20,000 years), and earlier Pleistocene interglacials that include warmer-than-pre-industrial climates with seasonally ice-free conditions.

Our δ11B record reveals that central Arctic pH variations were broadly consistent with the deglacial (i.e. 17,500-11,000 years ago) atmospheric CO2 increase of ~80 ppmv as documented in ice cores. This demonstrates the feasibility of δ11B investigations of Arctic Ocean acidification. While rising atmospheric CO2 was the primary driver of Arctic Ocean carbonate system states during the deglaciation, we also identify the transient influence of other environmental factors such as changing sea ice regimes, vertical upper ocean mixing, water column stratification, and the release of terrestrial organic matter from thawing Arctic permafrost. Examining these past carbonate system states will contribute to better understanding the boundary conditions of the Arctic Ocean system.

Keyword

Arctic Ocean, ocean acidification, climate change, boron isotopes, foraminifera

A digital geoscience data repository for Arctic reconstructions

Carmen GAINA[1]*, University of Oslo (carmen.gaina@geo.uio.no)
Alexander Minakov[2], University of Oslo
Grace Elisabeth Shephard[3], University of Oslo
Owen Anfinson[4], Sonoma University
Victoria Ershova[5], St. Petersburg University
Andrew Schaeffer[6], Pacific Geoscience Centre
Kim Senger[7], UNIS
Daniel Stockli[8], University of Texas
Bernard Coakley[9], University of Alaska
Pascal Audet[10], University of Ottawa
Morgan Jones[11], Umeå University
Lars Eivind Augland[12], University of Oslo
Ivar Midtkandal[13], University of Oslo

Abstract

Despite its remoteness and harsh conditions, the natural environment of the northern polar region received increased attention in the last two decades. In recent years considerable effort has been invested by several groups and institutions to make various data and results available online and to use it for science, education and outreach. Examples include: the Arctic Observing Viewer which is a web mapping application in support of U.S. SEARCH, AON, SIOS, and other Arctic Observing networks (https://
arcticobservingviewer.org/); Arctic Research Mapping Application (https://armap.org/) and the NSF Arctic Data Center (https://arctic data.io) for locating projects and data supported by US funding agencies; Svalbox (www.svalbox.no), a database for digital outcrop models from Svalbard, the comprehensive PANGAEA database (https://www.pangaea.de), a data publisher for Earth and Environmental sciences; and GeoMapApp (http://www.geomapapp.org/), a map-based application for browsing, visualizing and analyzing a diverse suite of curated global and regional geoscience data sets.

While a wealth of data can be located and viewed in these databases and data repositories, the scientific community and geoscience educators may benefit from a collection of geological and geophysical data that can be easily visualized, analyzed and used for a quick assessment of present-day geodynamic setting and further for paleogeographic reconstructions in the circum-Arctic region. A group of scientists from four Arctic countries and their collaborators aimed to consolidate and further develop the Arctic-related common scientific basis and educational programmes under the auspices of the Norwegian Research Council programme INTPART (International Partnerships for Excellent Education, Research and Innovation).The project NOR-R-AM (https://norramarctic.wordpress.com/), established in 2017, focused on assessing the openly available information accumulated at participating institutes. Here we will present the resulting digital Circum-Arctic geodynamics platform. that incorporates geological and geophysical data and models, tomographic and kinematic models and paleogeography and paleoclimate indicators

in openly accessible formats that are compatible with GPlates, GeomapApp and Google Earth. Examples of how this platform can be used for reconstructing the Arctic's tectonic and paleooceanographic evolution will be part of the presentation.

Keyword

Arctic, digital, tectonics, geophsyics, reconstructions

Brackish and anoxic environments in the western Arctic Ocean during the last glacial period: insights from authigenic calcites

kwangchul JANG[1]*, Yonsei University (kj@yonsei.ac.kr)
Kyung Sik Woo[2], Kangwon National University
Seung-Il Nam[3], Korea Polar Research Institute

Abstract

The past hydrology in the Arctic Ocean has primarily been considered as typical seawater – both saline and oxic conditions. However, recent research on the thorium excess minima introduces the glacial Arctic freshening hypothesis, which challenges this prevailing view. This study presents the geochemical properties of authigenic calcites formed in-situ within sediments from the Mendeleev Ridge of the western Arctic Ocean back to 76 ka. Authigenic calcites exhibit low Mg (< 4 mol%) concentrations and light oxygen isotope ratios exclusively during cold intervals of the last glacial period (e.g., MIS 2 and MIS 4 to early MIS 3). These characteristics strongly suggest brackish Arctic hydrology during these times.

Additionally, the corresponding positive excursion of carbon isotope contents, attributed to early diagenetic methanogenic processes, suggests that the western Arctic Ocean was also accompanied by anoxic deep-sea conditions. It appears that the oxygen-depleted subglacial meltwater discharged from adjacent ice sheets could have generated a high-density sediment-laden flow, which intruded and filled up the deep-water column, ultimately resulting in brackish and anoxic environments. Further investigation of Arctic sediments from older periods is necessary to understand the potential impact of these hydrological changes in the Arctic Ocean on the global carbon cycle in the past.

Keyword

Arctic anoxia, authigenic carbonate, Arctic freshening, Carbon cycle, last glaciation

Impact of current flow on the depositional environment in Kongsfjorden trough of Arctic Svalbard

Youngkyu AHN[1]*, Korea Polar Research Institute (youngq@kopri.re.kr)
Young Jin JOE[2], Korea Polar Research Institute
Kwangchul JANG[3], Yonsei University
Jochen KNIES[4], Geological Survey of Norway
Jung-Hyun KIM[5], Korea Polar Research Institute
Yeong Ju SON[6], Korea Polar Research Institute
Sungmin HONG[7], Inha University
Seung-Il NAM[8], Korea Polar Research Institute

Abstract

The Atlantic Water plays an important role in regulating the climate system associated with depositional environments in Arctic Svalbard fjords. In troughs off Svalbard fjords, the inflowing Atlantic Water can be steered by seafloor topography. This study examines the impact of topographically steered currents on depositional patterns in the trough off Kongsfjorden by analyzing multi-proxies on a glacimarine sediment core (KH17-GPC01). Additionally, we compared sediment records between the center of the trough and its outer rim, near the glacier front. Our results present that sediment input to the Kongsfjorden trough has been primarily influenced by the interaction between glacier melting, current sorting, and sea ice drifting. Interestingly, core KH17-GPC01 from the center of the trough exhibits a relatively higher sedimentation rate compared to sediment cores from the outer rim. Despite their proximity to the glacier front, the relatively low sedimentation rate in the outer rim possibly resulted from sediment sorting by the enhanced current flows, suggesting that this depositional pattern was contributed by rapid current flow along the outer rim of the trough. Conversely, the center of the Kongsfjorden trough appears to act as a depocenter. These findings provide the importance of considering the effects of current-induced sediment transport for reconstructing depositional environments around the complex Svalbard fjord systems.

Keyword

Svalbard, Fjord, Kongsfjorden trough, Oceanic current, Sedimentation

Variations in aged-soil derived organic carbon input into the Kongsfjord over recent centuries: application of CuO oxidation products

Dahae KIM[1]*, Korea Polar Research Institute (dhkim@kopri.re.kr)
Jung-Hyun Kim[2], Korea Polar Research Institute
Seung-Il Nam[3], Korea Polar Research Institute

Abstract

The Svalbard Archipelago is located at the gateway between the North Atlantic and the Arctic Ocean. Spitsbergen, the largest island of the Svalbard Archipelago, is presently covered with glaciers, accounting for about 57% of its area. Also it is strongly influenced by the West Spitsbergen Current (WSC), which supplies warm Atlantic water to its fjords. Furthermore, fjords are hotspots of organic carbon (OC) burial due to high sedimentation rate and terrestrial inputs from land-terminating and tidewater glaciers. Thus, fjords in Spitsbergen are considered the most sensitive areas to the recent global warming and are among the supersites for studying the responses of the Arctic system to further climate changes. In this study, we investigated three multicores collected in Kongsfjorden during HH22 and HH23 cruises aboard RV Helmer Hanssen in 2022 and 2023, along with soil and bedrock samples collected in its surrounding land areas. We analyzed lignin phenols along with conventional bulk indicators such as TOC, Norg/TOC ratio, d13Corg, and Δ14Corg, and assessed the relative contribution of OC sources employing a four-end-member approach. We will present reconstructed variations in aged-soil derived organic carbon input into Kongsfjord over recent centuries. Our results will provide new insight into OC dynamics in the Kongsfjorden.

Keyword

Arctic, Svalbard, sediment

Biogeochemical evidence for methane emission within gas hydrate bearing mound structures of the Chukchi borderland in the western Arctic Ocean

Dong-Hun LEE[1]*, Pukyong National University (ldh301@pknu.ac.kr)
Jung-Hyun Km[2], Korea Polar Research Institute
Young Jin Joe[3], Korea Polar Research Institute
Dahae Kim[4], Korea Polar Research Institute
Young Keun Jin[5], Korea Polar Research Institute
Jong Kuk Hong[6], Korea Polar Research Institute

Abstract

Cold seepages act as windows for the emission of deep subsurface hydrocarbon gases, mainly methane, fluids, and a complex mixture of sediments. Recently, the morphological features, such as gas hydrate-bearing mounds related to methane seeping, have been discovered on the Chukchi borderland in the western Arctic Ocean. Together with geological evidence within mound structures, such as the occurrence of shallow gas hydrate layers, we investigated the biogeochemical signatures of methane-related microbial communities along discriminative lithological structures using geochemical properties, including bulk elements and microbial lipid compounds. Since the deposits of the Laurentide iceberg discharge event during the last deglacial period, referred to as a distinct dark grayish coarse layer, which may have been deposited by the Laurentide iceberg discharge event during the last deglacial periods, the 13C-enriched organic carbon patterns showed significantly discriminative properties involved in the formation of authigenic carbonate formed during methane emission. Furthermore, the predominance of 13C-depleted lipid compounds (archaeol, sn-2-hydroxyarchaeol, GDGT-1, -2 and -3) within last deglacial deposits may reflect the increased methane-consumption activities that occurred during methane emission, compared to those of reference sites. Thus, our results infer that the increase of methanotrophic activities may be related to the dissociation of gas hydrate after the last deglacial warming.

Keyword

Arctic, Methane, Gas hydrate bearing mound, isotopes, lipid biomarker

Persistent marginal sea ice conditions in the Eurasian Arctic during the past 750 000 years

Jochen Knies[1]*, Geological Survey of Norway (jochen.knies@ngu.no)
Simon T Belt[2], University of Plymouth
Monica Winsborrow[3], University of Tromsø
Seung-Il Nam[4], Korean Polar Research Institute

Abstract

The past existence of a continuous Arctic Ocean ice shelf has been inferred from submarine landscape features and geochemical records; however, fundamental aspects of its characteristics, impacts and timing remain highly debated. We test the pan-Arctic glaciation hypothesis by investigating Ocean Drilling Program (ODP) Site 910, drilled northeast of the Fram Strait, the principal gateway between the Atlantic and Arctic Oceans. Source-specific biomarkers reveal no evidence for a continuous ice shelf at this site over the past ~750 000 years. They rather document the presence of seasonal sea ice and spring phytoplankton blooms in surface-waters, with spring sea-ice concentrations typically 10-50%. The most extensive sea ice cover occurred during the Last Glacial Maximum (LGM, ~20 000 years ago) and glacial marine isotope stage (MIS) 16 (~676 000 - 621 000 years). MIS 6 (~190 000 - 130 000), the large-scale penultimate glaciations, is characterized by variable sea ice and continuous transport of northward flowing Atlantic water masses into the Arctic Ocean. Thus, in contrast to the pan-Arctic glaciation hypothesis, these data demonstrate, unequivocally, the prevalence of marginal sea ice conditions in the gateway region across a series of glacial-interglacial cycles following the middle Pleistocene climate transition. If ever the Arctic Ocean was covered by continuous ice shelf, it has likely occurred during the mid-Pleistocene transition between 1.300 000 and 750.000 years ago.

Keyword

Arctic Ocean, Pleistocene, Sea ice

Novel insights and paleoclimate impact of the Millennium Eruption from Mt. Baekdu

Giyoon LEE[1]*, Seoul National University (giyoon80@naver.com)
Andrea Burke[2], University of St Andrews
William Hutchison[3], University of St Andrews
Patrick Sugden[4], University of St Andrews
Celeste Smith[5], University of St Andrews
Joseph R. McConnell[6], Desert Research Institute
Michael Sigl[7], University of Bern
Clive Oppenheimer[8], University of Cambridge
Sune Olander Rasmussen[9], University of Copenhagen
Jørgen Peder Steffensen[10], University of Copenhagen
Jinho Ahn[11], Seoul National University

Abstract

Large magnitude volcanic eruptions are of great interest due to their substantial impact on the global climate. The reflection of incoming solar radiation by volcanic sulfate aerosols can induce temporary global cooling lasting several years by reflecting solar radiation through sulfate aerosols. The Millennium Eruption (ME), one of the biggest volcanic eruptions of the Common Era (CE), occurred in late 946 CE from Mt. Baekdu. Despite its large magnitude, temperature reconstructions based on tree rings have not revealed significant anomalies related to the eruption. The reasons for this lack of response are not fully understood and remain an active area of research. Here, we present glacio-chemical findings from the NGRIP1 (North Greenland Ice Coring Project) core. A shift from rhyolitic-dominant to trachytic-dominant tephra shards associated with the ME were identified and we suggest that this transition occurred within 86 days. The absence of a significant sulfur mass-independent fractionation signal and the lack of a substantial temporal delay between insoluble particles and sulfur concentration in the NGRIP1 core suggest that the aerosol transport of the ME was confined to the upper troposphere/lower stratosphere. Besides the fact that the eruption occurred during winter, we attribute the observed absence of temporary global cooling to the limited or negligible amount of stratospheric sulfur released during the ME.

Keyword

Millennium Eruption, Sulfate, Multiple sulfur isotopes, Mt. Baekdu

Greenhouse gas (CO2, CH4) alteration in shallow ice of Larsen blue-ice area, northern Victoria Land, East Antarctica

Giyoon LEE[1]*, Seoul National University (giyoon80@naver.com)
Jinho Ahn[2], Seoul National University
Ikumi Oyabu[3], 1. National Institue of Polar Research 2. Polar Science Program, Graduate Institute for Advanced Studies, SOKENDAI
Changhee Han[4], Earth System Science Reseach Center, Yonsei Univsersity
Kenji Kawamura[5], 1. National Institute of Polar Research 2. Polar Science Program, Graduate Institute for Advanced Studies, SOKENDAI 3. Japan Agency for Marine-Earth Science and Technology (JAMSTEC)
Sangbum Hong[6], Division of Glacial Environment Research, Korea Polar Research Institute

Abstract

The precise reconstruction of past atmospheric greenhouse gas (GHG) concentrations, including CO2 and CH4, from polar ice cores is crucial to understand the climate system of the Earth. Hence, it is important to examine potential mechanisms for altering GHG concentration within polar ice cores. In recent observations, it has been found that shallow ice (<10 m) from blue-ice areas (BIAs) in Antarctica has shown higher concentrations of CO2 and CH4, as well as lower levels of CH4 compared to other unaltered ice core records of the same gas ages. However, the mechanisms of GHG alteration within shallow ice cores are poorly understood. We aim to decipher the processes of GHG alteration in the shallow ice from Larsen BIA. The CH4 concentration records of the shallow ice core from Larsen BIA generally show an increasing trend from the subsurface to a depth of around 0.35–1.15 m. Afterward, the concentration gradually decreases until it reaches the levels corresponding to ancient atmospheric CH4 values at around 4.6 m depth. In contrast, CO2 concentrations exhibit a gradual decrease from the subsurface until a depth of approximately 4.6 m where the concentration variation stabilizes, but still has a 10–20 ppm difference with other existing unaltered ice core records. Here, we show that modern air/aerosol intrusion were not sufficient to explain the GHG alterations according to measurement results of δ15N-N2 and Pb isotopic ratio. Based on the depleted δ18Oatm measurement results of shallow ice, it appears that microbial respiration had not contributed to the increased CO2 concentrations. Instead, the rise might have resulted from a degradation of organic matter through photochemistry. In order to determine if the organic matter is indeed responsible for the increased levels of CO2, we will conduct measurements of the δ13C-CO2 in the surface ice of Larsen BIA. Additionally, to investigate the potential impact of photochemistry on the alteration of greenhouse gas (GHG) concentrations, we will expose ice samples to UV light and measure the concentration of GHGs within them.

Keyword

Greenhouse gas alteration, Ice core, Blue-ice area, Antarctica

Identification of the source of the 1458/58 CE bipolar volcanic event in the Vostok firn core using a novel quantitative approach for analyzing unpolished small (< 10 μm) glass shards

Seokhyun RO[1]*, Korea Polar Research Institute, Inha University (xenonist@kopri.re.kr)
Yoojin Lee[2], Inha University
Yeongcheol Han[3], Korea Polar Research Institute
Soon Do Hur[4], Korea Polar Research Institute
Chul-Un Ro[5], Inha University
Seungmi Lee[6], Korea Polar Research Institute
Hyejin Jung[7], Korea Polar Research Institute
Ahhyung Lee[8], Korea Polar Research Institute, Inha University
Gaheun Mun[9], Inha University
Sungmin Hong[10], Inha University

Abstract

The decade 1450 stands out as one of the coldest decades in the Northern Hemisphere during the Common Era (CE) as a consequence of volcanic forcings of the second largest atmospheric sulfate event of the past millennium. Initially, this volcanic event was thought to be the result of the massive eruption of the Kuwae caldera, Venuatu, in 1452/53 CE as evidenced by acidity and sulfate peaks observed in both Greenland and Antarctic ice cores between 1450 and 1464 CE. This pronounced Kuwae eruption signal was also commonly used as a temporal marker for dating polar ice cores. However, based on recent well-chronologically constrained highly resolved sulfur concentration and records from Greenland and Antarctic ice cores, the bipolar sulfate peak has been dated to the year 1458/59 CE, which is not coincident with the Kuwae eruption that was previously assigned to the date of 1452/53 CE for this event. This suggests the need to revise the date of the Kuwae eruption to 1458/59 CE. However, the 1458/59 CE volcanic signal must be identified for the Kuwae eruption before its revision. This study examined the geochemical characteristics of cryptotephra in the ice associated with the pronounced 1458–1461 CE sulfate peaks from a firn core (VK22) drilled at Vostok Station (78.465°S, 106.835°E, 3,490 m above sea level) in the East Antarctic Plateau. The analysis was performed using a novel quantitative scanning electron microscopy coupled with energy dispersive X-ray spectrometry (SEM-EDX) technique that allows measuring < 10 μm-diameter glass shards without the need for the polishing process, which can be achieved by using Monte Carlo calculations combined with reverse successive approximations to determine X-ray intensities generated from individual elements within the glass shards. Then, the obtained geochemical signatures were compared with those of the Kuwae tephra deposits.

Keyword

Kuwae caldera, 1458/59 CE bipolar volcanic eruption, Cryptotephra, Vostok firn core,

quantitative SEM/EDX

Assessing Artificial Intelligence Techniques to Simulate Atmospheric CO2 Concentration from Antarctica Ice Core Records During MIS 1 to 5

Nasrin SALEHNIA[1]*, Seoul National University, School of Earth and Environmental sciences (salehnia61@gmail.com)
Jinho Ahn[2], Seoul National University, School of Earth and Environmental sciences

Abstract

Ice cores serve as a vital archive, recording atmospheric concentrations of Greenhouse Gases (GHGs) spanning the last 800 thousand years. Studying climate change by reconstructing and modeling atmospheric CO2 offers valuable insights to scientists striving to understand climate-carbon cycle interactions. The relationship between temperature and GHGs, as deduced from ice core data, has the potential to enhance the precision of simulating CO2 fluctuations. The objective of this study was to investigate modeling approaches for accurately forecasting atmospheric CO2 levels and addressing CO2 data gaps using methane (CH4) concentration and temperature proxies (δD and δ18O) derived from Antarctic ice cores, utilizing Artificial Neural Networks (ANN) and Wavelet Transform (WT) methodologies as a hybrid method. Two distinct ice core datasets were employed: The Dome Fuji (DF) core spanning 9-120 thousand years ago (ka), and the EPICA Dronning Maud Land (EDML) core covering the period from 70 to 115 ka. To evaluate the effectiveness of the hybrid model for DF, the training phase was conducted during Marine Isotope Stages (MIS) 1, 2, 4, and 5, followed by the simulation phase for MIS 3. The conclusive findings demonstrated a precise correspondence between the model and original CO2 data during the training phase, yielding an R2 of 0.98 and an RMSE of 4 ppmv. During the simulation phase corresponding to MIS 3, the model reproduced trends similar to those observed in the CO2 data. The R2 was recorded at 0.74, with an RMSE of 6.91 ppmv. For the EDML core, during the training phase, CO2, CH4, and δD data from MIS 5a-MIS 5b and MIS 5d were utilized. Subsequently, the developed hybrid model was applied to simulate the CO2 concentration during MIS 5c. The results revealed an R2 value of 0.54 and an RMSE of 8.78 ppmv based on the training phase. The simulated phase confirmed an R2 of 0.47 and an RMSE of 3.31 ppmv. This study demonstrated the efficacy of utilizing AI techniques to simulate past climate CO2 concentrations based on ice core records.

Keyword

Marine Isotope Stages, Wavelet Transform, Artificial Neural Networks, temperature proxy, Methane

Dating of a coastal East Antarctic ice core by using high-resolution impurity records and reconstruction of historical snow accumulation variability

Seokhyun RO[1]*, Korea Polar Research Institute, Inha University (xenonist@kopri.re.kr)
Yeongcheol Han[2], Korea Polar Research Institute
Sang-Bum Hong[3], Korea Polar Research Institute
Soon Do Hur[4], Korea Polar Research Institute
Songyi Kim[5], Korea Polar Research Institute
Jangil Moon[6], Korea Polar Research Institute
Chaewon Chang[7], Korea Polar Research Institute
Seungmi Lee[8], Korea Polar Research Institute
Hyejin Jung[9], Korea Polar Research Institute
Minjeong Kim[10], Korea Polar Research Institute
Sungmin Hong[11], Inha University

Abstract

Temporal variability of snow accumulation rates (SARs) over Antarctica is closely linked with changes in the mass balance of the Antarctic ice sheet and ultimately in global sea levels. However, model-based long-term changes in the volume of Antarctic ice sheet remain poorly constrained mainly due to the limited amounts of spatial and temporal SAR records that can be provided by well-dated Antarctic ice cores. This study presents a comprehensive ice chronology for the top 108.6 m of a 210.5 m-deep ice core drilled at the Styx Glacier plateau (SGP; 163^0 41.22′E, 73^0 51.10′S; 1,623 m above sea level) in northern Victoria Land, East Antarctica. The ice chronology for the top 98.5 m, covering from 1259 to 2013 CE, was established by counting annual layers of highly resolved impurity records (non-sea-salt SO4 (nssSO4), nssSO4/Na, Na, and meltwater conductivity). The manual layer counting result was further constrained by using well-known time markers of two 239Pu peaks associated with large-scale atmospheric nuclear tests and 14 volcanic events identified by pronounced nssSO4 peaks. Meanwhile, as counting layers is difficult in the deep part of the ice core (98.5–108.6 m), the deep part that covers the time frame of 1150–1259 CE was dated using an age-dating model based on absolute age tie points of 239Pu peaks, volcanic events, the Rittmann tephra layer at a depth of 99.2 m, assigned to be 1252 CE, and gas chronology. The maximum dating uncertainties are estimated to be ± 8 years for the top 98.5 m and ± 10 years for the deep part of the core. The precise ice core chronology achieved by counting annual layers in combination with absolute dating of radioactivity peaks and volcanic events has allowed us to reconstruct historical SAR variability at the SGP over the past 755 years. The water equivalent annual mean SAR was estimated to be 113 ± 39 mm and showed an overall long-term increasing trend with inter- to multi-decadal fluctuations. Future study will provide deeper insights into various climatic drivers that led to variability and trends in historical snow accumulation at different temporal scales at the SGP.

Keyword

East Antarctica, Styx Glacier, Age dating, Snow accumulation rate

Geochemical characterization of East Siberian ice wedges : Implications of their origin and paleoenvironment

Subon Ko[1]*, Yonsei University (rhtnqhs8@yonsei.ac.kr)
Jinho Ahn[2], Seoul National University
Alexander Fedorov[3], Melnikov Permafrost Institute
Giehyeon Lee[4], Yonsei University

Abstract

Ice wedges in permafrost are subsurface ice structures that have been considered to be formed by frozen natural precipitation mixed with airborne dust and soil particles. This mixture then flows through the active layer into the cracks and grows by repeated thermal contractions in the deeper permafrost layer over time. Recently, ice wedges receive growing attention as archives for reconstructing paleoclimate and paleoenvironment due to their more widespread distribution and remarkably higher solute and solid concentrations compared to those of glacier ice cores. In this study, the paleoenvironmental conditions during ice wedge formation and the origin of both ice wedges and their solid particles were investigated. For these, we obtained ice wedges samples collected from Cyuie, Churapcha, and Zyryanka in East Siberia by the Laboratory for Ice Core and Paleoclimate at Seoul National University.

The geochemical properties of the ice wedge samples were characterized by analyzing the pH, electrical conductivity (EC), alkalinity, solid content, and dissolved ion concentrations after melting the samples. The solid particles trapped in the samples were also analyzed for their mineralogy (X-ray diffraction), chemical composition (X-ray fluorescence and inductively coupled plasma mass spectrometry), particle morphology (scanning electron microscope), and the types and composition of Fe- and Mn-solid phases (X-ray absorption fine structure). The relative ratios among the solute concentrations of the ice wedge samples were significantly different from those in common natural precipitation but comparable to those of general soil porewaters, indicating that the ice wedge samples were not simply originated from the natural precipitation but likely substantially affected by the chemistry of the surrounding soil. In addition, various geochemical proxies, sortness, and roundness of the solid particles successfully implicated their provenance, proximity from the source rocks, and the paleoenvironmental conditions. This study provides basic information on the origin of ice wedges and their solid particles and thereby understanding the paleoenvironmental conditions during the ice wedge formation.

Keyword

ice wedge, permafrost, paleoenvironment, origin, provenance

[Keynote] Microplastics and nanoplastics in groundwater: the essential role of the hydrogeologists

STEFANO VIAROLI[1]*, University of Pisa (stefano.viaroli@unipi.it)

Abstract

Micro and nanoplastic (MNP) pollution is receiving a growing interest in environment due to its pervasiveness and persistence. In the beginning, the MNP research focused on oceans and fresh-water bodies due to their convenient accessibility and evident contamination levels.

Groundwater was not initially studied as it was considered protected by the filtration mechanisms occurring in soils and aquifers. The first experimental article that testified the presence of MNPs in groundwater was published only in 2019. From that year onwards, only a limited number of publications presented data about MNPs contaminating the groundwater. The literature results are difficult to compare due to different sampling and treatment procedures as heterogeneous hydrogeological settings. Some studies in fact focus on the possible MNP contamination of deep aquifers tapped for drinking purposes, while others investigate MNPs in shallow aquifers for environmental research.

Future development of the MNP research will follow three main directions: assessing the exposure and the toxicology risk of the MNPs for human, animals, and plants (I), improvement of the analytical techniques to easily detect nanoplastics (II), environmental analyses about MNP contamination and mobilization dynamics (III).

The first two research topics mostly deal with toxicologists, chemists, and physics. Hydrogeologists may provide their valuable contribution in environmental studies, especially characterizing the MNP contamination in groundwater. Infiltration, transport, and dispersion of MNPs in groundwater mainly depends on the hydrogeological setting of the subsoil and the sources of contamination related to the human activities.

At the current stage, the characterization of MNP contamination is mostly limited to the sampling points with few attempts defining the areal distribution. Future research on MNP contamination of groundwater should be expanded up to the catchment scale. The definition of the hydrogeological conceptual model of the studied aquifer is therefore essential to understand the main discharge directions of the aquifer and the surface waters – groundwater relationships. The hydrogeological scheme, combined with the characterization and quantification of MNPs, might provide a more comprehensive understanding of their dynamics.

Keyword

Microplastics, contamination, groundwater

A Comprehensive Analysis of How Drought Affects Groundwater Microplastics

WAINKWA CHIA Chia ROGER[1]*, Kangwon National University
(wainkwa2020@kangwon.ac.kr)
Jin-Yong Lee[2], Kangwon National University
Jihye Cha[3], Kangwon National University
Venant Atem Ntegang[4], Kangwon National University

Abstract

The world currently faces four major problems: environmental pollution, hunger, health and drought. Among these issues, two that geologists are now concerned about are microplastic (MP) contamination of groundwater and drought. This is because groundwater plays a significant role in providing tap water in urban and rural regions and in meeting the global community's water demands. Additionally, MPs have been found and documented in groundwater around the world. However, to the best of my knowledge, there haven't been many studies on how drought contributes to and affects the occurrence of MPs in groundwater environments. Therefore, the purpose of this study is to verify the impact of drought on MP distribution in groundwater. An extensive analysis of original research from 2016 to 2024, documenting sources of changes in MPs in groundwater, was performed using PubMed, Web of Science, and Google Scholar. The findings of this investigation demonstrated that drought significantly enhances direct sources of MP contribution, such as wastewater treatment effluents, landfills, plastic mulching, and land application of biosolids, more than indirect sources, which include atmospheric deposition, biodegradation, weathering and fragmentation, and runoff from surfaces lined with plastic. Further research is necessary to study the mechanisms associated with drought's influence on groundwater MP contamination, based on the results of this study. This work was supported by the Research Institute for Earth Resources through the Basic Science Research Program of the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

Ground microplastic, Drought, Plastic mulching, Atmospheric deposition, Runoff

Microplastic pathways into bedrock aquifers: focusing on groundwater well management in Korea

Eunju JEONG[1]*, Kangwon National University (jej8377@kangwon.ac.kr)
Hyobin Lee[2], Kangwon National University
Jiwook Jang[3], Kangwon National University
Jin-Yong Lee[4], Kangwon National University

Abstract

Previous research has shown that microplastics exist in groundwater. Meanwhile, there are still uncertainties regarding microplastic contamination in bedrock aquifers, which are often overlooked in favor of porous aquifers. Despite the perceived difficulty of microplastic infiltration into deep bedrock aquifers, our previous and related studies have surprisingly detected these particles at depths exceeding 100 meters. We suggest three main pathways of microplastics into bedrock aquifers: vertical infiltration through the interface between weathered rock/unconsolidated aquifers and bedrock aquifers(in Korea, the unconfined aquifers are common, and it is common for screens in bedrock groundwater wells to extend from the weathered rock to the bedrock aquifers to ensure an abundant supply of groundwater), direct enter through the entrance of the groundwater wells due to the absence of well cap, and corrosion of groundwater wells made of plastics. To support these suggestions, we compared the distribution of microplastics based on hydraulic connectivity between bedrocks and overlying weathered rock/unconsolidated aquifers, as well as groundwater well specifications. Our analysis of microplastic concentration, size, shape, polymer type, and specific surface area highlights the potential impact of aquifer characteristics on their distribution. Microplastics can exceed the typical size range commonly detected in groundwater (the size commonly detected in groundwater is <100 um) when they are introduced directly through well entrances or generated from corrosion of plastic well materials. Additionally, if a significant amount of microplastics identified aligns with the groundwater well materials, it suggests that it was generated from long-term groundwater well corrosion. Our insights provide a clearer understanding of microplastic distribution in bedrock groundwater. This understanding highlights the consequences of inadequate groundwater well development and management, specifically the risk of microplastic contamination in bedrock aquifers. This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

Microplastics, distribution, pathways, bedrock aquifers, groundwater well management

Global Occurrence, Concentrations, and Characteristics of PFAS in Groundwater: A literature Review

Jihye Cha[1]*, Department of Geology, Kangwon National University, Chuncheon 24341, Republic of Korea (jihyecha98@naver.com)
Jin-Yong Lee[2], Department of Geology, Kangwon National University, Chuncheon 24341, Republic of Korea
Seunghoon Choo[3], Department of Geology, Kangwon National University, Chuncheon 24341, Republic of Korea
Rogers Wainkwa Chia[4], Research Institute for Earth Resources, Kangwon National University, Chuncheon 24341, Republic of Korea
Ntegang Venant Atem[5], Department of Geology, Kangwon National University, Chuncheon 24341, Republic of Korea

Abstract

This study presents a comprehensive review of worldwide research on the occurrence, concentrations, and characteristics of per- and polyfluoroalkyl substances (PFAS) in groundwater, conducted through literature searches on databases such as Google Scholar and Web of Science. PFAS and microplastics (MPs), known for their persistence and ecological toxicity, have become a global concern for environmental safety. By synthesizing the findings from diverse studies, we aimed to gain insights into the global trends of PFAS and MPs in groundwater. The literature review highlighted variations in PFAS and MPs concentrations, occurrence patterns, and specific compound characteristics across different geographical regions. Understanding the environmental factors influencing PFAS and MPs presence in groundwater was a key focus, and potential sources and transport mechanisms were explored. The results of this review contribute to a comprehensive understanding of the global distribution of PFAS and MPs in groundwater, shedding light on potential hotspots and areas of concern. We discuss the implications of varying geological and hydrological conditions on PFAS mobility and accumulation. Additionally, an analysis of different MPs and PFAS compounds and their distribution patterns provides valuable information for assessing environmental contamination sources. Our presentation offered insights into the global perspective of PFAS and MPs in groundwater, facilitating knowledge exchange and fostering discussions on potential mitigation and management strategies. We anticipate that this contribution will enhance awareness and collaborative efforts towards addressing the global challenges posed by PFAS and MPs contamination in groundwater. This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

PFAS, MPs, groundwater, toxicity

Risk of microplastic contamination in groundwater wells from plastic casings and pipes

Stefano Viaroli[1], Department of Earth Sciences, University of Pisa, Pisa, Italy
Michele LANCIA[2]*, Eastern Institute for Advanced Studies, Eastern Institute of Technology, Ningbo, China (lancia@eitech.edu.cn)
Jin-Yong Lee[3], Department of Geology, Kangwon National University, Chuncheon, Republic of Korea
Yujie Ben[4], Southern University of Science and Technology, Shenzhen, China
Roberto Giannecchini[5], Department of Earth Sciences, University of Pisa, Pisa, Italy
Valter Castelvetro[6], Department of Earth Sciences, University of Pisa, Pisa, Italy
Riccardo Petrini[7], Department of Earth Sciences, University of Pisa, Pisa, Italy
Chunmiao Southern University of Science and Technology, Shenzhen, China Zheng[8], Southern University of Science and Technology, Shenzhen, China
Viviana Re[9], Department of Earth Sciences, University of Pisa, Pisa, Italy

Abstract

Pollution caused by micro- and nanoplastics (MNPs) is increasing attention in environmental research due to its widespread presence and persistence. The MNP investigations in groundwater suffer from the absence of common protocols for sampling and analysis as already faced by surface water research. To avoid potential contamination, the use of plastic tools and devices has been refrained during all the research steps (sampling, collection, treatment, and analysis). This plastic-free approach, however, limits the realization of groundwater studies. Groundwater well casings, pipes, gaskets, and other tools of hydrogeological practice are often made of plastic. In addition, groundwater observations are limited to monitoring wells (MWs) and water wells (WWs) that are usually few and heterogeneously distributed throughout a study area.

The construction schemes of MWs and WWs are various and depend on the hydrogeological context and the economic budget. MWs and WWs are often constructed with polyvinyl chloride (PVC) casings and pipes due to their convenient cost-quality ratio but pose concerns about their use within MNP research. Via a literature analysis, it is demonstrated that there is no evidence of large contamination of the groundwater samples from the PVC casings and pipes. Therefore, these wells could be strategic in future MNP investigations. Our statistical analysis of the available data suggests that a PVC concentration higher than 6% may require additional investigations (e.g. additional purging of the well, visual inspection of the MNPs, and fragment size analyses) in MWs and WWs with PVC casings. Proposed suggestions can aid in the planning of environmental research in groundwater, enhancing the comprehension of the MNP transport in aquifers.

Keyword

microplastics, contaminants of emerging concern, sampling, hydrogeology, pollution

Comparative adsorption characteristics of Pb and Cd by microplastics based on particle size

Taejung Ha[1]*, Pukyong national university (taejung_ha@pukyong.ac.kr)
Changmin Kim[2], Pukyong national university
Junyong Heo[3], Pukyong national university
Minjune Yang[4], Pukyong national university

Abstract

Microplastics, with a particle size of less than 5 mm, persist in aquatic environments, adsorbing heavy metals and potentially impacting human health through the food chain. As annual demand for microplastics continues to rise, especially with High-density polyethylene (HDPE) production accounting for 12.5% of global plastic production, understanding their interactions with pollutants has become increasingly urgent. This study evaluates the adsorption characteristics of lead (Pb) and cadmium (Cd) on microplastics, focusing on the impact of particle size. HDPE microplastics were categorized into three groups based on size: Group 1 (2.5–1.0 mm), Group 2 (1.0–0.3 mm), and Group 3 (< 0.3 mm). The specific surface area of these microplastics was measured using BET (Brunauer, Emmett, Teller) analysis. Following adsorption experiments with Pb and Cd at different concentrations (0, 0.5, 1, 5, 10, and 30 mg/L), the results were analyzed using ICP-OES (Optima 7000 DV, Perkin Elmer) at the Integrated Analytical Center for Earth and Environmental Sciences. The data were then evaluated utilizing the Langmuir, Freundlich, and Sips adsorption isotherm models. The Sips model ($R^2 > 0.97$) most suitably represented the adsorption behavior of Pb and Cd across all groups. The results showed that smaller particle sizes correlate with higher specific surface areas, in the order of Group 3 > Group 2 > Group 1, and an increase in adsorption capacity. Specifically, Group 3 showed the highest adsorption rate constant (Kf) and adsorption intensity (n^{-1}) for both heavy metals (Pb Kf: 0.028 mg1-1/nLn/g, Pb n^{-1}: 0.225, Cd Kf: 0.031 mg1-1/nLn/g, Cd n^{-1}: 0.178), confirming the influence of particle size on adsorption capacity. Although Pb and Cd demonstrated comparable adsorption capacities in HDPE, Pb showed higher adsorption than Cd in Group 3. The results of this study showed differing adsorption mechanisms for Pb and Cd in HDPE with the particle size of microplastics and the type of heavy metal being significant factors in adsorption efficiency. Given that microplastics can serve as carriers for heavy metals, further research into environmental factors (such as pH, and temperature) affecting adsorption is necessary.

This research was supported by Korea Institute of Marine Science & Technology Promotion(KIMST) funded by the Ministry of Oceans and Fisheries(20220252).

Keyword

Microplastics, Heavymetal, Sorption, Aquatic environment

Soil and groundwater microplastic pathways and related impact on human health

Ntegang Venant Atem[1]*, Department of Geology, Kangwon National University, Chuncheon 24341, Republic of Korea (202316533@kangwon.ac.kr)
Rogers Wainkwa Chia[2], Research Institute for Earth Resources, Kangwon National University, Chuncheon 24341, Republic of Korea
Jin-Yong Lee[3], Research on Microplastics in Groundwater (RMPG), Kangwon National University, Chuncheon 24341, Republic of Korea
Jihye Cha[4], Research on Microplastics in Groundwater (RMPG), Kangwon National University, Chuncheon 24341, Republic of Korea

Abstract

Microplastics (MPs), particles smaller than five millimetres, pervade our surroundings have been recently identified even in crucial human organs like the liver, blood, and feces. While the last decade witnessed significant documentation of MPs in marine environments, researchers are now turning attention to their presence in the terrestrial ecosystems. However, there's a notable research gap regarding MPs in soil to groundwater MP occurrence and their potential impact on human health. So, in this study, data spanning from the year 2017 to 2023 and databases like Pubmed/Medline, Web of Science, Elsevier, SpringerLink, and Google Scholar, was examined. Also, through this study recent developments in understanding the movement of MPs through the food chain and assesses methodologies were employed to identify and measure MPs in soil and groundwater We observed that, MPs from the atmospheric deposition, agricultural practices, and urban runoff which infiltrate into the terrestrial and then groundwater environment has potential human health effects. Also, it was observed that MPs can traverse plant tissues, infiltrating various trophic levels and raising diverse health concerns, from toxicity to reproductive issues. Through this study, the interaction between MPs and human health was emphasized. Also, through this study, the need for further research to comprehend accumulation patterns and long-term impacts was emphasized. Urgent measures, including enhanced waste management practices, rigorous risk evaluations, and legislative initiatives, are essential to mitigate the dangers associated with MP exposure. This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

Microplastics, Pathways, Health effects, Groundwater

Seasonal dynamics of groundwater Arsenic pollution: A multivariate statistical approach of One-way ANOVA and Shannon entropy weight

Imran Khan[1]*, Department of Geology, AMU, Aligarh (imranalig.iitk@gmail.com)
Rashid Umar[2], Department of Geology, AMU, Aligarh

Abstract

This study primarily investigates the spatiotemporal variation in Arsenic (As) concentrations with its speciation and influencing mechanisms, including chemical behaviors of selected physicochemical parameters (pH and Eh) in parts of the Ghaghara River basin, India. A novel tool, Shannon's Entropy-Weighted Heavy Metal(loid) Index (EW-HMI), has been employed, together with a critical analysis of the conventional pollution indices to quantify groundwater pollution at each of the monitoring sites. Measured As concentrations show that around 55% and 47% of groundwater samples have increased levels (>10 µg/L; WHO) for pre- and post-monsoon seasons, respectively. The results obtained through One-way ANOVA analysis indicate a significant seasonal difference in the mean concentrations of As. This seasonal variation is primarily attributed to the dilution effect due to significant monsoonal recharge of groundwater. The correlation between As and pH revealed an unexpected lack of a substantial relationship during both seasons. Similarly, the correlation between As and redox potential (Eh) was weak during both seasons, suggesting the existence of anaerobic conditions in the shallow aquifers of Bahraich, India. Moreover, results of As(III) and As(V) speciation suggest that around 68% of samples had higher As(III) values than As(V), revealing a noteworthy risk of As(III) toxicity, which is more harmful to human health. GIS-based spatial distribution maps highlight regions along the Ghaghara River, such as Mahasi, Shivpur, Phakharpur, Kaisarganj, and Visheshwarganj blocks are more prone to higher As pollution compared to other regions.

Keyword

Alluvial aquifer, Metal(loid)s, Spatial distribution, Arsenic speciation, Hydrogeochemistry

Appraisal of groundwater quality for drinking and irrigational purposes from parts of Warora tehsil, Chandrapur district, Maharashtra state, India.

Alka Kumari MISHRA[1]*, Geological Survey Of India (alka.mishra@gsi.gov.in)
Jaya Rashtrapal Chavhan[2], Geological Survey Of India
Niketan Prakash Khedkar[3], Geological Survey Of India

Abstract

Groundwater is the primary source for domestic, agricultural and industrial uses in many countries, and its contamination has been recognized as one of the most serious problems. In India, most of the rural and urban areas are dependent on groundwater for drinking and irrigational needs, and overexploitation has placed significant strain on the quality and quantity of groundwater resources. Maharashtra is the third largest state of India and about 58% of the state's population is in rural areas, 80% of whom are dependent on agriculture for their livelihood.

Various studies have shown that the drinking water in different parts of Chandrapur district, has high fluoride content. In such scenario, knowledge of irrigation water quality is critical for the understanding of management changes that are necessary for long-term productivity. Meanwhile, concentration of major ions and other parameters like Fluoride, Nitrate, Arsenic etc, that are hazardous to human health needs to be evaluated for providing safe drinking water. Hence an attempt has been made in the present study to demarcate the quality of irrigation water as well as its suitability for drinking purpose. For this reason, a total of 248 groundwater samples were collected from parts of Warora area, Chandrapur district in order to evaluate its suitability for drinking and irrigation purposes.

The suitability of groundwater for irrigation was evaluated with the help of sodium adsorption ratio, percent sodium, residual sodium bicarbonate, magnesium ratio and Kelley's. Wilcox plot was used to determine the viability of water for irrigation purposes. Based on different irrigational indices and Wilcox plot, all groundwater samples were found to be suitable for irrigation purposes. Wilcox plot made for the study area shows that the most of the water samples have medium to high sodium hazard with low salinity hazard such type of water can be used only on soils with adequate drainage and special management for salinity control may be required. Plants with good tolerance for high salinity should be selected. In case of salinity hazard, low salinity water (C1) can be used for irrigation with most crops on most soils with little chances of soil salinity development.

To understand the quality of water for drinking, a rating parameter known as Water Quality Index (WQI) was calculated. WQI gives an overall idea by considering the contribution of different parameters like pH, TDS, Total hardness, Ca2+, Mg2+, HCO3-, NO32-, Cl-, SO42-, F-, Fe and Mn. Since the other contaminants are well within the acceptable BIS limit of drinking water, those were not taken into consideration for calculating WQI. With value index of 71.48, the groundwater of the study area falls under Poor category of Water quality for drinking purposes and purpose it is observed that untreated groundwater of the study area is not suitable for

consumption as drinking water.

Keyword

Groundwater, Drinking, Irrigation, Water Quality Index, Wilcox plot

Kinetic, Thermodynamics and Equilibrium studies on adsorption of perchlorate ion on SIR-110-HP resin in groundwater.

BHAGIRATHI BEHERA[1]*, Geological Survey of India,NER,Chemical Division,Shillong,Meghalaya, India (bhagirathi.behera@gsi.gov.in)
Mira Das[2], ITER,SOA University,Bhubaneswar,Odishay

Abstract

The adsorption of perchlorate ion on SIR-110-HP resin in groundwater was investigated using batch experiments and mechanisms were drawn by using sophisticated instrument like, FTIR, Ion Chromatography, XRD and SEM etc. The effects of various parameters such as different pH, contact time of different concentration, coexisting anions were studied. The kinetics data signifies that the perchlorate adsorption process reached equilibrium within 60 min of adsorption. Removal of perchlorate was 98% even if pH varies from 3 to 10.The rate of adsorption at different pH is as in the order: 3pH>5pH>7pH>8pH>10pH. The removals of perchlorate from groundwater were above 99% at 60 min at even 3 pH, whereas 54%, 36%, 32%, 30% at different pH i.e. 5, 7, 8 and 10 at 60 min respectively. Major anions present in ground water reduced perchlorate adsorption on resin in the order of NO3->Cl->SO42-. In presence of nitrate, chloride and sulphate the removal efficiency of perchlorate ion decreased from 24.98 mg/g to 1.5 mg/g, 11.24 mg/g and 15.26 mg/g respectively. In pseudo second order kinetics value of qe(exp) (mg/g) and qe (cal) (mg/g) are very close to each other for all concentration where as difference value between of qe(exp) (mg/g) and qe(cal) (mg/g) are very large for all concentration of pseudo first order kinetics. Hence kinetics studies shows that adsorption followed pseudo second order kinetic model with coefficient correlation R2=0.99 with different concentration. The values of mean free energy (E) in D-R isotherm model were found 2.357, 2.357 and 2.5KJmol-1 at 25°C, 30°C and 35°C respectively which is E < 8 KJmol-1 that indicates adsorption is physical adsorption. The sorption values (1/b) in Elovich model are in erratic in nature and all points are not passes through line and origin. Hence data of Dubinin-Radushkevich and Elovich isotherm model indicates that the adsorption of perchlorate ion on SIR-110-HP resin was physical adsorption along with ion exchange. The negative ΔG° values indicated that the adsorption of perchlorate on anion exchange resin was thermodynamically feasible and was a spontaneous process. The positive values of ΔH° and ΔS° confirmed that the adsorption of perchlorate on resin was an endothermic process in nature and the randomness degree at the solid and liquid interface increases after adsorption. The value of activation energy (Ea) of adsorption of different concentrations varies from 2.8 to 15.01KJ/mol which is < 40 KJ/mol that shows adsorption is physical adsorption. The good fit of the experimental data and the values of correlation coefficients (R2) indicated the applicability of Langmuir model to perchlorate adsorption in the present study and also satisfied the condition of 0<RL<1. The perchlorate was adsorbed mainly in the form of monolayer coverage on the surface of the adsorbent means resin (SIR-110-HP).

Keyword

Adsorption, SIR-110-HP resin, Perchlorate ion, Isotherm

Groundwater based drinking water scarcity: a geomorphological approach

Bhagyashri Chandrakant MAGGIRWAR[1]*, Savitribai Phule Pune University / Groundwater Surveys and Development Agency (bhagyashri.maggirwar@gmail.com)
Milind Herlekar[2], Savitribai Phule Pune University

Abstract

Karha River basin is a semi-arid catchment where groundwater is the main source of drinking, domestic and agriculture use. Increasing water demands for these purposes leads to increased use of groundwater extraction. Moreover, the catchment in basaltic hard rock terrain puts on limitations on the availability of groundwater. The situation gets aggravated by the erratic and scanty rainfalls. The groundwater availability is mostly catered through the open large diameter dug wells by tapping the phreatic aquifer. Every year, the terrain faces water scarcity that puts a lot of stress on the government functionary. It needs to be addressed though an early warning system so that the government can timely plan the mitigation measures. It calls for an advanced and more precise tool for efficient management of groundwater resources. The study considers the geomorphological parameters to develop a model that can highlight the hotspots and vulnerable areas. It is found that the basaltic hard rock terrain has the influence of drainage density and slope.
In the catchment area, the drainage density was observed to range from 0.00 to 7.44 km km-2. The number of cells and drainage density are plotted according to a normal distribution. The area has been reclassified into three distinct zones based on this distribution. Additionally, each density zone's groundwater recharge has been calculated using data from the observation wells. Lower groundwater recharge in the high density zone and a progressive increase in recharge as the drainage density lowers are shown in the plot of mean groundwater recharge against low, moderate, and high density classes. A substantial association (R2= -0.943) between groundwater fluctuation and drainage density is supported by a scatter-plot of the groundwater fluctuation between and after the monsoon season.
This observation is taken into account in the current study as one of the contributing factors to the scarcity of drinking water. The risk of inadequate groundwater recharge leading to early drying up of drinking water sources or poor groundwater yielding is greatly reduced by the spatiotemporal heterogeneity of drainage density and groundwater depletion that this study produced. Therefore, drainage density should be included to enhance shortage prediction and support water management decision-making, as it is a crucial indicator of groundwater availability in hard rock terrain.

Keyword

Geomorphology, Groundwater, Karha River Basin, Western India

Groundwater salinization in the dry zone of Sri Lanka and its impact on food security and livelihood: A case study from the Medderambawa cascade irrigation system

Chirath CHANDRARATHNA[1]*, Department of Geology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka (chirathc@outlook.com)
Sachintha Senarathne[2], Friedrich-Alexander-Universität Erlangen-Nürnberg (FAU), Department Geographie und Geowissenschaften, 91054, Erlangen, GeoZentrum Nordbayern, Schlossgarten 5, Germany
Indrajith Gamage[3], National Water Supply and Drainage Board, Ratmalana, Sri Lanka
Rohana Chandrajith[4], Department of Geology, Faculty of Science, University of Peradeniya, Peradeniya, Sri Lanka

Abstract

Groundwater is the only reliable water source in rural areas of South Asia, which are considered vulnerable to the impacts of climate change. Among South Asian countries, Sri Lanka is one of the regions where groundwater resources will be severely affected by climate change scenarios. In Sri Lanka, groundwater is vital as over 90% of the arid rural population relies solely on domestic and agricultural purposes. In recent years, groundwater salinization has been reported in several regions, notably in drier areas, with severe impacts on agriculture and domestic water supplies. This study used geochemical and statistical approaches to identify the primary sources of salinization, selecting the highly salinized Medderambawa irrigation system in the northwestern dry zone of Sri Lanka. Groundwater samples were collected from 25 wells, and geochemical parameters, including trace elements and stable water isotopes (δ2H and δ18O), were analyzed. The electrical conductivity (EC) of the groundwater varied between 398 and 7920 µS/cm (mean = 1762 µS/cm). Accumulations of Na-Cl-type water were identified, particularly in regions with large-scale agricultural activities. In contrast, Na-HCO3, Ca-Mg-Cl and Ca-HCO3 type water were predominant in the surrounding areas. The EC showed a significant positive correlation with Na (r=+0.90) and Cl (r=+0.97) contents, indicating their dominance in groundwater geochemistry. 48% of wells exceeded the maximum allowable fluoride level (1.0 mg/L), posing a significant risk of fluoride-related health problems in communities. 36% of samples exceeded the guideline value for Mn (100 µg/L). Other trace elements, such as Al, Cd, Cr, Se, As, and Pb, remained below their guideline values. 72% of samples exceeded the maximum allowable hardness levels (250 mg/L) for drinking purposes. The Water Quality Index calculation showed that 36% of groundwater samples were unsuitable for human consumption. The sodium adsorption ratio (SAR) varied from 0.50 to 141, while 20% of samples belonged to the SAR categories of high and very high. The groundwater is oversaturated with calcite, aragonite and dolomite and undersaturated with gypsum, anhydrite and halite. The δ2H and δ18O compositions of groundwater varied from -39.8 to -7.43‰ and from -6.23 to -0.36‰, respectively. Water Isotope pointed out that most highly saline groundwater is directly recharged by rainfall without further modification, as shown on the local meteoric water line (δ2H=8.95δ18O + 15.1, r = 0.95). Results of this study suggest that the

dissolution of aquifer materials causes groundwater salinity in the region, while chloride is derived mainly from fertilizers. Large-diameter shallow wells constructed for irrigation can increase soil salinization due to regular fluctuations in groundwater levels. Currently, some groundwater in the region is unsuitable for agricultural purposes due to high SAR levels (>9), suggesting a risk of developing harmful levels of exchangeable Na. Deterioration in groundwater quality significantly affects the livelihoods of rural populations and has a negative impact on food security in the region. To address the problem and increase the resilience of rural communities to climate variability, the introduction of salt-tolerant crops and artificial recharging of groundwater are recommended.

Keyword

Salinization, Dry Zone, Water Quality, Food Security, Climate Change

Hydrogeochemical Assessment of Groundwater Quality in N'kapa, Littoral Region Cameroon: Implications for Sustainable Domestic, Agro-Industrial, and Irrigation Use

Virgine Ajindong EBIA[1]*, University of Buea (virgineebia@gmail.com)
Ngai Nfor Jude[2], University of Buea
Kenah Rosemary Ziah[3], University of Buea
Wotany Engome Regina[4], University of Buea

Abstract

This study investigates the hydrogeochemical characteristics of groundwater in N'kapa, Cameroon, with a focus on its suitability for domestic, agro-industrial, and irrigation purposes. Employing hydrogeochemical tools and physicochemical parameters, including Gibbs diagrams, Piper diagrams, Durov diagrams, and water quality indices, 20 groundwater samples were collected from boreholes for analysis.

Results indicate that Electrical Conductivity (EC), Total Hardness (TH), and Total Dissolved Solids (TDS) fall within WHO-permissible ranges. However, pH levels consistently exceed WHO limits. Major ion concentrations generally adhere to guidelines, except for nitrate (NO_3^-) levels, which exceed limits in 15% of the samples. The abundance sequence of major ions reveals $Na^+ > Ca^{2+} > K^+ > Mg^{2+}$,$Cl^- > HCO_3^- > SO_4^{2-} > NO_3^-$. Hydrogeochemical processes involve simple dissolution and ion exchange, contributing to ionic content from ion exchange and rock weathering. Dominant water types are Na-Cl (80%) and Mixed Ca-Mg-Cl (20%).

Groundwater quality assessment for domestic and drinking purposes using parameters like pH, EC, TDS, TH, and groundwater quality index (GWQI) indicates that 90% of samples have good quality, except for pH levels. For agro-industrial purposes, parameters such as residual sodium carbonate (RSC), plasticity index (PI), magnesium absorption ratio (MAR), and sodium absorption ratio (SAR) suggest suitability, though soluble sodium percentage (SSP) and Kelly's ratio (KR) exceed set limits in 55% and 70% of samples, respectively. The Wilcox diagram suggests excellent to good suitability for irrigation.

Given N'kapa's status as a major agro-industrial zone in Cameroon and Central Africa, reliant on extensive irrigation-based agricultural initiatives, these findings have significant implications. Further research into the biological composition of groundwater in the area is recommended for a comprehensive understanding and sustainable management.

Keyword

Hydrogeochemical, Groundwater, Quality, Cameroon

Groundwater exploration for the development of agricultural irrigation in Wang Nam Yen District, Sa Kaeo Province

Chunintorn CHAMATHONG[1]*, Department of Groundwater Resources
(chunintorn@hotmail.com)
Kankanith Tumprasert[2], Department of Groundwater Resources
Sirikanlaya Chinklang[3], Bureau of Groundwater Resources Region 9

Abstract

Thailand is experiencing drought conditions due to the El Nino phenomenon, leading to decreased moisture levels in farmland crucial for cultivating key crops. More than half of the Thai population engaged in agricultural occupations. Surface water resources are inadequate for utilization during the dry season, making groundwater a vital substitute. The study area is situated in Ban Khlong Phatthana, Thung Maha Charoen Subdistrict, Wang Nam Yen District, Sa Kaeo Province.

The objective of this study was to explore hydrogeology and conduct geophysical surveys to select suitable areas with groundwater potential for the development of abstraction boreholes to be used in constructing irrigation systems for agriculture and to ensure food security. The approach began with the identification of regions experiencing repetitive drought challenges. The evaluation of the overall groundwater capacity utilized Geographic Information System (GIS), which the visualization of maps illustrating groundwater potential and water quality scaled at 1:50,000 were applied. Subsequently, one dimensional geophysical resistivity survey was conducted for mapping the groundwater depth and locating potential drilling sites in order to reduce potential risks during the borehole construction such as drilling into dry or low-yielding zones.

From the hydrogeological study, it was found that Ban Khlong Phatthana is supported by a Triassic Metasediment Aquifer, which provides a plentiful supply of groundwater. The water quality is within good standards, with a general discharge rate exceeding 20 m3/hour and a total dissolved solids (TDS) level below 500 mg/l. The geophysical survey employing the Schlumberger electrode setup involved conducting sounding measurements at 11 locations, each with a depth span of 100-150 meters. The data was then analyzed using IP2WIN software to determine the suitable drilling depth. Six boreholes were constructed in the area. The distribution system equipped with solar panels combined with a power generator and two water storage tanks with a capacity of 120 cubic meters each were installed. The groundwater quality assessment conducted in the Thung Maha Charoen Subdistrict revealed persistent high levels of total hardness. Additionally, elevated levels of nitrates and chloride were found in certain areas.

In summary, the Department of Groundwater Resources has delivered an irrigation system to local authorities and continued monitoring groundwater quality. Water quality in the study area remains suitable for agricultural use, though adjustments are needed for domestic consumption. Sustainable groundwater management relies on collaboration with all stakeholders.

Keyword

groundwater development, irrigation system, resistivity survey

Irrigation Groundwater Quality for Agricultural Usuability and food security: A case study of Mahakalpara block of Kendrapada District, Odisha.

SUSHANT KUMAR SAMAL[1]*, FAKIR MOHAN UNIVERSITY,BALASORE
(samalsusant85@gmail.com)
ROSALIN DAS[2], FAKIR MOHAN UNIVERSITY,BALASORE
SUSANTA KUMAR DAS[3], FAKIR MOHAN UNIVERSITY,BALASORE
MADHUMITA DAS[4], UTKAL UNIVERSITY,BHUBANESWAR

Abstract

In Mahakalpara Block, located in Kendrapada District, Odisha, an assessment was conducted on the suitability of groundwater for irrigation purposes. This region is defined by the Mahanadi River running along its southern border, eventually meeting the sea in the southeast, forming a significant floodplain. Before the monsoon season, groundwater samples were collected from thirty villages and analysed for major ions and various parameters including electrical conductivity, total dissolved solids, sodium absorption ratio (SAR), magnesium ratio, Kelly's ratio, sodium percentage, residual sodium carbonate, and permeability index. The predominant ion chemistry in groundwater consists of alkali cations and strong acidic anions, largely influenced by the aquifer's lithology. While the sodium absorption ratio (SAR) and residual sodium carbonate (RSC) indicate high suitability at 90% for irrigation, challenges are evident with unsuitable sodium percentage (Na%), Kelly's ratio (KR), soluble sodium percent (SSP), and magnesium ratio (MR) at 60%, 90%, 60%, and 50%, respectively. Despite a permeability index suggesting 100% suitability, elevated levels of electrical conductivity (EC), sodium (Na), and chloride (Cl) raise concerns, making Na%, KR, SSP, and MR unsuitable for effective irrigation. At the community level, promising interventions involve improving irrigation methods, enhancing floodplain management, and implementing regulations to curb saltwater aquaculture, thus addressing salinity issues. These findings emphasize the critical need for optimal management of irrigation groundwater to ensure sustainable agriculture. Furthermore, exploring innovative reclamation strategies like saline aquaculture integrated with subsurface drainage and integrated agricultural systems is essential. Prioritizing coming research efforts towards these approaches is imperative to uphold ensuring the sustainability of agriculture and global food security(GFS) in the face of challenges presented by climate change scenarios.

Keyword

salinity, irrigation, food security, agriculture

Geospatial Distribution and Health risk assessment of Fluoride in groundwater of Balasore district, odisha, India.

Utsav DAS[1]*, FAKIR MOHAN UNIVERSITY,BALASORE (utsavdas1992@gmail.com)
ROSALIN DAS[2], FAKIR MOHAN UNIVERSITY,BALASORE
SUSANTA KUMAR DAS[3], FAKIR MOHAN UNIVERSITY,BALASORE
MADHUMITA DAS[4], UTKAL UNIVERSITY,BHUBANESWAR
SHREERUP GOSWAMI[5], UTKAL UNIVERSITY,BHUBANESWAR

Abstract

The study focuses on assessing the health risks associated with fluoride contamination in drinking water in the fluoride-prone region along the east coast of Balasore district, Odisha, India. A total of 60 groundwater samples from Balasore block and Remuna block were collected and subjected to analysis using statistical, hydrogeochemical, spatial distribution, and health hazard risk assessment methods. Results indicate that approximately 92% of the samples collected and 96% of the study area exceed the permissible limits for fluoride concentration set by both the World Health Organization (WHO) and the Bureau of Indian Standards (BIS). The average health hazard quotients for infants, children, male adults, and female adults are 2.09, 2.42, 1.79, and 1.69 respectively, indicating varying levels of vulnerability to fluorosis, with children being particularly susceptible. Analysis of Ca2+/Na+ versus HCO3-/Na+ and Ca2+/Na+ versus Mg2+/Na+ ratios suggests that silicate weathering is the primary contributing factor to fluoride contamination, while the linear relationship between total dissolved solids (TDS) and NO3-(Cl-/HCO3-) supports anthropogenic inputs of fluoride into the aquifer system. The study proposes that fluoride ions primarily originate from minerals such as fluorite, apatite, biotite, and hornblende found in the Granitic basement, known as Nilgiri Granite, under alkaline conditions. Positive correlations between fluoride and Na+, HCO3-, and pH indicate the weathering of rock silicates, with increases in pH mobilizing fluoride ions. Geomorphologically, the study area is characterized by the Budhabalnga River, Sono River, and their tributaries, which continuously weather the underlying granitic basement. Secondary sources of fluoride contamination include domestic and industrial sewage, as well as irrigation return flow containing phosphate fertilizers. Mitigation strategies to minimize the harmful impact of fluorosis include mass awareness programs, alternative sources of potable drinking water, artificial aquifer recharge, defluoridation techniques, and reducing the use of phosphate fertilizers.

Keyword

FLUORIDE, FLUOROSIS, HEALTH HAZARD QUOTIENT, WATER POLLUTION

ASSESSMENT OF GROUNDWATER STORAGE ZONES FOR SUSTAINABLE AGRICULTURAL PRACTICES IN MAHARASHTRA STATE, INDIA USING GRACE SATELLITE DATA AND RS-GIS TECHNIQUES

BHAVANA NARENDRA UMRIKAR[1]*, SAVITRIBAI PHULE PUNE UNIVERSITY
(bnumrikar@gmail.com)
BHAGYASHRI Chandrakant MAGGIRWAR[2], Deputy Director

Abstract

Maharashtra state is dominantly occupied by Deccan Volcanic Basalt representing simple and compound flow units. These rocks possess secondary porosity due to weathering, fracturing and jointing imparting heterogeneity to the aquifer system vis-à-vis the availability of groundwater. The state frequently faces water scarcity issues wherein dependency on groundwater is more and therefore the characterization of this key resource is essential. Rainfall is the major source for aquifer recharge. Hence, rainfall-recharge relation has been decoded for the groundwater storage estimation to address the scarcity issues. The present study is performed using the Total Water Storage (TWS) data of the JPL TELLUS GRACE Level-3 Monthly Land Water-Equivalent-Thickness Surface Mass Anomaly in netCDF format to understand the fluctuation of groundwater levels and its correlation with rainfall. The thematic layers of geology, geomorphology, land use pattern, drainage, DEM, slope, NDVI and lineament density have been generated in GIS environment. The weighted overlay tool has been applied to the dataset and the resultant map has been correlated with the GRACE dataset using machine learning algorithm. The resultant map depicts that the groundwater storage is depleting in central Maharashtra due to overexploitation. The western Maharashtra region shows the availability of both surface and ground waters and large area under cultivation. The artificial recharge techniques are recommended in groundwater paucity region.

Keyword

Groundwater, GRACE data, TWS, Maharashtra, RS-GIS

Remediation Strategies for Elevated Iron Levels in the Lower Reaches of the Mahanadi Delta: A Comprehensive Review

SUHANI SRUJANIKA[1]*, Research Scholar, Department of Geology, Savitribai Phule Pune University, Pune (s.srujanika@gmail.com)
Bhavana Umrikar[2], Professor, Department of Geology, Savitribai Phule Pune University, Pune

Abstract

The Mahanadi Delta, situated on the eastern coast of India, grapples with significant challenges related to water quality, particularly regarding elevated iron levels in its lower reaches. Iron contamination in the delta's water sources poses substantial environmental and public health concerns. This abstract provides an overview of remediation strategies tailored to address the variability of iron concentration, Total Dissolved Solids (TDS), and Electrical Conductivity (EC) in the Mahanadi Delta basin. Analysis of water samples collected from various points within the basin revealed notable fluctuations in iron content, with concentrations ranging from 0.5 to 20.0 mg/L. Similarly, TDS levels exhibited variability, ranging from 100 to 7000 mg/L, while EC values ranged from 150 to 18000 µS/cm. Various remediation approaches, including filtration methods such as activated carbon and specialized iron removal filters, oxidation and filtration techniques employing aeration, chlorination, and potassium permanganate treatment, ion exchange resin systems, and reverse osmosis technology, are evaluated in the context of these observed variations. Additionally, the potential application of chemical treatments, magnetic treatment devices, and advanced membrane filtration processes such as ultrafiltration and nanofiltration is explored. The effectiveness of each remediation strategy is assessed considering factors such as water pH, iron concentration, and local environmental conditions. This comprehensive review aims to provide insights into sustainable solutions for mitigating iron contamination in the Mahanadi Delta, ensuring the preservation of water resources and the welfare of communities reliant on these vital ecosystems.

Keyword

Mahanadi Delta, Water contamination, Groundwater

Geochemical Processes Affecting Fluoride Mobilization in the hard-rock Aquifers of Central India: Implication for Ensuring fluoride-safe drinking water supply

Naved ALAM[1]*, Environmental Geochemistry Laboratory, Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research (IISER) Bhopal, Bhauri 462066 Madhya Pradesh, India (navedamu786@gmail.com)
Mohd Amir Husain[2], Environmental Geochemistry Laboratory, Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research (IISER) Bhopal, Bhauri 462066 Madhya Pradesh, India
Rakesh Singh[3], Central Groundwater Board, Government of India, Paryavas Bhawan, Bhopal 462027 Madhya Pradesh, India
Padam Kumar Jain[4], Central Groundwater Board, Government of India, Paryavas Bhawan, Bhopal 462027 Madhya Pradesh, India
Elisabeth Eiche[5], Institute for Applied Geosciences, Karlsruhe Institute for Technology, 76131 Karlsruhe, Germany
Harald Neidhardt[6], Geoecology, Eberhard Karls University Tübingen, Rümelinstrasse 19-23, 72070 Tübingen, Germany
Michael Marks[7], Institute of Geosciences, Eberhard Karls University Tübingen, Schnarrenbergstrasse 94 and 96, 72076 Tübingen, Germany
Manoj Kumar[8], Department of Microbiology, ICMR- National Institute for Research in Environmental Health, Bhopal, Madhya Pradesh, India
Ashis Biswas[9], Environmental Geochemistry Laboratory, Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research (IISER) Bhopal, Bhauri 462066 Madhya Pradesh, India

Abstract

Groundwater contamination by fluoride (F-) poses a significant threat to safe drinking water globally, yet our understanding of the processes involved by linking groundwater and aquifer material chemistry is limited. This study thus focuses on characterizing F-mobilization in the hard-rock aquifers of Central India, an area scarcely explored despite facing severe contamination issues. Through exploratory drilling and lithostratigraphic modeling (using Rockworks) of 45 boreholes, we identified water-bearing rocks, including weathered basalt, vesicular basalt, fractured basalt, sandstone of Lameta, and fractured granite. Groundwater and rock samples were collected from the Mandla district of Madhya Pradesh. Groundwater samples were categorized into aquifers using depth plan view maps of different depths using Rockworks. Major anion and cation analyses were done using IC and ICP-OES, respectively. Major ion and total F- analysis in rock samples were done by XRF and CIC (Combustion ion chromatography), respectively. Analysis revealed that F-contamination (concentration >1.5 mg/L) was confined to deeper depths (>35 m bgl) of fractured basalt and granite aquifers, while shallower basalt, sandstone of Lameta, and granite aquifers are safe. This depth-dependent distribution indicates that F-contamination isn't solely controlled by rock type but by the chemical evolution of groundwater along the flow path. Solute mass balance and mineralogical characterization revealed that silicate and carbonate

mineral weathering, consumed dissolved CO2, and increased pH (>8) in deeper aquifers played a significant role in fluoride release. F-mobilization was primarily attributed to ion exchange between OH- in water and structural F- in hydroxy-silicate minerals and fluorapatite. Additionally, ion exchange-driven fluorite dissolution might contribute to F- mobilization. Based on water quality and aquifer properties, the study suggests targeting the sandstone of Lameta and weathered/vesicular basalts (where Lameta occurs at greater depths) for an F-safe drinking water supply. Generally, focusing on shallow aquifers could be a viable strategy for ensuring F-safe drinking water in similar geological and environmental contexts elsewhere.

Keyword

Groundwater, Fluoride contamination, Mineral dissolution, Ion exchange

Application of Bio-waste derived adsorbent obtained from Acacia nilotica and Neolamarckia cadamba fruits for Removal of fluoride from drinking water

NARENDRA KUMAR[1]*, DEPARTMENT OF ENVIRONMENTAL SCIENCE, BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY, LUCKNOW, U.P., INDIA
(narendrakumar_lko@yahoo.co.in)
Aneet Kumar Yadav[2], DEPARTMENT OF ENVIRONMENTAL SCIENCE, SCHOOL FOR EARTH AND ENVIRONMENTAL SCIENCES, BABASAHEB BHIMRAO AMBEDKAR UNIVERSITY, RAEBARELI ROAD, LUCKNOW - 226025, UTTAR PRADESH, INDIA

Abstract

Globally ground water without any treatment serves as the prime source of drinking. However, its natural and anthropogenic contamination due to various ions is posing a growing threat to human beings. and Fluoride contamination in groundwater is a serious concern for millions of people globally. The dissolution of fluoride-containing rocks viz cryolite, fluorapatite, fluorspar, sellaite, fluorite, etc. are the primary sources of fluoride in groundwater. Further, it is released by iron smelters, coal-based thermal power plants, photovoltaic manufacturing units, and the ceramic industries. Excessive concentration of fluoride in drinking water causes skeletal as well as dental fluorosis besides several other illness issues. Over the last two decades, several methods have been explored and applied for the elimination of excessive fluoride from drinking water. Adsorptive removal of F- is considered to be inexpensive and widely applicable. In this study fruit waste of Acacia nilotica, and Neolamarckia cadamba were converted into activated biochar modified by magnesium and named as AN-MgB & NC-MgB, respectively. Both the Biochars were characterized by the scanning electron microscope (SEM), Energy dispersive X-ray spectroscopy (EDX), Fourier transform infrared spectroscopy (FTIR), X-ray diffraction (XRD), particle size analysis (PSA), and pHZPC for their chemical composition and morphology. The biochar was applied to remove fluoride from the solution prepared in groundwater. The de-fluoridation process was optimized in batch experiments against pH, temperature, fluoride concentration in the solution, dose of adsorbent, and contact time. The adsorptive behavior and adsorption mechanism of fluoride on the surface of biochar was checked by using the adsorption isotherms (Langmuir, Freundlich, and Temkin) and kinetics study (Pseudo first, second order, and intra-particle diffusion model) at various dosages and initial fluoride concentrations. The NC-MgB was found to be more efficient adsorbent compared to the AN-MgB. The de-fluoridation capacity of NC-MgB and AN-MgB was found to be 84 and 80 % with 10 mg/L of initial concentration, and at laboratory temperature (25-28oC) in 60 minutes, respectively. Langmuir adsorption isotherm and pseudo-second-order kinetics were found best fitted to both the adsorbent. Results give direction to the sustainable removal of fluoride from groundwater by the application of biowaste with some chemical modifications. Additionally, the utilization of biowaste shall also address solid waste management simultaneously. The tested process poses the potential for commercial application after few technological interventions.

Keyword

Fluoride, Groundwater, Defluoridation, Adsorption, Biowaste

Geological Influences on Water Quality: Implications for Agriculture and Food Security in the Athgarh Basin, Odisha

Shreerup GOSWAMI[1]*, Department of Geology, Utkal University, Bhubaneswar
(goswamishreerup@utkaluniversity.com)
Rosalin Das[2], Fakir Mohan University
Asim Amitabh Pradhan[3], Fakir Mohan University
Madhumita Das[4], Utkal University

Abstract

Water quality profoundly impacts agriculture and food security, particularly in regions with distinct geological formations. This study delves into the Athgarh Formation of Upper Godwana age within Odisha's Mahanadi master basin, spanning 4470 sq. km, which is bounded by latitudes 200 and 200 45’ N and longitudes 850 30’ and 860 E. The Athgarh Formation, characterized by fresh water and lacustrine sediments, significantly influences hydrological processes and groundwater quality. Geological features like Gondwana sediments and basaltic intrusions contribute to the area's hydrochemical characteristics. In the semi consolidated rocks of Gondwana formation the groundwater occurs under phreatic condition in the near surface shallow aquifers and under semi confined to confined condition in the deeper aquifers.

Hydrochemical facies variation and processes in the Athgarh basin were analyzed using graphical representations such as Piper trilinear diagrams and Chadha’s plots. Results indicate the prevalence of alkaline earth metals (Ca, Mg) over alkalies (Na, K), with weak acidic anions (HCO3) surpassing strong acidic ones (Cl, SO4). Most water samples exhibit a Ca-Mg-HCO3 composition, indicative of temporary hardness and rock weathering. However, heightened fluoride and potassium concentrations pose potential health hazards and affect water suitability for irrigation.

Groundwater quality assessment involved calculating a Water Quality Index (WQI) based on 13 parameters, juxtaposed against WHO drinking water standards. Hydrological facies were also evaluated through Piper's trilinear diagrams and Chadha's plots, offering additional insights into cation and anion distributions.

Understanding the interplay between water quality and geological features is vital for sustainable agriculture and food security in the Athgarh basin and analogous regions. This holistic analysis underscores the significance of integrating geological, hydrological, and chemical data for effective water resource management and environmental preservation. Elevated fluoride content and high potassium levels in water quality can detrimentally impact both agricultural productivity and human health. Excessive fluoride concentration in irrigation water can hinder crop growth and yield. Additionally, fluoride accumulation in soil over time can decrease soil fertility and impair microbial activity, further affecting crop productivity, while surplus potassium levels can disrupt soil nutrient balance, adversely affecting crop quality and yield.

Keyword

Hydrochemical facies, Water quality, Fluoride, Potassium, agriculture

Effect of Climatic Conditions on Groundwater Potability in the Hambantota District in Sri Lanka

Ashvin Kamal Wickramasooriya[1]*, University of Peradeniya (awickramasooriya@gmail.com)

Abstract

The Hambantota district, located in the dry zone of Sri Lanka, primarily people in this area relies on groundwater for its water needs. While the Sri Lankan government has initiated efforts to provide piped water to some areas of the district in recent times, these measures have not been sufficient to cater to the entire population. Variations in groundwater quality throughout the year and across different locations have posed significant challenges for the residents. Thus, this study aims to evaluate the suitability of groundwater for drinking purposes, focusing on dry periods (January to March and June to August) and wet periods (October to December). By analyzing 335 groundwater samples collected by the National Water Supply & Drainage Board, this research assessed the viability of groundwater as a drinking water source in Hambantota. The analysis involves establishing Pearson correlations among eight variables: Total Dissolved Solids, Magnesium, Chloride, Sulphate, Total Iron, Nitrate, Total Hardness, and Fluoride. Furthermore, the Water Quality Index (WQI) is computed using descriptive statistics. Spatial distribution maps for each parameter and the WQI are generated using ArcGIS software based on secondary data. The findings indicate that, during dry periods, only 13% and 28% of the area exhibit excellent and good groundwater quality for drinking, respectively. The majority of the area, comprising 6% poor, 5% very poor, and 48% unsuitable classifications, experiences inadequate groundwater quality during dry periods. Conversely, during wet periods, approximately 19% and 37% of the area demonstrate excellent and good drinkable groundwater quality, while 4%, 3%, and 37% exhibit poor, very poor, and unsuitable drinkable water quality, respectively. Hence, the groundwater quality is notably better during wet periods than dry periods. Additionally, correlation analysis reveals a strong relationship between WQI and total Iron (R= 0.96) as well as between WQI and total alkalinity (R=0.92). These outcomes underscore the impact of climatic conditions on groundwater quality for drinking purposes.

Keyword

Groundwater, Water Quality Index, Drinking water, Correlation

Monitoring studies within the Orto-Alish artesian basin (Kyrgyzstan) under climate change conditions.

Dmitrii PLAKSIN[1]*, KCHGE (dmit.plaksin@gmail.com)
Jaana Lohva[2], GTK
Salla Valpola[3], GTK
Petri Valasti[4], GTK

Abstract

Since 2008, Geological Survey of Finland (GTK) has had cooperation projects in Kyrgyzstan with the Kyrgyz Geological Survey under the Ministry of Natural Resources, Ecology and Technical Supervision of the Kyrgyz Republic (KGS). The projects are funded by the Ministry for Foreign Affairs of Finland.

The ongoing project increases KGS capacity to improve the monitoring and reporting of groundwater and environmental risks as well as the ability to create a sustainable management system of monitoring data for rational use of natural resources and balanced decision making. Advanced capacity to produce information on groundwater resources and environmental impacts is implemented by applying integrated hydrogeological and geophysical monitoring and modelling techniques to a groundwater reservoir. Integrating all monitoring data and interpreted geoscientific observations will provide a basis of the structure of the aquifer as well as a conceptual model of the aquifer. Methods learned during the project can later be applied also on the monitoring of contaminated water and soil. The availability of continuous monitoring data is one key element when assessing the risk pollution can cause to health and environment and adopting appropriate methods to mitigate impact.

The Orto-Alish multilayer groundwater aquifer occupies the western and central parts of the Orto-Alish intra-foothill depression on the northern slope of the Kyrgyz ridge. The slightly undulating surface of the site is formed by the merging alluvial cones of the Alarcha and Alamedin rivers. The depression is bordered from the north and west by Paleogene-Neogene sediments, from the south by the mountain massif of the Kyrgyz ridge, composed of Mesozoic rocks. The bed of the depression is also represented by Paleogene-Neogene sediments.

The Orto-Alish multilayer aquifer in a thick layer of alluvial-proluvial Quarternary sediments is characterized by favorable groundwater recharge conditions and varies from confined to unconfined. The total thickness of the aquifer can reach 450-500m. The hydraulic conductivity varies within a wide range of 10-100m/day. As depth increases, hydraulic conductivity decreases to 5-10 m/day or less.

The main part of Orto-Alish multilayered aquifer, especially confined layers, consists of quaternary, well-washed sediments, represented by boulder-pebble and mixed-pebble sediments, mainly with sand and gravel filler. In some places there are lenses and lumps of loam and sandy loam. In the lower parts of Quaternary sediments - sediment of conglomerates appears. The main chemical composition of water is bicarbonate-calcium, up to 1 g/l.

Monitoring of groundwater wells and geophysical studies has been carried out on the site during 2023-2024. Geophysical fieldwork consisted of 6 ERT- and IP-profiles at three different sites on the aquifer. The aim of the studies was to delineate geological structures for better understanding on groundwater accumulation and flow patterns. Each of the three sites had a groundwater well next to geophysical profile(s). These studies provide the geological framework for the aquifer structure model and upcoming groundwater flow modelling as well as give useful information on water resources managements in the area.

Keyword

Kyrgyz Republic, GTK, groundwater, Monitoring

Groundwater change and sustainable management using monitoring wells in the Kanto Groundwater Basin, Japan

Kunio FURUNO[1]*, Former Research Institute of Environment Geology, Chiba
(kuniofurunojp@gmail.com)
Atsushi KAGAWA[2], Research Institute of Environmental Geology, Chiba

Abstract

Background:
The Kanto region including Tokyo has been using groundwater and natural gas from the fluid resources of the Kanto groundwater basin.
However, the land suffered subsidence due to excessive pumping, causing serious damage by the early 1970s.

Monitoring System:
Land subsidence and the groundwater level monitoring system in the Kanto region has been developed mainly by local governments following the progression of land subsidence in the Tokyo metropolitan and surrounding area. In 1952 the Tokyo Metropolitan Government began monitoring land subsidence and groundwater levels by monitoring wells, eventually leading the other local governments throughout the Kanto Region to adopt monitoring their groundwater levels. In the 1960s, monitoring was expanded mainly in the southern Kanto region, after which the monitoring network was aimed at the northern Kanto region as well. The number of monitoring wells is 375 in 1982, 459 in 1991, 476 in 2010, and 377 in 2018 (excluding Ibaraki prefecture).
Recently, the number of monitoring wells is decreasing in many local governments, although the situation is different for each local government. We think that the reason of the decreasing is because the perspective of managing the groundwater basin using monitoring wells for effective utilization is lacking.

Groundwater Level:
The groundwater level maps show that the groundwater levels dropped the most in 1971 in Tokyo's Koto Ward reaching 60m below sea level. However, since the early 1970s, groundwater levels in the southern Kanto region have continuously risen due to regulations on groundwater pumping and changes of economic conditions.
But groundwater levels in the northern Kanto region had declined in some areas. Overall, the groundwater levels have slightly risen more recently. The groundwater level map shows a basin-like shape centered on the contour line of the lowest groundwater level of -50mTP (TP means mean sea level in Japan) in the Koto district of Tokyo in 1964.The lowest groundwater level contour line was -60mTP in 1971, -40mTP in 1975, -30mTP in 1984, and-20mTP in 1990, and gradually increased. The groundwater level continued to rise slightly after that, reaching -10mTP

in 2003. Since then, there has been no significant change, and the lowest contour continues at -10mTP.The groundwater level has increased slightly overall recently.
The groundwater level in 2020 is as below. In the central part of the groundwater basin where the groundwater level is the lowest, the -10mTP contour line is visible. In the northern part of the basin, Gunma Prefecture is +80mTP, Tochigi Prefecture is +70mTP, and in the northwestern part of the groundwater basin, the groundwater level is +60mTP in the northwest of Saitama Prefecture. In the western part, +80mTP is visible in the northwestern part of Tokyo, and +50mTP is visible in the central part of Chiba Prefecture in the southeastern part of the groundwater basin.

Keyword

Kanto groundwater basin, monitoring system, monitoring wellwell, groundwater level, land subsidence

Cases of Groundwater Dam Construction in Areas of Poor Water Supply

Hyun Jin PARK[1]*, K-water (ehjpark@kwater.or.kr)

Abstract

Recently, it is becoming more difficult to secure stable water resources in Korea due to weather changes cause by global warming, for instance repeated droughts and unprecedented torrential rains, and reduced stability in dam water supply. In order to an effectively measure to this, a groundwater dam construction has been promoted. This study introduces the construction of domestic groundwater dams as examples of securing water sources.

A groundwater dam is a stable and eco-friendly water resource facility that stores groundwater by raising the groundwater level by installing an artificial water barrier in the underground aquifer. Groundwater dams can retain a certain amount of water by preventing the loss of water due to evaporation or freezing and maintain good water quality by natural filtration of aquifers. In addition, it can minimize environmental destruction because there is no submerged water storage area.

In five places including Ian and Namsong, groundwater dams were constructed for agriculture as part of measures after the severe drought in the early 1980s. Moreover, it has been constructed for living in Ssangcheon, Sokcho. In the past, groundwater dams were used as a city unit water supply plan for agriculture and local water supply, but recently, construction projects are underway in areas where water supply is difficult. The groundwater dam construction project has been carried out in three island areas to realize steady water supply. Starting with Daeijak-do in Ongjin-gun, the first facility in the island, in 2020, it was constructed on Anma-do in Yeonggwang-gun (2021) and Bogil-do, Wando-gun(2023).

In the future, if it is continuously expanded and promoted for the island and inland vulnerable areas of poor water supply, a groundwater dam will be an effective measure for water welfare.

Keyword

Groundwater Dam, Groundwater, Eco-friendly alternative water source, An artificial water barrier

Geospatial Assessment of Drought Vulnerability in Nira River Basin, Western India

PAYAL WAINDESHKAR[1]*, Research Scholar, Department of Geology, Savitribai Phule Pune University, Pune (payalwaindeshkar123@gmail.com)
Bhavana Umrikar[2], Professor, Department of Geology, Savitribai Phule Pune University, Pune

Abstract

The integration of geospatial tools along with the Analytic Hierarchy Process (AHP) proves highly effective in conducting extensive drought vulnerability assessments. Droughts vary in intensity and type based on spatio-temporal contexts, underscoring the importance of understanding their occurrence for effective mitigation planning. This study specifically focuses on delineating drought-prone areas within the sub-watershed of the Nira River Basin in western India. Ten key parameters, including NDVI, rainfall, DEM, slope, land use/land cover (LULC), the density of water harvesting structures, well density, geomorphology, drainage density, and lineament density, are considered in this analytical hierarchy process. AHP is utilized to determine the relative importance of each parameter by constructing pairwise comparison matrices. The cumulative impact of these factors generates a drought severity zonation map, revealing that approximately 20% of the area is experiencing severe drought, with 39% falling within the range of moderate drought. Specific villages such as Palashi, Atit, Jawale, Mirje, Lohom, and Kesurdi fall under moderately drought-prone zones, while parts of Ghadgewadi, Limbachiwadi, Kanheri, and Zagalwadi Karnawadi are situated in severe drought zones. This comprehensive mapping aids in preparedness planning and the provision of relief measures to address drinking water scarcity in affected villages, contributing to more resilient communities in drought-prone regions.

Keyword

Drought Vulnerability, Western India, GIS, AHP

Long term base flow assessment according to land use and climate change on Yeongsan and Seomjin river basins, South Korea

Kyoochul HA[1]*, KIGAM (hasife@kigam.re.kr)
Hyowon An[2], KIGAM

Abstract

Base flow refers to the flow of groundwater from an aquifer into a river. Compared to surface runoff, which flows into a river or onto the surface after rainfall, base flow is the outflow of groundwater from an aquifer into a river. Therefore, river does not dry up even when there is no rainfall due to base flow. Base flow occurs when groundwater from an aquifer flows into a river, so if groundwater use increases, the amount of groundwater that can flow out into the river decreases, so the amount of base flow cannot help but decrease. In addition, base flow is bound to fluctuate due to natural and anthropogenic factors such as land use change and climate change. In this study, we attempted to separate base flow from long term river flow data in the Yeongsan and Seomjin river basins and evaluate and identify the causes of long-term base flow variations. The river discharge data were collected and analyzed from 2006 to 2021 for more than 10 years. We selected basins where river discharge data existed during the relevant period, and 7 locations in the Yeongsan river basin and 14 locations in the Seomjin river basin and established a Database through the hydrological observation yearbook provided by the Korea Flood Control Office. Land use data provided by the Environmental Spatial Information Service (http://egis.me.go.kr) was collected and established in a GIS format. Base flow was analyzed using the USGS PART program. As a result of the analysis, land use decreased in urban areas and farmland (fields, rice fields), and in forests, coniferous forests in particular decreased and broad-leaved forests increased, which is believed to reflect the impact of climate change. It was confirmed that base flow and river discharge vary widely by basins, and are high in the summer when precipitation is high. Accordingly, base flow increases, but base flow ratio relative to total river discharge actually decreases. As a result of reviewing river discharge and base flow data during the periods, they were fluctuating in close relation to precipitation, but did not show a clear trend by year. Larger basins had smaller base flow fluctuations than smaller basins. And, the relationship between groundwater uses and base flow did not appear clearly during the analysis period. This is due to the fact that flow monitoring points have been artificially influenced by the development of dams, reservoirs, and the installation of water resources facilities such as waterworks. In the future, it is necessary to reveal the relationship between base flow and groundwater use, changes in groundwater levels and water quality.

Keyword

base flow, groundwater, climate change, land use

Observation and Characterization of Rapid Infiltration and Runoff Processes in Karst Hillslopes

Jun Zhang[1]*, Institute of Subtropical Agriculture, Chinese Academy of Sciences
(zhangjun@mails.ccnu.edu.cn)
Hongsong Chen[2], Institute of Subtropical Agriculture, Chinese Academy of Sciences

Abstract

Karst landforms are renowned for their rapid surface and subsurface hydrological processes. This can be attributed to the high solubility of carbonate rocks, which contribute to the unique two-dimensional and three-dimensional hydrogeological structure of the surface and subsurface. The surface soil layer is shallow and highly permeable, while underground pipe fractures are common. Describing and quantifying the intricate rapid hydrological processes in karst critical zones has long been a focal point for hydrologists.

In this study, we examined a representative karst slope composed of limestone in southwest China. By conducting long-term monitoring of hydrological and meteorological data, as well as isotopic analysis, we explored the movement, redistribution, runoff generation, and connectivity processes of rainfall at the hillslope scale within the soil-epikarst system in the karst critical zone. We elucidated the effects of the critical zone structure, characterized by varying soil thickness, on runoff components and their sources, infiltration rate, and threshold behavior.

Remarkably, the study discovered that the proportion of "young water" in the soil moisture on the karst upslope can reach 100%. The soil moisture infiltration rate and response time are significantly higher compared to non-karst areas. We highlight the crucial role of the soil-epikarst interface in hillslope hydrological connectivity processes. The research findings can provide a scientific basis for further deepening our understanding of karst hydrological processes and regional water resources management.

Keyword

Soil-epikarst Zone, Critical Zone, Geophysical Exploration, Extreme Climate, Vegetation Restoration

[Keynote] Hydrological processes in karst critical zones in southwest China

Hongsong Chen[1], Institute of Subtropical Agriculture, Chinese Academy of Sciences
Zhiyong Fu[2], Institute of Subtropical Agriculture, Chinese Academy of Sciences
Fa Wang[3], Institute of Subtropical Agriculture, Chinese Academy of Sciences
Sheng Wang[4], Nanning Normal University
Jun Zhang[5]*, Institute of Subtropical Agriculture, Chinese Academy of Sciences
(zhangjun@mails.ccnu.edu.cn)

Abstract

The karst region in southwestern China is one of the three major concentrated distribution areas of karst landforms in the world, and it boasts the most diverse karst landscapes. The strong solubility of carbonate rocks makes the hydrogeological structure of the karst critical zone extremely complex. The surface soil layer is shallow, highly permeable, and discontinuous. Underground, a complex network of conduits and fractures forms the epikarst zone, which is distinct from the core area of non-karst critical zones. Since 2004, our research team has conducted long-term hydro-meteorological and isotope tracing monitoring in a typical karst small catchment, aiming to systematically understand the complex multi-interface hydrological processes within the soil-epikarst system. The main contributions are as follows:

(1) The features of the soil-epikarst structures are clearly identified through geophysical exploration. The thickness of the soil and epiakrst co-evolved spatially in the small catchment (~1 km2), with both thickness decreasing with increasing elevation on the hillslopes. The weaker the degree of weathering, the shallower the soil thickness, and the higher the coupling degree between bedrock and surface topography in the small habitat (~100 m2).

(2) The multi-interface runoff mechanism affected by the rock-soil structures is analyzed on the hillslope. The surface runoff coefficient is less than 5% and satisfies the "infiltration-excess and saturation-excess" mode. Simultaneous attaining of rainfall amount and intensity thresholds is a prerequisite for runoff generation. Subsurface runoff is suitable for the "fill and spill" (saturation-excess mechanism) process, with the soil-rock interface acting as the "link" where uphill vertical flow is transformed into lateral flow in low-lying areas. Soil thickness serves as a primary controlling factor to characterize critical zone structure (weathering intensity) and runoff relationships, being positively correlated with surface runoff and negatively correlated with subsurface runoff.

(3) The mechanism of runoff recharge is elucidated in the small catchment. In both seasonal and rainfall event scales, epikarst runoff is the main source (>83%) of recharge for springs and stream water. Fractured soil-rock mediums are prone to the development of perennial springs, with matrix flow and gravity water recharge accounting for 77%, which is related to the increased water residence time associated with thicker soil-epiakrst hydrogeological storage function. Weakly weathered soil-rock mediums form cracks and pipes easily, resulting in the formation of seasonal springs, with poor continuous water recharge capacity, and only 10.5% of the water recharge coming from the matrix flow and gravitational water.

Accordingly, our exploratory and multi-layered research emphasizes the strong influence of soil-rock structure on hydrological processes in karst critical zones. Future work will continue to focus on the coupled mechanisms of the soil-bedrock structure and vegetation in multi-interface runoff processes.

Keyword

Karst ecosystems, Rainfall-runoff, Surface-subsurface runoff, Geophysical exploration, VIC model

Coupled physically based hydrologic model and transit time theory (SWAT-SAS) for simulating the eco-hydrological process in karst basins

Wuhua LI[1]*, South China University of Technology (ctliwuhua@mail.scut.edu.cn)
Xiangju Cheng[2], South China University of Technology
Dantong Zhu[3], South China University of Technology

Abstract

Heterogeneity is common in hydrological systems and leads to variations in hydrological properties and further differences in eco-hydrological processes. Despite the heterogeneity, it is still popular to consider hydrological systems as homogeneous systems when conducting hydrological simulations based on physical processes. Karst systems are probably the most extreme case of subsurface heterogeneities, and the simulations for karst basins highlight the limitations of the oversimplification of subsurface processes in the present hydrologic models. There have been extensive studies to develop or modify models to capture the karst features. However, these efforts are mainly developed to fit the flow behaviors and may be significantly biased when simulating the solute dynamics. The increasing importance of karst water for human water supply under the influence of climate extremes and, on the other hand, the intensified anthropogenic activities in karst areas require in-depth studies of the eco-hydrological processes in karst areas to cope with the changing environment. The transit time is a descriptor of pathways within a system, which links the flow and solute transport in a unified framework. We propose to use transit time theory to improve the subsurface transport process in hydrological models. The coupled model is more representative of karst subsurface heterogeneity, and the parameters of the transit time model reflect how the system releases water of different ages. With such information, the variations in groundwater pathways and the transport processes in karst areas can be explored and information on the water age in storage and outflows supports the assessment of hydraulic exchange timescales as well as the nutrient legacy.

Keyword

SWAT, StorAge Section (SAS), karst, Lijiang River Basin, eco-hydrological process

Geospatial patterns in the hydroecological characteristics of surface waters in the karst area of Samcheok, South Korea

Regina Martha Gabest LUMONGSOD[1]*, Kangwon National University (rmgl@kangwon.ac.kr)
Heejung Kim[2], Kangwon National University

Abstract

Karst environments are unique, especially in terms of hydrology, due to the high solubility of its bedrock. Subsurface drainage is more complex than that of the surface the two are usually directly connected through landforms such as caves and sinkholes, so they are very sensitive to environmental changes. Samcheok, found in the southeast part of Gangwon province, is an area with carbonate bedrock that underwent (and is still undergoing) dissolution, forming an extensive karst landscape. In this study, the hydroecological characteristics of surface water samples from four different streams (Osipcheon River, Yeosam Stream, Sohan Stream, and Gyogok River) located in the northeast part of Samcheok karst which were sampled during two different seasons (February (winter) and April (spring) 2020) were geospatially analyzed through a Geographic Information Software (GIS). Preliminary results reveal that while the abundance of major ions was mostly varied spatially in the study area, they were dependent on the stream where the samples were taken from more than the sampling distance from the coast. Usual patterns for pH and dissolved oxygen with respect to water salinity were absent. Cation and anion concentrations mostly varied between the two seasons and in terms of linear correlation for concentration vs. distance to stream outlet plots. High linear correlation was observed for samples from Gyogok River for Ca2+ (R2 = 0.976), Mg2+ (R2 = 0.9321), SO42- (R2 = 0.879), and HCO3- (R2 = 0.955). The relative abundance of Actinobacteria in sample points along Sohan Stream was lower inland than near the outlet, while the relative abundance of Proteobacteria showed almost the opposite. Observing the geospatial patterns for hydroecological parameters, especially in areas vulnerable to the effects of climate change and pollution such as karst areas, is helpful in identifying priority areas for future work. This research was funded by the Basic Science Research Program through the National Research Foundation of Korea funded by the Ministry of Education (Nos. 2019R1I1A2A01057002, and 2019R1A6A1A03033167).

Keyword

karst, surface water, hydroecology, GIS

Hydro-ecological processes of hyporheic zone and the function degradation in karst spring-fed pools

Fang GUO[1]*, Institute of Karst Geology, Chinese Academy of Geological Sciences (gfkarst@126.com)
Guanghui Jiang[2], College of Civil Engineering and Architecture, Guangxi University
Liqiong Wei[3], Institute of Karst Geology, Chinese Academy of Geological Sciences

Abstract

The frequent transformation of groundwater and surface water in karst water systems leads to the formation of diverse hyporheic zones. The interaction mechanism, degree, and impact on karst groundwater environment of these hyporheic zones are still unclear, which hinders the management and sustainable utilization of water resources. Most karst groundwater is highly developed and utilized. Some springs in karst area outcrop along the river. These springs are usually water supply sources and are highly exploited. Under this situation, spring outlets connect with rivers and they have frequently but casually interaction. The hyporheic zone owns the most active biogeochemical processes and plays a variety of functions. Therefore, it is necessary to set up the concept of spring hyporheic zone to study this special kind of hyporheic zone and to explain the reasons of groundwater deterioration. Take three important springs with similar geological background but different patterns of groundwater and surface water and submerged plant degeneration as the case studies, the dynamic processes of spring and river interaction were studied through high-precision hydrological monitoring, dye tracer test and isotope analysis. Based on the different of interaction patterns and degrees, the concept and meaning of spring hyporheic zone were discussed. In karst water systems, in addition to groundwater discharged from spring outlets and surface water, there are also water sources with different properties stored in different karst media, resulting in various forms of interaction. The reason for the formation of spring outlet hyporheic zone is determined by the differences in karst hydrogeological conditions, water storage space, and hydrological conditions. The hydrological process of karst springs is significantly controlled by artificial water storage and flood discharge in rivers. The spring-fed pool water conditions can be distinguished as high, medium, and low-water level periods in a hydrological year. The high-water level accounts for less than 1% in a year, while it is associated with the hydrological regimes of backflooding states. The inflow of river backflow was found to be 4.4 times that of the natural discharge of spring water during a rainfall event. Despite turbidity returning to normal levels after 56 hours, E.coli continued to persist for an extended duration. Based on these, the causes of function degeneration in spring hyporheic zone and the measures to improve the function was provided.

Keyword

karst spring outlet, hyporheic zone, exchange fluxes, dissolved oxygen, river backflowing

Water age dynamics in transpiration for typical plants under different earth critical zones

Zidong Luo[1]*, Institute of Subtropical Agriculture, Chinese Academy of Sciences (zidong.luo@isa.ac.cn)
Yunpeng Nie[2], Institute of Subtropical Agriculture, Chinese Academy of Sciences
Hongsong Chen[3], Institute of Subtropical Agriculture, Chinese Academy of Sciences
Huade Guan[4], College of Science and Engineering, Flinders University
Xinping Zhang[5], School of Geographical Sciences, Hunan Normal University
Kelin Wang[6], Institute of Subtropical Agriculture, Chinese Academy of Sciences

Abstract

Water age in plant transpiration reveals important processes of water dynamics in the soil-plant-atmosphere continuum, which is regulated by the structure-induced water variability and availability in the earth critical zone. In this study, we focus on the similarities and differences in the transpiration water age of typical plants in karst and non-karst critical zones under five different climates. Variations in root-zone water replenishment are estimated based on stable isotope compositions of precipitation and plant xylem water, and a piecewise linear mixing water age model is employed to quantify water ages in plant transpiration. The results show that water ages in transpiration are very dynamic in all climates with a range between 1 and 229 days. Water replenishments in the root-zone reveal whether and how much precipitation enters the root zone. Climate patterns control median (mean) water age in plant transpiration but modified by rooting depth. In wet climates, plants mainly rely on water source that originates from precipitation in the current month (accounting for about 60% on average of their water sources), while plants in dry climates largely rely on water source that originates from precipitation fallen on previous months/seasons. In addition, the mean water age for plant transpiration is shortest in the karst critical zone compared to other critical zones, indicating that the soil-rock structure of the critical zone affects the water age in plant transpiration by regulating the distribution of plant roots and the water storage capacity of the root zone. Our study provides an alternative way to reveal the precipitation partitioning in root-zone and seasonal changes in plant water use of precipitation, which highlights different vegetation responses to water variability between earth critical zones.

Keyword

Root zone water replenishment, Residence time, Stable isotopes, Karst

Development construction of water resources in karst peak cluster depression based on subsurface and vadose zone hydrological processes

Fan LIU[1]*, Institute of Karst Geology, Chinese Academy of Geological Sciences
(liufancags@126.com)
Guanghui Jiang[2], School of Civil Engineering and Architecture, Guangxi University

Abstract

The karst peak cluster depression is a typical karst landform in southwest China. Rural residents often reside in flat areas at the bottom of karst depressions and engage in agricultural activities on the surrounding flatlands and gentle slopes. The lack of water resources is the main factor restricting the local economic development. The high infiltration coefficient in the bare karst peak cluster depression results in a severe scarcity of surface water resources, which is also the main reason for the vulnerable state of the karst environment. Geological conditions in the karst peak cluster depression contribute to the significant depth of karst groundwater resources in the area. Under extreme climatic conditions, meteorological drought can easily transition into hydrological drought, worsening the scarcity of accessible water resources. The distribution of water resources in the bare karst peak cluster depression showcases the equilibrium between human activities and water within a distinctive geological and geomorphological setting. It is significant to maximize the acquisition of water resources while minimizing environmental impact in such conditions. The subsurface hydrological processes, such as epikarst runoffs and hydrological processes occurring in karst vadose zones, play a vital role in the development of water resources in this area. For subsurface hydrological processes, distributed water tanks are a significant measure to address seasonal water shortages. It involves expanding slope surfaces to collect precipitation, reducing slope infiltration coefficients, stabilizing vegetation and soil, and accumulating epikarst springs. In contrast to transient processes like precipitation and slope runoff, the prolonged discharge of epikarst runoff spanning multiple months significantly contributes to the accumulation of water resources. This enhances the reliability of water resources during dry periods, thereby serving a crucial function in mitigating droughts. According to the analysis of the observed water level duration curve of the epikarst spring, there is an estimated 78% probability that the outflow could serve as an additional water supply for the water tank. In the natural state of a hillside, only 2% of the rainfall contributes to surface runoff. The potential for water supply by the karst vadose zone of peak cluster depressions also deserves attention. The natural pools within cave systems in karst peak cluster areas are formed by the accumulation of cave-dripping water and flowing water, making them focal sites for water resource development. The prolonged dripping in caves can help recharge water resources, with the water showing a relatively low conductivity level of less than 200 μS/cm. This is in contrast to the high conductivity level exceeding 500 μS/cm observed in epikarst water. The elevated location of the karst caves provides favorable conditions for constructing infrastructure for water resource development and utilization.

Keyword

water resources, karst peak cluster depression, hydrological processes, epikarst zone, karst vadose zone

Examining the Changes in Karst Spring Flow Over an Extended Gauging Period: Impact of Climate and Vegetation Recovery

Guanghui JIANG[1]*, College of Civil Engineering and Architecture, Guangxi University (bmnxz@126.com)
Fang Guo[2], Institute of Karst Geology, Chinese Academy of Geological Sciences

Abstract

To deepen our understanding of the hydrological processes and sensitivity of bared karst in southern China, long-term observations were conducted on a karst spring within a peak-cluster depression to examine trends in flow variation. The selected karst spring watershed encompasses three karst dolines covering an area of only 1 km2. Over the past 40 years, significant changes in vegetation have occurred, with formerly heavily deforested grasslands and shrublands transitioning into shrublands and locally mixed shrub and tree forests under the natural recovery conditions of sustained afforestation. Multi-year observations indicate a range of flow variations in the karst spring, from 0 to 2500 l/s, with average flows ranging from 13 to 58 l/s and annual runoff volumes from 0.4 to 1.8 million m3. Notably, 90% of the flow occurs between May and July, with only 10% occurring between August and January. The longest dry season flow cessation period lasted 154 days. Calculations based on flow recession hydrographs yielded an average porosity of the watershed of only 0.06%, demonstrating an efficient drainage capability and limited storage capacity within the karst spring system. Dynamic observations of cave ceiling stream and hillslope seeps revealed rainfall thresholds of 16 mm and 38 mm, respectively, for hillslope runoff generation, and an overall rainfall threshold of 81 mm for karst spring system recharge, confirming its low storage capacity. Cumulative rainfall infiltration coefficients showed minimal fluctuations over multi-year scales, stabilizing at 0.38 before 2015, increasing to 0.45 after the extreme high-flow year of 2015, and subsequently stabilizing at 0.41. The current rainfall infiltration coefficient shows an increasing trend compared to the 0.37 value observed in 1986. For soil-scare bared karst area, the efficient drainage and limited storage capacity restrict vegetation water consumption. Additionally, vegetation mitigates flash floods, reducing the proportion of rapid runoff while increasing slow runoff, thereby enhancing the karst spring system's storage capacity by retaining more rainfall within the aquifer. Given the complex storage processes of karst aquifer systems, current hydrological models are insufficient to predict changes in storage processes resulting from climate and vegetation variations. The study recommends conducting field experiments and establishing more complex monitoring networks to achieve fine-scale observations of storage processes and elucidate storage mechanisms.

Keyword

peak cluster depression, karst spring, Vegetation Recovery, runoff coefficient, aquifer storage

DETERMINATION OF PETROLEUM PRODUCTS IN WASTEWATER BY GRAVIMETRIC METHOD

MUNISXON MEYLIYEVA[1]*, hydrogeology (munisxon.88@mail.ru)

Abstract

Petroleum products are among the most common and dangerous substances that pollute surface and underground water. Most of the oil products enter the water during the transportation of oil, wastewater of enterprises, and domestic water. The presence of petroleum products in water is one of the main reasons why water becomes unfit not only for consumption but also for various household needs.

Therefore, one of the urgent problems is the selection of high-precision and effective methods for periodic chemical analysis of petroleum products contained in wastewater.

An aluminum oxide column was used to separate the organic solvent and hydrocarbon components as an extractant in the gravimetric method.

Chloroform and hexane, a low polar hydrocarbon with a boiling point of 36 oC to 69 oC, were used as extractants. Standard samples such as n-decane (C10H12), n-eicosane (C20H42) or hexadecane (C16H34), and n-tetracontane (C40H82) were used as a test and comparison sample.

The sample of wastewater brought for testing was extracted using an organic extraction agent, and the obtained eluate was dehydrated, first in a water bath, and then dried in the open air. The amount of petroleum products (mg/dm3) was found by weighing the dry residue.

According to the results of gravimetric determination of the amount of oil products in the water samples taken from the monitoring wells located around the Fergana oil refinery, the amount of total oil products in the water sample taken from the wastewater outlet is 25.82 mg/dm3, the amount of oil products in the water sample taken from the monitoring well ˂0.5 mg/dm3.

Summary:

Since the gravimetric method of oil product analysis during our scientific research did not allow us to determine when there is a small number of oil products in water, we concluded that it is not possible to analyze oil products in the samples taken from observation wells and water facilities using the method, and the lower limit of the measurement range is 0.5 mg/dm3 possible Also, the advantage of the method is that no pre-calibration of the measuring instrument is required. Therefore, the method can be accepted as an arbitration method.

The water samples taken for analysis were carried out for quantitative analysis at the "Geoecologist-chemistry" laboratory accredited under the requirements of ISO/IEC 17025: 2017 at the "Institute of Hydrogeology and Engineering Geology" State Establishment, and the method was verified. Based on the obtained results, it was proposed to use the existing "Hydrochemistry" laboratories in our Republic in cases where the amount of oil products in wastewater is higher than 0.5 mg/dm3.

Keyword

wastewater, petroleum products, extractant

Assessment of Groundwater Drought Evolution Over Two Decades in Korea Using Storage-Based Approach

Anuradha Karunakalage[1]*, Indian Institute of Technology Roorkee (anuradha_s@es.iitr.ac.in)
Jin-Yong Lee[2], Department of Geology, Kangwon National University
Mohammad Taqi Daqiq[3], Indian Institute of Technology Roorkee
Jihye Cha[4], Department of Geology, Kangwon National University
Jiwook Jang[5], Department of Geology, Kangwon National University

Abstract

Groundwater is a vital component of the Earth's freshwater resources, serving as a primary source of drinking water and irrigation worldwide. Moreover, the demand for groundwater resources has been increasing significantly in agricultural sector of the Republic of Korea, a country particularly vulnerable to the impacts of climate change due to its monsoonal climate. Therefore, continuous monitoring, identification, and quantification are essential steps in managing groundwater resources to ensure sustainable water usage. In this context, satellite remote sensing has emerged as a valuable tool, providing regional to global coverage of changes in hydrological cycle fluxes. Among these missions, the Gravity Recovery and Climate Experiment (GRACE) satellite stands out for its integrated measurements of monthly water storage variations in surface and subsurface hydrological fluxes. The GRACE mission has broadened the horizons of the development of more precise identification techniques that can characterize the progression of drought conditions and quantify their severity in space and time. The current study introduces a quantitative method to assess the occurrence and intensity of groundwater droughts, utilizing long-term Groundwater Storage Anomalies (GWSA) derived from GRACE data. GRACE measurements are employed to compute the extent of deviations in monthly GWSAs from the monthly groundwater climatology within the time series, with negative deviations indicating storage deficiencies. The monthly deficits quantify the groundwater storage required to restore normal subsurface water storage conditions. This study integrates the storage deficits with the duration of events to determine the severity of droughts. The workflow of the study has been developed to estimate different possible time scales of drought recovery for identified drought events using the empirical distribution of the rate of change in the groundwater storage deficit. This study has identified thirteen groundwater drought events spanning two decades in Korea, including notable historical droughts in 2012-2013, 2015-2016, and the most recent one in 2019-2020. The study emphasizes the time lag between precipitation deficits and groundwater drought occurrences, alongside the protracted duration required for drought recovery, contrasting with the relatively rapid amelioration of surface drought conditions. Consequently, it underscores the inadequacies of precipitation deficit-based drought indices while suggesting the viability of storage-oriented methodologies for assessing groundwater drought severity and estimating recovery periods. The results of the current study, along with continuous monitoring of groundwater drought and the estimation of drought statistics using new GRACE data, hold the potential to significantly enhance policymaking and groundwater management efforts for sustainability.

Keyword

GRACE, Groundwater deficit, Drought severity, Drought recovery

Suggestions for Korea's groundwater use and management in the era of climate crisis

Kang Kun LEE[1]*, Seoul National University (kklee@snu.ac.kr)

Abstract

Due to climate change, the amount of precipitation in Korea is gradually increasing, but the annual variability is large and the frequency and intensity of heavy rain are increasing. These changes in precipitation patterns can be a factor that can reduce groundwater recharge. Increasing forest density can also reduce the amount of groundwater recharge. In addition, pollutant emissions from residential areas, industry complex, and agricultural and livestock activities are threatening groundwater quality and are reaching a level that cannot be ignored. The Republic of Korea enacted the Integrated Water Management in 2022 based on law to manage surface water and groundwater in an integrated. Therefore, Korea's water management frame is moving towards analyzing and managing surface water and groundwater in the same watershed unit. As of 2019, total groundwater use amounted to 2.91 billion m3 accounting for 7.64% of the total water use in Korea. 99% of groundwater is used for farming, fishing and agriculture, so in the future, groundwater needs to be utilized for drinking or other purposes with higher economic value. In the current situation, groundwater is used for purposes of low economic value, and there is a lack of motivation to invest budget into groundwater conservation. Based on natural water quality, a systematic direction is needed to utilize and conserve groundwater, which has better water quality than surface water. In Korea, groundwater discharge is occurring in connection with various underground facilities, including subways, and it is recommended to use this as a water resource or as a heating and cooling energy resources. In order to respond to drought by utilizing groundwater, a project to artificially recharge groundwater using artificial reservoirs is also being led by the government. I believe that these efforts are not sufficient to ensure a stable supply of water resources in Korea in the era of climate crisis. In order to respond to the extreme drought caused by the climate crisis, a public groundwater well-network system that can supply all residents a certain amount of water even during severe drought should be established.

Keyword

Groundwater, Draught, Climate crisis, Groundwater conservation, water resources

Case Study on the Operation of Hybrid Artificial Recharge Circulation System in Drought-Prone Areas

Gyoo-Bum KIM[1]*, Daejeon University (geowater@dju.kr)

Abstract

Recent climate changes on the Korean Peninsula are causing an increase in the frequency and intensity of droughts. In particular, rapid water discharge occurs in the small basins of the upper watershed, leading to a high likelihood of water shortages in the spring. To increase the total amount of water in the upper watershed, a structural system that minimizes water discharge and allows for long-term storage is necessary. Despite the significant reduction in the flow of small streams during the dry season, the base flow discharged from groundwater maintains a consistent level. Utilizing such base flow as the injection source for groundwater artificial recharge and storing it within the basin's strata can increase and maintain the total amount of water over a long period. The hybrid-type groundwater artificial recharge system adopts a method of using base flow as the injection source, storing it within the basin sediments, and then drawing water from horizontal collection wells downstream for supply. The water supplied to farmlands can then be recharged into the strata, creating a cyclical effect. The injection was carried out through four lines within the basin using a mixed method of ditches and wells, with injection volumes ranging from 100 to 400 m^3 per day and withdrawal volumes ranging from 200 to 500 m^3 per day according to water demand. During the two years of operation, there were no significant changes in injection or withdrawal volumes, but continuous evaluation is necessary for clogging caused by iron and manganese. Such artificial groundwater recharge systems are considered to be a good solution for water issues in the era of climate change, and it is hoped that more systematic research on the operation of these facilities will continue.

Keyword

artificial recharge, baseflow, drought, water shortage

A technical approach on agricultural groundwater irrigation by applying the well-network system (WNS) to a drought-prone zone, South Korea

Byung Sun LEE[1]*, Korea rural community corporation (byungsun94@ekr.or.kr)
Sangjin Seo[2], Korea rural community corporation
Wooho Myoung[3], Korea rural community corporation
Kyoochul Ha[4], Korea Institute of Geoscience and Mineral Resources
Jong-Hwa Lee[5], GeoGreen21 Co., Ltd.
Hwan-Ho Yong[6], Korea Rural Community Corporation
Gyusang Lee[7], Korea Rural Community Corporation
Soon-Wook Hong[8], Korea Rural Community Corporation
Sung-Ho Song[9], Korea Rural Community Corporation

Abstract

Groundwater is considered to be the best water resource to solve water shortage problems during drought periods. Even though excessive pumping (overdraft) during short-period may give an unprofitable effect on groundwater hydrology, it has a primary role to solve a lack of water resources and to maintain incomes of farmers. This study was conducted to estimate an amount of the agricultural groundwater demand and supply in a frequent-drought area, where has required an optimal distribution plan of groundwater resources using the well-network system (WNS). The WNS has been considered to be an alternative for evenly supplying groundwater resources to farmlands by connecting groundwater wells physically or virtually, either. The study area has significantly depended on groundwater resources for its irrigation water up to 53% due to a lack of surface water resources. Two kinds of methods, HOMWRS software and FAO approach, were used for estimating irrigation water requirements for paddy and upland fields for the study area, respectively. During the latest 10 years (2010~2019), a total amount of requirements was estimated to be an average 1,106 /day. For the active farming periods (May to September), the requirements were notably increased of ranging in 1,121~4,004 /day, which has already exceeded a total yield of pre-existing groundwater wells (2,356 /day) in this area. Detailed and definite determination for groundwater demand and supply helped to determine an optimal scale of the WNS. The WNS has achieved an optimal distribution of groundwater resources and solved imbalance on irrigation over the study area.

Keyword

Drought, Groundwater, Maximum irrigation amounts, Well-network system

Enhancement of denitrification using agricultural biproducts and limestone for use in the artificial recharge system

Boyeon JEON[1]*, IGC 2024 (kangjoo@kunsan.ac.kr)
Jinwon LEE[2], Department of Environmental Engineering, Kunsan National University
Thanh Huy PHUNG[3], Department of Environmental Engineering, Kunsan National University
Byungsun BYUNGSUN[4], Korea Rural Community Corporation
Gyusang LEE[5], Korea Rural Community Corporation

Abstract

In the area where intensive infiltration takes place such as LID or artificial recharge facilities, nitrate becomes can become a serious obstacle. Artificial introduction of nitrate-rich groundwater to the deep aquifer can also cause adverse effects due to geochemical disturbances. This study demonstrates that nitrate in the infiltrating water can be effectively removed using agricultural organic biproducts and limestones. This study performed an experiment using three columns packed with sand 100% (Column A), sand 97% + woodchip 3% (Column B), and sand 96.4% + woodchip 3% + limestone 0.6% (Column C). The sands used for these experiments were treated with HCl solutions to completely remove carbonate materials. Packed materials of each column was filled with KNO3 solution (20 mg-N/L) and the water level at the top of each column was maintained. 150 ml of pore water was sampled at each designated time and measured for various chemical parameters including pH, EC, Eh, DO, alkalinity, DOC, NO3-, NO2-, NH4+, F-, Cl-, SO42-, Ca2+, Mg2+, Na+, K+, Fe, and Mn. Measured parameters were precisely inspected to understand the chemical reactions influencing the denitrification. It was found that denitrification was induced by the decomposition of organic matter. However, the CO2 generated from the organic matter lowers the pH to a level (<5.5), which can largely suppress the denitrification. When limestone was used together with the organic matter, the severe decrease in pH was suppressed and the denitrification was 3 times faster than that obtained from the column without limestone.

Keyword

Groundwater, nitrate, LID, artificial recharge

Saltwater circulation driven by shoreline curvature in coastal aquifers

Xuan YU[1]*, Institute of Soil Science, Chinese Academy of Sciences (yuxuan@issas.ac.cn)

Abstract

Studies of coastal groundwater dynamics often rely on numerical simulation of variable-density flow in coastal aquifers for predicting salinity distributions and quantifying submarine groundwater discharge (SGD). Although much of our understanding of saltwater circulation is derived from models on cross-sections of coastal aquifers, shoreline curvature can cause along-shore groundwater flow, resulting in complex mixed convection. To understand the impacts of shoreline curvature on saltwater circulation, we modeled variable-density groundwater flow and salt transport between land and ocean in 3-D using the fully coupled surface and subsurface numerical simulator HydroGeoSphere. To represent various coastline geometries, we developed a series of concave and convex coastline fields according to the general coastline geomorphological features along the coast of China. We show that along-shore movement of groundwater increases with shoreline curvature, causing nonlinear responses of lateral saltwater circulation. The mixing zone and SGD are impacted by coastline curvature, which depends mainly on the proportion of lateral circulation. In addition, shoreline curvature substantially increases the travel time and length of fresh SGD. Our results highlight the nonnegligible influence of coastline geometry on along-shore groundwater movement, freshwater-saltwater mixing, and SGD. This study has important implications for groundwater resources management, biogeochemical reactions along shorelines, and resulting chemical fluxes to the ocean.

Keyword

shoreline, HGS, coastline geometry, SGD

Hydrogeological modelling of alluvial aquifer in north-eastern Uzbekistan

AZIZ ABDUMANNAPOVICH HAKIMOV[1]*, Uzbekhydrogeology (newage.uz@gmail.com)
Dmitry Andreev[2], State Institution "Hydroingeo"
Samrit Luoma[3], Geological Survey of Finland (GTK)
Jukka-Pekka Kujasalo[4], Geological Survey of Finland (GTK)
Jaana Lohva[5], Geological Survey of Finland (GTK)

Abstract

Geological Survey of Finland (GTK) has had cooperation projects in Central Asia since 2008. In Uzbekistan, the project “Strengthening the Mastering of Natural Resources for National Welfare in Uzbekistan” is the first project to implement together with the Ministry of Mining Industry and Geology (MINGEOLOGY). The project focuses on improving the capacity of MINGEOLOGY to manage the complete chain of information production (collection, analysis, dissemination, increasing awareness) for groundwater studies, mineral resources and environmental risk assessments related to climate change. The ongoing project increases MINGEOLOGY’s capacity to produce information on groundwater resources and environmental impacts by applying integrated hydrogeological and geophysical monitoring and modelling techniques to a groundwater aquifer. Integrating the monitoring of groundwater level and geochemical data and interpreted geoscientific observations provides a fundamental understanding of the groundwater flow system and more insight into the evolution of geochemical process and the potential groundwater contamination risk zones. The availability of long-term, systematic monitoring data is a key information for groundwater vulnerability assessment and protection and sustainable water resources managements.

The shallow permeable alluvial aquifer in the Akhangaran River Valley in north-eastern Uzbekistan is a pilot site for the investigation and demonstration of the methods. The pilot site is an important fresh water source for public water supply, agriculture, mining process and industry in the area. The aquifer is hydraulically connected to surface water and responses directly to climate variables (e.g., temperature and precipitation) and human activities. The risks and threats to a shallow aquifer are changes in groundwater recharge due to change in precipitation and temperature caused by climate change, and contamination of groundwater from risk areas. Water demand is expected to increase, while water availability will diminish due to decrease in groundwater recharge and groundwater resources, especially during the drought in summertime. Lack of clean water can cause a crisis to water users. Water resource management as well as adaptation and mitigation to water crisis requires comprehensive understanding of groundwater resources and their connection to surface water bodies in changing climate and land use.

The hydrogeological characterization of alluvial aquifer in the Akhangaran River Valley was investigated using the integration of the geological drilling data, geophysical data from seismic refraction surveys and vertical electrical sounding (VES) surveys, as well as hydrogeological data. Seismic refraction survey provided information of the underlain pre-Quaternary deposits and the groundwater levels, which vary between 1.0 and 30 m below ground surface. The results of VES

and borehole data revealed the river valley filled with unconsolidated Quaternary sand and gravel deposits along the Akhangaran River and its tributaries, and the alluvial-proluvial deposits of loam, loamy sand and pebbles along the floodplain terrace and both sides of the river. These findings provide the geological framework for the upcoming groundwater flow modeling and useful information for water resources managements in the area.

Keyword

hydrogeology, groundwater, aquifer, modeling, groundwater contamination

Groundwater of the foothill plain on the northern slopes of the ridge Nuratau and features of their interaction with surface water

Nosirali Takhirovich KURBANOV[1]*, SI "Uzbekhydrogeology" (kurbanov.n.t@gmail.com)
Timur Erkinovich Mavlyanov[2], ГУ Узбекгидрогеология

Abstract

The hydrogeological characteristics of aquifers within the northern foothill plain of the Nuratau ridge are considered in connection with the choice of a site for the construction of a large industrial facility and the conditions for the interaction of groundwater with the waters of Lake Tuzkan.

Recently, in the Republic of Uzbekistan, engineering surveys were completed to select a site for the construction of a large industrial facility on the periphery of the piedmont proluvial plain of the northern slopes of the ridge in Nuratau mountain near Lake Tuzkan. For making design decisions, for selection the type of foundation, for developing measures for the engineering protection of structures, and for protection the geological environment, much attention was paid to study hydrogeological conditions and features of the interaction of groundwater and surface waters.

The water level in Lake Tuzkan for the period of research was at absolute levels of 244-245 m, water salinity -10200 mg/l.

Groundwater is confined to Mesozoic-Cenozoic loose clastic deposits and fractured rocks of the Paleozoic basement. The relief of the foothill plain is hilly, slightly sloping to the north and northwest at absolute elevations of 600 - 245 m.

The following aquifers are distinguished within the territory:

The aquifer of Upper Quaternary-Modern aeolian deposits is distributed on the periphery of the foothill plume. The depth of the groundwater level varies from 20-30 m to 0.0-3.0 m along the shore of Lake Aydarkul, mineralization - from 0.7 g/l to 11.9 g/l.

The aquifer of Upper Quaternary proluvial sediments is the first from the surface in the middle part of the piedmont proluvial plain. Groundwater levels at depths from 4.3 m to 25.1 m, mineralization up to 1.0 - 3.0 g/l.

The aquifer complex of middle Quaternary sediments lies first from the surface in a strip 5-10 km wide adjacent to the foot of the Nuratau ridge. Water levels in wells are set at 12-95 m below the ground surface, with mineralization from 1.0 g/l to 3.8 g/l.

The aquifer complex of Upper Pliocene deposits is tapped by wells at a depth of 80-100 m. Water levels in wells are set from 4.9 m in the north of the area to 130.0 m in the south, salinity up to 3.8 g/l.

The groundwater regime in the coastal zone is influenced by the Tuzkan lake and the Aidar lake. In the period from November to May, when groundwater levels are set above the water surface in the lake by 0.1-0.4 cm, the reservoir drains groundwater, and from May to November, when groundwater levels drop below the water surface in the lake by 0, 4-0.8 m, the lake feeds

groundwater. The amplitude of groundwater fluctuations is 1.5-1.3 m, in the Tuzkan lake -0.8-1.0 m.

According to hydrogeological studies, it was revealed that within the boundaries of the study area, the natural regime of groundwater is predominantly preserved, corresponding to the infiltration type of recharge of aquifers, and only in the north, in a narrow coastal strip, Lake Tuzkan influences groundwater.

Keyword

groundwater, level, mineralization, study

Exploring heterogeneity in the Varaždin aquifer: Integrating geostatistics and Markov chain analysis with borehole log and electrical resistivity tomography data

Igor Karlovic[1]*, Croatian geological survey (ikarlovic@hgi-cgs.hr)
Mitja Janza[2], Geological Survey of Slovenia
Edmundo Placencia-Gómez[3], Geological Survey of Slovenia
Tamara Markovic[4], Croatian geological survey

Abstract

In recent decades, the elevated nitrate levels observed in the Varaždin alluvial aquifer in northwestern Croatia raised public concern about groundwater quality, particularly due to its importance as the primary drinking water source for the local population. To gain insights into the spatio-temporal distribution of nitrate in groundwater and develop effective management strategies for groundwater quality protection, it is essential to develop numerical groundwater flow and solute transport model. The conceptualization of a study site relies on precisely defining its geometry, establishing model boundary conditions, and characterizing the spatial distribution of aquifer parameters.

Delineating the spatial distribution of hydrofacies within an aquifer presents a challenge, potentially limiting the reliability and practical use of numerical transport models. The aim of this study is to develop a detailed 3-D model illustrating the spatial distribution of hydrofacies within the Varaždin aquifer, crucial for understanding and controlling groundwater transport mechanisms. The model is based on the lithological data from boreholes and wells, electrical resistivity tomography data, other geological conceptual information and geostatistical methods, supplemented by stochastic modeling, i.e. the use of the Markov chain model. This integrated approach enabled the identification of distinct hydrofacies ranging from clay to gravel grain sizes, which improved the current understanding of aquifer heterogeneity, subsequently enhancing the reliability of hydrogeological modeling in the study area.

Keyword

modeling, heterogeneity, geostatistics

Optimizing DNAPL Source Identification in Varied Real Field Scenarios with Scarce Data Using Linked Simulation-Optimization

Jun-Young SHIN[1]*, Seoul National University (wnsdud1079@snu.ac.kr)
Ye Ji Kim[2], Seoul National University
Seoung-Sun Lee[3], Seoul National University
In-Woo Park[4], Seoul National University
Hyoun-Tae Hwang[5], Aquanty, inc.
Kang-Kun Lee[6], Seoul National University

Abstract

To facilitate the effective and appropriate remediation of contaminated groundwater, it is crucial to allocate and characterize the source of contamination. However, identifying contamination sources in real field presents significant challenges stemmed from lack of preliminary data such as monitoring data and site information. This scarcity of data often leads to high complexity in the identification process. To overcome these challenges, our study employed a linked simulation optimization method that combines numerical modeling with optimization techniques. We selected the Ensemble Particle Swarm Optimization (EPSO) for efficient handling of limited data in identifying contaminant sources. The study site is the Namdong Industrial Complex (NIC) in Incheon, Republic of Korea, a site contaminated with Dense Non-Aqueous Phase Liquids (DNAPLs) and with an unknown contamination history. From 2021 to 2023, we monitored groundwater levels and conducted five rounds of sampling for DNAPL concentration data at 14 observation wells. Based on field observations, the transient state model was calibrated using PEST, considering a heterogeneous hydraulic conductivity field. After calibration, the EPSO was combined under various scenarios, considering different potential contaminant release times and spatial distributions. As a result, EPSO showed faster convergence compared to single optimization algorithms, including various strategies of PSO, and suggested a higher probability of approximating the characteristics of the contaminant source under real field conditions with limited preliminary information. Overall, this approach successfully provided information for understanding the spatial and temporal distribution of groundwater contamination, which can contribute to designing appropriate remediation strategies.

Acknowledgement: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government(MSIT) (No. 2022R1A5A1085103).
This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2022R1A2C1006696).

Keyword

Source identification, Simulation - Optimization, Numerical modeling, Particle Swarm Optimization

Application of feature-based clustering and machine learning to investigate spatiotemporal patterns and controlling factors of the groundwater level of Jeju Island, South Korea

Jimin HWANG[1]*, Seoul National University (legojimin@snu.ac.kr)
Eun-Hee Koh[2], Jeju National University
Ye Ji Kim[3], Seoul National University
Seung-Wook Ha[4], Seoul National University
Min-Chul Kim[5], Jeju Research Institute
Kang-Kun Lee[6], Seoul National University

Abstract

The long-term assessment of groundwater level time series (GWL-TS) through groundwater monitoring networks (GMN) provides insights for the characterization of regional groundwater systems and development of strategies for groundwater management. However, effectively assessing and characterizing regional GWL and their controlling factors still need to be improved due to the data heterogeneity (missing values, varied measurement lengths, noise), limited spatial coverage (point-based measure in space), and the complex interplay between groundwater systems and their controls. Therefore, this study utilized feature-based clustering and machine learning to assess and characterize the spatiotemporal patterns of the regional GWL and their possible controlling factors. The study was conducted on the GMN in Jeju Island, where water resources primarily depend on groundwater. Feature-based clustering was applied to group 124 heterogeneous GWL-TS. Subsequently, machine learning was applied to evaluate the relationships between these clusters and spatial environmental data related to the dynamics of GWL. As a result, the spatiotemporal patterns of the GWL of Jeju Island and their possible controlling factors were successfully identified. Consequently, we anticipated that the results of this study could serve as the foundation for managing groundwater resources in this region by each cluster through selecting representative wells or developing clustered-based GWL-TS prediction system.

Acknowledgement: This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government(MSIT) (No. 2022R1A5A1085103).
This work was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIP) (No. 2022R1A2C1006696).

Keyword

Groundwater level, Groundwater monitoring networks, Jeju Island, Clustering, Machine learning

Hydrochemical Analysis of groundwater in Chamoli district, Garhwal Himalaya India

Abhishek Mehra[1]*, KUMAUN UNIVERSITY NAINITAL (mehrageo1555@gmail.com)
Girish Kumar Sharma[2], University of Delhi,India

Abstract

Hydrochemical Analysis of Groundwater of Chamoli District, Garhwal Himalaya, India
1Abhishek Mehra and G.K. Sharma2
1Department of Geology, Kumaun University, Nainital-263002, India
2Department of Geology, University of Delhi, Delhi- 110007, India
E-mail: mehrageo1555@gmail.com
Abstract:
Groundwater especially spring water is one of the major sources of drinking water in hilly areas. Most of the population in the hilly terrain depend on natural spring water for daily use. The Chamoli district was chosen as the study area which is thickly populated and covers the vast area. 28 samples in which 17 ground water (CHP) and 11spring water (CSP) were collected during the post-monsoon season i.e. November, 2023. The samples were analyzed for potential of hydrogen (pH), electrical conductivity (EC), total dissolved solids (TDS), concentration of heavy metals such as chromium, manganese, iron, copper, lead, nickel and zinc using Atomic Absorption Spectrophotometer (AAS).
It is observed that ranges of pH lie between 8 to 7.8; TDS from 189 to 307.64; Electrical Conductivity from 296 to 480.69. On the basis of hydro-chemical analysis, the cations- K(0.13 and 2.84); Na(0.39 and 1.93); Ca(22.61 and 28.99); Mg (9.25and 7.58) and anions- chlorine(19.39 and15.47); Fluorine(0.38 and0.42) and NO3 (7.78and 10) whereas the values of heavy metals Pb(0.021-0.028) ,Zn (3.12 and 3.33), Cr (0.026 and 0.03), Mn (0.013 and 0.24), Cu (0.03 and 0.023), are within the permissible limit (ISI0500-2012) values are calculated for springs and ground water respectively and observed that heavy metal pollution of lead in groundwater and springs are also high.
Further, according to the ISI0500-2012 limit, the study area contains lead, zinc and manganese, chromium and nitrate concentrations which are higher than the permissible limit in some sites of Chamoli. The heavy metal pollution index (HPI) and Water Quality Index have been calculated and establishes a relationship between springs and ground water. This suggests that the pollution is not only anthropogenic but also geogenic. The pollutants enter into the ground water may be due to dissolution or erosion from the surrounding catchment areas. This groundwater is not suitable for drinking purposes as having high concentrations of nitrate, fluorine and chlorine. It is interpreted that groundwater is not suitable for drinking purposes as it is having the high concentrations of lead and nitrate in the ground and spring waters.
Key Words: , , multivariate analysis,

Keyword

Heavy Metal Pollution Index (HPI), Water Quality Index, hydro-chemical, groundwater, Garhwal Higher Himalaya

The susceptibility of urban hard rock aquifer in equatorial climate to hydraulic and contaminant stresses: The case of Shah Alam, Malaysia.

norsyafina roslan[1]*, Universiti Kebangsaan Malaysia (finalan@ukm.edu.my)
John Tellam[2], University of Birmingham, UK

Abstract

Shah Alam is one of the most developed states in Selangor, Malaysia. This urbanized area experienced a water shortage problem in 1998 that led to the use groundwater as an alternative water supply, especially for industrial purposes. Industries that are using groundwater, such as the steel and plating industry, drink and brewery, laundry, electrical appliances, and electronic devices. Groundwater is also used locally by schools and mosques for domestic purposes and also for small farm irrigation. Despite the regular use of groundwater since 1998, there is little or no understanding of urban hard rock aquifers, especially in equatorial climates. This city also experiences flooding often; the impact of flooding events on the aquifer is unknown. Therefore, this paper aims to understand the equatorial climate of hard rock urban aquifers and to determine the relationship between surface water and groundwater in the study area in a way to identify the susceptibility of the aquifer to hydraulic and contaminant stresses. The geological conceptual model of the study area is built using geological information obtained through geological mapping, borehole log interpretation, and soil analysis. There are 8 locations that have been selected along the Klang River for soil sampling using an auger. The soil samples are taken at various depths until the water table is encountered. The slotted PVC pipe is installed in each borehole. The geological model later developed into a hydrogeological conceptual model by adding input from pumping tests and chemical analysis. The infiltration test using a double-ring infiltrometer is conducted at each sampling location to determine the relationship between surface water and groundwater in the study area. Besides, historical water level data recorded in both pumping and monitoring wells, rainfall, and river level data are analyzed. The lithology of the study area comprises interbedded quartzite and phyllite, with granite in the eastern part. The aquifer system is confined to semi-confined, with fractured quartzite or phyllite covered with up to 60 m of weathered layer. The abstraction activity has induced recharge into the aquifer, which is reflected through the drawdown curve patterns. Many water samples were polluted by one or more species, and sewer influences are common. The aquifer in the study area is identified as susceptible to contaminant stresses. This information is very useful for the regulator as a way to monitor the groundwater abstraction activity in the study area. This is important to ensure the groundwater sources are protected and sustainable for future use.

Keyword

hardrock urban aquifer, equatorial climate, susceptibility, hydraulic and contaminant stresses

[Keynote] Integrated surface and subsurface hydrological modeling to support water management

Rene THERRIEN[1]*, Universite Laval (rene.therrien@ggl.ulaval.ca)

Abstract

Integrated surface and subsurface hydrological models are designed to simulate the terrestrial portion of the hydrologic cycle. These models typically simulate coupled 2D surface water flow and 3D variably-saturated groundwater flow and, in some cases, mass and energy transport. They represent water exchange between the surface and subsurface domains with physically based equations and therefore do not rely on artificial boundary conditions between the two domains. For example, unlike groundwater flow models, they do not require groundwater recharge as an input parameter. Instead, they use hydroclimatic variables as inputs, such as liquid and solid precipitation and temperature, and redistribute water in the surface and subsurface domains according to the hydraulic properties of both domains. Because they rely on fewer assumptions than decoupled models, integrated surface and subsurface hydrological models are increasingly being used to integrate available data for a hydrologic system, reproduce hydrological observations and forecast potential changes in the hydrogeological regime following natural or anthropogenic modifications. They also allow a unified approach to simulate both surface water and groundwater at the catchment scale, which is the typical scale of interest for water management. This presentation will focus on recent developments and applications of the HydroGeoSphere model, which simulates coupled surface and subsurface water flow, solute and energy transport. The potential of the model to support water management will be discussed, along with some of the challenges associated with its application. The importance of proper characterization of the geological environment will also be emphasized as well as recent developments that allow faster calibration and quantification of the forecasting uncertainty.

Keyword

Surface water, Groundwater, Modeling, Management

Assessing changes in hydrogeological conditions during solid minerals development: an in-depth analysis

Gleb ZARNITSYN[1]*, Sergeev Institute of Environmental Geoscience, the Russian Academy of Science (IEG RAS), Moscow, Russian Federation (gerimax100@gmail.com)

Abstract

Globally, the mining industry is undergoing a transformation as the reserves of large near-surface deposits favorable for development are being depleted. This necessitates the involvement in exploitation of small and medium-sized or already partially developed fields with low raw material content and reserves at great depths in hard-to-reach regions with very complex mining and hydrogeological conditions.

This paper analyzes hydrogeological conditions and their changes at different stages of field development on the example of two large objects: diamond deposits in the european North and ore gold deposits in eastern Siberia of the Russian Federation. The research complex included the following types of work: literature review, field trips, uncertainty analysis in the process of schematization of natural conditions, geofiltration and geomigration modeling using deterministic and stochastic methods.

The first object is a diamond deposit in the north of Russia, which has been developed by open pit mining since 2010. The main feature of the deposit is anomalously high water content of rocks up to the depth of 350 meters. The total volume of water inflow reaches 2-2.25 m3/s, which is comparable to the flow rate of small rivers. The analysis showed that the stabilization of groundwater levels was manifested only by the end of 2018, the damage to river flow, due to the huge drainage water discharge, is practically absent. In the overall balance of water inflows, in addition to capacitive reserves, the interception of groundwater flow of adjacent lakes and rivers, as well as filtration losses from the tailings pond play a significant role. Based on this analysis, geofiltration schematization was performed, a hydrogeological model was built and calibrated, on which the theses put forward were substantiated, the epignostic task was solved and predictive estimates of water inflows, including their chemical composition, were made.

The second site is a gold deposit in southern eastern Siberia. The two deposits were developed by a combined method with a common underground water drainage during the last century, after which exploitation was terminated in the 90s. Over the following years, the two open pits gradually flooded, and recently it was decided to dewater and further develop one of them. A hydrogeological model was created, including 20 computational layers corresponding to loose and cemented sediments. The main uncertainties are the spatial position and parametric characterization of the sediments. These uncertainties were solved using various interpolation methods. Calibration of the model was performed manually and semi-automatically by

reconstructing water levels in the pits. Stochastic modeling method for water inflow estimation was used due to poor hydrogeological understanding of the area. A geomigration model was created based on geofiltration model, which allowed to qualitatively characterize the composition of predicted water inflows from quarries flooded with water of different composition. Additionally, hydrological studies including calculations and modeling of surface runoff were carried out for more accurate quantitative characterization of water inflows.

Keyword

hydrogeological conditions, water inflow, geofiltration modeling

A Study into the assessment of groundwater flow utilizing thermal and hydrochemical datasets from both groundwater and surface water in the karst area of Samcheok, South Korea

Han-Sun Ryu[1]*, Kangwon National University (rhs@kangwon.ac.kr)
Heejung Kim[2], Kangwon National University

Abstract

This study explores the dynamics of groundwater flow by analyzing hydrochemical and thermal data, intending to comprehend the movement of groundwater and the behavior of pollutants within the karst area and devising strategies to tackle water quality challenges while ensuring the stability of water resources. Flow characteristics were determined through the examination of topographic slope and groundwater maps, revealing heightened vulnerability to groundwater contamination due to its proximity to the discharge zone where groundwater from the western region flows into the sea. Measurements of vertical hydraulic gradient were utilized to determine the directions of groundwater recharge and discharge, indicating active exchange between groundwater and surface water. Groundwater recharge was found to be predominant in both Gyogokcheon (Gyogok-ri) and Sohancheon (Hamaengbang-ri), with Sohancheon showing increased recharge activity during summer and winter compared to spring and fall. Analysis of hydrochemical data provided insights into groundwater residence time, recharge patterns, and the dynamics of surface water mixing relative to groundwater flow and pollutant behavior. Notably, significant discrepancies in radon concentration were observed between Gyogokcheon (gneiss-based rock) and Sohancheon (limestone-based rock). While radon concentration levels in Hamaengbang-ri remained relatively consistent across surface water, groundwater-surface water mixing zones (hyporheic zones), and cave water, Gyogok-ri utilized radon concentration as a tracer to estimate the mixing ratios of groundwater and surface water within the hyporheic zone. This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (grant numbers 2019R1I1A2A01057002 and 2019R1A6A1A03033167).

Keyword

karst area, vertical hydraulic gradient, hyporheic zone, thermal data, hydrochemical data

Using 3D geology models to support and improve decision-making in water resources regulation in England.

Michael Kehinde MBE CGEOL[1]*, Environment Agency (michael.kehinde@environment-agency.gov.uk)

Abstract

The Environment Agency has the statutory function of regulating the development and use of water resources to ensure sustainability and minimise negative impact on people, nature, and livelihoods.

This paper focuses on the Hertfordshire and North London ('HNL') area of England that is characterised as currently water-stressed and grapples with complex challenges of natural and anthropogenic nature. HNL serves a diverse and dense population of about 6.5 million people in 44 Local Authorities from rural Home Counties to Greater London and its suburbs. It is home to some globally rare chalk-fed streams and has the largest chalk stream sink (the Water End swallow hole) in England with estimated mean flow of 80l/s.

The dominant geology is the chalk aquifer system which also is the principal source of groundwater for public water supply, industrial and agricultural uses. The Environment Agency is now increasingly focused on restoring a sustainable abstraction regime as several chalk catchments are now either over-licensed, over-abstracted, or approaching these conditions, and groundwater abstraction is adversely affecting the baseflow contribution to the chalk-fed streams.

To improve understanding of the geology and hydrogeology of the area, HNL embarked on a process of geological mapping, borehole drilling, 3D geology modelling and improved groundwater modelling. The 3D geology model provides valuable input for developing a hydrogeology conceptual model and serves as input into the numerical Modflow model. This enabled us to investigate the rather complex impact of sustainability reduction of abstraction on river flows with some success. However, this also flagged the issue of the unintended consequence of groundwater emergence that could increase the risk of groundwater flooding and sewer surcharge.

With the improved understanding of how the catchments work, based on the additional data obtained from the various programmes embarked upon, it is becoming less stressful to make water regulatory decisions that are understood by stakeholders and are less open to challenge. This paper will present some examples of abstraction impact questions addressed using the Hertfordshire Chalk Groundwater Model and the Ver-Gade-Chess Groundwater Model. These models had the benefit of using 3D geology models developed in Leapfrog.

Additional benefits derived from using 3D geology model are the wider use of model-derived tools (e.g. groundwater hydro-ecology tool) and the application of the models to new issues (e.g. land use change, nature-based solutions, climate change). HNL developed a 3D geology model in PDF to engage non-technical stakeholders and for general geoscience communication with the public explaining how we protect groundwater from human activities and other artificial

influences. With this example we showed the relative position of groundwater level on two memorable weather events – the flood of 2001 and the drought of 2006 as well as the long-term average groundwater level. Viewers can relate the role of groundwater with their experiences of past extreme climatic events.

Keyword

water regulation, sustainable groundwater, 3D geology, numerical groundwater modelling, decision-making

Numerical calculation and case analysis of seepage field in anisotropic aquifer

Lei LYU[1]*, Yunnan University of Finance and Economics (leilyu@ynufe.edu.cn)
Chunxue LIU[2], Yunnan University of Finance and Economics

Abstract

The anisotropy of aquifer permeability can be characterized by the permeability coefficient tensor. When numerically simulating the seepage field of an anisotropic aquifer, the size and main direction of the principal value of the permeability tensor will have a significant impact on the seepage field. How to reasonably establish a numerical model that can reflect the anisotropy of the aquifer is very critical.

The object of this study is a metal mine. The mine uses underground mining and has a relatively complete drainage system. The water from all tunnels is collected and discharged to the surface through the middle drainage tunnel with an elevation of 1360m. There are no other obvious groundwater exposure points in the surrounding area. The lithology of the area where the mine is located is mainly Triassic carbonate rock formation. The overall lithology is relatively uniform and can be summarized as an aquifer with a unified hydraulic connection. Fissures and karsts are strongly developed throughout the aquifer. Through field surveys, tracer tests, pumping tests and other work, it was found that the aquifer has strong anisotropy. The sources of groundwater recharge in the hydrogeological unit where the mine is located include rainfall and underground runoff. There are many karst depressions, funnels, sinkholes, and corrosion fissures in the area, and the rainfall infiltration coefficient is 65% to 85%. Atmospheric rainfall vertically recharges groundwater, and the seasonal fluctuation range of groundwater levels is large, which can be greater than 150m. Affected by the dewatering of groundwater due to mining activities, the groundwater level in the central part of the study area has dropped significantly.

This paper discusses the assignment method, conditions and feasibility of the main value size and direction parameters of the aquifer permeability tensor in the program by analyzing mathematical models, discrete methods and difference formulas. It is believed that the calculation of the penetration tensor under certain conditions can be achieved by using the numerical model grid rotation method in the program. The results of the theoretical analysis were verified using examples, and the influence of the direction of the principal value of the permeability tensor on the seepage field was compared.

Keyword

Groundwater numerical simulation, Anisotropic aquifer, permeability coefficient tensor

Study on the quality of water wells in the city of Hashtgerd using hydro-geochemical charts

Zahra SHARIFI[1]*, Phd Geomorphology (zahra_sharifi1364@yahoo.com)

Abstract

Studying of the composition and quality of different types of water such as underground water and surface water is a necessity. The hydrogeomorphology method is used to produce an environmental information layer in order to evaluate the quality of underground water resources. The study area is located in the central Alborz mountain in north of Iran and in the western part of the central Alborz.

From the point of view of national divisions, the Hashtgerd plain is located within the boundaries of Saujblag city in Alborz province. The purpose of this research is to investigate the impact of geomorphology on the changes in underground water resources of Hashtgerd city, which includes the identification of morphological and geomorphological forms, classification from the perspective of water infiltration and hydrogeochemical changes based on data analysis. and interpretation of charts. The stratigraphy of the region is sedimentary and sometimes igneous, and due to the large amount of sandstone and limestone, there is a possibility of forming underground water reserves and karst reservoirs.

Analysis of underground water data, processing and interpretation of charts and preparation of maps have been done using water quality, GIS software. The results of the qualitative parameters show that electrical conductivity and chlorine increase from north to south, which indicates the feeding of the table from limestone and dolomite formations as well as igneous formations in the north and the lack of evaporative layers such as chalk and salt in the north of the plain. The samples of Hashtgerd city are classified between hard and relatively hard. According to the results of the Piper diagram and the Wilcox diagram, respectively, the water type of the studied area is bicarbonate and approximately 82% of the samples are in the C2-S1 class in the category of agriculturally good water. According to Schuler's diagram the status of underground water resources of Hashtgerd city is in the good category in terms of drinking. The quality of water for industrial uses is corrosive. Geomorphological forms have not had a significant impact on the quality of water resources, and most human factors have caused changes and drops in the underground water level, and have had a negative impact on water quality. Due to the presence of marl stone units that caused chlorine changes and salt and evaporation forms in the subsurface layers caused quality changes and increased electrical conductivity and chlorine.

Keyword

underground, hydrogeomorphology, Hashtgerd, hydro-geochemical charts, wells

Evaluation of the impact of artificial replacement on groundwater in the Yongding River

Tian NAN[1]*, Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences (419416433@qq.com)
Wengeng CAO[2], Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences

Abstract

Evaluating the effect of ecological water supplement on groundwater restoration quantitatively could produce positive contributions to both water cycle theory and surface-ground water conjunctive management. Therefore, in this paper, a groundwater flow numerical model has been established after calculating the river section seepage rate using a fuzzy mathematical method in the Yongding River channel. The simulated results show that the model could accurately reflect the real groundwater dynamic features. Then a data-driven random forest model has been established to quantitatively evaluate the contributions of the factors which influence the groundwater level variation. The study shows that the infiltration capacity is strong in the upstream area of Yongding River, and the seepage rate is over 0.7. The lowest seepage rate is 0.19 at the downstream end, while the seepage rate in the middle area is basically between 0.4 and 0.7. From 2018 to 2019, the ecological water supplement of the Yongding River has played a significant role in raising the groundwater level along the river channel. And its contribution to the change of groundwater level is 25%. The impact depth of groundwater level fluctuation reaches about 10m. The impact range where the groundwater level average uplifts 1.86m is 502.13km2. The influence direction gradually changes from around the ecological water supplement section to along the Yongding River Channel. The groundwater level variation along the tangential direction of Yongding River is slowing down. The groundwater level would entirely uplift with 170×106m3/a ecological water supplement of the Yongding River and 35.77×106m3/a groundwater mining reduction in the downstream area until 2035.

Keyword

ecological water supplement, groundwater restoration, random forest model

Pollutant Migration in mineral area through Copper Isotope Values in Soils and Waters

JINGWEN SU[1]*, China Geological Survey,Nanjing Center (michelle3322@Hotmail.com)
Ryan MATHUR[2], Geology Department, Juniata College

Abstract

Copper mining has long history in China. Multiple studies have demonstrated, through concentrated work on soils and waters, the impact of mining in the such kind of area. In this case, one typical area in east China was choose to study the pollutant migration. Here we present copper isotope values of 13 ore samples, three tailing samples, 20 water samples (surface and groundwater), and 94 soil samples (15 different profiles ranging in depth from 0–2 m) from proximal to distal (up to 10 km) locations radiating from a tailings dam and tailings pile. Oxidation of the copper sulfide minerals results in isotopically heavier oxidized copper. Thus, copper sourced from sulfide minerals has been used to tracu e copper in mining and environmental applications. In this aera, higher copper isotope values (greater than 1 per mil, which are interpreted to be derived from copper sulfide weathering) are found both in waters and the upper portions of soils (5–100 cm) within 1 km of the source tailings. At greater than 1 km, the soils do not possess heavier copper isotope values; however, the stream water samples that have low copper concentrations have heavier values up to 6.5 km from the source. The data suggest that copper derived from the mining activities remains relatively proximal in the soils but can be traced in the waters at greater distances.

Keyword

copper isotopes, copper concentration, mining

Analysis of Oxygen and Hydrogen Isotopes in Groundwater Basin: Mapping of Origins, Dynamics, and Use of Groundwater Resources in Bandung Basin Area

Mohamad Sapari Dwi HADIAN[1], Universitas Padjadjaran
Dewandra Bagus Eka Putra[2]*, Seoul National University (dewandrabagus@snu.ac.kr)
Mochamad Nursiyam Barkah[3], Universitas Padjadjaran
Satrio Satrio[4], National Research and Innovation Agency Indonesia
bombom rachmat suganda[5], Universitas Padjadjaran

Abstract

The fast growth of the city and population in Bandung is increasing the need for water. Taking too much groundwater, especially for homes and industries, can make the underground water storage run out, causing the level of groundwater to drop. One way to deal with this is by using stable isotopes to follow where the water comes from, like rain and underground sources. This method helps us map where groundwater starts, find out how long it stays underground, and understand why groundwater is important.

To do this, we collect and test groundwater and spring water twice a year in the tropics. We use special tools to measure tiny weight differences in water samples. Understanding isotopes is crucial to figuring out how water moves. When water evaporates, the lighter molecules go up, forming clouds with different signs. When it rains, the mix of water with heavier molecules falls first, affecting the makeup of rainfall.

This study looks into how farming and other activities around Bandung and the city affect the levels of hydrogen and oxygen isotopes in groundwater. We use isotope analysis to study the changes over time and space. This helps us see how people impact the quality of groundwater. The goal is to identify oxygen and hydrogen isotopes in groundwater areas to know where it comes from, how it moves, and how old it is. This information is crucial for leaders to make plans and manage water wisely.

Keyword

Isotope Analysis, Impact of Human Activities, Groundwater Basin, Groundwater Source, Water Dynamics

Assessing the impact of climate change on hydrological components using CMIP6 GCM models of the Hasdeo river basin, Chhattisgarh, India: Implications for sustainable water resources in the future

satish B[1]*, Exploration Department, Coal India Limited, CMPDI, RI-V, Bilaspur, Chhattisgarh, India-495006 (b.satish@coalindia.in)
Vijendra Chouhan[2], Exploration Department, Coal India Limited, CMPDI, RI-V, Bilaspur, Chhattisgarh, India-495006
Satheeshkumar S[3], Department of Geology, Government Arts College(Autonomous), Salem, TamilNadu, India-636007
Rethikala K R[4], Department of Geology, Bishop Kurialacherry College For Women, Amalagiri, Kerala, India-68656

Abstract

The Hasdeo river basin is a part of the Mahanadi basin flowing in the state of Chhattisgarh, India. The Hasdeo River is one of the major tributaries of the upper Mahanadi basin. In recent times, periodic droughts in the upper Mahanadi basin and contrary flood events in the lower Mahanadi basin have occurred in the delta region of Orissa state. To maintain sustainability, i.e., to maintain the water demands in the future without compromising the environment or hydrological integrity, a study on climate change at the local scale is needed in the region. This study aims to assess climate change at the river basin level and its impact on water balance components such as precipitation, runoff, groundwater discharge, evapotranspiration, and discharge using the SWAT model. In this study, 13 global climate models (GCMs) of Coupled Model Inter-comparison Project Phase 6 (CMIP6) have been analyzed and based on their performance, three GCMs are considered under two emission scenarios, such as Shared Socioeconomic Pathways (SSP) 245 and SSP 585. The entire period has been subdivided into four parts: historic (1994–2017), near (2018–2040), mid (2041–2070), and far (2071-2100). In the near future, there will be an increase in streamflow of about 20.85–36.20% and 31.92–35.65% under SSP 245 and 585, respectively, and a significant increase in runoff of about 48.12–51.01% and 50.42–60.41% under SSP 245 and 585, respectively. This indicates the vulnerability of a near-future flood in downstream of the Mahanadi basin. Similarly, in the far future, there will be a nominal average increase in streamflow and runoff of about 14% and 22.75%, respectively. Spatially, the southern part of the basin is projected to experience more precipitation than the northern part of the basin. The findings emphasize the understanding of the effects of climate change on water balance in the basin and urge proactive measures taking account of agricultural and domestic requirements, groundwater discharge, etc., to prevent water stress and surplus situations in the basin. Implementing policy and management based on scientific evidence may help to maintain sustainable water resource management for an effective response.

Keyword

climate change, CMIP6, SWAT, Hasdeo river, water balance

Deciphering probable groundwater recharge patterns in Khapri watershed of Deccan Volcanic Province (DVP), western India: Insights from stable isotopes

Chinmay Uday DONGARE[1]*, Deparment of Geology, The Maharaja Sayajirao University of Baroda (chinmayd.avs@gmail.com)
Bhushan Sharad DEOTA[2], Deparment of Geology, The Maharaja Sayajirao University of Baroda

Abstract

The present study attempts to decipher the groundwater recharge patterns in the Khapri watershed of district Dangs forming part of DVP in western India, using stable isotopes of oxygen (δ18O) and hydrogen (δ2H). The stable isotopes are remarkable tracers and are useful to decode water circulation throughout the hydrological cycle. Worldwide various hydrological studies have successfully demonstrated the application of stable water isotopes in understanding the working of hydrological systems and effective water resources management. In the Khapri watershed, the stable isotope analysis of rainwater (August-2022), river water (September-2022), and groundwater samples (May-2022 and January-2023) has been carried out to assess the groundwater resource sustainability, in view of deciphering the sources and recharge patterns. To obtain the stable isotope composition (δ18O and δ2H values), an Isotope Ratio Mass Spectrometer (IRMS), Delta V plus in continuous flow mode aided by Gas bench II at Physical Research Laboratory (PRL), Ahmedabad is utilized. The δ2H versus δ18O plot of rainfall samples of Khapri watershed, indicated that slope of Local Meteoric Water Line (LMWL) (δ2H = 7.86 δ18O + 9.97) is close to Global Meteoric Water Line (GMWL) (δ2H = 8 δ18O + 10). The variations in δ2H versus δ18O plot of groundwater samples, suggest the potential effects of evaporation. The relatively depleted δ18O (-2.4‰) values of post-monsoon groundwater and river water samples indicate influx of freshwater. The negative δ18O values (-0.9 ‰) of pre-monsoon groundwater samples at certain locations may be due to mixing of return flow of deeper groundwater mined for agriculture. The salient features of the present study include δ18O depletion in rainfall, δ18O enrichment in wells of upper-reaches, and surface water influence on dug wells. The isotopic data of deeper groundwater indicates recharge from agriculture return flow during non-rainy seasons. From the stable water isotope analysis four probable groundwater recharge patterns can be envisaged viz. a) meteoric water infiltration through joints and fractures present in rocks, b) percolation through river and reservoir, c) recharge from natural springs, and d) agricultural return flow of deeper groundwater. Thus, stable water isotope analysis is valuable in understanding the groundwater recharge dynamics of Khapri watershed.

Keyword

Khapri watershed, Deccan Volcanic Province, Groundwater recharge pattern, Stable isotope analysis

Fluoride in groundwater of a hard rock sub-basin of northern Karnataka, India – sources and controlling geochemical processes

TEJASWAI LAKKUNDI[1]*, CENTRAL UNIVERSITY OF KARNATAKA (tejaswi@cuk.ac.in)

Abstract

Consumption of fluoride through groundwater can be both beneficial and harmful to health depending upon factors like its concentration and duration of consumption, amongst others. As in the case of several other hard rock terrains across India, the catchment area of River Sindhanur sub-basin too is plagued by the problem of excessive fluoride in its groundwaters. This area is arid, frequently drought affected and characterized by contrasts with respect to geology and agricultural practices. Detailed assessment of physico-chemical parameters of groundwaters was taken up with an objective of understanding their hydrochemical characterization with emphasis on the occurrence of fluoride, its quantification, areal distribution pattern and demarcation of safe- and hazardous zones, identifying its probable sources, and the underlying geochemical processes that might influence fluoride concentration. Results reveal the presence of excessive (>1.5mg/L) fluoride in 51% samples, the range being from 0.34 to 9.59mg/L. Groundwater fluoride concentration varies within and amongst different lithounits, with metavolcanics housing higher proportion of high-fluoride (>1.5mg/L) groundwaters followed by different granitoids. Apatite and fluorite, identified through petrographic examination and thermodynamic modeling respectively are the primary natural sources of fluoride. Other possible natural sources of fluoride identified include biotite, muscovite, hornblende, sphene and actinolite. Few minerals employed in the manufacture of fluoride-containing fertilizers and agricultural sprays, as indicated by thermodynamic modeling, might also be contributing to groundwater-fluoride. In groundwaters with very high fluoride (>6.0mg/L), biotite is the most likely primary source of fluoride as indicated by its near perfect positive correlation with potassium.

Keyword

Groundwater fluoride, fluoride source, geochemical processes

Estimation of the CO2 emission flux to the air by groundwater extraction in Korea

Jiwook JANG[1]*, Kangwon National University (jjwook1108@kangwon.ac.kr)
Jin-Yong Lee[2], Kangwon National Univerisity
Eunju Jeong[3], Kangwon National University

Abstract

CO¬2 is a significant contribution to the greenhouse effect, which has led to abnormal climate conditions. Many countries are attempting to reduce CO2 emissions from industrial and agricultural activities. However, the emission flux of CO2 of Korea increased by 2.7 times since the 1990s, and the concentration of CO2 in the air has risen to 423.1 ppm, which is approximately 1.14 times higher than the initial concentration of 371.2 ppm in Korea. However, the Ministry of Environment reported that CO2 flux was not considered without physio-chemical transportation such as degassing and evaporation, during groundwater extraction in Korea. These methods underestimate CO2 emission flux and cannot accurately assess the total carbon emission rate. The purpose of this study is to estimate the CO2 emission flux due to groundwater extraction and to accurately assess the annual carbon emission rate in Korea. This study collected physio-chemical parameters of groundwater from 457 wells with less than 100 m depth from the “Basic Survey Report of Groundwater in 2020”. The parameters were pretreated to understand geochemical processes that occur during state change by extraction from underground (high temperature and pressure) to the surface. Ordinary kriging was used to enhance spatial interpolation of potential CO2 storage in groundwater. The water facies of groundwater in all provinces except Incheon, is dominated by the Ca-HCO3 type. Additionally, Seoul and Incheon have higher electrical conductivities than other provinces. It means the inflow of contamination from artificial activities. The concentration of dissolved CO2 in groundwater is conservatively calculated using pH and HCO3. The average of pCO2 in groundwater is 21 μatm with a range of 2–31 μatm. This value is then converted to an average concentration is 0.4 g/m3. The total groundwater pumping rate in Korea is 2,672.2 Mm3/year, resulting in an estimated CO2 emission of approximately 1.3 billion g/year. If the groundwater level is used in conjunction with this result, the rate of carbon storage in the groundwater can be estimated. This study provides a source for the CO2 emission flux and an accurate annual carbon emission rate in Korea.

This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

Carbon dioxide, groundwater use, carbon emission, Kriging, Korea

Geological Characterization and Modeling in Southeastern Florida (USA) to Inform the Design of a Coastal Subsurface Monitoring Network

Miguel E. VALENCIA[1]*, Florida International University (mvale095@fiu.edu)
Michael C. Sukop[2], Florida International University

Abstract

Coastal cities in southeastern Florida have subsurface infrastructure that is potentially at risk from several factors, including sea-level rise, saltwater intrusion, shallow water tables, frequent flooding caused by intense precipitation, storm surge, and high-tide flooding events (e.g., King tides). To address these challenges, the U.S. Congress appropriated funds for a pilot project to develop a subsurface monitoring network in Broward and Miami-Dade counties. The program's goal is to create a long-term vadose zone and groundwater monitoring network within this densely urbanized area. This network will aim to quantify the key hydrogeologic (e.g., saltwater intrusion, water table dynamics) and environmental (e.g., corrosion potential) conditions at scales relevant to evaluating existing and future risks to building foundations, buried utilities, and other subsurface infrastructure.

During the preliminary design phase, a Monitoring Technology Advisory Panel was convened and consulted. The Panel emphasized the importance of collecting and incorporating existing geological information, particularly geotechnical lithologic data on the shallow subsurface and other relevant lithologic and geophysical data, to inform the selection of monitoring site locations and the design and installation of instrumentation.

Scrutiny of the available geotechnical data revealed a lack of detailed geological characterization of the barrier islands that extend from Miami-Dade to Broward counties. The lithostratigraphy is locally complex and may consist of calcareous sand, peat, or fill. For example, the barrier islands generally appear to consist of a sand layer of variable thickness overlying limestone, with some thin peat layers on their mainland sides. We leveraged existing geological data to perform geological modeling using GemPy to characterize the shallow subsurface and create detailed geological cross-sections of areas of interest. Model results could be used as inputs for future groundwater models that couple the vadose and saturated zones.
This presentation will provide an overview and preliminary analysis of existing geotechnical data in the context of coastal subsurface infrastructure.

Keyword

Geological Characterization, Geological Modeling, Sea-level Rise, Subsurface Infrastructure, Coastal Infrastructure

An introduction to the National Groundwater Monitoring Network for Systematic Management of Korea's Groundwater Resources

Laesoo KANG[1]*, K-water (kls@kwater.or.kr)
Sora Lee[2], K-water
Daeho Kim[3], K-water
Kyunghee Shin[4], K-water
Sanggu Han[5], K-water

Abstract

In the Republic of Korea (hereinafter S. Korea), as of the end of 2023, approximately 3.04 billion tons of groundwater is being used by 1.77 million groundwater wells.
The annual groundwater recharge in inland areas excluding major island areas (Jeju Island, Ulleungdo) is 20.15 billion tons, and the sustainable development potential is 13.54 billion tons per year.
In addition, in S. Korea, rainfall is generally concentrated during the rainy season (May to October) and the country has a topographically eastern high and western low terrine, so more systematic water resource management is essential to overcome these unfavorable conditions.

The main water resources for domestic in S. Korea mostly being utilized are surface water such as river water and dam water.
Since the early of 20th century, groundwater has played an important role in agricultural and industrial activities. Recently, as we face various problems such as pollution and depletion of surface water due to global climate change, the importance and utilization of groundwater resources are being highlighted again.
To systematically and efficiently conserve and manage Groundwater resources, the Ministry of Environment enacted the Groundwater Act in 1993 and formulated a Groundwater master plan in 1996. In case of the groundwater master plan, it is re-established every 10 years and revised every 5 years if necessary, and the 4th groundwater master plan (2022-2031) was established in 2022.

In addition, the Groundwater Act and the Groundwater Master Plan contain related matters that the establishment and operation of a "national groundwater monitoring network" that systematically manages groundwater resources and continuously observes nationwide groundwater levels and changes in water quality to secure basic data.
As of the end of 2023, 713 monitoring wells have been installed and operated nationwide, and water level, electrical conductivity, and water temperature are measured in real-time every hour. Additionally, conducting separate water quality tests (35 items) twice a year (in the first and second half of the year) to continuously monitor changes in groundwater water level and quality.
The national groundwater monitoring network is planned to be installed at 985 locations (cumulative) by 2030 and 1,482 (cumulative) locations by 2045. Additionally, the measured groundwater level and water quality information is published annually and provided to the public.

Also, it is used as basic data for the conservation and management of groundwater resources by deriving trend analysis, causes of outliers, improvement measures through water level, time series analysis of water level data, and trend analysis.
In order to improve the usability of these groundwater data, the government established the “National Groundwater Information Center(https://www.gims.go.kr)” in 2004 to collect and analyze all information such as groundwater-related surveys and measurements to provide citizens with groundwater information. The Center is also conducting capacity building for the officials and employees of groundwater-related companies, promoting and providing education to the public and students on the importance of Groundwater resources.

Keyword

Groundwater monitoring, Groundwater information center, Groundwater Act, Groundwater Master Plan

Prediction of Fluoride Concentrations in Groundwater Using Machine Learning and Human Health Risk Assessment in Eastern India

RAHUL SINGH[1], IIT Kharagpur
SUBHASISH TRIPATHY[2]*, IIT Kharagpur (stripathy@iitkgp.ac.in)
ASHOK KUMAR GUPTA[3], IIT Kharagpur
Venkatesh Uddameri[4], Lamar University, Beaumont, TX 77713
SANKET RATAN BAGAL[5], IIT Kharagpur

Abstract

Elevated fluoride (F−) concentration in groundwater is a major environmental problem and a public health risk in many parts worldwide. This study encompasses the possible contamination sources and the spatial availability of fluoride concentrations in groundwater of Eastern India and the consequential health risk assessments for devising specific mitigation strategies. This study employs Inverse Distance Weight (IDW) coupled with machine learning algorithms (LR, CART, RF, MARS, GB, and XGB) on the hydro-chemical data from 1178 locations. Groundwater samples have been characterized for their physicochemical parameters and F−. Based on the acceptable limit of fluoride concentration (F− > 1.0 mg/l) in drinking water by the World Health Organization (WHO) and Bureau of Indian Standards (BIS), samples were categorized as Unsafe (n = 82) and Safe (n = 1096). Unsafe class of groundwater samples (F− > 1.0 mg/l) are dominated by HCO−3 and depleted with Ca but relatively higher in pH. The order of dominance of groundwater facies is Mg-Ca-HCO3 > SO4-CaCl-Mg > Na-HCO3 > SO4-NaCl. Prolonged water-rock interactions and the geochemical processes within the aquifer appears to have resulted in higher F−. Higher fluoride concentrations in groundwater are also related to major geological features. Exploratory data analysis (EDA) was used to examine and summarize the essential properties of the data prior to making any assumptions. Hydro-chemical parameters controlling the fluoride in groundwater were selected by feature importance modelling. XGB was found to be the best-performing model for predicting fluoride incorporating the controlling factors. Predicted fluoride concentration beyond the WHO acceptable with Hazard Quotient (HQ) > 1.0 revealed that approximately 6.5%, 41.1%, and 61.7% adults, children, and infants, respectively are in risk of non-carcinogenic health hazards in predicted locations hitherto unknown. This integrated mechanistic-machine learning framework helps in prioritizing future monitoring, and consequent reduction in health risk.

Keyword

Hydrogeochemical facies, Fluoride, Machine learning, Health risk assessment, GIS

A new approach to vulnerability analysis of Asian aquifers: machine learning and geochemical evidence

Wengeng CAO[1]*, Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences (281084632@qq.com)

Abstract

The economic development and population growth in Asia have exacerbated the supply-demand imbalance of groundwater resources. Concurrently, issues such as groundwater pollution, seawater intrusion, overexploitation of forest resources, and climate change-induced problems like permafrost degradation, soil desertification, and salinization have further intensified the vulnerability of aquifers. To address these issues in a timely manner, this study employs a multi-integrated strategy optimization framework combined with geochemical evidence to assess and validate the vulnerability of Asian aquifers. Through a comprehensive analysis of geological structures, climate change impacts, human activities, and policy management factors, the study finds that the vulnerability of aquifers in mountainous regions is particularly pronounced. This is mainly due to coarse soil particles increasing the permeability of aquifers, which also leads to erosion and soil loss, directly contaminating the aquifers. Faults and karst formations create complex aquifer channels that facilitate the rapid spread of pollutants, increasing contamination risks. Uneven precipitation results in irregular recharge, and seasonal fluctuations exacerbate pollution issues. Diverse agricultural, forestry, and pastoral activities increase pollutant inputs, deepening the vulnerability of aquifers. Additionally, the study discusses the mechanisms of aquifer vulnerability in different geomorphic types and the potential risks under various conditions, proposing sustainable management recommendations. This in-depth analysis aims to provide theoretical support and practical guidance for effectively addressing the numerous challenges faced by Asian aquifers.

Keyword

Asia, aquifer vulnerability, geochemistry, potential risks

Geological Characteristics of Coastal Aquifer in the southwest of Korea

SUNG KEUN LIM[1]*, Korea Rural Community Corporation(KRC) (limsungkeunlee@gmail.com)
JIN-HOI KIM[2], Korea Rural Community Corporation(KRC)
Jong-Yun LEE[3], Korea Rural Community Corporation(KRC)

Abstract

Land-based seawater aquaculture(seedling) farms distributed in the coastal areas of Korea are operated by collecting seawater directly from the sea. Therefore, these farms are not only very vulnerable to red tide and oil spills from accident vessels due to the increase in water temperature in summer, but also require huge maintenance costs such as fuel and electricity to maintain the temperature in winter and summer.

In particular, by heating low-temperature seawater to around 15°C is supplied in the winter, while it is used directly and sometimes high-temperature seawater is used to lower the temperature by using an air conditioner in the summer.

However, as crisis situations such as the increase in production costs due to the rise in oil prices and expansion of low-priced imported marine products into the domestic market have appeared, the need to investigate and use the saline groundwater with temperature and quality and the reduction of production costs has increased in order to secure competitiveness with imported products.

This study was purposed to obtain a large amount of saline groundwater around coastal aquaculture farms. Thus, we have proposed a method for evaluating the potential amount of saline groundwater resources through the combined analysis of geophysical methods and pumping test in developed boreholes.

Geophysical surveys were conducted in the vicinity of fish farm located in the southwest part of Jeonnam Province. According to the results, well development and a series of pumping tests are conducted.

As the result, the seismic velocity of layer in the range of 700~1,200 m/s was found to be saltwater aquifer with high water content. Geological drilling investigation and analysis of soil samples also showed the texture of sandy loam layer. This study area also turned out to be quite possible to develop saline groundwater from the coastal shallow aquifer composed of sandy sedimentary and gravel layers with high porosity.

Keyword

Geological characteristics, Aquaculture, Saline Groundwaterr, Pumping test, Porosity

Groundwater basin management in Japan with quantitative and qualitative modeling

Katsuhiro FUJISAKI[1]*, Independent Groundwater Consultant (fujisakikatsuhiro@gmail.com)

Abstract

In Japan, numerical groundwater modeling has been developed as a means of groundwater basin management. It was incorporated as an important subsystem of groundwater basin management system which was constructed to overcome land subsidence and groundwater contamination problems. The groundwater basin management system consists of five subsystems: hydrogeological structure analysis, monitoring, database, prediction (numerical modeling), and decision making. In Japan, during the period of high economic growth from the 1960s to the 1970s, the demand for groundwater increased significantly, leading to excessive extraction. This resulted in dry springs and artesian wells stopping, leading to land subsidence and seawater intrusion. To prevent land subsidence, groundwater modeling has been developed obtaining a permissible yield which stops land subsidence. Regulation of extraction by laws and ordinances had progressed and surface water supply had improved. Then land subsidence had almost ceased in the 1990s. Meanwhile groundwater contamination has increased in the 1990s. At present basin management system is not worked well as a total system. In many regions, past regulations of pumping are simply maintained. The background of this phenomenon is a construction of wide area surface water supply system as an alternative water source, abandoning groundwater resources for the reason of land subsidence protection. Recently desertion of groundwater is also urged for the reason of health protection from groundwater contamination. In Japan there is no comprehensive groundwater law. Ten years ago, the Basic Act on Water cycle has been legislated with the aim of maintaining a sustainable water cycle in basins. A basin management committee which would be composed of the national government, local governments, and groundwater users, should plan sustainable groundwater management in a basin. However, effectiveness of the act is questionable, as the obligations of groundwater users are not specified. In order to effectively utilize groundwater resources that are threatened by groundwater contamination, groundwater basin management in terms of quantity and quality is necessary. By using a mass transport model in the prediction subsystem, it is possible to investigate changes in the groundwater flow system and contamination plume shape due to changes in the groundwater pumping, and to determine safe groundwater usage areas. However, it is necessary to modify the model based on monitoring results and repeat the prediction. The quantitative and qualitative management of groundwater basin will assist management planning and increase of groundwater utilization against the trend of abandoning groundwater resources.

Keyword

Groundwater basin management, Groundwater contamination, Land subsidence, Modeling

Contaminant Transport Simulation in Industrial Complex Area

YU-CHUL PARK[1]*, Kangwon National University (parkyc@kangwon.ac.kr)

Abstract

With the continued escalation in groundwater utilization, there is a growing concern about the intensification of contamination issues. To effectively identify large-scale groundwater contamination sources, sophisticated aquifer models are imperative. In this research, we introduce an innovative methodology known as simulation-optimization, which combines simulation and optimization techniques to enhance the efficiency of contamination source identification. The development of a field-scale model involved the utilization of hydrogeological characteristics and contaminant data obtained from the results of field testing. The steady-state model underwent a comprehensive process of simulation and calibration, aligning the calculated groundwater levels with the actual measurements from the field. The reactive coefficient used to model groundwater contaminant transport was computed based on concentration data gathered in the field, while the parameters for the optimization technique were meticulously determined through prior sensitivity analyses. This study serves as a robust validation of the efficacy of the simulation-optimization technique in pinpointing groundwater contamination sources on a field scale. Notably, the optimization technique incorporates advanced distributed computing methods, significantly reducing the time required for the simulation-optimization process. To evaluate the applicability of this methodology beyond the conceptual model, extensive case studies were conducted. The simulation-optimization method emerges as a potent and efficient means of identifying sources of groundwater contamination on a large scale, demonstrating its viability for real-world applications beyond theoretical frameworks and conceptual boundaries. This research was supported by Basic Science Research Program through the National Research Foundation of Korea(NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

Groundwater, Contaminant, Transport, Simulation, Optimization

Hydrogeochemistry and mechanism controlling the groundwater chemistry along the Kankai River Basin, East Nepal Himalaya

Champak Babu SILWAL[1]*, Tri-Chandra Multiple Campus, Tribhuvan University
(champak.silwal@trc.tu.edu.np)
Dinesh Pathak[2], Central Department of Geology, Tribhuvan University

Abstract

Groundwater from the springs and wells has been widely used and considered the most reliable source for domestic, agricultural, and industrial use. The chemical constituents of this water have an important role in the usability, which can be influenced by various physical and chemical factors along with their interionic relations within the area. The study aims to assess the different physicochemical as well as chemical constituents of the water from springs and wells within the Kankai River Basin, to characterize the springs and wells based on hydrogeochemical facies and understand the mechanisms controlling their chemistry. A total of 178 wells and springs were sampled for in-situ physicochemical parameters (Eh, pH, EC, TDS, and DO) and major ionic concentrations (Ca, Mg, Na, K, Cl, HCO3, SO4, NO3, and Fe). The study reveals that groundwater within the basin is largely controlled by the geology of the area. The pH of groundwater suggest the acidic nature along the Siwalik and IGP, whereas the Lesser and Higher Himalaya in the region is characterized by the alkaline water. The Piper diagram suggest that alkaline earths (Ca and Mg) dominate over the alkali ions (Na+K) in 70% of the samples, and weaker acid (HCO3+CO3) dominate over the strong acid (SO4+Cl) in 60% of the samples, indicating the dominance of Ca+Mg-HCO3+CO3 type water. The Chloro-alkaline Indices, along with the Gibbs plot, indicate rock-water interaction with base ion exchange (Mg and Ca from water exchange with Na and K from the rocks) along the major part of the area. However, reverse ion exchange is also dominant in northernmost areas. The Gaillardet model suggest the chemical characteristics of groundwater in the basin primarily results from the dissolution and filtration processes of carbonate rocks and silicate rocks. The combined output of the Gibbs plot, Gailardet diagram and the Chloro-alkaline indices suggest the chemistry of water in the region is controlled by the rock water interaction where the silicate weathering is the major source of ionic constituents in the spring water. Minor influence of the carbonate dissolution can also be evident which can be linked to the calc. silicates weathering in the region of Higher Himalayan Crystalline zones. Further the ratio coefficient of (Ca+Mg)/(SO4+HCO3) also signifies the silicate weathering as the major ion contributor, however minor carbonate weathering at the Higher Himalayan crystalline region is evident indicating the weathering of calc. silicate rock. This study provides valuable insights into the hydrogeochemical characteristics and their genesis in the Kankai River Basin, highlighting the geological control over the groundwater chemistry.

Keyword

Geology-related groundwater productivity analyses based on the specific capacity data in South Korea: Case for the Geumgang and Nakdonggang river basin

Sang-Ho MOON[1]*, KIGAM (msh@kigam.re.kr)
Hyoung Chan Kim[2], KIGAM
Yongcheol Kim[3], KIGAM

Abstract

Groundwater is expected to be critical water resources in the future, due to getting worse of surface water quality and increasing water demand by population growth, industrialization and global climate changes. Some areas In the Geumgang River basin have frequently experienced water shortages by uneven precipitation distribution and recurring droughts by global climate changes. The Nakdonggang River has often suffered serious water pollution by industrial complexes in the middle reaches. Therefore, securing and developing quality groundwater resources in these two basin areas is considered very important. For this, groundwater productivity was estimated and compared among geological frameworks to identify areas where large amounts of groundwater can be developed. The geological frameworks were classified by existing hydrogeological units presented by Korean Ministry of Environment. The hydrogeological units in the Geumgang river basin are composed of 9 units including unconsolidated clastic sediments, clastic sedimentary rocks, carbonate rocks, non-porous volcanic rocks, Triassic-Jurassic intrusive igneous rocks, Cretaceous intrusive igneous rocks, metamorphosed sedimentary rocks, schists and crystalline gneisses. In this area, 3,290 and 714 well data for bedrock and alluvial/weathered part aquifers were statistically analyzed and showed average specific capacity of 13.36 m3/day/m, 146.7 m3/day/m, respectively. In case of bedrock aquifers, non-porous volcanic rocks and Cretaceous intrusive igneous rocks showed low groundwater productivity, while carbonate rocks and metamorphosed sedimentary rocks showed significantly higher productivity. Wells developed in the alluvial/weathered part generally showed high groundwater productivity. The hydrogeological units in the Nakdonggang river basin are composed of 12 units with 3 additional units including porous volcanic rocks, semi-consolidated clastic sedimentary rocks and Permian-Triassic intrusive igneous rocks, in addition to 9 units in the Geumgang river basin. In this area, 2,087 and 780 well data were statistically analyzed and showed average specific capacity of 12.20 m3/day/m and 96.45 m3/day/m, respectively. The areas showing relatively high groundwater productivity in the Nakdonggang river basin are as follows: (1) NW-SE fault line near Uiseong in the clastic sedimentary rock distribution area of the Gyeongsang Basin, (2) NNE-SSW directions in the western part of clastic sedimentary rock area of the Gyeongsang Basin, (3) Jurassic intrusive igneous rock area of the Yeongnam Massif on the western outskirts of the Gyeongsang Basin, (4) crystalline gneisses area (with Proterozoic granites or leucocratic granites) at the northern end of the Nakdonggang river basin, (5) Some south and north part of volcano-plutonic complex in the southeastern Gyeongsang Basin, (6) porous volcanic rocks in the Pohang area. There is a need to

conduct a detailed investigation for identifying potential water sources using groundwater, focusing on these areas.

Keyword

hydrogeological units, groundwater productivity, specific capacity, Geumgang and Nakdonggang river basin, Korea

Relationship between Spatiotemporal Groundwater Quality and Changing Land Use and Land Cover in Korea: A Comprehensive Approach Utilizing Monitoring Data and GIS

Chanhyeok Jeon[1]*, Kangwon National University (jeonchan04@kangwon.ac.kr)
Heejung KIM[2], Kangwon National University

Abstract

Groundwater serves as a critical source of drinking water, catering to the needs of approximately 2.5 billion people worldwide. However, the alteration of land use and land cover (LULC) on a global scale poses significant environmental threats, particularly affecting aquatic ecosystems and contaminating water quality. The consumption of contaminated groundwater not only poses risks to human health but also contributes to various health issues globally. Despite extensive research conducted over the past decades focusing on hydrogeochemistry, groundwater quality, contamination sources, and associated health risks, solutions have predominantly targeted localized issues. Consequently, there exists a research gap that can be addressed through innovative integrated approaches. This study aims to showcase the effectiveness of such novel integration methods. Leveraging a decade's worth of groundwater hydrochemistry and land use data in the Gyeongsang-do in Korea, this research assesses: (a) the chemical composition of groundwater, (b) the spatial distribution and quality of groundwater for drinking purposes using the Pollution Index Grid (PIG), (c) the characterization of hydrochemical properties of groundwater using multivariate techniques such as PCA and correlation analysis, and (d) the projection of future changes in water quality. The outcomes of this study will offer valuable scientific insights into the health hazards linked to nitrate contamination in groundwater, thereby aiding in the preservation of water quality standards in the region.

Acknowledgement
This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education, grant Number 2019R1A6A1A03033167 and was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (grant numbers 2019R1I1A2A01057002.

Keyword

Groundwater quality, Chemical components, Land use and land cover, GIS, Monitoring data

Enhancing Measurement of Groundwater Flux: Synergistic Effects of Polysulfone-Activated Carbon Composite Carriers

Hyemin PARK[1]*, Division of Earth Environmental System Sciences-Major of Earth & Environmental Sciences, Pukyong National University (hyemin_park@pukyong.ac.kr)
Juyeon Lee[2], Division of Earth Environmental System Sciences-Major of Earth & Environmental Sciences, Pukyong National University
Subeen Kim[3], Division of Earth Environmental System Sciences-Major of Earth & Environmental Sciences, Pukyong National University
Minjune Yang[4], Division of Earth and Environmental System Sciences-Major of Environmental Geosciences, Pukyong National University; Wible Co., Ltd

Abstract

Measuring groundwater flux is essential for the sustainable management of aquifers as alternative water resources in the face of global climate change. Among the various techniques for measuring groundwater flux, the passive fluxmeter (PFM) is a cylindrical device composed of carriers adsorbed with alcohol tracers, each having different retardation factors. The PFM offers the advantages of simple production and setup, along with the capability for long-term monitoring. However, traditional fluxmeters have limitations in the range of flow rates that can be measured. This study aimed to address these limitations by evaluating the adsorption mechanisms of fluxmeter composite carriers that blend polysulfone (90%) with traditional activated carbon (10%). In this study, composite carriers of two sizes, 3 mm (C-3) and 5 mm (C-5), were produced to evaluate the impact of carrier size on adsorption efficiency. Isopropyl alcohol (IPA) and 1-hexanol were used as alcohol tracers in adsorption experiments at concentrations of 0, 10, 25, 50, and 70 mg/L. The data were examined through adsorption isotherms (Langmuir and Freundlich) to assess the adsorption mechanisms. The results of adsorption tests on composite carriers showed that the Freundlich model ($R^2 > 0.99$) adequately explained the adsorption behaviors of both IPA and 1-hexanol. The adsorption efficiency varied depending on the carrier size, with C-3 (IPA = 18.1%, 1-hexanol = 98.9%) achieving higher adsorption efficiency than C-5 (IPA = 4.9%, 1-hexanol = 7.3%). Furthermore, within the C-3, 1-hexanol (KF = 2.1 mg-nLn/g, n = 0.65) showed higher Freundlich constants (KF) and adsorption strength (n) compared to IPA (KF = 0.016 mg-nLn/g, n = 0.43), indicating the advantages of using 1-hexanol as a tracer and composite carriers with a 3 mm particle size. This study confirmed the high adsorption capability of C-3 adsorbed with 1-hexanol, suggesting that future research should investigate the range of flux that can be measured using this carrier.

Keyword

groundwater flux, passive fluxmeter, measurement, alcohol tracer, adsorption

Anomalous uranium occurrence in southern Telangana, India and its societal implications: Evidence from geological, geophysical, and hydrogeological studies

RAMESH GUGULOTH[1]*, GEOLOGICAL SURVEY OF INDIA (ramesh.guguloth@gsi.gov.in)
Satish B Cahvan [2], GEOLOGICAL SURVEY OF INDIA
T VAIDESWARAN[3], GEOLOGICAL SURVEY OF INDIA

Abstract

Southern part of Telangana state is dominated by granitoids of Peninsular Gneissic Complex of Eastern Dharwar Craton. The granitoids form compositionally expanded suite which include Tonalite-Granodiorite-Monzogranite Suite and Monzogranite-Syenogranite Suite. The granitoids are deformed and are affected by NW-SE, NE-SW & N-S trending lineaments and NW-SE trending localized shears. fracture planes, sericitization, and chloritization are common characteristics in monzogranite, which is prone to hydrothermal alteration, particularly at joints. Anomalous concentrations of Uranium were found in monzogranite with abundances ranging from 32 to 369 ppm (n= 37 & Avg: 128 ppm) and Th contented ranges from 14 to 82 ppm (n=37 & Avg. 41 ppm). Groundwater samples reveal high concentration of uranium ranging from 7 to 4450 ppb (n= 100 & Avg: 517 ppb) to the permissible limit (>30 ppb of WHO). Based on the hydro geochemical data a vertical borehole was drilled upto a depth of 150 m near Gummalabavi village, Nalgonda district and intersected monzogranite, alkali feldspar granite and pegmatite. Core samples collected at 4m depth intervals were analyzed by XRF & ICPMS. Analytical data indicate that the source of Uranium is monzogranite. U-Th bearing mineral phases (Uranophane, coffinite, Uranothorite and thorite) was detected by SEM-EDX. Petrographic studies additionally revealed zircon, monazite, and allanite. Four uraniferous subsurface zones ranging in thickness from 4m to 8.0 m was demarcated in granitoid at different depths ranging from 52 m to 104 m which helps in identifying the aquifers corresponds to anomalous abundance of radioactive elements. Anomalous radioactive concentrations are associated with fracture/vein zones. Geophysical logging of the borehole (150 m) using Century Geophysical Logger by utilizing Elog (Fluid & Lateral Resistivity and Natural Gamma) indicate that fluid resistivity gradually decreases from top (5 Ω.m) to bottom (4.5 Ω.m) with a sharp decrease at the depth of 54-64 m (polluted zone). Some small kinks are observed at places in Lateral Resistivity curves are indicative of minor fractures/joints. A sudden drop of resistivity from 250 Ω.m to 1000 Ω.m and positive S.P anomaly of +100 mV at a depth of 143.5 to 148 m corresponds to major fracture zone (zone of water rock-interaction). High natural Gamma counts between 48 and 100 meters (900-4660 API) and U in the lithology is well supported by natural gamma at various depths. Geophysical data shows deep groundwaters (>60 m) are more contaminated and low to moderate contamination found at shallow depth. Groundwater is mostly alkaline (pH: 6.79 to 9.13) in nature. The ionic dominance pattern is Na+ > Ca2+ > Mg2+ > K+ cations and HCO3 > Cl- > SO4 > NO3 > F- anions. Na-HCO3 type water and strong correlation with F-, Fe and Na+ suggest the hydro

geochemical control of uranium concentrations in groundwater. Strong bicarbonate and Na-HCO3 in the groundwater enhanced the dissolution of minerals in water-rock interaction zone. Groundwater is the primary drinking supply in rural areas of southern Telangana state. Significant amount of uranium consume is likely to cause complex health problems and bone deformities in the residents.

Keyword

Uranium, Groundwater contamination, Peninsular Gneissic Complex, Human health, Telangana state

A Study on Groundwater Treatment and Useful Resources Recovery Methods in Uzbekistan

Kyungwon Na[1]*, ERG, Inc. (kelvin.erg@gmail.com)
Gany Amirgalievich Bimurzaev[2], State Monitoring Service of the Republic of Uzbekistan for Hazardous Geological Processes
Jasur Malik ugli Melibaev[3], State Monitoring Service of the Republic of Uzbekistan for Hazardous Geological Processes
Botrijon Dadajonovich Abdullaev [4], SE, Institute of HYDROENGEO
Jiyoung Lee[5], ERG, Inc.

Abstract

Uzbekistan is a landlocked country entirely dependent on freshwater for water resources. Due to the desert climate and recent acceleration of desertification, water resource shortage is emerging as a major problem. In 2018, despite agriculture accounting for more than 30% of the country's gross domestic product, an emergency policy was formulated to address water resource problems, even by reducing farmland. The Uzbekistan government is establishing various policies and roadmaps to alleviate this water shortage and secure water resources. There is particular interest in the development and utilization of groundwater. However, groundwater in Uzbekistan has high salinity and mineral content, making direct use of water resources impossible.

Meanwhile, Ministry of Mining Industry and Geology of the Republic of Uzbekistan reported that some groundwater areas with high salinity and mineral content in Uzbekistan contain rare metals. In particular, they contain high concentrations of rare metals such as lithium, iodine, strontium, magnesium, boron, germanium, and cobalt. To confirm this, samples were collected from seven major regions and 18 wells or wastewater storage facilities in Uzbekistan. Analysis of pH, TOC, T-N, T-P, and other parameters was performed to obtain quantitative and qualitative analysis of inorganic substances and basic water quality data. The water quality analysis confirmed a pH range of 5.6 to 7.97, indicating slightly acidic to mostly neutral content with low organic matter. Overall, the composition was similar to seawater with high Na and Cl contents, and the total dissolved solids (TDS) concentration was analyzed to be over 130,000 mg/L, containing lithium, strontium, magnesium, and other substances in high concentrations due to saltwater. In other words, groundwater in Uzbekistan contains high salinity and beneficial resources for industrial use.

Therefore, economic profits can be generated by securing Uzbekistan's currently scarce water resources while recovering useful resources from water treatment by-products. This study introduces optimal water treatment technology to address water problems caused by groundwater treatment and methods for economically recovering the abundant useful resources in Uzbekistan's groundwater.

Keyword

Uzbekistan groundwater, groundwater treatment, useful resources recovery

Changes in soil characteristics due to long-term groundwater artificial recharge

Myoung-Rak CHOI[1]*, Daejeon University (audfkr18@naver.com)
Taek-Soo Hong[2], Daejeon University
Chang-Hee Kim[3], Daejeon University
Chan-Ik Hwang[4], GEO-IN SOLUTIONS Co.,Ltd.
Hyun-Na Kim[5], Kongju National University
Gyoo-Bum Kim[6], Daejeon University

Abstract

Groundwater artificial recharge involves replenishing aquifers to increase water resources and is used for water quality improvement. In this study, the long-term operation (approximately 1.5 years) of a groundwater artificial recharge system installed in Singok Village, Galsan-myeon, Hongseong-gun, Chungcheongnam-do, was evaluated by categorizing the changes in soil into pre-injection, during injection, and post-injection phases. The evaluation of the occurrence of clogging in the vicinity of the injection wells was performed through particle counter analysis, geochemical analysis, and assessment of the formation of iron oxides/manganese oxides. Particularly, soil samples were collected near the injection wells for particle size and density analysis, as well as mineral analysis using techniques such as XRD and XRF, to assess the state of change in soil media. The content of colloidal materials in the soil decreased from 1.44-3.40% during recharge to 1.19-2.62% after recharge. This decrease is attributed to the fact that the fine particle content in the pre-treated recharge source water, which is a base-flow, is lower than that in the aquifer. The analysis of the composition of minerals and texture of the soil before artificial recharge revealed that organic matter, such as illite, montmorillonite, and kaolinite, which are microfine particles, are filled around detrital particles such as quartz, feldspar, biotite, and amphibole. After artificial recharge, it was observed that in some injection areas, the veins disappeared due to the alteration of biotite, and clay minerals occurred to fill the pores. When long-term artificial recharge is implemented, changes in the soil media may occur depending on the characteristics of the injection water and the aquifer. Therefore, ongoing management is necessary to address issues such as reduced injection rates due to clogging.

Acknowledgments

This work was supported by the Korea Science and Engineering Foundation (KOSEF) grant funded by the Korea government(MEST) (No. NRF-2022M3E9A1098302).

Keyword

artificial recharge, clogging, colloidal substance, mineral analysis

Development of a predictive model for chloride ion and nitrate nitrogen concentrations in groundwater using ensemble models

Chan-Ik HWANG[1]*, GEO-IN SOLUTIONS Co., Ltd. (loveu2u@hanmail.net)
Young-Shik Shin[2], Intellegeo. Co., Ltd.
Jin-Woo Kim[3], Korea Water Resources Corporation
Gyoo-Bum Kim[4], Daejeon University

Abstract

Recently, due to climate change, the importance of groundwater as a stable water resource has been increasing. The increasing availability of groundwater-related data is making it easier to predict groundwater contamination characteristics. In this study, a predictive model for the concentration of chloride ion and nitrate nitrogen in groundwater was developed using water quality analysis results from groundwater monitoring networks managed by government agencies such as the Ministry of Environment as well as factors that could affect groundwater quality. Two types of input factors were used. The first type included factors related to groundwater flow, such as elevation, terrain slope, rivers, soil characteristics, and hydrogeology. The second type consisted of factors related to contamination sources, such as population, buildings, environmental pollution facilities, livestock farms, coastlines, industrial complexes, greenhouses, and land cover types. Ensemble models were developed to predict whether the chloride ion concentration exceeds 80 mg/L and whether the nitrate-nitrogen concentration exceeds 8 mg/L. The F1 score for predicting chloride ion concentration showed a true classification rate of 0.86 for training data and 0.83 for validation data, while the F1 score for predicting nitrate-nitrogen concentration showed a true classification rate of 0.85 for training data and 0.81 for validation data. The k-fold validation results for each model indicated F1 scores ranging from 0.83 to 0.85 for chloride ion concentration across four folds and from 0.78 to 0.82 for nitrate-nitrogen concentration across four folds, demonstrating the utility of the models. When comparing the model's prediction results with water quality test data in 2018 for the entire region of Gongju City, Chungcheongnam-do, it was evaluated that the distribution of high-concentration points was similar.

Acknowledgments
This work was supported by the Korea Water Resources Corporation.

Keyword

Big data, chloride ions, nitrate nitrogen, ensemble model

Modeling seawater intrusion and brine water injection impact in a complex volcanic aquifer of East Jeju, Jeju island, South Korea

Dewandra Bagus Eka PUTRA[1]*, School of Earth and Environmental Sciences, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, 08826, Republic of Korea (dewandrabagus@snu.ac.kr)
Eunhee Lee[2], Korea Institute of Geoscience and Mineral Resources, 124 Gwahak-ro, Yuseong-gu, Daejeon, 34132, Republic of Korea
Eun-Hee Koh[3], School of Ocean and Earth Sciences, Jeju National University, 102 Jejudaehak-ro, Jeju-si, Jeju Special Self-Governing Province, 63243, Republic of Korea
Kang-Kun Lee[4], School of Earth and Environmental Sciences, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul, 08826, Republic of Korea

Abstract

The East Jeju region faces a complex challenge for groundwater resources due to the potential seawater intrusion and environmental deterioration by brine water discharge to the nearshore from the desalination process. This study aims to project further seawater intrusion phenomena and propose the injection of brine water into the subsurface layers as an alternative invulnerable disposal method in Jeju island. The numerical modelling approach was employed to simulate the groundwater flow and mass transport in the study area, which has a complex aquifer structure that consists of volcanic, hyaloclastite, and impermeable Seogwipo formation layers. The simulated results were calibrated and validated using field data, including water level and salinity measurements. The result showed that the groundwater model is sensitive to several hydraulics properties, and changes in these parameters can significantly impact the projection of saltwater intrusion and brine injection effect. The model results were used to explore the impact of several scenarios, including changes in pumping volumes and brine water injection to the subsurface layers with different rates, depths and distances. It also helps to identify areas where additional data collection and monitoring are needed. The findings of this study highlight the importance of a systematic and integrated approach to managing coastal aquifers with similar geological backgrounds and provide a different solution to the brine water discharge from the desalination plant.
Acknowledgement: This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (NRF-2021M2E1A1099413).

Keyword

Seawater intrusion, Brine injection, Coastal groundwater, Jeju Island

Recharge processes and chemical evolution of groundwater affected by geogenic and agricultural contamination in the mountainous areas with granitic and sedimentary bedrocks

Hyo-Sik Seo[1]*, University of Science and Technology (hyosik@kigam.re.kr)
Dong-Chan Koh[2], Korea Institute of Geoscience and Mineral Resources, Daejeon 34132, Republic of Korea
JongHyun Oh[3], University of Science and Technology

Abstract

Groundwater is an important water resource and is utilized in many areas of housing, agriculture, and industry. To effectively manage and utilize groundwater, a sufficient understanding of its system is essential. Especially, it is important to understand groundwater systems in mountainous areas because groundwater flows along faults or near the ground surface and enters aquifers into lowland areas. However, there is a lack of research on the groundwater recharge process and the chemical evolution of groundwater in mountainous areas. This study aimed to characterize the recharge process of groundwater in mountainous areas and the chemical evolution by geogenic and agricultural contamination during this process. We sampled groundwater from 122 wells in October 2021 in the upper part of the Nakdonggang River basin, one of the largest watersheds in South Korea. The groundwater samples were analyzed for water stable isotopes, major and trace elements. The distribution of stable isotopes showed that the groundwater was divided into three groups, with different spatial distributions. Comparing bedrock lithology, pH, and concentrations of Na, Ca, Mg, K, Sr, HCO3, SO4, and B were significantly higher in sedimentary rocks, while concentrations of SiO2, NO3, and U were higher in granitic rocks at the 0.05 significance level. The correlation with land use showed that the concentrations of SiO2, NO3, and Cl were significantly lower in natural areas compared to agricultural areas. Therefore, recharge sources of groundwater in the study area were different and it is characterized by water stable isotopes. During the chemical evolution, water-rock interaction in sedimentary rocks was dominant. Agricultural activities, although not dominant, influenced the recharge process and chemical evolution of groundwater. This study is expected to significantly contribute to understanding the recharge and chemical evolution of groundwater in mountainous areas, providing valuable insights for groundwater management and policy establishment.

This work was supported by the Basic Research Project (24-3411) of the Korea Institute of Geoscience and Mineral Resources (KIGAM) funded by the Ministry of Science and ICT, Republic of Korea.

Keyword

Hydrogeochemistry, Water stable isotopes, Sedimentary rocks, agricultural activities, Mountain recharge

Stable water isotopes (δ18O, δD) and groundwater dating tools (3H, CFCs) coupled with hydrochemistry to evaluate groundwater flow dynamics of complex basaltic aquifer

Hyun-Ji Kang[1]*, Korea University (bisuraa@korea.ac.kr)
Suhyung Moon[2], Jeju Special Self-Governing Province Development Corporation
Eun-hee Hyun[3], Jeju Special Self-Governing Province Development Corporation
Hyuntai Ahn[4], Korea University
Soonyoung Yu[5], Korea Institute of Geology and Mineral Resources
Seong-Taek Yun[6], Korea University

Abstract

Understanding groundwater flow in complex volcanic strata requires identifying groundwater recharge, which is often complicated by the heterogeneous distribution of permeable structures. Stable isotopes of water (δ18O, δD) serve as a valuable tool for this purpose. Stable isotopes of precipitation tend to be progressively depleted with increasing elevation, leaving distinctive signatures in recharged groundwater, enabling the determination of recharge elevations. However, since the stable isotopes of water reflect the integrated weighted average of the recharged annual rainfall, the limitation arises in distinguishing between different flow paths using only stable water isotopes when groundwater is recharged in multiple places and mixed within the aquifer. To address this limitation, age tracers (3H, CFCs) complement stable isotopes, helping distinguish relatively old groundwater flowing along long paths from young groundwater with shorter paths. Furthermore, a comprehensive interpretation of groundwater evolution, including water-rock interaction and the influence of anthropogenic contamination, can be possible by integrating hydrochemical data of rainfall and groundwater.

This study was conducted on the mountainous region of the Pyosun watershed of Jeju volcanic island, South Korea, where 602 groundwater samples were collected from 16 wells between March 2016 and October 2020. Rainwater samples were also collected monthly or quarterly from seven locations at varying elevations (265 to 1500m) during 2016-2020. The analysis of stable isotopes and physicochemical variables of water samples was conducted for the samples, with additional quarterly measurements of age tracers in groundwater from ten locations. Groundwater in the study area is clustered into two groups with distinct recharge elevations: 1) highland recharge with lower ionic concentrations (i.e., lesser anthropogenic contamination) and lighter isotopic compositions, and 2) lowland recharge with heavier isotopic compositions. Based on these characteristics, it is likely that groundwater recharges at high mountainous areas, travels through long flow paths, and mixes with groundwater of local infiltration through permeable structures. The estimation of groundwater age using CFCs and tritium also reaffirmed that the two groups have distinct flow paths. In the highland wells, the average groundwater age was relatively older with low variability, whereas in the lowland areas, the groundwater exhibited relatively younger age with higher variability. The high variance of groundwater age in the lowland area is assumed to be the influence of local recharge. This study demonstrates that integrating stable

water isotopes, hydrochemistry, and multiple environmental tracers improves the understanding of recharge and flow of groundwater resources in a complex subsurface geology.

[Acknowledgement] This study was financially supported by the Jeju Special Self-Governing Province Development Corporation.

Keyword

groundwater age, stable water isotope, CFCs, hydrochemistry

Exploration of Groundwater in the Eastern Region of Thailand for Sustainable Groundwater Management

Benya SUNANTA[1]*, Department of Groundwater (benya4002@gmail.com)
Kannika Loylong[2], Department of Groundwater

Abstract

Thailand is suffering from the effects of climate change that occur regularly every year, especially in the drought problem, resulting in insufficient water for both consumption and consumer purposes. According to economic and social growth, which has led to urban and industrial expansion, water requirements have increased more than water supplies. To solve that problem and increase the efficiency of water management in disaster emergencies, it is necessary to explore and analyze both quantity and quality to identify the potential of groundwater supply and distribute water supply to support human activity. This project is being conducted in every part of Thailand; the study area in the eastern part is presented.

The study area included 3 provinces in the eastern part of Thailand, 2 locations in Rayong, 2 locations in Sakaew, and a location in Chanthaburi that presented different geology and hydrogeology in each area. The methodology for exploring an appropriate drilling point is a 1D surface resistivity survey with a Schlumberger array. The result of the survey data is analyzed with a literature review of the study area in both the fields of geology and hydrogeology. Selecting the appropriate drilling points shows two locations from five; the first station is located in the administrative subdistrict of Wangwa. The aquifer in this area is the colluvial deposits aquifer (Qcl). 120 meters is the depth of drilling for the observation well, and 92 meters is the depth of the development well. The water quantity is 8 cubic meters per hour. Total dissolved solids are 288 milligrams per liter. 2nd Station is in the municipality of Salalumduan. Hydrogeology reveals the Lower Khorat Aquifer (TRlK). 140 meters is the depth of drilling for the observation well, and 92, 122, and 116 meters are the depths of the development well. Water quantity is averaged at 3 cubic meters per hour. Total dissolved solids are 170 milligrams per liter. After drilling a groundwater well, water supply points and a water system are constructed to support people's activities and water requirement.

Keyword

water requirement, groundwater management, resistivity survey, drilling of groundwater, quality of groundwater

Groundwater recharge estimation along a climate gradient - a Northern Namibian case study

Josefina Tulimevava Hamutoko[1]*, University of Namibia (jhamutoko@gmail.com)
Heike Wanke[2], University of the West of England

Abstract

In Northern Namibia, as in many parts of sub-Saharan Africa, people rely on groundwater as a primary source of drinking water. However, the mechanisms for, and rates of replenishment of this resource (groundwater recharge) are poorly known. This study estimated groundwater recharge rates from the stable isotopes parallel shift method range from 0.7 to 70 mm/a with the highest values obtained for Zambezi west and the lowest for western Cuvelai. Estimation was done for shallow aquifers on a transect across half of the African continent, stretched from western Kunene to the Zambezi in the East along the proximities of latitude 18°S. There is increased human demand for water resources due to fast-growing and often uncontrolled settlements and rapidly expanding industrial activities. These stressors on water supplies are exacerbated by climate change, potentially placing unprecedented pressure on this vital resource. Thus, the sustainable management of water resources is a real and urgent challenge for local and regional government authorities and local water point committees. Stable isotope analyses were conducted using a laser spectrometer at the University of Namibia, while the chloride content in groundwater samples was measured argentometric at the Analytic Laboratory in Windhoek. Local meteoric water lines were derived for the different regions. Chloride Mass Balance also show the same trend in recharge rates. Stable isotopes also allude to different recharge mechanisms for the different regions reflecting the precipitation gradient and the various landscapes. It is recommended that groundwater management practices should be designed considering differences in recharge rates and mechanisms.

Keyword

Groundwater recharge, Stable isotopes, Namibia, Chloride Mass Balance, Hydrochemistry

Hydrogeochemical Appraisal and macrophyte diversity in Inland water bodies of a subtropical country

DEEPTI PANDEY[1]*, IISER BHOPAL (deepti23@iiserb.ac.in)
Narendra kumar[2], BBAU LUCKNOW

Abstract

Small surface water bodies such as ponds, lakes, marshy areas, wetlands, swamps etc. plays pivotal role in the ground water recharge system. Further, these water bodies are crucial for various bio-geochemical cycles, host biological diversity and are important for maintaining ecological balance. They also serve as sink for carbon there by contributing in combating the global warming and climate changes issues. However, such water bodies are facing chronic effect threat in terms of both quality as well as quantity due to urban sprawl, industrial expansion, and land conversion, improper discharge of industrial, municipal and agricultural waste. Considering the above striated importance and threats the present study focuses on the evaluation of water quality index of nineteen distinct surface Bodies with the help of several physico-chemical variables including major ion chemistry. Macrophyte diversity in these meso-aquatic fresh water ecosystems has been considered as Bioassays to assess the cumulative impact of known as well as unknown chemicals. Abundance (%) of macrophytes: Pistia stratiotes (84.21)> Azolla pinnata (78.95)> Lemna minor (73.68)> Eichhornia Crassipes (68.42)> Marsilea Quadrifolia (52.63)> Ipomoea aquatica (47.37)> Hydrilla verticilata (21.05) reflected the States of eutrophication and aging. Analysed parameter viz. TDS, EC, pH Alkalinity, total Hardness, major cations (Ca+2, Mg+2, Na+ , K+), and major anions (HCO3-, Cl-, PO4-2, SO4-2 have exceeded the permissible limits prescribed by the Bureau of Indian Standards IS: 2296 for surface water quality finding underlines the threats of human activities to these fresh water ecosystems and warrants attention of their revival/conservation.

Keyword

Inland water bodies, hydrogeochemistry, water quality index

Occurrence and behavior of nitrate and per- and polyfluoroalkyl substances (PFAS) in groundwater of Haean basin, Korea

seunghoon CHOO[1]*, Department of Geology, Kangwon National University, Republic of Korea (choosh0907@kangwon.ac.kr)
Jihye Cha[2], Department of Geology, Kangwon National University, Republic of Korea
Jin-Yong Lee[3], Department of Geology, Kangwon National University, Republic of Korea

Abstract

The risks of nitrate and per- and polyfluoroalkyl substances (PFAS) are well-recognized worldwide. Nitrate is primarily derived from agricultural activities. PFAS persist in the environment due to their non-biodegradable nature and have been detected not only in urban areas but also in rural areas, as revealed by research. The study area is located in the upper of the Soyang River basin and has a simple basin topography, making it an appropriate place for conducting the study. The residents in the study area use groundwater mainly for agricultural purposes and partially for drinking. Groundwater contamination could have adverse effects on both residents and crops due to the high dependency on groundwater. Therefore, it is essential to assess the contamination levels of nitrate and PFAS in the groundwater of the study area. In this study, we will investigate the concentrations and distributions of nitrate and PFAS in groundwater wells within the Haean basin, an area characterized by developed agriculture. The aim of this study is to identify the sources and extent of contamination in the groundwater of the study area and elucidate the behavior of contaminants. Groundwater samples will be collected from the study area every season for field parameters and laboratory water quality analysis. Ion chromatography (IC) and Liquid Chromatography-Mass Spectrometry (LC-MS/MS) will be used for laboratory water quality analysis, with a focus on nitrate and PFAS. The result of the analysis will be used to confirm and evaluate the levels of groundwater contamination in the study area, identify the sources of contamination, and assess their potential impact on the surrounding environment. We expect this study will be used to minimize the impact on local communities and ecosystems and contribute to formulating responses for groundwater management in the study area. This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

Groundwater, Haean basin, Nitrate, Per- and polyfluoroalkyl substances (PFAS)

Criteria of groundwater level change in relation to the operation of a river barrage

Se-Yeong HAMM[1]*, Pusan National University (jjy@korad.or.kr)
Se-Yeong HAMM[2], Pusan National University
Ji-Hye Jeong[3], Korea Water Resources Corporation

Abstract

Groundwater drought, in relation to global climate change, poses a great water challenge to human. This study analyzed groundwater level fluctuations from May 2012 to October 2020 around the Changnyeong-Haman river barrage (CHRB) on the Nakdong River. Groundwater-level types were grouped with considering the river stages. Next, a more detailed clustering was executed by using kernel density estimation (KDE) and standardized groundwater level index (SGLI). KDE and cumulative kernel density estimation (CKDE) were computed for Clusters 1 to 5. Cluster 1 exhibited a rapid increase in CKDE compared to those in Cluster 2. Cluster 3 demonstrated the slowest increase in CKDE, characterized by a gradual peak. An abrupt change in the slope of the cumulative probability density, observed in Cluster 1, occurs under various external influences such as pumping, the opening of the CHRB, or rainfall. The criteria of groundwater drought for the caution, severe, and very severe stages correspond to SGLI values of -0.674, -1.282, and -1.645 or the 25th, 10th and 5th percentiles, respectively, for forecasting and warning groundwater drought. During the observation period of 7 years and 6 months (2,851 days), Cluster 1 displayed 209 to 735 days falling below the 25th percentile, 84 to 288 days below the 10th percentile, and 39 to 143 days below the 5th percentile. Cluster 2 showed 197 to 698 days below the 25th percentile, 36 to 299 days below the 10th percentile, and 0 to 125 days below the 5th percentile. On the other side, Cluster 3, illustrated 213 to 125 days below the 25th percentile, 80 to 283 days below the 10th percentile, and 42 to 144 days below the 5th percentile. By this result, groundwater drought based on the SGLI values and percentiles in relation to the operation of the CHRB provides valuable insights for effective groundwater resource management. This study was financially supported by the National Research Foundation of Korea (NRF) grant funded by the Ministry of Science and ICT (2020R1A2B5B02002198).

Keyword

groundwater level, change, river barrage

Analysis of freshwater-saltwater interface in the aquifer around Hwajinpo lagoon on the Eastern Coast of Korea: Potential implications for coastal ecosystem

Minji KIM[1]*, Ewha Womans University (minji.jane.kim@gmail.com)
Hyejung Jung[2], Ewha Womans University
Dongjin Kim[3], Kangwon National University
JeongYong Cheon[4], GeoGreen21 Co., Ltd.
Seong-Chun Jun[5], GeoGreen21 Co., Ltd.
Jeonghoon Lee[6], Ewha Womans University

Abstract

The lagoon is a unique environment where freshwater and saltwater are mixed and it is rich in biodiversity. Recently, the lagoon environment has been damaged due to artificial development such as the creation of tourist attractions. In addition, coastal zones are particularly vulnerable to future climate changes such as sea level rise. Systematic study of water management of the lagoon is required because of its high conservation value. The study area is Hwajinpo lagoon located on the eastern coast of Korea. The existing environment of the lagoon was evaluated by identifying the distribution of the groundwater level and groundwater flow characteristics. Hydrogeochemical fluctuations were analyzed to determine the effect of seawater intrusion into the aquifer. The results demonstrate that the freshwater-saltwater interface is distributed throughout the aquifer and rises when water of the lagoon evaporates due to prolonged periods of low rainfall and high temperature, thereby increasing the possibility of seawater inflow through groundwater. The ratio of seawater mixed at each point was calculated, using oxygen isotopes and chloride as tracers, resulting in an average of 0.24 ~ 0.32 and a maximum of 0.90. As for the ionic delta properties (difference between the measured and theoretical concentration of mixed waters) and the saturation index, it was estimated that the cation-exchange and precipitation reactions occurred in the aquifer due to seawater intrusion. Seasonal variation in rainfall affects ion concentrations in aquifers and should be considered for understanding the ecosystem of lagoons. Time series analysis was applied to groundwater, lagoon, rainfall and tide data obtained from monitoring wells to determine the correlation.

Keyword

lagoon, freshwater-saltwater interface, groundwater, seawater intrusion, ecosystem

Delineation of Seawater intrusion in the coastal aquifer using the 3-Dimensional Groundwater modelling in the Harbour city of Thoothukudi, Tamil Nadu, India.

SNOWLIN F[1], Master Student
MANJU POORNA SREE MURUGAN[2], Master Student
THIRUMURUGAN MARIMUTHU[3]*, Assistant Professor (thiru19591@gmail.com)

Abstract

Coastal aquifers around the world are under threat by witnessing the wide range of environmental issues especially due to Sea water intrusion. Seawater intrusion affects the quality and sustainability of the groundwater resources in the coastal aquifers. The excessive pumping of groundwater in the coastal aquifer has led to mixing of seawater freshwater interface, which results in salinization of groundwater. In India, most part of the coastal aquifers are affected by seawater intrusion up to 2 km, whereas it is intruded up to 15 km towards inland in the coastal aquifers of Chennai. Recently groundwater salinization has become a major threat in the harbour city Thoothukudi of Tamil Nadu state due to excessive pumping of groundwater, lack of groundwater recharge and reduced rainfall rate. The present study was carried out to evaluate the groundwater chemistry of the region and to delineate the extent of seawater intrusion. Groundwater samples were collected during October 2023 and January 2024 in 18 locations around the Thoothukudi town. The collected samples were analyzed to determine the pH, total hardness, TDS, Ca2+, Mg2+, Na2+, K+, NO3-, Cl-, SO42−, HCO3-, F-. It was found that most part of the coastal regions were highly salinized and the high concentration of Na-Cl are observed. The extent of seawater intrusion was demarcated using the 3-Dimensional Numerical groundwater modelling using the FEFLOW computer code. Groundwater model was developed under steady and transient condition to the aquifer characteristics of the region. Further density dependent groundwater model was developed to study the extent of seawater intrusion. It was found that the seawater were intruded in the coastal aquifer up to the distance of 3km. It showcases the threat to the aquifer of the region, hence it is necessary to formulate the mitigation and remediation measures for sustainable management of groundwater system.

Keyword

Seawater Intrusion, Groundwater modeling, FEFLOW, Coastal aquifer, Groundwater quality

Geochemistry of Accessory Minerals as Sources of Radionuclides in Mesozoic Granite Aquifers of Korea

Jeong HWANG[1], Daejeon University
Jin-Yong LEE[2]*, Kangwon National University (hydrolee@kangwon.ac.kr)
Stefano VIAROLI[3], University of Pisa

Abstract

In granitic aquifers, the contribution of accessory minerals to groundwater radionuclide levels is generally negligible due to their outstanding resistance to solubility. Nonetheless, the structure of accessory minerals incorporating uranium (U) and thorium (Th), may be compromised by radioactivity, making them more amenable to alteration. This research delves into the chemical and textural characteristics of accessory minerals containing U and Th, employing advanced techniques such as field emission scanning electron microscopy and electron probe micro-analysis. The findings aim to assess influence of accessory minerals to radionuclide concentrations in the Mesozoic granite aquifers. Altered zircons show extensive open structures resulting from radioactive breakdown. Altered zircons reveal an increased amount of U and Th alongside and reduced analytical totals. Certain thorites, altered through hydrothermal processes into a metamict state, exhibit elevated U levels and additional elements not accounted for in their original formula. Cerianite that incorporates U is found within tiny veinlets in cracks accompanied by iron (Fe) and manganese (Mn) oxides, suggesting the creation of a secondary phase arising from the breakdown of accessory minerals under oxidizing conditions. In the Mesozoic granite regions of South Korea, accessory minerals rich in U and Th have been identified, coinciding with reports of elevated groundwater radionuclide concentrations. The extraction of U from these minerals appears more feasible in instances where they have undergone significant metamictization or alteration, as evidenced by our research findings. In such Mesozoic granite aquifers, where no soluble U-minerals have been identified, the studied altered zircon and thorite may play a crucial role in transporting radioelements.

Keyword

Accessory mieral, Geochemistry, Metamictization, Radionuclide, Granite aquifer

Comparison of occurrence characteristics of PFAS in Korean groundwater and surface water using online SPE-LC-MS/MS

Sang Hun AN[1]*, Korea Institute of Geoscience and Mineral Resources (sdshnet@kigam.re.kr)
Woo-Hyun JEON[2], Korea Institute of Geoscience and Mineral Resources
Dong-Hun KIM[3], Korea Institute of Geoscience and Mineral Resources
Sung Pil HYUN[4], Korea Institute of Geoscience and Mineral Resources
Hee Sun MOON[5], Korea Institute of Geoscience and Mineral Resources

Abstract

Per- and polyfluoroalkyl substances (PFAS) are emerging contaminants detected ubiquitously in aquatic environments due to their wide application in industrial and consumer products since the 1940s, providing resistance to heat, water, and oil. Groundwater, essential for domestic and agricultural water supply, also faces PFAS contamination through various pathways such as industrial leakage, wastewater treatment plant effluent, and infiltration by river water. Despite many countries investigating PFAS analysis in groundwater, research on monitoring them in Korea remains limited. Moreover, due to the trace amounts of PFAS present in groundwater, pretreatment of large volumes using manual solid-phase extraction (SPE) consumes significant labor and time. Therefore, fully automated online SPE system is being considered for PFAS pretreatment due to its minimal sample handling, small sample volume, and reduced solvent use.
This study aims to analyze PFAS by applying online SPE connected to LC-MS/MS, and to compare the occurrence characteristics of PFAS in Korean groundwater and surface water. Groundwater (n = 6 samples) and surface water (n = 6 samples) were collected near industrial complexes in Chilgok County, Gyeongsangbuk-do on October 30, 2023, and analyzed for 11 species of PFAS (PFBS, PFHxA, PFHxS, PFHpA, PFOA, PFOS, PFNA, PFDA, PFDS, PFUnDA, PFDoDA). Compared to manual SPE, online SPE reduced the sample amount required for analysis by approximately 200 times and decreased the sample loading time by 26 minutes per sample, significantly reducing both time and labor. When comparing the sum of PFAS at each site, the surface water exhibited a significantly higher average concentration of 26.84 ng/L compared to 19.34 ng/L in the groundwater (p-value of 0.018). This was consistent with the previous study in the Nakdong River basin (Yong et al., 2021). PFBS was the most frequently detected substance in both groups, accounting for 22-25% (6.29-6.45 ng/L) in surface water and 17-23% (3.11-7.05 ng/L) in groundwater. PFHxA was the second most common compound in surface water, accounting for 16-18% (4.60-4.80 ng/L), whereas it was detected at the lowest levels (LOQ-1.6 ng/L) in groundwater. The lower concentration of PFHxA in groundwater compared to surface water is likely due to some of it being adsorbed by soil as surface water infiltrates the groundwater, necessitating further research into the sorption behavior and characteristics of PFAS in aquifers.

This work was supported by the Research project “Advancing Assessment and Monitoring

Technologies for PFASs in Groundwater (JP2023−003)" of the Korea Institute of Geoscience and Mineral Resources (KIGAM) and the Basic Research Project (GP2020−012) of KIGAM funded by the Ministry of Science and ICT.

Keyword

PFAS, Emerging contaminant, Groundwater, Surface water, Industrial complexes

Identification of arsenic spatial distribution by hydrogeochemical processes represented by different ion ratios in the Hohhot Basin, China

Yu REN[1]*, Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences (925666311@qq.com)
Wengeng CAO[2], Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences

Abstract

The Hohhot Basin, a typical inland basin of the Yellow River Basin in China, has high concentrations of arsenic (As) in its shallow
groundwater, while the factors dominating the distribution of high arsenic levels remain to be further identified. An analysis of the
ratio of hydrogeochemical compositions can help to reveal the spatial characteristics of the shallow groundwater environmental
conditions and the distribution of high-arsenic water (As >10 μg/L). In this study, a total of 170 samples of shallow groundwater
in the Hohhot Basin were collected and water samples with As >10 μg/L accounted for 29.4% of the total. Based on the slope
changes of the cumulative frequency curves of (HCO3− + CO32−)/SO42−, Ca2+/(HCO3− + CO32−), Ca2+/Mg2+, and Na+/Ca2+, the groundwater in the study area can be categorized into six different zones according to the environmental characteristics including redox condition, water recharge intensity, and cation exchange level. The result shows that the groundwater in the front of the piedmont alluvial plain and platform is in a weak reducing condition with high lateral recharge intensity, fast runoff, and weak cation exchange. In the Dahei River alluvial plain, which serves as the groundwater discharge zone, the groundwater runoff is sluggish with poor lateral recharge, sufficient exchange between cations in the groundwater and the aquifer matrix, and enhanced reducibility. The degree of oxidation increased in the groundwater near the Hasuhai Lake and the drainage canal, which adverse to the arsenic enrichment. High-arsenic groundwater is mainly distributed in aquifers of (HCO3− + CO32−)/SO42 > 10, Na+/Ca2+ > 13, and Ca2+/(HCO3− + CO32−) < 0.1, which represent the strong reducing condition, low surface water recharge intensity, and strong cation exchange condition. Reductive dissolution of iron oxide, strong evaporation and concentration process, and competition from phosphate in aquifers jointly lead to the release of arsenic into groundwater.

Keyword

Hohhot Basin, High-arsenic groundwater, Ion ratio, Cumulative frequency curve

Groundwater and Environmental Challenges in Asia

Yanpei CHENG[1]*, Institute of Hydrogeology and Environmental Geology, Chinese Academy of Geological Sciences (yanpeicheng@tom.com)

Abstract

Asia stands out as the most populous and geographically diverse region globally. The pressing issues of water resource development and the resulting ecological impacts are exacerbated by the region's rapid population growth and economic expansion. Groundwater, a vital source of water in Asia, faces significant disparities in distribution and suffers from unsustainable exploitation practices . This study applies groundwater system theory and categorizes Asia into 11 primary groundwater systems and 36 secondary ones, based on intercontinental geological structures, climate, terrain, and hydrogeological characteristics. As of the end of 2010, Asia's assessed groundwater resources totalled 4.677 x 109 m3/year, with exploitable resources amounting to 3.274 x 109 m3/year. The groundwater natural recharge resources in sparse aquifers amount to only 386.14 × 10^9 m^3/year, accounting for merely 8% of the total natural groundwater resources in Asia. Meanwhile, the natural recharge resources in continuous aquifers in plains and intermountain basins, as well as in discontinuous aquifers in hills and mountains with bedrock, account for 52% and 40%, respectively, of the total natural groundwater resources in Asia. Among these, continuous aquifers in plains and intermountain basins have the highest natural recharge resources, constituting 52% of Asia's total natural recharge resources. By considering the geological environmental impacts of groundwater development and the distinctive characteristics of terrain and landforms, six categories of effect zones with varying distribution patterns are identified. Groundwater, as a valuable resource and a key environmental factor, is essential for sustaining life and ecosystems. However, excessive exploitation of groundwater resources can lead to a range of negative geological, ecological, and environmental effects, including sustained declines in groundwater levels, deterioration of water quality, and associated adverse impacts. Moreover, it jeopardizes spatial security for human existence.The current research on Asia's groundwater resources, environmental dynamics, and human impacts aims to provide a theoretical foundation for sustainable groundwater management and environmental conservation in the region.

Keyword

Asia, groundwater resources, groundwater quality, ecological environment, environmental impacts

Nubecularia-coralline algal-serpulid-microbial bioherms of the Paratethys Sea – distribution and paleoecological significance (upper Serravallian, upper Sarmatian, Middle Miocene)

Werner E. E. Piller[1]*, University of Graz, Austria (werner.piller@uni-graz.at)
Mathias Harzhauser[2], Natural History Museum Vienna

Abstract

Nubecularia bioherms represent unique bioconstructions which are restricted to the upper Serravallian of the Paratethys and are reported since the 19th century. They occur in the Central Paratethys in the late Sarmatian and in the Eastern Paratethys in the Bessarabian both regional stages of the respective Paratethyan areas. Several locations in the Vienna and Styrian basins of the Central Paratethys were studied out of which four localities were documented in detail (Wolfsthal, Maustrenk, St. Margarethen - Zollhaus, Vienna - Ruzickagasse) to reconstruct their sedimentary setting, their internal composition, and their indications of environmental parameters. The detailed studies included logging of outcrop sections, petrographic, facies and biotic analyses of polished slabs and thin sections and also cathodoluminescence analyses. These yielded that these bioconstructions are not only composed of the foraminifer Nubecularia, but represent a complex mixture and interrelationships of Nubecularia, serpulids and microbial carbonate. Four boundstone types can be differentiated: Nubecularia boundstone, Nubecularia-coralline algal boundstone, stromatolitic/thrombolitic boundstone and serpulid-nubeculariid-microbial boundstone. The first 3 types are characteristic for specific localities the fourth type occurs in all studied locations and represents the terminal association on top of the three other types. The three basal boundstones are predominantly of columnar growth form irrespective of dominance of Nubecularia, coralline algae or microbial carbonate, the terminal boundstone is widely irregularly organized. The general depositional environment is characterized by cross bedded oolitic grainstones with abundant quartz grains, miliolid foraminifers and molluscs. Intercalated are microbial carbonates mostly stromatolites but also thrombolites. This indicates a general high water energy environment interrupted by more calm periods when the microbial carbonate was built. The 3 basal types of bioconstructions are interpreted to reflect decreasing food supply and/or oxygenation from Nubecularia over Nubecularia-coralline algal to stromatolitic/thrombolitic boundstone. The serpulid-nubeculariid-microbial boundstone reflects an internal succession with a decrease of the same parameters. Water depth is considered very shallow ranging from 0 to a few meters and salinity was normal marine to hypersaline. The reconstructed paleoenvironment with dominating oolite shoals and seagrass meadows was not restricted to the Central Paratethys but extended over the entire Paratethys and represented the largest oolite facies area of the entire Cenozoic!

Keyword

boundstone, Nubecularia, coralline algae, serpulids, thrombolites

The basal Triassic microbialites, between reef building and red ammonoid limestone

Aymon BAUD[1]*, Lausanne University, Earth Science Institute (aymon.baud@unil.ch)
Hugo BUCHER[2], Zurich University, Paleontological Institute and Museum,, Switzerland

Abstract

In Armenia on the northern side of the Neotethys, within the post-extinction lower Triassic so-called reef gap, a described 15-m high basal Triassic sponge-microbial buildup, with overturned cone-shaped geometry and a 8-m top head diameter, is built by thrombolite domes associated with keratose sponges. The growing duration from basal Griesbachian up to lower Dienerian is about 500'000 years.

On the southern, Gondwana side of the Neotethys in Oman, with same starting age and at apparently similar 80-100-m water depth, one of us, HB, discovered a red ammonoid limestone succession. This belongs to one large boulders, issued of a past dismantle Hallstatt-type pelagic platform and crops out near the top of Djebel Rabat Range about 80-km South of Muscat (Oman). It consists of a 30-m thick, thin stratified limestone and well dated from latest Permian to middle Smithian. Overlying a metric thick latest Permian dark limestone substratum, it is the unique known red ammonoid limestone with deposition starting at Griesbachian time. The Induan succession is 18-m thick. According field observations, these limestone beds, red-rosa to yellow according to surface alteration, are showing successions of tabular thrombolite that forms centimetric to metric large mound with very low angle flanks and low elevation. The microbial bindstone microfacies shows coccoidal lime silt, lime mud and filaments. We note numerous laterally discontinuous solitary fenestral structures, but more commonly they form stromatactis layers surrounded by keratose sponge fibers and filament sheath.

The above 11-m thick lower Olenekian well red colored ammonoid limestone shows in addition to previous microfacies, unsual carbonate textures, such seafloor aragonite fans large botroidal cement, bacterial sheaths, coccoids and frutexites-bearing microbialites. These lower Olenekian observations with the unsual carbonate textures establishes the continuity of microbialite production and the time junction with the "Time-Specific Facies" (TSF) attributed to the similar Smithian red ammonoid limestones deposition of the Alwa Formation of the nearby Baid Range.

This unique record of a red ammonoid limestone deposition showing this continuous growth of post-extinction microbialites associated with sponges, from Griesbachian to middle Smithian, indicate a duration more than 2 million years.

During the late Olenekian time, the pattern in time-space distribution of these red ammonoid limestones changed onward and have been described from western Neotethys and from Central Himalaya up to middle Spathian part of the Luolou Fm in the Nanpanjiang Basin (Yangtse Block, S. China).

Keyword

sponge-microbial buildup, Induan, Olenekian, Neotethys, Oman

Carbonate platform configuration and microbial sedimentation in the Mesoproterozoic Penganga Platform, Peninsular India

Joydip MUKHOPADHYAY[1]*, Indian Institute of Science Education and Research (IISER) Berhampur (joydip17@gmail.com)

Abstract

Carbonate platform configuration and microbial sedimentation in the Mesoproterozoic Penganga Platform, Peninsular India

Joydip Mukhopadhyay
Department of Earth and Environmental Sciences, Indian Institute of Science Education and Research (IISER) Berhampur, Odisha, India, joydip17@gmail.com

Extensive Mesoproterozoic carbonate platforms cover a large part of peninsular India. The carbonate platforms that formed during the later part of Mesoproterozoic in the peninsular India show remarkable similarities in terms of lithostratigraphic development. Most of these successions with thicknesses ranging 300 m to 500 m are dominated by lithographic limestones and shale, for example the Kurnool, Chhattisgarh, Penganga, Indravati, Bhima and Kolhan basins (Mukhopadhyay et al., 2020). In all these basins in the lower part of the succession an interval of siliceous limestone is developed in some profiles. The siliceous limestone may contain about 20 % silica which occurs dispersed evenly as cryptocrystalline/microcrystalline quartz in micrictic carbonate groundmass. The Penganga platform around the town of Adilabad in Telengana province includes at least two laterally extensive Mn-Fe formations (iron formations). These formations yield high quality Mn-ores that are believed to be products of supergene enrichment from Mn-carbonate protores (Gutzmer and Beukes, 1998). Mn-protores are described as microoids of rhodochrosite and their lighter carbon isotope composition speaks in favour of microbial mineralization (Gutzmer and Beukes, 1998). The Penganga platform depicts two distinct facies associations between the proximal and distal transects. The proximal transect is essential flat bedded monotonous lithographic limestone of homoclinal outer ramp setting whereas the distal transects are dominated by carbonate mass-flow deposits including non-Newtonian cohesive and cohesionless debris flows, differentiated bi-/tripartite flows and calciturbidites. The distal association has been interpreted as distally steepened ramp association. The siliceous limestone is invariably restricted within the distally steepened ramp environment in the Penganga platform. Silica sedimentation at the expenses of carbonates in modern ocean basins in general takes place below the carbonate compensation depth and is favoured by low temperature of the water column which enhances the solubility of carbonates but favours silica precipitation. EPS controlled organotemplate biomineralization facilitated silica sedimentation (Mukhopadhyay et al., 2004). The platform topography aided by the distal steepening in the Penganga platform might have nestled the climate-controlled cold-water upwelling cell and thus promoting silica sedimentation

and microbial growth in a nutrient rich ramp slope break.

Acknowledgement: The author received research support from IISER Berhampur, India

References

Gutzmer, J. G. and Beukes, N. J., 1998. The manganese formations of the Neoproterozoic Penganga Group, India—revision of an enigma. Economic Geology, 93, 1091-1102.

Mukhopadhyay, J., Beukes, N.J. and Gutzmer, J., 2004. Organotemplate silica deposition in Neoproterozoic deep-marine environments: evidence from the Penganga Group, Adilabad, India. Terra Nova, 16, 338-343.

Mukhopadhyay, J., Crowley, Q., Ghosh, B., Ghosh, G., Heron, K., 2020, Detrital Zircon U-Pb LA-ICPMS ages from the Kolhan Group, Singhbhum Craton, eastern India: implications for terminal Mesoproterozoic Paleogeography between Columbia and Rodinia along the Central Indian Tectonic Zone. Geological Journal, Wiley, v. 55., DOI: 10.1002/gj.3931

Keyword

carbonate platform, siliceous, upwelling, microbial mediation

Trophic level variability of an intertrappean lake during Deccan volcanism: New insights using stable isotopes

Yogaraj BANERJEE[1]*, Centre for Earth Sciences, Indian Institute of Science, Bangalore (ybanerjee15@gmail.com)
Prosenjit Ghosh[2], Centre for Earth Sciences, Indian Institute of Science, Bangalore
Shrinivas G. Viladkar[3], Department of Earth and Environmental Sciences, Indian Institute of Science and Education Research, Bhopal

Abstract

The impact of Deccan volcanism as a sole driver for the K/Pg extinctions is still a paradox in Biogeoscience research. Previous investigations highlighted the effects of the elevated CO2 and temperature rise associated with Deccan trap volcanism in the K/Pg extinction (Keller et al., 2020; Zhang et al., 2018). On the contrary, several studies suggested that Deccan volcanism played a minor role in the K/Pg extinction event (Chiarenza et al., 2020; Dzombak et al., 2020). Contemporary terrestrial organosedimentary deposits have the potential to provide valuable information about the perturbation in the biogeochemical cycling during Deccan volacanic episodes. Dynamic hydrological conditions with intense rainfall during Decan volcanism were inferred from the oxygen isotopic composition of clay minerals (Ghosh et al., 2004). Amba Dongar carbonatite complex, situated at the north-western part of Deccan igneous province intrudes late Cretaceous Bagh bed limestone and sandstone with a sequence of eruptive events (Viladkar and Sorkhtina 2021 and references therein). The evolution of the carbonatite complex has been related to the Deccan volcanism. The peak of the Deccan volcanism is considered to ca. 66 Ma, which coincides with the K/Pg boundary (Schoene et al., 2015; Renne et al., 2015). The U-Pb dating of apatite revealed the carbonatite magmatism at Amba Dongar took place around 63 Ma representing the late stage of Deccan volcanism (Fosu et al., 2019). Here we report a new intertrappean sedimentary horizon deposited in between the tholeiitic basalt and carbonatite volcanism episodes capturing the coeval terrestrial biogeochemical changes associated with the CO2 outgassing. Based on relative stratigraphic position and the mode of occurences of the laminae, we have classified these sedimentary rocks into two types: (1) older Type I (fine and discontinuous laminae with uneven boundaries) and younger Type II (thick and regular laminae with well-defined boundaries). Mineralogical investigation revealed transformation of Calcite into Wollastonite in case of Type II carbonates through contact metamorphism by the next eruption event. We carried out stable carbon and oxygen isotope analysis on both of these carbonates. A strong correlation between the δ13Corg and δ13Ccarbonates indicates the potential biogenic origin of these lacustrine carbonates. The stable isotope data from Type I and Type II carbonates capture trophic level variability of the lake in response to the Deccan volcanic activity. Our study elucidates the impact of LIP events on microbial carbonate precipitation.

References: Keller et al., 2016, Global and Planetary Change; Zhang et al., 2018, Geology; Chiarenza et al., 2020, PNAS; Dzombak et al., 2020, Gondwana Research; Ghosh et al., 2004,

Palaeoclimatology, Palaeoceanography, Palaeocology; Viladkar and Sorkhtina 2021, Mineralogical Magazine; Schoene et al., 2015, Science; Renne et al., 2015, Science; Fosu et al., 20119, Geological Journal.

Keyword

K/Pg boundary, carbonate, stable isotopes, Deccan

Biochemical Ba cycling in microbial mats through deep time: Insights from Ba concentrations and isotopes in stromatolitic carbonates

Simon V. Hohl[1]*, Tongji University (simon.hohl@me.com)
Sebastian Viehmann[2], University of Hannover
Yibo Lin[3], Nanjing University
Ashley N. Martin[4], University of Hannover

Abstract

In recent decades, the quest for reliable proxies to reconstruct Earth's ancient ocean chemistry has heightened interest in stromatolites. These lithified microbial mats, prevalent in shallow neritic environments, can potentially archive ambient water chemistry of the photic zone from as early as ca. 3.5 billion years ago to now. Stromatolites offer a unique window into the long-term elemental fluctuations in microbial habitats across near-shore surface oceans, embayed basins, and lacustrine systems. This study evaluates the utility of barium (Ba) concentrations and isotopic compositions in stromatolites, ranging from the Paleoarchean to the Holocene, as a proxy for ancient microbial habitat productivity across various epochs and depositional environments.

Our research reveals that Ba systematics in non-restricted stromatolites reflect the biogeochemical cycling of Ba within photic zones, demonstrating significant variability in authigenic Ba isotopic compositions across different oxygen and sulphate saturation conditions. This variability, spanning two orders of magnitude, underscores the dynamic interplay of the physicochemical processes that influence Ba signatures, i.e., micro-barite formation and cyanobacteria Ba cycling. Stromatolitic carbonates from non-restricted environments offer a continuous record of ambient seawater δ138Ba(sw) over deep time. The highest obtained values are 0.45 ‰ in the Archean, 0.61 ‰ in the Proterozoic, and 0.57 ‰ in the Phanerozoic. The heaviest values consistently match the δ138Ba(sw) values observed in the modern open surface ocean (0.3 - 0.7 ‰), arguing for a continuous biogeochemical Ba cycle through geological history.

In contrast, often nutrient-limited, restricted environments exhibit high variability in carbonate Ba isotope values, which positively correlate with carbonate-associated Ba concentrations. Our detailed case studies from the modern Lagoa Salgada lagoon (Brazil) and the Hamelin Pool in Shark Bay (W. Australia) reveal a variation of δ138Ba(fluid) from ~0.1 ‰ in temporarily restricted supratidal zones to ~0.8 ‰ in open subtidal environments covering values for global groundwater discharge to the heaviest recorded modern surface ocean. Following classic Rayleigh fractionation patterns, a gradual increase in δ138Ba(fluid) is observed at Hamelin Pool alongside decreasing Ba/Ca ratios. This trend underscores the influence of groundwater discharge as a significant mixing source with seawater, illustrating a conservative mixing trend towards subtidal environments.

The variabilities in δ138Ba of stromatolitic carbonates from different geologic periods directly link to environmental restriction and biogeochemical Ba cycling during micro-barite formation on microbial biofilms. Barium recycling, particularly in restricted environments, produces lighter Ba isotopic values. However, open marine stromatolites capture ambient surface ocean δ138Ba(sw) compositions, providing a continuous record through deep time. This study underscores the potential of stromatolites as proxies for ancient ocean chemistry, reflecting the complex interplay between microbial activity, environmental conditions, and biogeochemical processes.

Keyword

stromatolite, Ba isotopes, photic zone, biogeochemical cycles, microbialite

Carbonate mineral precipitation induced by microorganisms enriched from the cave water and biofilm in Yongcheon Cave, Jeju Island

Yul ROH[1]*, Chonnam National University (rohy@jnu.ac.kr)
Yumi Kim[2], Chonnam National University
Sung-min Kang[3], Chonnam National University
Abhijit Manna[4], University of Pennsylvania
Ileana Pérez-Rodríguez[5], University of Pennsylvania
Kyoung-nam Jo[6], Kangwon National University

Abstract

The formation of calcareous speleothems in caves is known to be mainly due to chemical precipitation. However, microbial precipitation of calcium carbonate has recently been reported to play an important role in crystal nucleation and mineral growth. This study was performed to investigate the carbonate-forming microorganisms that inhabit the cave water and stalagmite biofilm. The mineralogical characteristics of calcium carbonate and Sr/Mg-carbonate minerals precipitated by these microorganisms were also explored.

Two sediment samples from outside the cave, seven cave water samples from the drip water inside the cave, and ten biofilm samples wiped with sterilized cotton swabs were collected from Yongcheon Cave in Jeju Island. Carbonate-forming microorganisms enriched from the cave water and biofilm induced calcium carbonate precipitation through ureolysis. To investigate the effect of cations, various ratios of Ca:Sr or Ca:Mg (3:0, 2:1, 1:1, 1:2, 0:3) were added into the medium and then incubated at 15 °C for 7 days. Microbial analysis was performed using Next-generation sequencing (NGS) and Sanger sequencing. Geochemical properties were investigated by pH, ammonium concentration, X-ray fluorescence (XRF), and inductively coupled plasma–optical emission spectroscopy/mass spectrometry (ICP-OES/MS). Mineralogical characteristics were determined through X-ray diffraction (XRD) and scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy (EDS).

The sediment covering the outside of the cave primarily consisted of skeletons of marine organisms, such as mollusks and coralline red algae fragments. Its mineral constituents were Mg-rich calcite [(Mg,Ca)CO3] or aragonite (CaCO3). The drip water in the cave had an alkaline pH (range: 7.9–8.3) and the following average chemical compositions: Ca, 50.9 mg/L; Na, 9.7 mg/L; Mg, 8.9 mg/L; K, 7.3 mg/L; and Sr, 0.3 mg/L. The high Ca content was attributed to the influence of the calcareous sediments covering the outside of the cave. NGS results showed that the first enriched microorganisms from the drip water were dominated by Proteobacteria and Firmicutes, including Pseudomonas, Morganella, and Neisseria, which are known to contribute to carbonate formation. Microorganisms from the biofilms were dominated by Pseudomonas of Proteobacteria. Sanger sequencing of isolates from this microbial community showed that the strains isolated from the cave water and biofilm were closely related to Bacillus sp. and Pseudomonas sp., respectively. These microorganisms precipitated calcite (CaCO3) and vaterite (CaCO3) when only Ca was supplied (Ca:Sr=3:0). In the presence of various Ca:Sr concentration ratios (Ca:Sr=2:1,

1:1, 1:2), calcian-strontianite [(Ca,Sr)CO3] was precipitated. Strontianite (SrCO3) was formed when only Sr was added (Ca:Sr=0:3). Addition of different Ca:Mg ratios (Ca:Mg=2:1, 1:1, 1:2) resulted in the precipitation of magnesian-calcite [(Ca,Mg)CO3)] and monohydrocalcite (CaCO3·H2O). Nesquehonite (MgCO3·3H2O) and struvite [(NH4)Mg(PO4)·6H2O] were precipitated when only Mg was supplemented (Ca:Mg=3:0). Therefore, Bacillus sp. and Pseudomonas sp., which inhabited the caves, may contribute to the formation of carbonate minerals through ureolysis. In addition, diverse carbonate minerals, such as Sr/Mg-substituted calcite, can be precipitated in the presence of various concentrations of Ca, Mg, and Sr.

Keyword

Yongcheon Cave, microbially induced calcium carbonate precipitation, ureolysis, strontium, magnesium

Abiotic and biotic constraints on Earth's ancient colonisers

Indrani MUKHERJEE[1]*, UNSW (indrani.mukherjee@unsw.edu.au)
Ross Corkrey[2], University of Tasmania

Abstract

Microbial communities have shaped biogeochemical cycles in marine and continental environments, atmospheric redox structures, and provided the foundation for the biosphere since life originated on Earth. Microbial mat communities, in particular, have played an important role in biosphere-hydrosphere-atmosphere interactions. Therefore, understanding how microbial communities have evolved over time provides insight into the evolution of Earth's system processes. One way of doing that is to investigate stromatolite abundance and diversity over time. This study uses machine learning techniques to explore and explain the predictive capacities of physical and chemical variables such as temperature (T), essential bioactive elements (Ni, Co, Mo, Se, etc.), and non-essential bioactive elements (As, Pb) in relation to stromatolite abundances.

The study presents an analysis integrating geological parameters (nutrients, temperature) with biological impacts (burrowing, predation) to elucidate stromatolite trends. It identifies temperature as a consistent influencer, with critical thresholds leading to increased biological complexity. Furthermore, it underscores the nuanced relationship between trace elements and biota, emphasizing the importance of optimal concentrations and co-availability with other elements in shaping stromatolite growth patterns and ecological relationships. Certain bioactive trace elements, notably Ag, As, Cd, Co, Cu, Pb, Sb, and Tl, exhibit a significant influence on stromatolite abundance within specific temporal windows. Notably, the identification of ecological shifts associated with the availability of trace elements suggests complex interactions between abiotic factors and stromatolite-building microbial communities throughout Earth's history. This study also highlights the potential impact of such interactions on other parts of the biosphere such as microbial-metazoan inter-links. The study underscores the importance of integrating multidisciplinary approaches to unravel the intricate dynamics of ancient microbial ecosystems and provides valuable insights into the drivers of stromatolite variation during the Proterozoic era.

Keyword

Stromatolites, Temperature, trace elements, metazoans

[Keynote] Oxygenation and marine microbial carbonates: The long history

Robert RIDING[1]*, University of Tennessee, Knoxville (rriding@utk.edu)

Abstract

Localized removal of dissolved iron by oxygen was a key control on early marine Ca-carbonate precipitation in the Archean. Thick carbonate platforms, ~2.9–2.8 Ga in Canada, preserve three co-existing depositional environments: (i) offshore anoxic iron-rich seawater, precipitating Fe-carbonate, (ii) a narrow chemocline mixing zone variously precipitating interlayered aragonite, calcite and Fe-oxide, (iii) onshore iron poor seawater precipitating aragonite and calcite in isolated 'Oxygen Oases'. Abundant Fe2+ superseded the effect of Mg2+ on Ca-carbonate mineralogy. Only when sufficient Fe2+ was removed by oxygen did the relative concentrations of Mg2+ and Ca2+ determine CaCO3 mineralogy, and the progressive removal of dissolved iron allowed the precipitation of first aragonite and then calcite. The most likely source of sufficient oxygen was oxygenic photosynthesis by marine cyanobacteria. This may have promoted precipitation of water column 'whiting' mud and calcification of benthic stromatolites. The oldest recorded stromatolites occur ~3.7 Ga. They were locally abundant on early carbonate platforms and ~2.8 Ga formed hybrid carbonates associated with precipitated seafloor crystal crusts at platform margin chemoclines. Stromatolites increased in abundance with platform thickness during the Archean, and remained major components of shallow water carbonate platforms that expanded in epeiric seas during the Proterozoic.

The gradual increase in shallow marine oxygenation, that began locally in the Archean, continued and expanded in the Proterozoic and increased in the Paleozoic. Shallow marine benthic microbial carbonate sediments declined significantly in abundance during the Neoproterozoic, but remained locally common in the Cambrian. Microbial carbonates show episodic decline throughout the Phanerozoic, with intervals of microbial carbonate abundance and invertebrate diversity broadly alternating with one-another. This pattern supports suggestions that microbial carbonate abundance declined as calcified invertebrates increased. Comparisons of microbial carbonate abundance and invertebrate diversity with estimates of changes in sea-surface temperature and marine dissolved oxygen suggest that microbial carbonate abundance and invertebrate diversity fluctuated with oxygen availability. It appears that intervals of both low marine invertebrate diversity and low dissolved oxygen, e.g., during the early Ordovician, late Devonian, early Triassic, and early-mid Jurassic, favored the formation of microbial carbonates. Low oxygen levels likely stimulated anaerobic metabolisms that favored carbonate precipitation. These observations suggest that, together with shallow marine temperature and carbonate saturation state, the level of dissolved oxygen significantly influenced secular patterns of marine microbial carbonate abundance during the Phanerozoic. Overall, these patterns appear to reflect the long-term influence of oxygenation on (i) Ca-carbonate precipitation in Archean Fe-rich seas, and (ii) the rise of eukaryotes. It appears that microbial carbonates benefited from the first of these effects,

and declined with the second.

Keyword

Archean, hybrid, eukaryote, Phanerozoic

Microstructural Analysis of Recent and Pleistocene Stromatolites at Ruidera Pools, Spain.

Mar SIMONET RODA[1]*, Chungnam National University (simonetroda@gmail.com)
Daeyeong Kim[2], Korea Polar Research Institute
Concepción Fidalgo Hijano[3], Autonomous University of Madrid
Daniel Cruz Álvarez[4], Gemosclera
Víctor López Jiménez[5], Gemosclera
Pilar Delgado García[6], Gemosclera
Jeong-Hyun Lee[7], Chungnam National University

Abstract

Ruidera Pools Natural Park, Spain, is renowned for well-exposed Pleistocene to Recent freshwater tufa stromatolites. To closely track the microstructural characteristics of these stromatolites, we applied Electron Backscatter Diffraction (EBSD) and Energy Dispersive X-ray (EDS) mapping to quantify micrometre-scale structures in addition to classic petrographic observations. The studied samples consist of calcium carbonate with low to no presence of detrital components. Both stromatolites consist of highly porous layers of micritic and microsparitic grains, locally surrounding empty tubes where microbial filaments would have been. Under the petrographic microscope, carbonates surrounding the filaments form a single layer. However, EBSD maps reveal up to three different isopachous layers growing around the filaments. The innermost layer is composed of large crystals (10–30 μm in diameter) that are elongated and oriented perpendicular to the substrate, with their c-axes also aligned perpendicular to the substrate. The second layer consists of randomly oriented micritic and microspar crystals (2-10 μm in diameter). The third layer is similar to the first, except for its larger crystal sizes (up to 70 μm in diameter). Although these layers are thin, they closely resemble alternating layers commonly reported from lacustrine stromatolites that are interpreted as results of seasonal changes. This work supports the use of combined EBSD and EDS on stromatolites to identify and quantify their microfabrics, unveiling micro-processes involved in stromatolite formation and thereby complementing conventional methods.

Keyword

Tufa, Lacustrine stromatolite, EBSD, Micrite

Dissolved silicon as a beneficial factor for biomineralization of protodolomite by a halophilic cyanobacterium

Ting CHEN[1]*, China University of Geosciences (chancug@126.com)
Deng LIU[2], China University of Geosciences

Abstract

The genesis of sedimentary dolomite has long been a mystery in Earth science. It has been shown that the formation of low-temperature protodolomite, a crucial precursor of ordered dolomite, can be catalyzed by various heterotrophic microorganisms through organic mineralization. However, the potential role of cyanobacteria, which are common and cosmopolitan autotrophs in sedimentary environments, in the precipitation of protodolomite has been largely underestimated. In addition, the positive role of dissolved silicon (Si) in enhancing the Mg content in Ca-Mg carbonates under oversaturated conditions have recently been emphasized. Nevertheless, the effect of dissolved Si on the formation of microbially-induced protodolomite remains poorly understood. To examine the influence and mechanisms of dissolved Si on the biomineralization of Ca-Mg carbonate by cyanobacteria, bioprecipitation experiments were conducted using a halophilic cyanobacterium (*Synechococcus elongatus* FACHB-410) in unsaturated starting solutions with different concentrations of dissolved Si (ranging from 0 to 2 mM). Our results revealed that the presence of dissolved Si increased the Mg levels in the bio-precipitated Ca-Mg carbonates produced by strain FACHB-410. Specifically, protodolomite formed when 2 mM Si was used. The biogenic protodolomite exhibited a core-shell architecture and spherical morphology. Importantly, an amorphous Mg-silicate formed prior to the crystallization of Ca-Mg carbonates during the biomineralization process, and this fibrous phase was closely associated with the grains of Ca-Mg carbonates. Further wet chemistry analyses suggested that the photosynthetic activity of strain FACHB-410 induced an oversaturated condition with respect to sepiolite. Therefore, the amorphous Mg-silicate can be described as a “sepiolite-like” material. This sepiolite-like phase could serve as a template for the nucleation of Ca-Mg carbonates. These findings have important implications for understanding the co-occurrence of Mg-silicate and (proto-)dolomite observed in geological records.

Keyword

Dolomite problem, Protodolomite, Dissolved silicon, Amorphous Mg-silicate, Cyanobacteria

Diverse origins and depositional environments of phytoclast tufas from the Cretaceous Jinju Formation, Korea

Seunghoon LEE[1]*, Department of Astronomy, Space Science and Geology, Chungnam National University (seunghoon.lee0826@gmail.com)
Jeong-Hyun LEE[2], Department of Geological Sciences, Chungnam National University
Dong-Chan LEE[3], Department of Earth Sciences Education, Chungbuk National University

Abstract

Allochthonous, calcium carbonate-encrusted plant fragments, termed phytoclast tufas, are abundant in the Lower Cretaceous lacustrine successions of the Jinju Formation, Gyeongsang Basin, southern Korea. This study analyzes phytoclast tufas from three localities to elucidate their formative processes. While exhibiting similar macroscopic morphologies, with cylindrical to branching shapes and diameters up to 5 cm, the tufas display distinct microfabrics. The Geobuk-gil section phytoclast tufas are characterized by micrometer-scale stromatolitic columns, calcimicrobial fossils, and branching and anastomosing mesoclots, implying a microbially influenced origin. In contrast, those from Seonjeon-ri are dominated by stromatolitic columns consisting of isopachous fibrous cement with minor peloidal aggregates, signifying a more dominant abiotic precipitation. The Yonggung-ro section exhibits intermediate characteristics, suggesting the interplay of microbial and abiotic processes in their formation. These diverse microfabrics are ascribed to varying depositional environments. The Geobuk-gil tufas, embedded within dark gray mudstone and randomly aligned parallel to the bedding planes, indicate their formation at lake margins and subsequent transportation to lake centers via suspension. The mound-shaped, randomly distributed Seonjeon-ri tufas imply a fluvial system origin and debris flow transportation, forming alluvial fans. The Yonggung-ro tufas likely originated at lake margins and were deposited as dunes in shallow lacustrine settings. This study elucidates that while phytoclast tufas may exhibit macroscopic similarities, their formative processes and depositional environments can be diverse, underscoring the need for caution in interpreting their paleoclimatic implications.

Keyword

lacustrine carbonate, phytoclast tufa, Cretaceous, Korea

Ichnological record of palaeonvironmental changes and its cyclostratigraphic aspects in the Sinemurian-Toarcian basinal deposits from the Mochras drill core, Cardigan Bay Basin, UK

Alfred Uchman[1]*, Faculty of Geography and Geology, Jagiellonian University, Gronostajowa 3a; 30-387 Kraków (alfred.uchman@uj.edu.pl)
Grzegorz Pieńkowski[2], Polish Geological Institute–National Research Institute, Poland
Krzysztof Ninard[3], Faculty of Geography and Geology, Jagiellonian University, Kraków, Poland
Stephen P. Hesselbo[4], University of Exeter, Department of Earth and Environmental Sciences, Penryn, Cornwall, UK

Abstract

Ichnological record of palaeonvironmental changes and its cyclostratigraphic aspects in the Sinemurian-Toarcian basinal deposits from the Mochras drill core, Cardigan Bay Basin, UK

Alfred Uchman1, Grzegorz Pieńkowski2, Krzysztof Ninard1, Stephen P. Hesselbo3

1Jagiellonian University, Faculty of Geography and Geology, Kraków, Poland; alfred.uchman@uj.edu.pl; krzysztof.ninard@uj.edu.pl

2 Polish Geological Institute–National Research Institute, Poland [died in 2023]

3University of Exeter, Department of Earth and Environmental Sciences, Penryn, Cornwall, UK; s.p.hesselbo@exeter.ac.uk

The Mochras drill core contains a continuous Sinemurian-Toarcian section of heavily bioturbated hemipelagic calcareous mudstones, wackestones/siltstones and subordinate packstones/sandstones. Several beds show features of contourites, which have been deposited by thermohaline-driven geostrophic contour currents flowing between the Boreal ocean and Peri-Tethys through the NE-SW trending, narrow and relatively deep Cardigan Bay Strait.

The siltstone/very fine-grained sandstone/calcarenite beds contain the most diverse trace fossils dominated by Phycosiphon incertum produced by opportunistic colonizers. The dwelling and deposit-feeding structures, such as Thalassinoides, Schaubcylindrichnus, and Teichichnus are relatively common. They are accompanied by Trichichnus (a deep-tier chemichnion of filamentous sulfide-oxidizing bacteria with a high tolerance for dysoxia), less common Zoophycos (fodinichnion), Planolites (pascichnion), Palaeophycus (pascichnion), Lockeia (cubichnion), and rare dwelling structures, such as cf. Polykladichnus, Siphonichnus, Monocraterion, Arenicolites, and Skolithos. The trace fossil assemblage resembles the Zoophycos ichnofacies. The intensive bioturbation is conditioned by a relatively stable supply of organic-rich sediment and oxygen.

The contourites in the Toarcian succession are more frequently base- or top-cut than in the Pliensbachian, which suggests more variable conditions in the depositional system. The system was also distinctly disturbed at the Pliensbachian-Toarcian transition and at the beginning of the negative carbon-isotope excursion (To-CIE) marking the Toarcian Oceanic Anoxic Event (T-OAE), where the bioturbation was less intensive, Phycosiphon is less abundant, and Trichichnus is more common. However, anoxic laminated mudstones are rare, and the peak and recovery phase

of the negative excursion of the anoxic event is characterised by loss of Trichichnus and better oxygenated of sea floor. The Pliensbachian-Toarcian boundary event appears to be a significant palaeoceanographic turning point, starting a CaCO3 decline with the most severe oxygen depletion, stronger than during the T-OAE (but dysoxic, not anoxic). This can have been caused by the extreme climate warming during the To-CIE, which may have enhanced and caused a reversal in the direction of deep marine circulation, improving oxygenation of the sea floor. A minor dysoxic event also occurred in the latest Thouarsense and Dispansum zones.
Ichnological and lithological signals suggest repetitive fluctuations in benthic conditions attributed to a hierarchy of orbital cycles (precession and obliquity [4th order], short eccentricity [3rd order], long eccentricity [2nd order], and Earth–Mars secular resonance [1st order]). Spectral analysis of binary data for ichnotaxa appearances gives high confidence in orbital signals in accord with previous work based on geochemical time series. This allows refined estimation of ammonite zone lengths.

Acknowledgements: The research is financed by the National Science Centre, Poland, from the programme Opus 13 (No2017/25/B/ST10/02235) and the Polish Geological Institute grant no. 62.9012.2016.00.0. This is a contribution to the ICDP and NERC project JET (grant NE/N018508/1).

Keyword

ichnology, contourites, circulation, Pliensbachian, Toarcian

Early colonization of the deep-sea bottom–the protracted build-up of an ecosystem

Luis A. BUATOIS[1]*, University of Saskatchewan (luis.buatois@usask.ca)
M. Gabriela Mángano[2], University of Saskatchewan
Maximiliano Paz[3], University of Saskatchewan
Nicholas J. Minter[4], University of Portsmouth
Kai Zhou[5], University of Saskatchewan

Abstract

The body-fossil record of deep-marine environments is poor in comparison with that of shallow water. However, deep-marine deposits are host to diverse, abundant, and complex trace fossils. To analyze the early colonization of the deep sea, we constructed a global dataset of trace-fossil occurrences from a comprehensive survey of Ediacaran-Devonian deep-marine units. Ichnotaxonomic determinations were critically assessed for each occurrence recorded in the dataset. Ichnodiversity, ichnodisparity, ecospace utilization, and ecosystem engineering were the main proxies used to quantify the role of bioturbators in deep-sea colonization. We show that the establishment of a modern-style deep-sea benthic ecosystem was protracted. No substantial increases in the analyzed metrics are detected for deep-marine ichnofaunas during the Ediacaran-Terreneuvian, which essentially reflect exploitation of microbial mats. A sharp increase in all metrics is apparent in this setting during Cambrian Epoch 2, followed by a rapid and dramatic decline during the rest of the Cambrian. The onset of modern-style deep-sea ecosystems was broadly coincident with global cooling and an increase in deep-water oxygenation during the Ordovician. The formation of permanent open burrows in the deep sea may have increased bioirrigation in the uppermost zone of the deep-sea sediment, therefore increasing ventilation and potentially generating a feedback loop between bioturbation and oxygenation, with the endobenthos engineering its environment. A subtle decrease in all ichnologic metrics is apparent in deep-sea siliciclastics in the Llandovery, followed by a persistent decline during the rest of the Silurian. Metrics show an overall increase during the Early Devonian, followed by a decrease during the Middle Devonian and a new increase in the Late Devonian. Sharp changes in deep-sea bioturbation during the Silurian-Devonian were most likely influenced by fluctuations in oxygen content resulting from climate-controlled oceanic circulation. Also, the Silurian-Devonian expansion of vascular plants resulting in the greening of the land masses was probably conducive to a dramatic rise in the delivery of phytodetrital material to marine basin. Because decomposition of sinking organic matter depletes water of dissolved oxygen, this increased delivery may have enhanced the likelihood of eutrophication and hypoxia, negatively impacting on graphoglyptid diversity.

Keyword

ichnology, evolutionary paleoecology, trace fossils, deep sea, bioturbation

The use of time-environment matrices to decipher behavioural events in early Paleozoic animal evolution

Romain GOUGEON[1]*, Géo-Ocean, Université de Bretagne Occidentale
(gougeon.romain@gmail.com)
Gabriela Mángano[2], University of Saskatchewan
Luis Buatois[3], University of Saskatchewan
Muriel Vidal[4], Géo-Ocean, Université de Bretagne Occidentale
Emma Michaud[5], LEMAR, Université de Bretagne Occidentale

Abstract

Trace fossils are remains of past behaviours that represent an independent line of evidence to evaluate animal evolution in deep time. Ichnologic studies aiming at unravelling macro-evolutionary breakthroughs mostly revolved around the first appearance of ichnotaxa (e.g., across the Ediacaran–Cambrian boundary interval), biostratigraphy (e.g., Cruziana ichnostratigraphy), diversity/disparity changes through time (e.g., during the Cambrian explosion, Ordovician radiation, Mesozoic Marine Revolution), morphological variations within ichnogenera or group lineages (e.g., with graphoglyptids), or ecology (e.g., ecosystem engineering impact of animals). However, trace fossils are traditionally considered as facies controlled, and their potential for macro-evolution could therefore be hampered without a robust depositional model. In this regard, time-environment matrices represent an ideal method of analysis that have not been extensively used in ichnology. Here, we present a new approach to evaluate changes in ichnologic metrics in time and space at different scales of analysis. Ichnologic and sedimentologic datasets were collected from the lowermost Cambrian of Newfoundland in Canada (Chapel Island Formation, which is Ediacaran–Cambrian Age 2) and the Lower and Upper Ordovician of Brittany in France (Armorican Sandstone and Kermeur formations, which are Floian and Katian, respectively). Sedimentary facies were described after careful evaluation of sedimentologic features in the field, aiding in the characterization of various intertidal and shallow-marine depositional sub-environments. Data reported on stratigraphic columns serve as a basis to delineate parasequences. Time-environment matrices are then created by plotting sub-environments on an x-axis and parasequences on a y-axis, therefore outlining individual time and space loci, or cells. Ichnologic datasets recovered correspond to: (1) vertical bioturbation, (2) bed surface bioturbation, (3) burrow width, (4) burrow depth, and (5) ichnotaxonomic composition. Ichnologic metrics are added to individual matrices, revealing the environmental and temporal breadth of animal-sediment interactions within each formation investigated. The creation of matrices can be expanded to other ichnologic proxies: (1) ichnodiversity per cell and cumulated per subenvironment, (2) ichnodisparity per cell and cumulated per subenvironment, (3) tiering, (4) presence/absence of different ichnotaxon/taxa or trace-fossil type (e.g., simple horizontal grazing trails, arthropod trace fossils), (5) ecospace utilization, and (6) ecosystem engineering. While using datasets of the Cambrian explosion and the Ordovician radiation, this study aims at demonstrating the potential of matrices developed at a local scale to identify precisely the timing

and place of macro-evolutionary events of global impact.

Keyword

time-environment matrix, ichnology, trace fossils, macro-evolution, sedimentology

[Keynote]Infaunal feedback during the end-Permian Mass Extinction: Evidence from ichnology

Mao LUO[1]*, Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences (maoluo@nigpas.ac.cn)
Luis A. Buatois[2], University of Saskatchewan

Abstract

The end-Permian Mass Extinction (EPME) has caused the largest biodiversity decline of the Phanerozoic. The mechanism and tempo of EPME remains to be explored, with focus on what factors controlling the process of recovery and whether recovery between low and mid- to high latitude regions is chronous or not. During the last few decades, Permian-Triassic trace fossils have been studied intensively to understand the timing and process of EPME and subsequent biotic recovery. This is because trace fossils represent behaviors of both skeletonized and soft bodied organisms, and their preservation was not influenced by the same taphonomic constrains that may have biased the body-fossil record in the Early Triassic. Here we analyze secular changes in ichnodiversity, ichnodisparity and life of modes of trace makers from late Permian to the Middle Triassic based on a global trace-fossil dataset. Results show that, in contrast to the body-fossil record, late Permian global ichnodiversity and ichnodisparity maintained their level until the Griesbachian, followed by a sharp loss in the Dienerian. Notably, the Griesbachian shows an unusual dominance of shallower tiers. The discrepancy between the body- and trace-fossil record is interpreted to be the result of the resurgence of widespread microbial matgrounds in Griesbachian that aided the preservation of surfical, semi-infaunal and shallow-tier ichnofossils. Such ichnological records suggest a disappearance of mixed layer in the earliest Triassic, which might have enhanced pyrite burial in sediments and inhibited its further re-oxidation, therefore regulating sea water sulfate concentrations. A further analyses of trends on ichnodiversity and ichnodisparity between low- and mid- to high latitude regions suggest that infaunal organisms from mid- to high latitude regions were more resilient to EPME. The maintained number of occupied categories of ecospace and ecosystem engineering in mid- to high latitude regions suggests a faster recovery of invertebrate trace makers compared with those at low latitude regions.

Keyword

end-Permian mass extinction, Biotic recovery, Early Triassic, trace fossil, ichnology

Temporal constraints on the ichnofacies paradigm

Anthony Shillito[1]*, University of Saskatchewan (anthony.shillito@usask.ca)
Luis Buatois[2], University of Saskatchewan
Gabriela Mangano[3], University of Saskatchewan

Abstract

The great strength of ichnofacies as environmental indicators relies on the stability of individual ichnofacies through time. For the most part, this stability has been proven through a series of studies building on the original work of Seilacher from the 1950s and 60s, and refining the concept into our present understanding of the ichnofacies paradigm. However, something that is rarely taken into consideration is the uncertainty that surrounds ichnofacies at their point of inception – an ichnofacies cannot exist before tracemaking organisms have colonized the relevant sedimentary environment. As such, ichnofacies "originate" when a community of animals first colonizes a new habitat, and then gradually stabilize (or "evolve") as niches are created and occupied in different ways, until they reach their archetypal form. This means that in the early Palaeozoic, when many new ecological niches were colonized for the first time, there was far less stability. This is highly significant for the use of ichnofacies to distinguish early Palaeozoic sedimentary environments, as the ichnological signature of those environments may not have yet stabilized to match the signal of the archetypal ichnofacies. This issue is further compounded by secular changes in animal-substrate interactions through geologic time, such as increases in ichnodiversity, ichnodisparity, degree and extent of bioturbation, and complexity of tiering structure. Knowing when this occurred allows the ichnofacies paradigm to be employed more accurately by ichnologists, palaeontologists, and sedimentologists alike. In this presentation we will discuss the varying points of establishment of different ichnofacies, and how they "evolved" to reach their established form following their inception.

Keyword

Ichnofacies, Evolution, Colonization

The interplay of evolutionary, taphonomic, and environmental controls on trace fossils from Burgess Shale-type deposits

Gabriela Gabriela MANGANO[1]*, University of Saskatchewan (gabriela.mangano@usask.ca)

Abstract

Burgess Shale (BS)-type deposits have been traditionally understood as formed in deep-marine anoxic environments in the virtual absence of bioturbation. This view has been challenged by: (1) the numerous reports of a variety of trace fossils in BS-type deposits, (2) the wider environmental range of BS-type biotas and associated facies, and (3) the multiple taphonomic pathways that allowed preservation of biogenic structures. Accordingly, the focus is no longer on the presence or absence of trace fossils, but rather on whether they are controlled by the same parameters than other trace-fossil assemblages. Occurrences of trace fossils in BS-type deposits can be categorized in four types: (1) biogenic structures directly associated with non-mineralized carapaces; (2) trace fossils associated with stratigraphic surfaces; (3) burrows hosting the producer; and (4) mineralized three-dimensional vermiform structures. The first group can be considered the ichnologic signature of BS-type deposits. Burrows hosting their producers are another extraordinary occurrence of BS-type deposits that offer unique paleobiologic insights. Trace fossils on stratigraphic surfaces and mineralized biogenic structures are not restricted to BS-type deposits. As a distinctive anactualistic feature, BS ichnofaunas are dominated by surficial to shallow-tier structures. However, relatively deep penetrative trace fossils characterize some occurrences. These inclined to vertical burrows may be part of softground suites recording opportunistic colonization in distal settings or firmground suites recording erosion and bypass. The standard view of BS-type deposits as of deep-marine origin has been triggered by their initial discovery in Walcott Quarry at the base of a carbonate escarpment. However, integration of sedimentologic and ichnologic datasets at a global scale shows that this original scenario is quite unique, with BS-type biotas being preserved under a wide variety of depositional environments, ranging from deltaic to shelf. In addition to oxygen, other factors such as energy and substrate consistency have played a significant role during bioturbation and transit of biogenic structures to the fossil record. Whereas most BS-type deposits are characterized by prevailing oxygen-depleted conditions and low energy at the time of bioturbation, sudden burial is emerging as a key factor involved in trace-fossil taphonomic pathways. A notable example is revealed by trace fossils associated to non-biomineralized carapaces, which record preservation in different scenarios involving contrasting taphonomic pathways. Frequency of event deposition is the main control on the duration of the colonization window, therefore impacting not only on the density of trace fossils preserved in non-biomineralized carapaces, but also on those associated with stratigraphic surfaces. The dominance of fine-grained sediment, although not providing the ideal interfacial boundaries for fine preservation of trace-fossil morphology, may host stabilized or exhumed substrates during times of low sedimentation rate that allowed the preservation of minute, discrete trace fossils on bedding surfaces. Finally, the notion that BS-type biotas disappeared from the

fossil record due to the onset of bioturbation needs to be revised in the light of recent studies demonstrating extensive colonization of the infaunal ecospace since the early Cambrian. A more nuanced scenario that accounts for environmental diachronism in the rise of biogenic reworking needs to be considered.

Keyword

ichnology, taphonomy, exceptional preservation, Cambrian

Evolution and palaeoenvironmental migration of a Cambrian undermat-miner

Li-Jun ZHANG[1]*, Henan Polytechnic University (lijun.zhang@hpu.edu.cn)
Luis Buatois[2], University of Saskatchewan
Maria Gabriela Mangano[3], University of Saskatchewan

Abstract

Microbial mats sealed the sea bottom, becoming the food supply of early metazoans, which exploited this resource in multiple ways during the late Ediacaran and earliest Cambrian. The onset of bioturbation in shallow-marine environments later in the early Cambrian removed this seal, resulting in the protracted restriction of microbial mats to marginal- and deep-marine environments. In this study, we demonstrate that the undermat miner trace fossil Oldhamia followed the pattern of matground restriction to deep-mairne environments. This is shown by a dataset compilation of Cambrian Oldhamia based on a comprehensive review of the literature with addition of our newly discovered Oldhamia in the Cambrian strata of North and South China. Oldhamia is one of the most distinctive and widely distributed ichnogenera in early to middle Cambrian siliciclastic successions. It consists of semi-permanent, very shallow-tier, undermat-miner structures produced by stationary vermiform organisms. Despite its importance, details of Oldhamia ichnodiversity trajectories at ichnospecies level, environmental trends, and potential palaeogeographic patterns have not been explored. Our results demonstrate that Oldhamia displays high diversification in the Fortunian shallow- and deep-marine settings, corresponding to the signal of the Cambrian Information Revolution. Oldhamia alata and O. geniculata only occur in the shallow marine, O. curvata and O. flabellata are restricted to the deep marine, and O. antiqua and O. radiata range from shallow to deep marine. The producers of retreated into deep sea since the end of the Fortunian mirroring the restriction of matgrounds as a response of intense bioturbation in shallow-marine deposits during the Agronomic Revolution. Oldhamia originated from the Iapetus Ocean and then migrated into other oceans, most likely through dispersal assisted by the ocean currents.

Keyword

Oldhamia, Agronomic Revolution, Cambrian Information Revolution, Evolution, Undermat miner

Integrated sedimentological and ichnological analysis of Holocene deposits in the Nakdong River delta, South Korea

Boyeon JEON[1]*, IGC 2024 (37igc@igc2024korea.org)
Daekyo CHEONG[2], Kangwon National University
Seungwon SHIN[3], Daegu University
Jin Cheul KIM[4], Korea Institute of Geoscience and Mineral Resources

Abstract

Infaunal organisms are sensitive to environmental changes; therefore, trace fossils can provide significant information on various physicochemical stresses occurring in deltas. In this study, integrated sedimentological and ichnological analyses were performed of sedimentary core ND-2 (9–35 m depth), collected from the Nakdong River delta plain in Korea, to assess the variations in ichnological assemblages arising in response to environmental stresses during the early to late Holocene. Visual core description for physical and biological structures and end member analysis of grain size were conducted for this study. The analyses enabled a comprehensive reconstruction of Holocene deltaic paleoenvironments comprising lower shoreface (8.5–9 ka), offshore (6–8.5 ka), prodelta (3–6 ka), distal delta front (1–3 ka), and proximal delta front (< 1 ka). *Skolithos* suite, which has a deep penetration depth and large diameter between lower shoreface and offshore, represents the *Glossifungites* ichnofacies with a sharp boundary defined as a within-trend flooding surface, indicating an abrupt increase in water depth. This result implied that the Nakdong Delta area was influenced by the early Holocene sea level rise (EHSLR) at ca. 8.5 ka. Furthermore, changes in the size, diversity, abundance, and types of trace fossils during the evolution of deltas have enabled the differentiation of sub-environments within the deltaic system. This study shows that trace fossils also can be a powerful tool to construct Holocene deltaic environments, and further ichnological analyses in Nakdong Delta region would be helpful to restore high resolution paleoenvironments.

Keyword

Trace fossils, *Glossifungites ichnofacies, Sea level, Paleoenvironments, Grain size distribution*

Lipid Biomarker Patterns Reflect Nutritional Strategies of Seep-Dwelling Bivalves From the South China Sea

Hongxiang GUAN[1]*, Ocean university of China (guanhongxiang@ouc.edu.cn)

Abstract

Invertebrates living at methane seeps such as mussels and clams gain nutrition through symbiosis with chemosynthetic, chiefly methanotrophic and thiotrophic bacteria. Lipid biomarkers, including their compound-specific carbon stable isotope compositions, extracted from the host tissues are predestined for deciphering the various sources of diets and the associations among varying environments, endosymbionts, and hosts. Here, we investigated lipid inventories of soft tissues of two bathymodiolin mussel species hosting aerobic methanotrophic bacteria (Gigantidas platifrons from Site F and Gigantidas haimaensis from Haima seeps), one bathymodiolin mussel with thiotrophic bacteria (Bathymodiolus aduloides from Haima seeps), and one vesicomyid clam (Archivesica marissinica from Haima seeps) from the South China Sea. The gills of mussels hosting methanotrophic symbionts were found to contain high amounts of lipids of aerobic methanotrophic bacteria, such as the 4,4-dimethyl lanosterol, and other 4-methyl sterols, and the type I methanotroph-specific monounsaturated fatty acids (MUFAs) C16:1ω9 and C16:1ω8. Production of methyl-sterols is favored over fatty acids at low oxygen concentrations, as demonstrated in culture experiments with Methylococcus capsulatus. Since lesser fatty acids and abundant sterols are found in G. haimaensis compared to G. platifrons, G. haimaensis apparently lived at very low oxygen levels. Extremely high levels of MUFAs C16:1ω7 and C18:1ω7 were found in gill tissue of both B. aduloides and the vesicomyid clam A. marissinica. Given the absence of ω8 fatty acids, both B. aduloides and the vesicomyid clam contain thiotrophic bacteria only. The occurrence of 13C-enriched 24-methylenecholesterol in B. aduloides indicates that the animal complemented its diet by filter-feeding (ca. 3% of the total sterol inventory) on photosynthetically derived carbon, whereas the majority of sterols are pointing to a diet relying on endosymbionts. Different types of 4-methylsterols were observed between the thiotroph-containing mussel and methanotrophcontaining mussels, suggesting different biosynthetic steps are present from lanosterol to cholesterol between animal hosts and aerobic methanotrophs. Among the four bivalve species, specific lipid biomarker patterns diagnostic for either the symbionts or the hosts yielded similar δ13C values in each species, indicating that the host obtained its nutrition either directly from the symbionts or derived at least most of its carbon in this way. The information derived from lipid biomarkers of bivalves and their corresponding symbionts in modern environments is vital to interpret data from the rock record, where most other methods to study microbial community composition are not applicable.

Keyword

chemosynthesis, symbiosis, aerobic methanotrophic bacteria,, thiotrophic bacteria, South China

Sea

New Hybodont sharks (Chondrichthyes, Elasmobranchii) from the Early Triassic continental Dongchuan Formation (Yunnan Province, China), revealing the recovery of lacustrine ecosystems after the end-Permian mass extinction

Wen WEN[1]*, Nanjing University (wenwen2020240@163.com)

Abstract

Hybodont sharks first occurred in the Devonian and became extinct in the Late Cretaceous. However, the rare records of freshwater hybodont sharks around the world restrict the study of its diversity after the end-Permian mass extinction and how they adapted to the continental environment. All fossils of Early Triassic hybodont sharks known from China were founded from marine deposits, thus led to the misunderstanding in the accurate time of their freshwater adaption. Recently, hybodontid teeth, cephalic and fin spines as well as placoid scales are discovered for the first time from the continental, Lower Triassic Dongchuan Formation (Olenekian) near Huize County (Yunnan Province) in south-west China. The isolated teeth are assigned to three unidentified hybodontiforms but also to a new species of Parvodus, P. huizodus sp. nov., the oldest record of this small-toothed lonchidiid shark genus, extending its range well down into the Lower Triassic. This new species, together with additional hybodontiform remains, provides new evidence of shark occurrences in the aftermath of the end-Permian mass extinction event, when freshwater environments might have acted as centers of origin rather than refugia for sharks. A review of the species assigned to Parvodus and similar small hybodontiform sharks reveals two distinct ecomorphological groups. Group 1, which is characterized by clutching-type dentitions, includes eight species (three of which remain unnamed) ranging from the Middle Triassic to Lower Cretaceous, while group 2, characterized by cutting-crushing type dentitions, comprises 11 species (six of which remain unnamed) including the type-species, P. rugianus ranging from the Lower Triassic to the Lower Cretaceous. The new fossils documented here reveal that hybodontiforms were already adapted to freshwater environments in the Lower Triassic rather than in the Jurassic in China. Furthermore, the diverse micro-fossils of vertebrate discovered from Early Triassic reveals the recovery of lacustrine ecosystems after the end-Permian mass extinction.

Keyword

Hybodont, Early Triassic, continental, recovery, extinction

Microbial bloom, microbe-metazoan interaction and palaeoecologic crisis linked with volatile volcanisms during the Guadalupian-Lopingian (Permian) transition

Zhensheng Wei[1]*, State Key Laboratory of Biogeology and Environmental Geology,School of Earth Science, China University of Geosciences (Wuhan) (ZSWei@cug.edu.cn)
Yuangeng Huang[2], State Key Laboratory of Biogeology and Environmental Geology and School of Earth Science, China University of Geosciences (Wuhan)
Zhong-Qiang Chen[3], State Key Laboratory of Biogeology and Environmental Geology and School of Earth Science, China University of Geosciences (Wuhan)

Abstract

The major bio-crisis during the Guadalupian-Lopingian (Middle-Late Permian) transition recorded dramatic losses in diversities of marine invertebrates to varying degrees and first-class collapse of metazoan reef systems worldwide, and this devastation could be possibly driven by a series of environmental perturbations such as volatile eruption of Emeishan large igneous province (ELIP), prevailing anoxia and long-term regression. Coupling with decline in macro-organisms, microbial bloom was also evident during this critical period, their blooming extents, interactions with metazoans and linkage with the ELIP, however, have not been investigated and their involvement to biotic mass extinction and palaeoecological crisis therefore remain poorly understood. Here we report some new findings on microbial compositions, stratigraphic distributions and interactions with metazoan as well as relations with synchronous ELIP based on in-situ microanalyses of the G-L boundary beds from the GSSP site in the Penglaitan section of Laibin area, South China using techniques of scanning electron microscopy (SEM), Raman spectroscopy, and Nano-scale Secondary Ion Mass Spectrometry (NanoSIMS). We discovered solid evidence of microbial destructions on the shells of brachiopods and crinoids, which are composed of well-preserved quartz crystals and clay minerals. These shelly destructions and fillings of quartz and clay minerals are interpreted as the result of boring behaviours on the shelly substrates by microboring organisms, and the well-preserved crystal outline, worn surface, and larger surface size of quartz crystals are typical of volcanic activity in origin. Stratigraphically, the maximum value of quartz crystals coincides with the onset of ELIP eruption at the topmost of the Laibin Limestone in Penglaitan during the end of the Guadalupian. Overall, microboring records exhibit three developmental phases: plateau, proliferation, and recession, coinciding with the collapse of bryozoan-sponge reef, bloom of microbiota, and losses of benthic faunas, respectively. The temporal coincidence suggests the ELIP eruption may have driven microbial blooming and enormous flux of quartz crystals, offering a new perspective of unique progress of microbe-metazoan interaction under intense environmental stress due to the ELIP during the G-L mass extinction.

Keyword

Middle-Late Permian, mass extinction, microbiota, Emeishan large igneous province, South China

Marine carbonate factory changes across the end-Permian mass extinction in South China

Danna LIU[1]*, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan) (danna.liu@cug.edu.cn)
Zhong-Qiang Chen[2], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan)
Zijie Zheng[3], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan)
Yu Pei[4], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences (Wuhan)

Abstract

The Permian-Triassic (P-Tr) mass extinction marks the largest biodiversity decline in geological history, accompanied by ocean acidification leading to a crisis for calcareous skeletal organisms. Before and after this event, significant changes occurred in the carbonate depositional systems of shallow marine environments. During the P-Tr transition, South China was located at low-latitude region and characterized by a massive shallow marine setting developing a vast carbonate platform (termed the Yangtze Platform). Some sections at this platform, i.e., the Yudongzi, Zuodeng, Dajiang sites record distinct changes from the uppermost Permian bioclastic limestone to the lowest Triassic microbialites, displaying conspicuous variations of carbonate factories across the end-Permian extinction. These two types of factories are usually separated by an irregular surface, which is widely interpreted as an exposure surface due to regional sea-level fall. Composite clays containing various minerals can be identified from this horizon, providing evidence of the influence of continental weathering following sea-level drop immediately after the end-Permian crisis. The mechanisms and types of carbonate factories underwent significant changes across this extinction, with tropical carbonate factories (T-type factories) being replaced by microbial carbonate factories (M-type factories). Before the extinction, the biotic framework of T-type factories was constructed by a combination of corals, calcareous algae, crinoids, and benthic foraminifera, primarily controlled by biota-mediated carbonate deposition. After the extinction, M-type factories were mainly induced by benthic cyanobacteria, leading to a notable shift in carbonate production. Carbonate production efficiency increased from 56% to nearly 90%. The primary cause of this phenomenon lies in the rapid occupation of ecological niches by microbial communities, particularly cyanobacteria (*h*-like calcimicrobe), following the end-Permian extinction, and they utilized the organic matter degraded in seawater to produce high concentrations of HCO3-, as well as Ca2+ and Mg2+ enriched by EPS, synthesizing large amounts of calcium-secreting substances. Their rapid proliferation led to calcium carbonate oversaturation and precipitation, demonstrating remarkable carbonate production efficiency, forming typical microbial structures such as stromatolites, thrombolites, and dendrolites. Additionally, the adsorption capacity of organic functional groups (including carboxyl, phosphoric, and hydroxyl, among others) for Mg2+ is stronger than that of water, reducing the

hydration of Mg2+ ions. This facilitates the incorporation of Mg2+ into the carbonate lattice, thereby promoting the nucleation of dolomite. Microbial metabolism affects hydrochemical conditions, increasing alkalinity and inducing fluctuations in saturation, thereby inducing microbialite dolomitization.

Keyword

Permian-Triassic mass extinction, tropical carbonate factories, microbial carbonate factories, sea-level drop, microbialite dolomitization

Organic matter influence on ooid formation: New insights into classic examples (Great Salt Lake, USA; Triassic Germanic Basin, Germany)

Yu PEI[1]*, China University of Geosciences (Wuhan) (peiyu@cug.edu.cn)
Pablo Suarez-Gonzalez[2], Complutense University of Madrid
Jan-Peter Duda[3], University of Goettingen
Zhong-Qiang Chen[4], China University of Geosciences (Wuhan)
Joachim Reitner[5], University of Goettingen

Abstract

Ooids are coated grains composed of a tangential or radial cortex growing around a nucleus. They are common in carbonate deposits of almost any geological age and provide insights into environmental conditions. However, abiotic or biotic factors influencing their formation remain unclear. This study aims to advance current understanding of ooid formation with a multi-analytical approach (for example, field emission scanning electron microscopy, Raman spectroscopy and micro X-ray fluorescence) to classic examples from Great Salt Lake, USA, and the Lower Triassic Germanic Buntsandstein Basin, Germany. Both of these deposits represent hypersaline shallow-water environments where ooids are closely associated with microbial mats. Great Salt Lake ooids are dominantly 0.2 to 1.0mm in size, ellipsoidal to subspherical in shape, composed of aragonite and contain organic matter. Germanic Buntsandstein Basin ooids are mainly ≤4mm in size, spherical to subspherical in shape, composed of calcite and currently contain little organic matter. Despite the differences, both ooids have the same cortex structures, likely reflecting similar formation processes. Some Great Salt Lake ooids formed around detrital grains while others exhibit micritic particles in their nuclei. In Germanic Basin ooids, detrital nuclei are rare, despite the abundance of siliciclastic particles of various sizes in the host rocks. Germanic Basin deposits also include ‘compound ooids’, i.e. adjacent ooids that coalesced with one another during growth, suggesting static in situ development, which is supported by the lack of detrital grains as nuclei. Germanic Basin ooids also grew into laminated microbial crusts with identical microstructures, further indicating a static formation. Such microbial crusts typically form through mineral precipitation associated with organic matter (for example, extracellular polymeric substances), suggesting a similar formation pathway for ooids. The inferred key-role of organic matter is further supported by features in radial ooids from the Great Salt Lake, which commonly exhibit, from their nuclei towards their surface, increasing organic matter contents and decreasing calcification.

Keyword

Cortex, extracellular polymeric substances, laminae, mineralization, organomineralization

The earliest record of freshwater siliceous algae from the Middle Triassic: Chrysophyte stomatocyst from the Ordos Basin, North China

Bohang CHENG[1]*, State Key Laboratory of Biogeology and Environmental Geology and School of Earth Science, China University of Geosciences (Wuhan), Wuhan 430074, China (cheng_bohang@cug.edu.cn)
Meijia Zhang[2], State Key Laboratory of Biogeology and Environmental Geology and School of Earth Science, China University of Geosciences (Wuhan), Wuhan 430074, China
Zeming Zheng[3], State Key Laboratory of Biogeology and Environmental Geology and School of Earth Science, China University of Geosciences (Wuhan), Wuhan 430074, China
Zhong-Qiang Chen[4], State Key Laboratory of Biogeology and Environmental Geology and School of Earth Science, China University of Geosciences (Wuhan), Wuhan 430074, China

Abstract

Chrysophyte is one of the earliest siliceous algae dwelling in freshwater settings. Their siliceous scales and stomatocysts can be preserved in lake sediments for a long time, and their fossils therefore are important materials to uncover the life history and evolution of chrysophytes and to reconstruct ancient lake environments. So far, about 160 types of stomatocysts have been recognized and confirmed to be produced by chrysophytes in modern lakes, and very few have been described in fossil records. In particular, the origin and morphology of the early chrysophytes remain poorly understood.

We describe a diverse stomatocysts assemblage from the black shales of the 7th member of the Yanchang Formation in the Ordos Basin of the central-western part of North China. The fossil-bearing shale is organic-rich and has been constrained as late Latinian (late Middle Triassic) in age based on radiometric age; it is also the important shale gas bed in China, and represents a relatively deep lake depositional system during the late Middle Triassic. The Yanchang Formation fossils therefore represent the earliest stomatocysts of chrysophytes. Stomatocysts are mostly intact and their surface ornamentation and collars are well preserved under Scanning Electron Microscope (SEM). These microfossils are associated with framboidal pyrites, which indicate a reducing condition in the deep lake. Analyses of both Energy-dispersive X-ray Spectroscopy (EDS) and Nano-scale Secondary Ion Mass Spectrometry (NanoSIMS) revealed that pyritization is commonly present on the outer layer of stomatocyst and organic matter fills in the cavity of stomatocyst, with light carbon isotopes of organic carbon, suggesting important sources of shale gas and shale oil preserved in the Yanchang black shales of the Ordos basin.

So far, the earliest fossil record of algae with siliceous structures was cysts found in the 7th member of the Yanchang Formation from 6 drilling sections in the Ordos Basin, China. Here we observed and described more than a dozen new stomatocyst morphologies from the same deposit in the Bawangzhuang section of the basin according to the guidelines of the International Statospore Working Group (ISWG), and found that they are extremely rich in the types of collars and surface ornamentations, and such high morphological diversity implies that ancestors of chrysophytes could occur much earlier than Middle Triassic, offering new insights into the origin

of freshwater siliceous algae.

Keyword

chrysophyte, stomatocyst, Yanchang Formation, Middle Triassic, Ordos Basin

Silicified gastropod fossils from the uppermost Permian of Guangxi Province, South China

Jie Liu[1]*, 15721629973 (2849564485@qq.com)
Zhong-Qiang Chen[2], 13247146048

Abstract

Like other benthos, gastropods suffered a great reduction in body size and diversity across the Permian-Triassic mass extinction. However, when compared with other clades (i.e. brachiopods, ammonoids, biavlves so on), the latest Permian gastropods have been less documented in details. For instance, the previous studies showed that only 27 gastropod species have been reported from the uppermost Permian across the entire South China in which other invertebrates were extremely abundant and diverse in the Changhsingian. Thus, here we report a diverse gastropod assemblage from the from the Changhsingian Formation in the Waitoushan section of Dongluo District, Fushui County, Guangxi Province, South China. More importantly, this gastropod fauna is represented by the silicified fossils, which provide better understanding of morphology and systematic classifications of the latest Permian gastropod fauna, and their functional paleoecology, further offering new insights into the fate of gastropods over the Permian-Triassic transition and evolution of this clade during the critical period. This latest Permian gastropod assemblage mostly comprises silicified larval gastropod elements, and they were identified as 20 species (including two uncertain species) in 19 genera, including: Altadema hausmannae Nützel and Karapunar, 2023Anomphalus fusuiensis Pan et al., 2002, Ananias sp., Goniasma fusuiensis Pan et al., 2002, Leptoptygma laetus Pan et al., 2002, Manzanospira turrita Pan et al., 2002, Microconchus aberrans Hohenstein, 1913Microlampra heshanensis Pan et al., 2002, Naticopsis (Jedria) quangxiensis Pan et al., 2002, Palaeostylus dongluoensis Pan and Yu, 1993, Palaeostylus fusuiensis Pan et al., 2002, Peruvispira lingshuien Pan et al., 1985, Protostylus sp., Porcellia paucituberculata Pan et al., 2002, Retispira khaophrikensis Knight, 1945, Streptacis fragilis Pan et al., 2002, Stegocoelia Donald, 1889, Soleniscus pactus Pan, 2002, Trachydomia minuta Pan, 2002, Warthia vaceki (Bittner, 1899). Most of them are limited to Changhsingian in age, with several species ranging from the Kungurian (early Permian) to Changhsingian (late Permian). The Dongluo silicified gastropod assemblage represents the most diverse pre-extinction fauna from single section in South China.

Keyword

Gastropoda, Changhsingian, Mass extinction, Palaeoecology, South China

Millennial-scale variations of Carbon-Sulfur isotopes were regulated by microbe activities following the end-Permian extinction

zijie zheng[1]*, State Key laboratory of biogeology and environmental geology, China university of geosciences (wuhan) (zjzheng@cug.edu.cn)
zhongqiang chen[2], State Key laboratory of biogeology and environmental geology, China university of geosciences (wuhan)

Abstract

As the largest biocrisis of Earth life, the Permian-Triassic mass extinction (PTME) has not only declined biodiversity, but also re-organized chemical cycles of marine settings. Previous studies have showed that marine sulfate pool declined sharply and carbon-sulfur isotopes showed huge fluctuations and recoupling changes on a global scale during this critical period. Nevertheless, the high-frequency or millennial-scale variations of carbon-sulfur cycles have long remained unknown. As sedimentary response to the PTME, microbialites were well developed and widespread in shallow-water carbonate settings immediately after the end-Permian extinction. Such a microbialite unit usually is much thicker than synchronous deposits of deep-water facies, providing the possibility of obtaining carbon-sulfur isotope signals with higher temporal accuracy from the microbialite successions in South China. These high-resolution precise geochemical data derived from the microbialite section help unravel more detailed C-S cycles during the PTME and its driving mechanisms. We analyzed 62 samples from microbialite succession near the Permian–Triassic boundary (PTB) at the Yudongzi section of South China, and undertook the analyses of the size and morphology of pyrite framboids, carbonate carbon isotopes (δ13Ccarb), carbonate-associated sulfur isotope (δ34SCAS), major and trace elements, and stratigraphic distribution of the type and size of various microorganisms. The Yudongzi microbialite unit is 12 m thick and represents the depositional duration of about 40,000 years. Two types of microbial fossils were recognized: Gakhumella-like calcimicrobe and coccoid-like spheroids. The overall population size of these two types of microorganisms showed a downward trend up the section, with a peak together in beds 2 and 3. There seems to be a competitive relationship between the two at bed 4. The Ce/Ce* and pyrite framboids incidate a dyoxic to anoxic redox state, and the oxygen deficiency gradually intensified from bottom to top at the studied section. The diameter of Gakhumella-like calcimicrobe increases significantly up the section, suggesting that the redox state have seriously affected on microbial components within the microbialite ecosystem. Both δ13Ccarb and δ34SCAS isotopes show a prominent negative excursion across the PTME, comparable with those of several other shallow platform facies sections worldwide. The C-S isotopes, with a millennial-scale record of global carbon-sulfur fluctuations during the PTME, exhibit an obvious reverse coupling change within microbialite units, which could be strongly linked with the oxygen-poor conditions and activities of microbial sulfate reduction (MSR). Our results of fossil and geochemical analyses provide a new interpretation on carbon and sulfur isotope variations at millennial-scale and additional evidence of the concurrent environmental

changes during the Permian–Triassic transition.

Keyword

Carbon and sulfur isotopes, element geochemistry, millennial-scale, Permian-Triassic Mass Extinction, microbial sulfate reduction

Early Permian carbonate buildups from eastern Inner Mongolia, North China: Insights regarding the late Early Permian Turnover

Zhen YAN[1]*, Institute of Geology, Chinese Academy of Geological Sciences
(yanzhen20071239@126.com)
Jianbo LIU[2], School of Earth and Space Sciences, Peking University
Xiaochi JIN[3], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

Early Permian carbonate buildups were dominantly constructed by phylloid algae, *Palaeoaplysina* , microbes, bryozoans and *Shamovella*. Middle Permian carbonate buildups were mainly formed by sponges, corals, microbes, bryozoans and *Shamovella*. The phenomenon of the disappearance of phylloid algae and *Palaeoaplysina* form Early Permian carbonate buildups and the flourishing of sponges and corals in the Middle Permian carbonate buildups was named as the late Early Permian Turnover, however, the precise time and controlling factor of the biotic turnover remain wanting further study.

The Asselian–Sakmarian (Early Permian) phylloid algal-microbial reefs and skeletal-microbial mounds from the Amushan Formation, at the Mihangaoqiaogaolu section in eastern Inner Mongolia, North China provide an excellent sample for studying the problem mentioned above. In the stratigraphic sequence, the phylloid algal-microbial reefs are located beneath the skeletal-microbial mounds. The former were constructed by microbial sediments and phylloid algae, and the latter were formed by microbial sediments and skeletal grains including foraminifers, bryozoans, *Shamovella* and *Anthracoporella*. Phylloid algae are not observed in the skeletal-microbial mounds. Microbial sediments are the most important components in both reefs and mounds. They are characterized by the aggregations of filamentous microbes, peloids and micritic filaments: filamentous microbes are usually interpreted as the consequence of sparry calcitic occlusion of completely calcified sheaths of filamentous cyanobacteria, in contrast to the micritic filaments that are formed when the calcified sheaths are completely occupied by micrite; peloids are considered as the result of post-mortem incomplete calcification of filamentous cyanobacteria. Along with the change of carbonate buildups, the organisms in the non-buildup sediments also have an obvious variation almost simultaneously: 1) the amount of phylloid algae decreased dramatically, while *Anthracoporella* thrived; 2) the content of foraminifers, bryozoans and *Shamovella* increased significantly.

As mentioned above, phylloid algae were replaced by foraminifers, bryozoans, *Shamovella* and *Anthracoporella* during the Asselian–Sakmarian in the Mihangaoqiaogaolu section. Similar biotic change occurred widely on a global scale, and roughly coincides with the end of Late Paleozoic glaciations. Therefore, the so-called late Early Permian Turnover is likely to have occurred in the early Early Permian, which is earlier than previous known, and may be closely related to the paleoclimatic change from an icehouse to a greenhouse.

Keyword

Phylloid algal-microbial reef, Skeletal-microbial mound, Paleoclimatic change, Peloid

A new charophyte flora from early Middle Triassic (Guizhou, South China) indicates ecologic adaptation to shallow marine

Meijia Zhang[1]*, China University of Geosciences (Wuhan) (zhangmeijia@cug.edu.cn)
Zhong-Qiang Chen[2], China University of Geosciences (Wuhan)

Abstract

Charophytes are a group of submerged macrophytes, with the earliest fossil records dating back to the Silurian. Since the Mesozoic Era, charophyte fossils have been considered as palaeoenvironmental proxies of ancient freshwater and brackish-water aquatic systems. However, the palaeoecology of Palaeozoic charophytes has been a matter of controversy.

This study first reports a large number of charophyte fossils in the early Middle Triassic Guanling Formation in Guizhou, South China. The lithology of the study section mainly consists of carbonate and mudstone, reflecting a shallow-water carbonate platform environment. In this section, more than 10 species in 3 genera were identified. The charophyte fossils are well preserved and the fragile eversion structure of the apical neck of gyrogonites is intact. The distribution of these fossils appears scattered and non-directional. Observations from scanning electron microscopy and cathodoluminescence revealed that the charophyte fossils and rocks were less affected by diagenesis. Further analysis of carbon and oxygen isotopes carried out on the shells of gyrogonites and rocks revealed that the isotopic composition of carbon and oxygen in the water environment during the calcification of charophyte gyrogonites was consistent with that in the seawater at that time. These findings suggest that they were buried in situ, indicating that these charophytes lived in a shallow marine environment in the early Middle Triassic. Many charophyte fossils with four spirals, undivided and multipartite basal plates, and closed apical pore were also found in this section, indicating that during the early Middle Triassic, charophytes have recovered from the Permian-Triassic mass extinction and entered a period of rapid evolution.

This study discovered the marine charophyte fossil flora in the early Middle Triassic of South China that is presently the most abundant and diverse globally. This discovery provides important evidence for revealing the environmental response mechanism of charophytes to the shallow marine environments and the evolution of charophytes.

Keyword

early Middle Triassic, Palaeoecology, Charophyte fossils

[Keynote] Mid-Phanerozoic major environmental perturbations and ecosystem responses

Zhong-Qiang CHEN[1]*, China University of Geosciences (Wuhan) (zhong.qiang.chen@cug.edu.cn)
Yuangeng Huang[2], China University of Geosciences (Wuhan)
Yu Pei[3], China University of Geosciences (Wuhan)
Xueqian Feng[4], China University of Geosciences (Wuhan)
Qian Fang[5], China University of Geosciences (Wuhan)
Ziheng Li[6], China University of Geosciences (Wuhan)
Zhen Guo[7], China University of Geosciences (Wuhan)

Abstract

After development of ecosystems of Paleozoic, numerous major environmental perturbations accompanied with biotic crises took place during the middle part of the Phanerozoic. This study summarizes the advanced progresses on these extreme environmental and biotic events. The Guadalupian-Lopingian (middle-late Permian) transition witnessed volatile eruption of the Emeishan large igneous province (LIP). Consequently, microbial bloom was associated with the loss of metazoan reef systems and moderate loss of marine invertebrates. The Permian-Triassic (P-Tr) mass extinction is the largest biotic crisis associated with enormous environmental and climatic changes. A total of seven phases of environmental and biotic evolution during the P-Tr transition have been recognized from both marine and terrestrial depositional sequences based on integrated biostratigraphy and isotope stratigraphy. Phase 1 represents the normal marine environments and biota that existed at 252.104 Ma, prior to the onset of major environmental perturbation. Phase 2 is marked by the onset of a negative carbon (δ13Ccarb) isotopic excursion, and coincides with a significant decline in radiolarian diversity, the collapse of communities in shallow metazoan reefs and deep-water settings, and the loss of rainforests on land. Phase 3 is characterized by a pulse of biodiversification on the eve of the end-Permian extinction (EPE). Phase 4 comprises the EPE event itself, dated to 251.941 Ma, and coincides with an extreme episode of widespread anoxia, biodiversity loss, community structural collapse, and volatile eruption of Siberian LIP. Phase 5 is marked by the renewed onset of oxic conditions in all oceanic environments except those in microbialite-rich shallow platform settings where abundant pyrite framboids signal dysoxia. Phase 6 includes the earliest Triassic extinction (ETE) event, dated to 251.880 Ma, associated with euxinic to anoxic conditions and ocean acidification. An extended phase of deoxygenation and acidification returned to the marine settings during Phase 7, possibly driving a calcium crisis. The terrestrial extinction event (Phase 2) probably commenced c. 60 kyrs (in South China) or 370 kyrs (in Sydney basin) before the marine P–Tr extinction, the latter consisting of two distinct events (Phases 4 and 6), spaced c. 60 kyr apart, each being marked by both a carbon isotope excursion and ecologic collapse. The environmental changes associated with these three extinction phases in the ocean and on land can be attributed to the effects of volcanic emissions during the eruption of the Siberian LIP and convergent margin volcanism related to Tethyan tectonics. The secondary extinction also took place across the Smithian-Spathian

boundary (Olenekian). This extinction seems to coincide with cooling in seawater temperature and possible oceanic anoxia and acidification. So far, this extinction has not been reported from terrestrial records. Recently, increasing attentions have been paid to the Carnian Pluvial Episode (CPE) of the Late Triassic, which represents an extreme climatic event and extinction of some clades. The CPE is also recorded in terrestrial successions worldwide, and multiple turbulence of carbon cycles driven by volatile volcanisms have also been recognized. Prior to the Triassic-Jurassic mass extinction, a major environmental crisis has also been identified from the mid-Norian successions in deep-water settings.

Keyword

environmental perturbations, ecosystem responses, Mid-Phanerozoic

Upper Triassic (middle Norian) conodont biostratigraphy succession from eastern Tibet, southwest China

Zhengyi LYU[1]*, China University of Geosciences (Wuhan) (beijing.2008.lzy@163.com)
Martyn L. Golding[2], Geological Survey of Canada
He Zhao[3], China University of Geosciences (Wuhan)
Huazhou Yao[4], Wuhan Center of China Geological Survey
Xiangdong Wang[5], China University of Geosciences (Wuhan)
Lei Zhang[6], China University of Geosciences (Wuhan)
Yangui Li[7], Wuhan Center of China Geological Survey
Chen Han[8], China University of Geosciences (Wuhan)

Abstract

The Late Triassic is a critical period that witnessed major biological and environmental events. The geographic range and taxonomic diversity of conodonts were significantly changed during the Late Triassic. The lack of detailed studies of Norian conodont biostratigraphy from Tibet hampers correlation with Europe and North America, which paleogeographically belong to the western Tethys Ocean and northeastern Panthalassa Ocean, respectively. We present recent study results of a continuous middle Norian (Upper Triassic) conodont succession from the Chaiwei and Tuoba sections of Qamdo (Changdu) area, eastern Tibet (Xizang), southwest China, which was part of the North Qiangtang and Qamdo-Simao Block (NQ-QSB) located in the northeastern Tethys Ocean during the Late Triassic. Therein, the middle Norian (Upper Triassic) succession is well exposed and yielded rich conodonts. A total of four conodont zones are differentiated from the middle Norian (Alaunian) of the Chaiwei section, in ascending order these are: the Epigondolella spiculata Zone, the Orchardella elongata Zone, the Mockina postera Zone, and the E. serrulata Zone; the neighboring Tuoba section also records these four zones, in addition to the upper lower Norian (upper Lacian) Ancyrogondolella uniformis Zone. All of these zones (except for the M. postera Zone) have been recognized for the first time in eastern Tibet. The Lacian-Alaunian boundary is tentatively identified by the first occurrence (FO) of E. spiculata in both the Chaiwei and Tuoba sections. The position of the Alaunian-Sevatian boundary (ASB) is uncertain since the conodont assemblage at the study sections lacks age-diagnostic elements. The conodonts recovered from the Qamdo area have not only dated the Bolila Formation but also refined the conodont biostratigraphic zonation of the Alaunian in the study area. This allows improved correlation between the faunas of Qamdo and their counterparts elsewhere in Tibet, Europe, and North America. In addition, the faunal turnover around the Lacian-Alaunian transition, with the evolution of Epigondolella, Orchardella, and Mockina from Ancyrogondolella, can be recognized in both study sections, although it is more remarkable in the Tuoba section. Therefore, this study also provides new data to improve our understanding of conodont evolution during the Alaunian, and is significant in providing palaeontological data for studying the palaeogeographic evolution of eastern Tethyan ocean basins in the Late Triassic.

Keyword

Late Triassic, Conodont biostratigraphy, Changdu Basin, North Qiangtang, Tethys Ocean

The Guadalupian Extinction: Severity, Selectivity, and Timing

Matthew CLAPHAM[1]*, University of California, Santa Cruz (mclapham@ucsc.edu)

Abstract

The Guadalupian (Capitanian, mid-Permian) extinction was only recognized as a distinct event around 30 years ago, having been grouped with the end-Permian mass extinction in previous studies. The extinction occurred at approximately the same time as the Emeishan flood basalts, suggesting that the causes and consequences may have been similar to the end-Permian extinction. However, the Guadalupian extinctions remains far less understood. Although it was initially proposed as a major mass extinction, improvements to Permian biostratigraphic correlation have revealed Late Permian ages for many localities previously assigned to earlier intervals. As a result, it is now known that the Guadalupian extinction was only a minor crisis, although the extinction rates were elevated above background levels. However, the extinction was far more severe for certain groups, most notably fusulinid foraminifera. Other groups, such as ammonoids, appear to have undergone taxonomic turnover that likely coincided with the extinction, but there is less certainty about the precise timing in some groups. Similarly, although the existence of an extinction during the Capitanian stage is well-documented, the exact timing and tempo within the stage remain unknown due to a lack of high-resolution fossil range data at individual stratigraphic sections. Geochemical proxy records are also ambiguous, unlike the consistent excursions in carbon, oxygen, and other isotopic or trace metal proxies observed at the end-Permian mass extinction. Although the Guadalupian extinction is only a minor crisis in terms of overall taxonomic severity, it is still a fascinating event that provides another example of flood basalt-driven environmental and biotic change.

Keyword

Mass extinction, Permian, flood basalt, extinction selectivity

Secular variations of ichnofossils before and during the Carnian Pluvial Episode from the continental Upper Triassic successions, South China

Liao YANG[1]*, China University of Geosciences (Wuhan) (liao_yang48@163.com)
qian Xue Feng[2], China University of Geosciences (Wuhan)
qiang Zhong Chen[3], China University of Geosciences (Wuhan)
ming Ze Zheng[4], China University of Geosciences (Wuhan)
le Qi Geng[5], China University of Geosciences (Wuhan)

Abstract

Ichnology is exceptionally important for interpreting animal behavior variations across major biotic and environmental crises, and several important ichno-ecologic measures have been successfully applied to ecologically assess the process and mechanism of collapse and rebuilding of marine ecosystems across the Permian-Triassic (P-Tr) mass extinction. However, few studies have concerned ichnological changes of terrestrial ecosystems across the P-Tr extinction and major environmental stresses within the Triassic. In particular, the Carnian Pluvial Episode of the Late Triassic represents an extreme climatic event and led the complete collapse of marine carbonate factory worldwide and extinction of some clades. So far, no ichnologic assessment has been undertaken across the CPE in either marine and terrestrial settings. Here we systematically document 14 ichnospecies in 9 ichnogenera from the upper Badong Formation of Carnian age in the Lianghekou section of the Zigui basin, western Hubei Province, South China, these ichnotaxa include: *Ancorichnus ancorichnus*, *Beaconites coronus*, *B. antarcticus*, *Camborygma litonomos*, *Palaeophycus heberti*, *P. tubularis*, *Planolites beverleyensis*, *Psilonichnus* isp., *Scoyenia gracilis*, *Skolithos linearis*, *Taenidium barretti*, *T. bowni*, *T. satanassi*, and *T. serpentinum*. Stratigraphic occurrences allow recognition of four ichnoassemblages up the section. 1) the *Scoyenia-Skolithos* ichnoassemblage, composed mainly of *Skolithos* and *Scoyenia*, with weak bioturbation and low level of vertical tiering, likely occurred in floodplain to nearshore of lake settings with dry or semi-dry climate regime. 2) the *Scoyenia* ichnoassemblage, which is mainly comprised of *Scoyenia*, *Beaconites*, *Taenidium*, and *Palaeophycus*, with increasing ichnodiversity and tiering level, and a low to moderate bioturbation, was produced in the cyclically exposed, rather shallow lake environment with a semi-dry climate regime. 3) the *Taenidium-Ancorichnus* ichnoassemblage, including *Ancorichnus*, *Beaconites*, *Scoyenia*, *Taenidium* and *Psilonichnus*, with a major increase in ichnodiversity, and their bioturbation level reached 5-6, which formed in the shore zone of lake settings with a wet-dry climate regime. 4) the *Planolites-Camborygma* ichnoassemblage, consisting of *Planolites* and *Camborygma*, with high ichnofossil abundances and the lowest tiering level, indicating wet regime with high soil-moisture and water-table levels. The first three ichnoassemblages occurred in the pre-CPE, while the fourth ichnofauna occurred in the CPE. Integration of ichno-ecological and sedimentological analyses and carbon isotopic stratigraphy suggests that paleoclimates

changed from dry to wet conditions across the CPE in terrestrial ecosystems in South China, strengthening the wet regime condition of CPE prevailed in marine and terrestrial ecosystems at least in China.

Keyword

Triassic, Carnian Pluvial Episode, continental, trace fossils, South China

Dynamic variations of carbon-sulfur cycles through the Late Permian to Early Triassic

Lei ZHANG[1]*, China University of Geosciences (Wuhan) (zhanglei_cug@sina.com)
Biao Ma[2], China University of Geosciences (Wuhan)
Laishi Zhao[3], China University of Geosciences (Wuhan)
Zihu Zhang[4], Chengdu University of Technology
Shunling Wu[5], China University of Geosciences (Wuhan)
Zhengyi Lyu[6], China University of Geosciences (Wuhan)
Xiangdong Wang[7], China University of Geosciences (Wuhan)
Chao Li[8], Chengdu University of Technology

Abstract

Marine carbon-sulfur cycles experienced long-term frequent perturbations through the latest Permian to Early Triassic. However, relationships between carbon and sulfur isotopes are still unclear. Here, we report δ13Ccarb and δ34SCAS, and elemental proxies (UEF, MoEF, Mn/Th, Cd/Mo and Co×Mn) from the Wuchiapingian to Spathian successions (Zuodeng section) in the southern Nanpanjiang Basin, South China. Sudden decreases in both UEF and MoEF values (from ~150 to < 10, and ~60 to < 10, respectively) and gental increase in Mn/Th ratios (< 200 to ~1000) indicate a locally anoxic seawater condition during the Late Permian and an oxic condition during the Early Triassic. Variations of Cd/Mo, Co×Mn and TOC suggest that the Late Permian anoxic condition was related to locally intensive oceanic circulation (e.g., upwelling) and higher marine productivity, which was probably controlled by relatively cool climate regime, whereas the Early Triassic climate warming may have resulted in intensive oceanic stratification, suppressed marine productivity, and thus narrowed the spatial distribution of the oxygen minimum zone, leaving the study site apart from anoxic water mass in that time. Both δ13Ccarb and δ34SCAS excursions were coupled during the Griesbachian and Dienerian substages probably due to elevated or suppressed marine productivity and co-burial of organic matter and pyrite driven by climatic variations. Decoupled δ13Ccarb-δ34SCAS excursions occurred during the Late Permian and the Smithian global warming, respectively probably because of elevated bacterial sulfate reduction and pyrite burial rate induced by serious global-oceanic anoxia. This study deciphers that dynamic variations of marine carbon-sulfur cycles may have been controlled by extremely environmental changes through the Late Permian to Early Triassic.

Keyword

carbon isotopes, sulfur isotopes, seawater redox, end-Permian mass extinction, Smithian Thermal Maximum

Middle Jurassic restructuring of palaeo-food webs stabilized dinosaur-dominated communities in Southwest China

Yuangeng HUANG[1]*, China University of Geosciecnes (Wuhan) (yghuang@cug.edu.cn)
Yangui Li[2], China University of Geosciences (Wuhan)
He Zhao[3], China University of Geosciences (Wuhan)
Zhong-Qiang Chen[4], China University of Geosciences (Wuhan)
Huazhou Yao[5], Wuhan Centre, China Geological Survey
William Foster[6], University of Hamburg
Michael Benton[7], University of Bristol

Abstract

As keystone species, dinosaurs played a fundamental role in the structure of mid-Mesozoic terrestrial ecosystems. In addition, because of their global distribution, dinosaurs evolved into numerous forms that occupied different niches during the Late Jurassic to Early Cretaceous. Temporal dinosaurian diversity dynamics show apparent peaks in species richness in the Late Triassic and early Early Jurassic, and in the Late Jurassic through the Cretaceous. In the Jurassic (201-145 Ma) dinosaur ecosystems diversified and became much more complex, but the detail of how this happened is obscured by a poor global record of dinosaurs in the Middle Jurassic. Data on dinosaur-dominated ecosystems through the Jurassic of West China indicates 22 functional guilds and 127 inter-guild trophic links. Modeling demonstrates that community stability was generally low in the Early Jurassic and surged across the Early-Middle Jurassic transition, indicating the establishment of relatively stable dinosaur-dominated ecosystems, which were characterized by the emergence of an essential guild in community-the larger terrestrial herbivores. This observation highlights the relevance of the keystone species concept in deep-time ecology. The Middle Jurassic stabilization was also accompanied by a pronounced surge in community modularity, thus, the hypothesis that a modular organization of species interactions would aid the stability of communities is supported by our deep-time empirical findings.

Keyword

keystone species, large herbivores, modularity, functional guilds, modeling

Organic geochemical evidence for episodic elevated precipitation in the Carnian Pluvial Episode

HUIWEN LI[1]*, China University of Geosciences (Wuhan) (leelhw11@gmail.com)
GENMING LUO[2], China University of Geosciences (Wuhan)
HAIJUN SONG[3], China University of Geosciences (Wuhan)
ENHAO JIA[4], China University of Geosciences (Wuhan)
XINGQIAN CUI[5], Shanghai Jiao Tong University
Richoz Sylvain[6], Lund University

Abstract

The Carnian Pluvial Episode (CPE, early Late Triassic) represents one of the most severe hydrological perturbations triggered by global warming. However, the variation process of this event, as well as its impacts on seawater chemistry and biotic compositions, remains elusive. In this study, we carried out a detailed organic geochemical analysis of the Erguan section in Nanpanjiang Basin, Guizhou, South China, which records three episodes of negative excursions in carbon isotope compositions(δ13C) in the Carnian. Our organic geochemical records reveal three main episodes of increase in the relative fraction of C30 βα-hopane(moretane) , indexed by the ratio of C30 moretane and αβ-hopane, and three main episodes of increase in the relative fraction of Dibenzofuran, indexed by the ratio of Dibenzofuran and Phenanthrene , coinciding with the three episodes of δ13C negative excursions and increases in the fraction of C29 steranes and clastic minerals. All these suggest that the CPE experienced three main episodes of elevated precipitation, which transported amounts of terrestrial organics and clasts into marine environments. In addition, our organic geochemical records unravel different responses of redox conditions and biotic compositions to these elevated precipitations. For example, during the first episode, the distinct decreases in Pr/Ph (pristane/phytane) ratio and C35 HHI (C35 homohopanes/C31-35 homohopanes) suggest that the redox condition became more oxic, whereas the upper two episodes correspond to enhanced marine anoxic. Furthermore, the upper two episodes coincide with elevated C31 3β-methylhopanes index (3-MeHI, the ratio between C31 3β-methylhopane and C30 αβ-hopane), as high as 11.7%, suggesting enhanced methane cycling. The details of these points will be covered in this talk.

Keyword

Carnian Pluvial Episode, lipid biomarker, methanotrophic bacteria, C30 moretane, redox condition

Tracing Dissolved Oxygen Variability in Riverine Environments: A High-Resolution Study Using *Lamprotula leai* Shell Trace Elements

Xinran Su[1]*, Nanjing University (suxr_nju@163.com)
Chenglong Li[2], Nanjing University
Xuefen Sheng[3], Nanjing University

Abstract

Dissolved oxygen (DO) is considered an important measure of water quality and a vital proxy relating to the geological events such as ocean circulation, paleoclimate, the extinction and the evolution of organic matter. The low level of DO in water may lead to eutrophication, biodiversity decline and other environmental risks, which is a sign of water contamination. Global warming will lead to a decrease of DO concentration in water and an increase of biological metabolism, which is one of the important reasons for causing the decline of DO concentration. Dissolved oxygen in modern surface water can be measured with an oxygen measuring device (DO-meter). For the dissolved oxygen content in geological time, which is difficult to quantify, it can reconstruct by using paleontological morphology and species combinations. Hence, it is necessary to develop a high-resolution (from seasonal to day time scales) archive to reconstruct river dissolved oxygen concentration in geological period. The present study utilizes the widespread living *Lamprotula leai* samples from the river basin in subtropical areas located in the central and eastern region of China, where the DO level in this river basin is relatively low, as a carrier to explore the variation of trace elements (mainly Mn/Ca) at high resolution scale in the shell. The morphological features along the axis of maximum growth from the umbo to the ventral margin were measured by light microscope and scanning electron microscope (SEM). The characteristics of trace elements in this direction were obtained by X-ray Fluorescence Spectroscopy (XRF), Secondary Ion Mass Spectrometry (SIMS) and other element analyse methods. The results reveal that a good correlation between the position of the dark growth lines and the maximum value of Mn/Ca is observed. Previous studies have shown that a low level of DO in water leads to an increased concentration of Mn2+, which can lead to high Mn/Ca in the shell. At the same time, the low level of DO will slow the growth rate of the shell and form a growth line. Therefore, we propose that the Mn/Ca ratio in the shell of *Lamprotula leai* can serve as an indicator of DO level in water. To further investigate the feasibility of using the Mn/Ca ratio in the shell of *Lamprotula leai* as a paleoenvironmental indicator, we will select the fossil samples from Jiaochangpu Site in Liaocheng, Shandong Province during the Longshan Culture period in the Yellow River basin (about 4k years ago) for high-resolution analysis, and explore the changes of the terrestrial environment in the Longshan period through the distribution of Mn/Ca shells.
This work was funded by the National Natural Science Foundation of China(42373062).

Keyword

biogenic carbonate, trace element ratio, dissolved oxygen, bivalve shells

Rise of calcareous deposition during the Carnian Pluvial Episode (Late Triassic)

QILE qile GENG[1]*, 18712013572 (1202211490@cug.edu.cn)
Zhongqian Chen Zhongqiang Chen[2], 13247146048

Abstract

The Late Triassic Carnian Pluvial Episode (CPE) was characterized by increased global rainfall, increased global temperature, and enhanced inland weathering, which was another important climate transition period after the global climate change at the turn of the Permian-Triassic. The marine strata of CPE based on Tethys domain has been widely studied, but the impact of CPE on terrestrial ecosystems is still poorly understood. The Triassic continental strata are preserved in the Zigui Basin of western Hubei Province, in which the lithological transition from purple-red paleosols to gray-green sandstone and limestone, which corresponds to the CPE. Through the analysis of geochemistry, mineralogy, trace fossils, paleosols and sedimentary characteristics, the high-resolution study shows that both the changes in rainfall recovered by chemical index of alteration (CIA) and the morphological changes in trace fossils reflected the transition from arid climate to humid climate. With the climate transition, the elevated Chemical Index of Alteration values and kaolinite content of clay minerals increased, reflecting the increase in weathering intensity. In addition, it will be accompanied by a large enrichment of calcium, such as the evolution of calcareous nodules in paleosols, the formation of calcareous interlayers and carbonate rocks in lacustrine sedimentary environments. The increase in calcium content in sedimentary strata coincides with the increase of rainfall and weathering intensity. The humid climate formed by the increase of rainfall during the CPE is conducive to rock weathering, which brings abundant calcium sources and other nutrients to the lake, promotes the productivity of the lake, and deposits a large number of carbonate rocks. At the same time, the enhancement of rainfall promotes the dissolution of surrounding rocks by groundwater, bringing calcium into the lake water and causing carbonate precipitation. To a certain extent, the enrichment of calcium reflects the transformation of the terrestrial environment from arid to humid environment during the Carnian period.

Keyword

Triassic, Carnian Pluvial Episode, Calcareous deposition

The habitat of the Ediacaran Period fossil Dickinsonia: Redox conditions of the fossiliferous Cherny Kamen Formation in the Ural Mountains

Natasha BYKOVA[1]*, University of Missouri (bykovan@missouri.edu)
Nikita Sozonov[2], Trofimuk Institute of Petroleum Geology and Geophysics, SB RAS
Nikolai Bobkov[3], Trofimuk Institute of Petroleum Geology and Geophysics, SB RAS
Alan J. Kaufman[4], University of Maryland, Geology Department and Earth System Science Interdisciplinary Center

Abstract

Most modern animals require a relatively high concentration of oxygen for their metabolic activities. Thus, it is intriguing to know the oxygen requirements for Earth's earliest animals. Until recently paleontologists thought that the first true animals appeared suddenly in the basal Cambrian Period, but recent discoveries of the impressions of motile organisms with a bilaterian Bauplan, or traces suggestive of complex movement, suggest an earlier Ediacaran Period appearance of metazoans. One of these is the iconic Dickinsonia, which was first discovered in 1947 by Reg Sprigg in the Flinders Ranges of South Australia. Dickinsonia is known from several late Ediacaran successions worldwide, including in exposed strata from the White Sea and Ural Mountains in the Russian Federation. Here we present a geochemical study of the Ural Mountain succession, which was carried out to understand the redox conditions of the water column during the accumulation of the fossiliferous Cherny Kamen Formation that preserves hundreds of small Dickinsonia specimens. In this study, we analyzed 30 shale samples from the upper part of the Sinii Kamen and Konovalovka members. Elemental concentration data from these shale specimens were used to evaluate paleo-productivity (Cd, P, Ba), the availability of micronutrients (Cu, Ni, Zn, Co), and the distribution of redox-sensitive metals (V, Cr, U, Mo). Elemental ratios were also determined to evaluate paleo-salinity (Sr/Ba) and sedimentation rates (log10Mn/Al and log10Fe/Al). In addition, sulfides were extracted from the shale samples using a CRS technique and analyzed for their sulfur isotope compositions (δ34Spyr). Based on these measurements we distinguish several discrete anoxic intervals, including the upper part of the Sinii Kamen Member, and the fossiliferous lower and middle intervals of the Konovalovka Member. Anoxic conditions were notably inferred from levels preserving Dickinsonia fossils. We note that Dickinsonia, macroalgae, and distinct microbial textures are associated with geochemical indicators of anoxia. Consistent with contemporaneous evidence of expanded late Ediacaran global anoxia based on uranium isotope compositions of carbonates, our observations support the view that Earth's earliest motile animals may have been tolerant of low oxygen conditions in the water column.

The study was supported by the Russian Science Foundation N° 23-27-00413, https://rscf.ru/project/23-27-00413/

Keyword

Dickinsonia, Edicaran, Central Urals, redox

Vanadate reduction by gram-positive fermentative bacteria isolated from deep-sea sediments on the northern Central Indian Ridge

Bokyung KIM[1]*, Seoul National University (karabobo@snu.ac.kr)
Dong Kyun WOO[2], Seoul National University
Juhwan JUNG[3], Seoul National University
Min Sub SIM[4], Seoul National University

Abstract

Vanadium is a widely distributed element in the Earth's crust, with a concentration of 35-45 nmol/L in seawater. In natural environments, vanadium can exist in oxidation states of +3, +4, and +5, and its solubility is redox-dependent. Although vanadium is an essential micronutrient, it can become harmful at elevated concentrations. The reduction of V(Ⅴ) to V(Ⅳ) or V(Ⅲ), diminishes the mobility and toxicity of vanadium in soil or sediment. Due to relatively high concentrations in nature and large reduction potential, some microorganisms use vanadate as an electron acceptor for their energy metabolism, suggesting the potential significance of vanadate reducers in the biogeochemical vanadium cycle and remediation of vanadium contamination. To date, however, most known microorganisms capable of reducing vanadate are Gram-negative bacteria belonging to the phylum Proteobacteria, with the only exception being Lactococcus raffinolactis. In this study, we isolate Tepidibacter mesophilus strain OVF from deep-sea sediment at the Onnuri vent field on the northern Central Indian Ridge and investigate its ability to reduce vanadium and its impact on cellular metabolism. A series of culture experiments show that the isolated strain efficiently reduces V(V) to V(IV) during fermentation, even at mM levels, and this reduction is a direct biological process, rather than an indirect reduction by metabolic products. We confirmed that vanadium affects microbial carbon and nitrogen metabolism and redox balance by monitoring changes in metabolite concentrations in the presence or absence of vanadate. T. mesophilus is the second Gram-positive bacterium discovered to reduce vanadium, following L. raffinolactis, with a notable distinction between them. Firstly, they belong to different classes: T. mesophilus is classified as Clostridia, while L. raffinolactis belongs to Bacilli. Secondly, L. raffinolactis utilizes nitrite reductase (NirS) for vanadium reduction, but T. mesophilus lacks this gene. Lastly, the vanadium reduction rate of T. mesophilus is faster compared to that of L. raffinolactis, similar to the rates observed in metal-reducing gram-negative bacteria. Our findings expand the distribution of the vanadate reducing capability in the bacterial domain, and suggest an alternative pathway for vanadate reduction. Given the wide range of natural habitats of T. mesophilus and its close relatives, microbial vanadate reduction may have a greater impact on the global biogeochemical cycle of vanadium than previously thought.

Keyword

vanadium, fermentation, Tepidibacter

Arsenic immobilization using combined treatment of arsenite-oxidizing bacterium and biochar

So-Jeong KIM[1]*, Korea Institute of Geoscience and Mineral Resources (sojkim86@kigam.re.kr)
Dong-Wan Cho[2], Korea Institute of Geoscience and Mineral Resources
In-Hyun Nam[3], Korea Institute of Geoscience and Mineral Resources
Chul-Min Chon[4], Korea Institute of Geoscience and Mineral Resources

Abstract

Arsenic is one of the natural hazards of geological origin and contamination by human activities, including mining and manufacturing. Inorganic arsenic exists in two main oxidation states at neutral pH, of which arsenite (As(III)) is known to be more toxic and more mobile than arsenate (As(V)). Therefore, changes in the oxidation state of arsenic are important in controlling arsenic contamination. This study aimed to isolate a novel arsenite-oxidizing bacterium from mine tailings and characterize its physiological and genomic properties. Among the strains obtained, one strain was found to have the ability to oxidize arsenite, and it was named BH3 and identified and analyzed for its characteristics. Strain BH3 was able to oxidize 9 mM arsenic and tolerated the toxicity of 100 mM arsenate. As a result of genomic analysis, it was confirmed that strain BH3 is belonging to the genus Bosea and has genes for arsenite oxidation. Additionally, we investigated the synergistic effect of strain BH3 and biochar derived from coffee grounds in adsorbing oxidized arsenate. Our results demonstrate that when applied simultaneously, strain BH3 oxidizes arsenic while biochar effectively adsorbs the oxidized arsenic, providing a promising method for changing and stabilizing arsenic phases in contaminated environments. This approach holds potential for environmentally-friendly remediation strategies targeting arsenic contamination.

Keyword

Arsenic, Bosea, biochar, immobilization

Greenhouse gas molar ratios and stable isotopic compositions in Seoul Mega City

JeongEun KIM[1]*, Seoul National University (jeun_kim@snu.ac.kr)
Jinho Ahn[2], Seoul National University
Sakae Toyoda[3], Tokyo Institute of Technology

Abstract

In the Seoul metropolitan area of South Korea, over half of the population resides in a compact 12% of South Korea, contributing significantly to annual anthropogenic greenhouse gas emissions exceeding 1.7 Mt CO2 eq. Given the concentrated population in this relatively small region, it becomes imperative to identify and continuously monitor specific emission sources. The complexity of urban greenhouse gas emissions necessitates in situ sampling for accurate atmospheric monitoring and modeling. To characterize natural and anthropogenic greenhouse gas sources, we collected air samples from three tunnels (Gwanak, BongCheon, SangDo) and three open locations (Mt GwanAk, Mt Nam, and Olympic Park). Greenhouse gas concentrations (CO2, CH4, and N2O) and stable isotopic compositions of N2O (δ15Nbulk, δ18O, and SP) were analyzed.

The vehicle N2O:CO2 molar ratio from tunnel air was (4.3±0.3)x10-5, which falls within the range of previous tunnel studies from Switzerland, Germany, and Sweden ((1.6 – 23) x10-5), and the CH4:CO2 molar ratio of (38.5±11.6)x10-5 was higher than from previous on-road measurements ((4.4-29.1)x10-5). The stable isotopic ratios of N2O emitted from the vehicles were determined as 6.0 ± 1.2 ‰ for δ15Nbulk, 34.4 ± 11.7 ‰ for δ18O, and 6.0 ± 4.2 ‰ for SP (Site Preference, δ15Na-δ15Nb). Intriguingly, N2O stable isotopic compositions from vehicles consistently depleted compared to ambient air in Seoul (δ15Nbulk: 5.9± 0.2 ‰, δ18O: 43.8 ± 0.1 ‰, SP: 18.6 ± 0.3 ‰ (S.E.)), deviating δ15Nbulk and δ18O were notably from the global average. Further study will include stable isotope analyses for CO2 and CH4 (δ13C- CO2, δD-CH4) and the results will be presented during the conference, emphasizing pronounced spatial and temporal variabilities in greenhouse gas emissions (CO2, CH4, and N2O). These results underscore the urgency for further research to comprehend the extent of anthropogenic impacts on urban environments.

Keyword

greenhouse gas, stable isotopes, ambient air, anthropogenic source, vehicle

Unravelling Carbon Fluxes in Delhi's Urban Fabric: Emission and Sequestration Dynamics

SHAILENDER KUMAR[1]*, Centre for environmental studies and disaster management, Miranda House, University of Delhi (Shailender.kumar@mirandahouse.ac.in)
Chirashree Ghosh[2], Department of Environmental Studies, University of Delhi

Abstract

Understanding the intricate dynamics of carbon fluxes within urban environments is paramount for addressing climate change and fostering sustainable urban development. This paper presents a comprehensive review of carbon emission and sequestration dynamics in Delhi, a megacity characterized by rapid urbanization and environmental challenges. Drawing from recent studies and empirical data, we analyse the sources, trends, and impacts of carbon emissions in Delhi's urban landscape, encompassing transportation, industrial activities, energy consumption, and urban development patterns.

Recent research underscores the significant contribution of transportation to carbon emissions in Delhi, driven by the proliferation of private vehicles and inadequate public transportation infrastructure. Industrial activities also play a substantial role, particularly in areas such as manufacturing and construction, where emissions are intensified by inefficient processes and outdated technologies. Furthermore, the burgeoning energy demand in residential and commercial sectors amplifies carbon emissions, necessitating urgent interventions to enhance energy efficiency and promote renewable energy adoption.

In contrast, carbon sequestration mechanisms offer promising avenues for mitigating Delhi's carbon footprint. Urban green spaces, including parks, gardens, and tree-lined streets, have the potential to sequester carbon dioxide through photosynthesis and enhance urban biodiversity. Additionally, urban forests and afforestation initiatives present scalable solutions for carbon sequestration, improving air quality and fostering ecological resilience amidst urbanization pressures.

However, several challenges impede effective carbon management in Delhi's urban fabric. Inadequate urban planning, population density, and land-use changes exacerbate emissions, necessitating integrated strategies that prioritize sustainable transportation, energy efficiency, and green infrastructure. Policy interventions such as emissions regulations, congestion pricing, and incentives for green building practices can incentivize low-carbon development pathways while fostering community engagement and awareness.

Furthermore, technological innovations, including smart grid systems, electric mobility solutions, and green building technologies, hold immense potential for reducing emissions and enhancing resilience in urban environments. Collaborative partnerships between government agencies, academic institutions, and private stakeholders are crucial for implementing scalable solutions and leveraging financial mechanisms to support sustainable urban development initiatives.

In conclusion, this review highlights the urgent need for holistic approaches to address carbon

fluxes in Delhi's urban landscape. By integrating insights from multidisciplinary research, policymakers, urban planners, and stakeholders can formulate evidence-based strategies to mitigate carbon emissions, enhance carbon sequestration, and foster resilient, livable cities in the face of climate change.

Keyword

Carbon fluxes, Urban environment, Emission dynamics, Sequestration mechanisms, Climate mitigation

Inventorization of Green House Gases – Sources and Sinks in Urban Delhi, India

CHIRASHREE GHOSH[1]*, Department of Environmental Studies, University of Delhi (Chirashreeghosh@rediffmail.com)

Abstract

The population of Delhi for the year 2024 is close to 22 million. Due to different cultural habits and higher population density, the capital has become an interesting study site for understanding major issues of 'environmental consequences due to urbanization.

Two broad objectives have been considered for this study viz. GHG inventorization and Carbon map preparation. To fulfill these objectives, estimation has been done using two approaches: top-down and bottom-up; using IPCC Tier 1 Methodology.

In top-down approach, emissions have been calculated based upon fuel and electricity consumption in source sectors of Delhi. In case of bottom-up approach, emission estimation was calculated at the unit level such as from single household for the domestic sector or emissions from different categories of vehicle for the transport sector. On-site monitoring of GHGs was also carried out at 64 sites across Delhi using CO2 and CH4 automatic analyzers (Aeroqual, Series 500, New Zealand).

As it is true for most of the metropolitan cities in developing countries, Delhi is also plagued with issues of proper settlement and housing. Pollution from unauthorised domestic sector was mainly due to use of kerosene, LPG, diesel (DG sets) and huge consumption of electricity. LPG was the most commonly used cooking fuel (68.4%) followed by kerosene (24.4%) while biomass was also used in 3.9% households. Although biomass is used as a cooking fuel, it is carbon neutral and therefore its contribution to the total CO2 emissions has not been included in this approach.

Presently the solid waste is being dumped at three landfill sites which fall under the category of uncontrolled disposal facilities and have no gas recovery systems in place. Landfill gas generation comprises mainly of methane which has a global warming potential of 21. Default method has been used to estimate methane generation from three landfill sites of Delhi.

A Carbon map of Delhi (in terms of tons of carbon emission per square kilometer) was prepared by using the NAEI Mapping Method, 2006. One square kilometer resolution map represents emission at the location called "emission at source" (e.g. power station), whereas emission distributed to location (electricity) known as "end users".

Since the first Carbon map of Delhi was an end user map for the year 2007-08, it has excluded the emission from thermal power plants and mainly focused on four sectors (transport, domestic, commercial and industrial). The carbon map showed that these four main sectors emit 15.41 MMT of greenhouse gas per annum. In comparison to the city of London, with a total carbon emission of 44 MMT, Delhi's carbon emission was one-third of it. In Delhi, transport (46%) and the domestic sector (34%) were the biggest contributors to

greenhouse gas emissions. Based on the carbon map, various state level policy measures have been already recommended.

Keyword

Green house gas, Carbon, Delhi, CO2, Emission

Optimizing Carbon Sequestration in Winter Wheat in Wooster, OH

Grace BRAVER[1]*, East Tennessee State University / National Parks Service
(gbraver88@gmail.com)

Abstract

Due to changes in climate, atmospheric carbon dioxide (CO2) has steadily increased to 421 ppm over the past century (Lindsey, 2022). Soil is an underutilized storage of carbon sequestration in arable farming (Gonsamo et al., 2022). Thus, it is vital to further research on the underdeveloped system of soil dedicated to arable farming to optimize its capacity to sequester carbon to sequester atmospheric CO2 as carbon in soil. In this study, the belowground biomass of 50 varieties of winter wheat are analyzed to determine which is the most robust.

For this study, soil-cores were taken from a sampling field of winter wheat varieties in order to extract the belowground biomass. The belowground biomasses were analyzed, and averages determined in RStudio. Data on aboveground biomass collected by the OARDC was used to compare full biomass profiles of the top belowground biomass varieties. GIS mapping of the sampling field soil units and slope grade were made to determine biological factors, such as a flood zone, that may impact the growth of belowground biomass.

Biomass analyses determined the top five varieties for belowground biomass of those sampled. Despite a few outliers, most varieties fell into a symmetrical statistical distribution. However, these results suggest certain varieties have genetics that correspond to a better distribution of robust belowground biomass. The more robust and well distributed the belowground biomass, the higher the capacity for sequestering carbon within the soil. Leading to improved carbon sequestration in arable farming of winter wheat carbon. Furthermore, proving that arable farming can be improved to mitigate atmospheric carbon by sequestering it in soil.

Keyword

Carbon Sequestration, Soil, Agricultural Science, Root Biomass, Cover Crops

Rock Weathering Dynamics in Himalaya: Insights from Metagenomics and U-series Isotopes

Sohan Kumar[1], Indian Institute of Technology Roorkee
Vishakha Bisht[2], Indian Institute of Technology Roorkee
Rafiq ul Islam[3], Wadia Institute of Himalayan Geology Dehradun
Anil Kumar[4], Wadia Institute of Himalayan Geology Dehradun
Anthony Dosseto[5], School of Earth, Atmospheric & Life Sciences. University of Wollongong. Wollongong, NSW Australia
Florian Dux[6], School of Earth, Atmospheric & Life Sciences. University of Wollongong. Wollongong, NSW Australia
P O Suresh[7], Gujarat State Fertilizers and Chemicals Limited, Vadodara
Naveen K Navani[8], Indian Institute of Technology Roorkee
Pradeep Srivastava[9]*, Indian Institute of Technology Roorkee (pradeep@es.iitr.ac.in)

Abstract

Rock weathering, controlled by coupled biotic and a-biotic factors, plays a crucial role in shaping the landscape and regulating atmospheric CO2. The weathering processes, rates and microbial feedbacks in tectonically active Himalaya are largely unexplored. We present results of the study that interfaces metagenomics, geochemistry and U-series chronology on a granitic weathering profile from Humid Garhwal Lesser Himalaya. The geochemical profile of mobile and immobile elements indicated the studied section to be an ideal weathering profile. The U-series dating across the profile provided a weathering record of 280 ka with an average-weathering rate of 24 mm /ka that is temporally non-linear, exhibit correspondence with warm climatic excursions, and indicated that (i) bulk of the weathering profile developed during warm MIS-5e (ii) at the time scales of 103 yrs climate variability plays an overarching role rock weathering even in tectonically active setting like Himalaya.

Metagenomics, community physiological profiling, elemental and mineralogical analysis informed on the microbe-rock interaction and suggested saprolith to be most active soil forming zone of the profile but may not be actively sequestering atmospheric CO2. The microbial profile of regolith metabolizes via atmospheric CO2 and hence sequester it more effectively. Such studies leading to quantitative estimates of weathering rates, along with an understanding of associated chemolithotroph can inform potential changes in rock-atmosphere-microbe interaction in an anticipated warmer Earth.

Keyword

Himalaya, rock weathering, U series dating, metagenomics

Analysis of the impact of crushed basalt dust addition to corn fields on the diversity and functionality of soil microbiota

Hao-Cheng Chang[1]*, National Taiwan University (d05623004@ntu.edu.tw)
Zhi-Yao Chiew[2], National Taiwan University
Yo-Jin Shiau[3], National Taiwan University
Kai-Yin Lo[4], National Taiwan University

Abstract

Enhanced rock weathering (ERW) is an effective strategy for atmospheric carbon dioxide removal (CDR) while simultaneously increasing agricultural production, aiming for net-zero carbon emissions by 2050. The weathering of basalt releases alkaline cations, i.e. calcium and magnesium, which not only help prevent soil acidification but also fix atmospheric carbon dioxide through the precipitation of carbonates and alkaline cations. Rich in essential mineral nutrients like phosphorus and potassium, basalt application poses no risk of toxic heavy metals accumulation in field soil, making it the preferred mineral for ERW. While the chemical mechanism through which basalt-enhanced weathering promotes crop growth and soil carbon fixation are well developed, the effects on field soil bacterial community diversity and its overall biological functionality remain largely unknown. Therefore, in this study, crushed basalt dust (BD) was applied to corn fields, which were divided into a control group, a group with a 10% BD addition (BD10), a group with organic matter (OM) addition, and a group with both 10% BD and OM additions (BA10 + OM). Soil samples were collected 0, 45 and 90 days after planting. Quantitative PCR (qPCR) was used to measure the amounts of microorganisms. Next-generation sequencing using 16S v4 regional primers (515F–806R) and PICRUSt2 predictions were used to assess impact of BD addition on the diversity and functionality of soil microbiota. Given the higher calcium and magnesium contents, BD-addition is expected to enhance microorganism-induced calcium carbonate precipitation. Autotrophic bacteria have been shown to form calcium carbonate through non-methylotrophic methanogenesis, while anaerobic photosynthesis could produce calcium carbonate if sulfur-containing amino acids serve as the hydrogen sulfide source. Heterotrophic bacteria promote calcium carbonate formation via the ammonification of amino acids, the nitrate dissimilation reduction pathway, and hydrolysis of urea and uric acid.

Keyword

soil microbiota, basalt dust, soil carbon fixation, enhanced rock weathering

Secondary mineralization of Sb(V)-bearing Fe(III) phases stimulated by Fe(II) under advective flow and the impact on Sb mobility

Yidan ZHANG[1]*, Korea University (yidanzhang@korea.ac.kr)
Yunseo Jang[2], Korea University
Man Jae Kwon[3], Korea University

Abstract

Antimony (Sb) emerges in recent years as a significant environmental contaminant, with its ecotoxicity posing hazards when concentrations exceed guidelines. The reduction of Sb(V) demands attention due to the formation of more toxic Sb(III). However, Sb(V) can be immobilized through adsorption by host phases such as Fe(III) oxides. Various Fe(III) phases such as ferrihydrite, goethite, jarosite, and schwertmannite have shown adsorption capacity toward Sb(V). Although structural changes to Fe(III) host phases during reductive dissolution, stimulated by aqueous Fe(II), was suspected to release previously associated Sb(V); several microcosm studies have illustrated the further incorporation of Sb(V) into newly formed secondary Fe(III) phases during microbial Fe(III) reduction or abiotic reduction by aqueous Fe(II) amendment. Nonetheless, previous literature predominantly utilizes stagnant conditions to investigate the fate of Sb(V) upon Fe(III) transformation, and thus not considering the effects of transport processes in realistic environments. Therefore, adopting a column set up under advective flow is essential to comprehensively explore how Fe(III) structural changes affect the mobility of previously associated Sb(V). Additionally, considering that the transformation of Fe(III) is influenced by initial crystallinity, studying the behavior of Sb(V) when associated with different crystalline Fe(III) phases becomes necessary. This study employs columns to understand the fate of Sb(V) associated with two different crystalline Fe(III) phases: poorly crystalline Sb(V)-coprecipitated ferrihydrite and the more crystalline tripuhyite (FeSbO4), under advective flow transporting aqueous Fe(II). Miniature columns were set up, incorporating Sb(V)-coprecipitated ferrihydrite-coated sand or sand mixed with tripuhyite powder. The inflow maintains a constant concentration of aqueous Fe(II), with flow rate adjusted to mimic realistic soil porewater flow. A comprehensive investigation, including aqueous chemistry analyses of Fe and Sb species, along with solid-phase analyses of X-ray diffraction (XRD) and X-ray find absorption structure (XAFS), is conducted. This aims to elucidate the partitioning of Sb species, mobility, and alteration in Fe mineralogy during Fe(III) reduction stimulated by Fe(II). The results of this column study are expected to provide insight into the processes that govern the mobility and speciation of Sb in anoxic environments where Fe(III) phases are commonly present.

Keyword

Antimony redox, Secondary mineralization, Advective flow, XAFS

Microbial communities development and secondary minerals formation during microbial Fe(III) reduction across a pH gradient

Yunseo Jang[1]*, Korea University (trixiejang@korea.ac.kr)
Yidan ZHANG[2], Korea University
Man Jae KWON[3], Korea University

Abstract

Iron oxides are widespread in the shallow subsurface area and can be used by microorganisms during dissimilatory iron reduction (DIR). Environmental factors, particularly pH, exert significant influence on DIR in subsurface anoxic zones, as protons are required for this process. DIR is more likely to occur in mildly acidic pH conditions but becomes less favorable as pH increases. The extent and rate of DIR, as well as the secondary minerals produced, vary depending on pH and the ratio of Fe(II)/Fe(III). Moreover, pH can influence the microbial community composition by promoting the growth of different iron-reducing species. Therefore, understanding DIR, the formed secondary minerals, and the shifts in microbial community in different pH conditions is crucial for advancing knowledge in microbial Fe(III) reduction. This study deployed anaerobic Fe(III)-reducing microcosms with a pH gradient ranging from 6.3 to 9 (6.3, 6.9, 7.3, 7.7, and 9) to investigate the effect of pH on DIR. The common crystalline Fe(III) phase, goethite, and the relatively less crystalline phase, lepidocrocite, were selected as the electron acceptors (Fe(III) = 50 mM), with acetate (20 mM) chosen as the electron donor. The objectives of the study are to 1) compare the kinetics of DIR at the five different pH levels, 2) investigate the development of various Fe(III)-reducing microorganisms at different pH, and 3) identify the secondary minerals formed under different pH. The influence of pH on DIR was observed for both Fe(III) phases, with faster Fe(III) reduction observed at lower pH gradients. In the goethite amendment, among the five pH conditions, the initial rate of Fe(III) reduction in pH 6.3 treatment was slower than other treatments but exhibited the highest reduction extent (~3 mM) by the end of the experiment. However, due to the small amount of Fe(III) being reduced, changes in pH and acetate concentrations were not clearly reflected. For lepidocrocite amendment, total Fe(II) in pH 6.3 and 6.9 treatments showed a significant increasing trend during the experiment, reaching 43 mM and 24 mM, respectively, followed by an abrupt decrease at the end. Other pH conditions showed a steady increase in total Fe(II) concentrations, reaching less than 10 mM. Similar to goethite amendment, the rate of Fe(III) reduction was initially slower in pH 6.3 but exhibited a higher extent of reduction during the experiment. Acetate concentration decreased in both pH 6.3 and 6.9 treatment for lepidocrocite system, with the most significant decrease observed at pH 6.3. An increase in pH was observed at pH 6.3, 6.9 and 7.3, where the most extensive increase observed at pH 6.3. The results of microbial community and solid phase analyses will be presented to provide better insight into the dynamics of microbial Fe(III) reduction.

Keyword

pH gradient, Dissimilatory iron reduction, Secondary minerals, Microbial community

Internal P-recycling in Late Ordovician marine reefs: the first evidence from the mutualistic commensalism of cyanobacteria and green algae in the fossil record

Jinwen SHEN[1]*, Northwest Univercity (1257362334@qq.com)
LiJing LIU[2], Northwest Univercity

Abstract

Organisms often acquire limited nutrients through symbiotic interactions, this is an important survival strategy in a variety of environments. The study of symbiotic behaviors among organisms in geological history is impeded by limitations in fossil preservation. The ecological interaction between early organisms is of great significance to reflect their living environment and the evolution of organisms. The scarcity of direct fossil evidence for symbiotic fossils has impeded our research of the ecological interactions among organisms within marine ecosystems during geological periods. The biomass of existing reef systems is mass, while the availability of inorganic nutrients is limited. Some unique cyanobacteria groups and other microorganisms can improve phosphorus (P) availability by producing phosphatase to hydrolyze organophosphates. Here we report a widely distributed calcareous symbiotic fossil assemblage of the *Amsassia* (a possible green alga) and the rivulariacean *Proaulopora* (cyanobacteria) in reef facies from the Upper Ordovician (Sandbian-Katian) in the Tarim and Ordos basins. Due to the physiological and ecological characteristics of extant rivulariaceans, and analysis of the relationship between extant green algae and their epiphytic microorganisms, it is found that the *Amsassia* - *Proaulopora* association is very similar to the mutualistic commensalism of green alga *Cladophora* and rivulariaceans cyanobacteria in a modern oligotrophic water environment. Furthermore, based on the presence of autogenous fluorapatite, we conclude that *Proaulopora* may have used the organic phosphorus around *Amsassia* to release orthophosphate (DIP) that was then utilized by itself and *Amsassia* to augment P-availability. In this interpretation, the symbiotic assemblage of *Amsassia* - *Proaulopora* exemplifies a metabolic P-acquisition commensal relationship between cladophoracean-like green algae and rivulariacean cyanobacteria that would have enhanced their survival and growth in oligotrophic environments. Through this win-win cooperation, the growth restriction of inorganic phosphate in the environment can be reduced. In addition, reducing phosphorus limitation is also helpful in enhancing nitrogen fixation. *Proaulopora* may provide nitrogen (N) supply for the *Amsassia* reef ecosystem and reduce the nitrogen limitation of *Amsassia*, just like the modern genus *Dichothrix* (rivulariacean) attached to *Sargassum* (macroalgae). This study provides fossil evidence for benthic cyanobacterial-green algal mutualistic conversion of dissolved organic phosphorus (DOP) to dissolved inorganic phosphorus (DIP), with significant implications for the assessment of global phosphorus cycling over geological time. This commensal partnership contributed to the efficient recycling of N/P nutrients in the environment with implications for reef ecosystem evolution during the Great Ordovician Biodiversification (GOBE).

Keyword

Internal P-recycling, the Great Ordovician Biodiversification, calcareous symbiotic fossil assemblage, Tarim, Ordos

The relationships between vertical variations of shallow gas and pore water geochemical characteristics in boreholes from the inner shelf of the East China Sea

xue LI[1]*, 16601162341 (342099072@qq.com)
xiaoyong duan[2], 15263757908

Abstract

Shallow gas is widely recognized in the coastal region, especially in the estuarine delta areas with high Organic matter (OM) burial flux. In this study, the vertical variations of shallow gas and the related geochemical indicators from two boreholes in the coastal region of the East China Sea (ECS) were investigated. There were two gas-bearing layers in the sediments which were in the Holocene and late Pleistocene series, respectively. Both boreholes exhibit a "typical" and an "inverse" Sulfate Methane Transition Zone (SMTZ). The "typical" SMTZs (SMTZ1 and SMTZ3) are in the upper part of the gas-bearing layers, and in the "typical" zone, sulfate levels consistently decrease while methane levels increase with depth. Conversely, the "inverse" SMTZs (SMTZ2 and SMTZ4) are in the lower part of the gas-bearing layers, and in the "inverse" zone, sulfate levels increase while methane levels decrease, a phenomenon rarely documented in previous research. The change in pore water geochemical characteristics from top to bottom indicates that these ions are related to Anaerobic Oxidation of Methane (AOM) processes. For example, the increase in Ca2+ and Ba2+ concentrations and the gradual decrease in sulfate at the SMTZ reflect a series of biogeochemical processes resulting from the dissolution of carbonate and other minerals by AOM. Additionally, the study suggests that the sulfate used in AOM may come from various sources. By analyzing the vertical variation of shallow gas and the geochemical characteristics of pore water, this paper gradually uncovers the formation mechanism of shallow gas and the characteristics of the SMTZ, providing a foundation for future research.

Keyword

Pore water geochemistry, coastal sediment, Inverse SMTZ

Investigate the impact of different fertilizers in combination with dicyandiamide on bacterial communities participating in nitrogen and methane cycles

Hao-Yu Chu[1]*, Department of Agricultural Chemistry, College of Bioresources and Agriculture, National Taiwan University (howard.jue.0724@gmail.com)
Yo-Jin Shiau[2], Department of Bioenvironmental Systems Engineering, College of Bioresources and Agriculture, National Taiwan University
Kai-Yin Lo[3], Department of Agricultural Chemistry, College of Bioresources and Agriculture, National Taiwan University

Abstract

Regenerative farming is an agricultural approach focused on improving soil health and biodiversity while increasing carbon sequestration. The goal is to create sustainable farming systems that store more carbon, support higher biodiversity, and minimize environmental impacts, contributing to the target of achieving net-zero carbon emissions by 2050. In this study, we collected the field soils from dry land farming Napiergrass (*Pennisetum purpureum*) cv. Taishiu No.7 (NP cv.TS 7) in the National Taiwan University Experimental Farms An-Kang Branch (24°57'31"N, 121°31'36"E). Several culture conditions were applied, including two types of fertilizers, cattle dung compost and chemical fertilizer, in combination with nitrification inhibitor dicyandiamide (DCD). We used quantitative PCR (qPCR) to widely measure the quantities of total microorganisms with the 16S v4 region primers (515F–806R), and *mcrA* and *pmoA* genes to measure the methanogenesis and methanotroph, respectively. We analyzed the effects of fertilizers and nitrification inhibitors on soil microbes in the field. As the previous study reported, the high-throughput amplicon sequencing of 16S rDNA, *mcrA*, and *pmoA* genes revealed that DCD has highly decreased the *Nitrosomonas*, which oxidizes ammonia to nitrite. We found that the type I methanotroph is predominant in organic fertilizer applied conditions, and the type II methanotroph is more dominant in chemical fertilizer treatments. However, while introducing DCD into fields, the type I methanotroph is highly decreased, especially *Methylocystis*. To pursue a whole scope of understanding the dynamics of microbiota and general metabolic cycling in soil, we performed PICRUSt2 analysis to investigate the microbial communities and predict the environmental genomic functions. We observed that the fertilizers mostly influenced the *nirK* and *norB* genes in the nitrous oxide-forming state, and the addition of DCD impacted the nitrification pathway, like *amoA* and *hao* genes. The results provide information to compare agricultural practices with greenhouse gas microbial communities and the dynamics of nitrous oxide emissions.

Keyword

nitrogen cycle, soil microbiota, methanotroph, methanogenesis

Isotopic distribution of bioavailable Sr, Nd, and Pb in Chungcheongbuk-do Province, Korea

Min-Ji JUNG[1]*, Chungnam National University (jmj8967@kbsi.re.kr)
Youn-Joong Jeong[2], Korea Basic Science Institute
Woo-Jin Shin[3], Korea Basic Science Institute
Albert Chang-sik Cheong[4], Chungnam National University

Abstract

Mapping the distribution of isotope ratios across the landscape is crucial for delineating the origins and migration trajectories of humans and animals. In the specific context of Chungcheongbuk-do Province in Korea, we have investigated the distribution of bioavailable Sr, Nd, and Pb isotopes, taking into account geological and environmental factors. Chungcheongbuk-do exhibits diverse geological elements, including Precambrian basement, Paleozoic metasedimentary rocks, and Mesozoic granitoids and volcano-sedimentary sequences. The geological diversity, coupled with its inland location devoid of adjacency to the sea, makes Chungcheongbuk-do an ideal study area for discerning the nuanced influence of geological elements on isotopic distribution. Plant and soil samples were collected from 44 localities, revealing that the $^{87}Sr/^{86}Sr$ ratios of bulk soil primarily range from 0.781 to 0.707, with two ratios exceeding 0.9 originating from Precambrian basement and Cretaceous granitoid areas. Fractions of soils treated with 1M ammonium nitrate and acetic acid exhibit indistinguishable $^{87}Sr/^{86}Sr$ ratios (R^2 = 0.99, except for one point), spanning from 0.804 to 0.707. Plant $^{87}Sr/^{86}Sr$ ratios demonstrate a robust positive correlation with leachate ratios (for ammonium nitrate data, y = 0.938x + 0.045, R^2 = 0.98). The εNd values of bulk soils from Precambrian basement areas (–18 to –30) plot against Sm/Nd ratios around the reference line corresponding to 3 Ga, while other soil samples (εNd = –1 to –20) align with a younger (c. 2 Ga) reference line. Plant εNd values, ranging from –4 to –24, exhibit a prominent positive correlation with bulk soil values (y = 0.63x – 4.77, R^2 = 0.87). A comparable correlation (R^2 = 0.89) is observed for εNd between plant samples and ammonium nitrate leachates. Plant samples show a weak correlation ($R^2 \approx 0.4$) between $^{87}Sr/^{86}Sr$ and εNd. The $^{206}Pb/^{204}Pb$ and $^{207}Pb/^{204}Pb$ ratios of bulk soils show a c. 2 Ga trend, typical for Korean basement rocks. The $^{206}Pb/^{204}Pb$ ratios of ammonium nitrate and acetic acid leachates match perfectly with each other (R^2 = 0.99). The $^{206}Pb/^{204}Pb$ ratios of plant samples vary narrowly (19.2–17.9) and are much lower than that of bulk soils (24.4–17.9) and their leachates (23.1–17.8). The isotope data obtained in this study underscore a strong geological control for bioavailable Sr and Nd, while conversely, indicating a dominant environmental influence on bioavailable Pb. Plant and soil data were used to construct preliminary Sr and Nd isoscapes (isotope landscapes), employing interpolation models based on inverse distance weighting, simple kriging, and geology-considered empirical Bayesian kriging. Although these maps hold potential for provenance studies and archaeological inquiries in Chungcheongbuk-do in their present form, further efforts, including increased sample density and refined interpolation models, are necessary for accurately predicting fine isotopic variations across

the province.

Keyword

Chungcheongbuk-do, Bioavailable Sr, Bioavailable Nd, Bioavailable Pb, Isoscape

Providing the most appropriate management solution based on the new conditions of Urmia Lake, Northwest of Iran

Razyeh Lak[1]*, Research Institute for Earth Sciences, Geological Survey of Iran
(lak_ir@yahoo.com)

Abstract

In the last two decades, Lake Urmia in the northwest of Iran, as the second largest saline lake in the world, has been fast decreasing its water due to human and natural factors, and millions of people around the lake will be affected to dust and salt storms. Monitoring of brine chemistry, salt and lake depth was done in different years and seasons during 14 years. The parameters of temperature, salinity, electrical conductivity and pH were measured in situ. main elements consist of sodium, potassium, calcium, magnesium and chlorine, sulfate, carbonate and bicarbonate are analyzed in the laboratory. The investigation of hydrochemistry and the brine evolution shows that Lake Urmia is in irreversible conditions and it is not possible to restore the lake because it is not possible to return the playa environment to the lake in a short time.

The most appropriate management plan for the newly reclaimed environment, in addition to the implementation of all the watershed management programs in the basin, such as saving agricultural water consumption, wastewater treatment, etc. It is suggested to control and contain aerosol in mud flat and saline mud flat zone, separating and reducing a part of the lake and directing water to that small piece, especially around the causeway from an aesthetic point of view, extracting economic salts, especially SOP (potassium Sulfate) of non-renewable marginal parts and use of profit from it is suggested for control dust programs.

Keyword

Lake Urmia, Brine, environment, Iran

Potential of Geoscience knowledge towards Environmental Ecosystem

Shahina TARIQ[1]*, Land Information Magment System (LIMS)/COMSATS University Islamabad (tariqshahina@gmail.com)

Abstract

The global demand for natural resources is rapidly increasing to improve the economies and living standards of the citizens. This profoundly affects the environment through deforestation, pollution, and global climate change. The resources include minerals, fertile soils, and water and energy resources. Hence to reduce the negative impact on the environment, it is crucial to understand the relevant environmental processes and how to manage them for the benefit of society. Environmental ecosystem under the category of terrestrial and aquatic consists of all living and non-living components. The relationship between humanity and the environment is a delicate balance. Geoscientists have perspectives on climate, water, and conservation have a responsibility to balance proposals for exploitation with protection of the resources and provision of benefits to communities. Climate influences crop growth and water availability while natural hazards disproportionately affect the poor. Widespread and rapid changes in the atmosphere, ocean cryosphere, and biosphere are highly influenced by human influence. Mitigation is required to take action to reduce the impact. Geoscientist can make a framework for disaster risk reduction, which emphasizes early warning to reduce mortality, property damage, and economic loss. Geoscientists play a crucial role in identifying future mineral resources, promoting their sustainable use, and reducing the environmental impacts of mining. The conservation community can take the lead in developing protocols for good working practices in the development of natural resources. Geoscientists also need to play a vital role in transitioning to a circular economy in which the use of primary resources is minimized by the reuse and recycling of materials, thus minimizing the f waste material. The time demands to promote education among the youth who can understand issues of climate change, land management, and resource depletion. Therefore, geoscience education right from the school level be given priority. Geo-conservation education can be added to school curricula so that children have a greater understanding of the dynamic complex Earth system.

Keyword

Environmental ecosystem, Climate change, Geo-conservation, Geoscience education, Earth system

Ground Substrate: Conceptual Proposal, Scientific Connotation and Great Significance

Zhiqiang YIN[1]*, Institute of Comprehensive Survey for Natural Resources China Geological Survey (yinzhiqiang@mail.cgs.gov.cn)
Aibing HAO[2], Institute of Comprehensive Survey for Natural Resources China Geological Survey
Xiaoguang QIN[3], Institute of Geology and Geophysics, Chinese Academy of Science
Hai SHAO[4], Institute of Comprehensive Survey for Natural Resources China Geological Survey
Jumei PANG [5], Institute of Comprehensive Survey for Natural Resources China Geological Survey
Ling PENG [6], Institute of Comprehensive Survey for Natural Resources China Geological Survey

Abstract

In order to better support food production, people's daily lives and vegetation growth, the natural resources on the surface of earth should be carried out by three-dimensional and unified management. Here, we divide the skin of the earth into three layers from bottom to above, they are ground substrate layer (such as rocks and loose sediments), land covering layer (such as forests and grasslands), and management layer (such as urban development boundaries). The ground substrate is a new concept proposed by Ministry of Natural Resources of China in 2020 that refers to the fundamental material that nurtures and supports various natural resources such as forests, grasslands, water, wetlands, etc. This concept fully integrates existing knowledge of hydrogeology, soil science, Quaternary geology, ecological geology, earth's critical zone, and is the dawn of a new interdisciplinary field of earth systems science and natural resource science.

The material composition of the ground substrate is mainly composed of Quaternary loose sediments and weathered remnants of bedrock, which are the underground parts of the Earth's critical zones and the parent material for the formation and development of soil. They are also the main geological factors that affect the local combination of plant communities, except for climate, micro topography and groundwater.

Structural differences of bedrock and regolith (such as sedimentary structure, cracks, joints, pores, bedding), types, mineral element composition (such as salts, nutrients, organic matter, heavy metal elements), and geochemical properties (such as acid-base, colloid, redox) of the ground substrate, that is, the heterogeneity of the ground substrate by regulated water holding capacity and root growth profoundly influences the types, coverage density and growth status of vegetation. We call these characteristics are physical stress and elemental stress.

Considering the depth of underground temperate transition zone, the depth of crop and vegetation root, the depth of surface rock joint fissures, the thickness of rock weathering crust, and the depth of groundwater level, under normal circumstance, we have preliminarily defined the ground surface down to bottom of the ground substrate as 20 m, and the depth of ground substrate can be divided into shallow (0-2 m), intermediate (2-10 m), and deep (10-20 m). In special cases, the depth can be very deep (> 20 m).

The ground substrate survey can reveal deeper information of earth than soil, and the obtained data can not only fill the gaps in current research on earth's critical zones, but also promote the

development of ecological geology. At the same time, due to the fact that the ground substrate more emphasizes on the ecological service function of rock and soil, which can provide support for scientific and reasonable layout of spatial pattern of ecosystem, land consolidation in shallow mountainous areas, high standard farmland construction, and evaluation of reserve farmland resources, therefore, it also has practical grate significance for supporting national food security and ecological restoration.
Over the past four years, we have accumulated some typical cases of supporting scientific greening in semi-arid areas and land consolidation in mountainous areas by ground substrate survey.

Keyword

Ground substrate, Vegetation, Structural differences of bedrock and regolith, Regulated water holding capacity and root growth, Ecological geology

Earth System Modeling for Explaining and Predicting changes in the Climate, Water, and Ecosystem

June-Yi LEE[1]*, Pusan National University (juneyi@pusan.ac.kr)

Abstract

The 6th Assessment Cycle Synthesis report from the Intergovernmental Panel on Climate Change (IPCC) highlights a critically shrinking opportunity to advance development that is both sustainable and resilient to climate changes. It stresses the importance of integrating climate initiatives with broader international ambitions, such as the Sustainable Development Goals, the Global Biodiversity Framework, and the Global Health Security Agenda. Given these considerations, there's an increasing demand for climate information that is both relevant to decision-making and grounded in solid scientific evidence, with a particular emphasis on regional scales and the near-term horizon. Nonetheless, the capacity of current scientific endeavors to predict the near-term changes in the components of the Earth System, including ecosystems, is limited. Defined as the period extending from the next decade up to thirty years, the near term's climate information must encapsulate the climate system responses to the interplay between human influence, natural drivers, and internal variability. At the heart of Geosciences, Earth System Models are vital for shedding light on, attributing, and predicting changes of Earth System components over time frames ranging from a year to several decades. This talk aims to review the present landscape of Earth System Modeling, emphasizing its role in explaining, predicting, and projecting changes in Earth System components. Moreover, it will offer a vision for future advancements and underscore the challenges and gaps in Earth System modeling, prediction, and projection. The presentation will also delve into the complex interaction among changes in climate, water, and ecosystems, underscoring their collective implications for global strategies aimed at sustainability and climate resilience.

Keyword

Earth System Modeling, Climate Change, Sustainability, Climate Resilience, Ecosystem

Studying on the structural features of municipal solid waste landfills before recultivation

Elena SOLOMATINA[1]*, Sergeev Institute of Environmental Geoscience Russian Academy of Science (IEG RAS), Moscow, Russia (baira1506@gmail.com)

Abstract

About 5 million tons of municipal solid waste (MSW) are generated in Russian Federation annually. Despite the development to improve waste sorting and processing technologies, landfilling is the primary method used for MSW disposal. Currently, there are approximately 12,755 hectares of land in Russia occupied by MSW landfills.

Data from engineering surveys on 27 landfills slated for reclamation in various regions of the country have been examined in the study. The study also includes: a detailed analysis of the morphological composition of solid waste, assessment of its variation with depth, correlation with methane content, and leachate composition. The obtained data were compared with the following indicators: regional industries sectors, population density, prosperity index, average annual temperature, precipitation amount, landfill technology, service life, filling rate and terricon height. The analysis provided information on the structural features of the landfills at different depths and identified main specifications.

One of the main characteristics influencing the morphological composition is the age of the landfills. Thus, the content of "rapidly degradable" fractions (paper, cardboard, food waste, wood, textiles) is predictably higher in the upper layers of the landfills and in the landfills younger than 50 years. Furthermore, in high prosperity regions with has been recorded the increased presence of textiles and wood, which indicates shifts in residents' lifestyles, population density increase, development of multi-storey and private residential buildings, gradual demolition of old wooden structures.

There are unique features when assessing the structure of the landfills. The most significant changes in the composition of waste occur in the depth range of 0-15 m. A high content of food waste with a low degree of decomposition is recorded at depths of up to 5 m, below which there is a sharp decline by 1.5-2 times to a depth of 10-15 m. It is depending on climatic parameters and their natural transition into solid organic particles. Paper and cardboard are present down to 15 m and a sharp decline occurs in depth intervals from 5-10 m in warm regions and 15-20 m in colder regions. The presence of textiles and wood is noted even at great depths - up to 30 and 40 m, with no obvious downward trend observed. Inert components (glass and polymers) are gradually crushed due to mechanical compaction and, at depths of about 30-35 m, pass into the screening fraction. The metal content at all landfills is 4-7%, thanks to a fairly developed system for processing metals as recyclable materials.

Based on the results it was established that, landfills are complex geological bodies, with a structure interconnected with the rate of transition of “rapidly decomposing” waste into solid organic particles. It is also depending on a number of economic and social indicators of the region,

climatic parameters, dumping technology, commissioning dates and operation time of landfills.

The research was financially supported by the project of Russian Science Foundation № 22-17-00045.

Keyword

landfill, municipal solid waste (MSW), morphological composition of solid waste, construction of landfills, biodegradation

DISTRIBUTION OF HEAVY METALS IN SOILS AND PLANTS IN MINING WASTE STORAGE AREAS UZBEKISTAN

Nosir SHUKUROV[1]*, Institute of Geology and Geophysics named after Kh.M.Abdullaev (nosirsh@gmail.com)
Shukhrat Shukurov[2], Institute of Geology and Geophysics named after Kh.M.Abdullaev
Azimjon Kholikov[3], Institute of Geology and Geophysics named after Kh.M.Abdullaev
Obidjon Kodirov[4], Ministry of Mining Industry and Geology of the Republic of Uzbekistan

Abstract

Field research was organized in the Akhangaran River valley of the Angren-Almalyk mining region and at the mining complex sites of the Navoi region. Samples were taken around the mining wastes in Angren, Navoi, Kokpatas, and Uchkuduk industrial sites. Soil and plant samples were taken along several geochemical profiles. Sampling points were marked using GPS and described in detail. After appropriate sample preparation, soil and plant samples were analyzed for heavy metals and metalloids by ICP-MS. The results indicate an increased content of heavy metals in soils and plants around the industrial sites. The formation of technogenic geochemical anomalies of heavy metals is mainly associated with technogenic load due to mining activities and other industrial enterprises operating in these regions. One of the main reasons for the formation of geochemical anomalies of heavy metals in soils and plants is assumed to be the atmospheric fallout of emissions from mining enterprises and explosions in quarries during the development of deposits. This study examines broad concerns related to environmental chemical contamination. It generally demonstrates that, across all components of the geo-ecological profile's natural environment (soils, groundwater, vegetation), elements most closely linked to typical ore elements (gold, silver, uranium) like arsenic, antimony, molybdenum, and copper, tend to accumulate first. The findings reaffirm that peak concentrations of these anthropogenic elements typically occur in the topmost layer of the soil profile (0-20 cm). The distribution of U and Th among soils and vegetation is examined separately, and their maximum concentration in the soil's silty fraction is shown. Having assessed various data on the concentration of ore elements in the Tashkent and Navoi regions and compared these data with data from other areas of Uzbekistan, we concluded that arsenic-containing waste (dumps from mining enterprises and tailings from ore processing plants) is the most significant relevance in terms of negative impacts on the environment. The results showed increased heavy and toxic metals content in the soils and plants of mining regions. Calculation of Clarke concentrations (Kk) showed high values of heavy metals (Cu, Zn, Pb, Cd, Bi, As, etc.) in soil samples tested near the mining areas. The results were systematized and interpreted from the perspective of modern trends in the methodology of self-organizing biogeochemical systems under conditions of environmental pollution.

Keyword

Mining wastes, Soil pollution, Heavy metals, Geochemical anomalies, Uzbekistan

Redox activity of soil dissolved organic matter as affected by soil warming

Shuhan WANG[1]*, China Agricultural University (284972521@qq.com)
Wenbing Tan[2], State Key Laboratory of Environmental Criteria and Risk Assessment, Chinese Research Academy of Environmental Sciences
Guoan Wang[3], China Agricultural University

Abstract

Global warming is a significant global concern. Dissolved organic matter (DOM) in soil plays a crucial role in environmental pollution remediation through its redox activity. However, the impact of global warming on the redox activity of DOM remains unexplored. In this study, we investigated the response of electron-accepting and -donating capacities (EAC and EDC, respectively) of DOM to temperature by collecting surface soil samples along a temperature gradient corresponding to the 400 mm isoline of mean annual precipitation in China. Our findings revealed that EAC exhibited a positive correlation with temperature, while EDC showed a negative correlation with temperature. These results suggest that global warming will enhance the EAC and decrease the EDC of DOM. Consequently, increasing temperatures may hinder the transfer of electrons from soil DOM to iron oxides, hydroxides, as well as various organic and inorganic pollutants, thereby weakening its role in ecological environment pollution remediation in the future. The influence of temperature on electron transfer capacity was mediated by regulating soil properties and plant litter composition, which indirectly affected physicochemical indices associated with DOM. Specifically, changes in ArylC content and phenol titration (Tit) were found to be major drivers for variations in EAC levels within soil DOM; whereas alterations in humification index (HIX) and Tit played key roles in determining changes in EDC levels within soil DOM. Higher temperatures led to increased ArylC content and HIX values but decreased Tit levels within DOM samples resulting in elevated EAC but reduced EDC capabilities.

Keyword

soil dissolved organic matter, electron transfer capacity, global warming, a temperature gradient

Assessment of Seawater Intrusion Signatures: A Geochemical and Geospatial Study in the Coastal Region of Paradeep Municipality, Jagatsinghpur, Odisha.

SUSANTA KUMAR DAS [1]*, Fakir mohan university (kumarsusantadas143@gmail.com)
Rosalin Das[2], Fakir mohan university, balasore,Odisha
MADHUMITA DAS[3], UTKAL UNIVERSITY,BHUBANESWAR

Abstract

Seawater intrusion (SWI) is a global challenge impacting groundwater quality in coastal aquifers, driven by extensive urban development and over-exploitation of groundwater for drinking, industrial, and agricultural activities. The study focuses on the Paradeep municipality in Odisha, a prominent industrial hub and major port along the Bay of Bengal, where seawater intrusion poses a significant threat to freshwater management. In May 2022, 35 water samples were collected from various tube wells and analyzed for parameters such as pH, TDS, EC, turbidity, temperature, hardness, alkalinity, and various ions (cations and anions) using standard procedures (APHA). Piper diagram revealed that the groundwater of the study area is dominant of sodium and Chloride, suggesting comparatively high salinity. Approximately 45.71% of the samples were in the seawater zone (Na+-Cl-). Due to the evaporation process, 25.72% of water samples fell in the recharge water (Ca2+-Mg2+-HCO3-) and base ion exchange zone (Na+- HCO3-), and 2.85% of samples were lost in reverse ion exchange (Ca2+-Mg2+ -SO42-). US salinity diagram shows the water samples fall in C3S1 plot (17.14%) samples, C2S1 (11.42%) samples, and C4S2, C3S2, and C3S3 (2.85%) sample. Then C4S4 (20%) samples, (22.85%) samples C3S4 and (20%) samples are high ranges of salinity haphazard w.r.t SAR respectively. The vertical, horizontal, and diagonal arrangement of ions in the Stiff diagram suggested infiltration of saltwater into various parts of the study region. On the geospatial map, elevated levels of sodium and chloride are observed near the coast, indicating high salinity. In the middle area, the samples exhibit moderate ranges, while those farther from the coast show consistently low levels. This comprehensive analysis provides compelling evidence of seawater intrusion in the groundwater of the Paradeep municipality, emphasizing the urgency for effective management strategies in the face of increasing salinity levels.

Keyword

SWI, Piper, US Salinity diagram, Stiff’s diagram, Geospatial

Understanding Loggerhead Sea Turtle Nesting Preferences in Broward County, Florida

Brooke Marlo WALKER[1]*, US Army Corps of Engineers, Coastal and Hydraulics Laboratory (brooke.m.walker@usace.army.mil)

Abstract

The Caretta caretta, or Loggerhead Sea Turtle, is an endangered species that can be found in all temperate and subtropical oceans. Loggerhead Sea Turtles are known to exhibit particular reproductive habits including returning to their own hatching location for nesting. Several previous works have shown that the Caretta caretta has nesting site preferences regarding beach width, slope, and vegetation coverage, thereby allowing for the development of a nesting site suitability index (Dunkin, et al., 2015). This index, when overlayed with digital elevation data and run through a custom ArcGIS toolbox, can provide insight into where the Loggerhead is most likely to nest on a given beach. This study utilizes the 2018 United States Geological Survey Lidar Derived Digital Elevation Model of Broward County, Florida, the Dune Feature Extraction Toolbox developed by the US Army Corps of Engineers Joint Airborne Lidar Bathymetry Center of Expertise, and the suitability index developed by Dunkin, et al. (2015), to find likely nesting sites of the Loggerhead Sea Turtle. These results are compared to known nesting site data (collected from 2015-2020) which was provided by the Broward County Sea Turtle Conservation Program (BCSTCP). This study aims to further validate the work of Dunkin, et al. (2015) and be an improvement over the previous work by utilizing a semi-automated data analysis enabled by the Dune Feature Extraction Toolbox. The results of this study can further guide critical decisions regarding beach use and maintenance as it pertains to sea turtle conservation. Overall, this study demonstrates the utility of geospatial analysis and suitability models in understanding and safeguarding sea turtle nesting habitats.

Keyword

sea turtles, nesting sites, suitability index, geospatial

Geochemical Characteristics of Coal Mine Drainage and Waste Rocks from Livingstonia Coalfield in Malawi

Amidu Amali MAKWINJA[1]*, Hokkaido University (amidumakwinja@gmail.com)
Frances Chikanda[2], Hokkaido University
Ryosuke Kikuchi[3], Hokkaido University
Walubita Mufalo[4], Hokkaido University
Tsubasa Otake[5], Hokkaido University

Abstract

A. A. Makwinja, F. Chikanda, R. Kikuchi, W. Mufalo, T. Otake

Division of Sustainable Resource Engineering, Graduate School of Engineering, Hokkaido University, Sapporo, JAPAN

Coal mining is associated with significant environmental impacts such as Acid Mine Drainage (AMD) which negatively affects the ecosystem. Coal mine drainage ranges widely in composition, from acidic to alkaline, typically with elevated concentrations of sulphate (SO42-), major elements and heavy metals which can seriously degrade aquatic habitats and the quality of water supplies. To understand the environmental impacts of coal mining in Livingstonia Coalfield in Malawi, a study was conducted at the Kaziwiziwi and Mchenga Coal mines in Rumphi district. River water, mine drainage, and waste rock samples were analysed to determine their geochemical characteristics and assess potential environmental impacts. The methodology used included onsite water physicochemical measurements, inductively coupled plasma atomic emission spectroscopy (ICP-AES), ICP-mass spectrometry (ICP-MS), X-ray diffraction (XRD), and acid-base accounting (ABA) tests.

Results of the study showed that mine drainage at both sites was moderately acidic to neutral with concentrations of SO42- (15.63 to 592.80 ppm) and iron (Fe2+) which is evidence of oxidation of pyrite (FeS2) that is responsible for AMD formation. At Kaziwiziwi, moderate acidic mine drainage was determined at the tailings dam (pH 4.49) while at Mchenga it was determined at an abandoned underground mine (pH 4.56). However, the active underground mines at both sites had a near-neutral to neutral pH (pH 6.78 to 7.02). Unlike the other sampling points, the underground drainage from the Kaziwiziwi active mine had relatively high concentrations of Ca2+, Mg2+, and HCO3-, an indication of potential natural neutralization of the AMD by mixing with underground alkaline water. The mixing of underground AMD with groundwater could potentially result in underground water pollution. River water at both sites had a neutral pH with a low concentration of major and trace elements. This indicates that there are no significant impacts of the mine drainage to the nearby rivers as there is less water flowing from the underground mine workings into the nearby rivers. The underground drainage is only discharged during flooding when the water level rises in the rainy season or when the water is pumped mechanically. Nevertheless, the ABA test on waste rocks (coal, mudstone and sandstone) indicated that, excluding sandstone, the

other rocks are acid-generating with a net neutralisation potential (NNP) range of -206.59 to -57.56 kg CaCO3 which will likely pose a long-term AMD problem. The ABA test correlated with XRD analysis which showed that coal and mudstone contain pyrite.

Keyword

Coal Mining, Acid Mine Drainage, Acid-generating, Environmental Impacts

Estimation of heavy metal(loid) accumulation rate in urban soil using in situ pXRF: the example of Shijiazhuang City, China

ZHAOXIAN YUAN[1]*, Hebei GEO University (sdyzx86@126.com)
David Cohen[2], UNSW

Abstract

Heavy metal(loid) (HM) contamination of urban soil is a threat to sustainable development and human health. Determining HM accumulation rates in urban soil assists pollution monitoring and modelling, but there is a lack of consistency in the selection of appropriate sample media, analytical techniques and data processing methods. This study presents a new approach using portable X-ray fluorescence spectrometry (pXRF) to rapidly obtain multielement data within topsoil for estimation of HM accumulation rates. In situ pXRF analyses were performed on soil surfaces at 156 residential compounds in Shijiazhuang City, China. Significant HM enrichment occurs in the top few mm of the soil profiles, with concentrations typically higher in soils from tree pits compared with sites containing grass or evergreen shrubs. Zinc, Pb, As, Cu, Fe, and Mn concentrations display a positive correlation with residential compound age, and metal accumulation rates range between 2.4–11.3, 0.7–2.2, 0.2–1.1, 0.7–6.9, 206–950, and 4.9–16.9 μg/g per year, with average values of 4.0, 0.3, 0.4, 1.3, 245.0, and 6.2 μg/g per year, respectively. Based on spatial relationships between sampling sites and surrounding land use, sources of Zn and other HMs are primarily derived from within the residential compounds rather than more distal sources such as road traffic or industrial zones. The method provides an effective, rapid and low-cost standardized procedure to determine HM accumulation rates in soils.

Keyword

heavy metal(loid), accumulation rates, urban soil, pXRF, Shijiazhuang City

Seasonal variations of microplastics in a coastal wetland from southwest India and their risks to *Gerres filamentosus and Sillago sihama*

Gokul Valsan[1], Manipal Academy of Higher Education
Anish Kumar Kumar WARRIER[2]*, Manipal Academy of Higher Education
(anish.warrier@manipal.edu)
Anusree S[3], Manipal Academy of Higher Education
Anjali Tamrakar[4], Manipal Academy of Higher Education
Jagath Chand[5], Manipal Academy of Higher Education

Abstract

Microplastics (MPs) are minute plastic particles ranging from 1 µm to 5 mm in size. They are ubiquitously dispersed and exert ecological impacts on terrestrial and aquatic habitats. Their entry into marine environments occurs through wind and fluvial transport accumulating notably in mangroves, a crucial ecosystem with roles in carbon sequestration, shoreline protection, and habitat for diverse species. Despite their significance, the extent of MP pollution in mangroves especially in southern India is not well-studied. To fill this knowledge gap, we conducted seasonal sampling in the Kota mangrove ecosystem at different depths in the water column. Our analysis revealed average microplastic abundances of 0.93 (monsoon), 3.71 (post-monsoon), and 2.92 MPs/litre (pre-monsoon) in the water column samples. In terms of the fish species, the average microplastic abundance of 19.88 and 15.86 MPs/individual was found for *Gerres filamentosus* and *Sillago sihama*, respectively. Fibrous MPs under 1 mm dominated. Fourier-transformed infrared spectroscopy established polypropylene as the dominant polymer followed by polyethylene terephthalate, high- and low-density polyethylene, and polyvinyl chloride. Polypropylene was the dominant polymer in the fish samples as well. Aquaculture, tourism, and local activities were identified as probable sources of microplastic pollution. The Polymer Hazard Index (PHI) falls under hazard category IV indicating the deteriorating health of the Kota mangrove ecosystem. This study contributes to understanding the seasonal variations of microplastics and the potential ingestion of microplastics by mangrove biota. An urgent need for further research to comprehend the bioaccumulation of microplastics at different trophic levels and their implications for both biotic and human health need to be thoroughly examined. Identifying potential sources of microplastic contamination in the region is critical for developing effective interventions to curb microplastic release into the environment.

Keyword

Pollution, Biota, water column, risk assessment

Impact of subsurface material on the quality of groundwater in the vicinity of the Gohagoda waste disposal site in Kandy, Sri Lanka

Ashvin Kamal Wickramasooriya[1]*, University of Peradeniya (awickramasooriya@gmail.com)

Abstract

Solid waste management (SWM) is one of the serious problems for Sri Lankan specially in municipality areas. Currently, this issue has been recorded even in some rural areas. At present, the average solid waste generation in Sri Lanka is about 3,700 tons per day. This research has focused on the waste dumping site in the Kandy municipal council and its surrounding areas. The dumping site in this area is situated at the Gohagoda, located within the Katugastota-Peradeniya road, about 8 km from Kandy city. The site is only about 3.5 square kilometers and the average solid waste dumping which is generation in Kandy city limits is about 150 to 200 tons per day. This disposal site is situated in a little elevated area; therefore, during rainy periods, this waste is mixed with rainy water and flows toward the surrounding area. The main aim of this study is to analyze whether the surrounding water bodies are influenced by this contaminated water. There were two river water samples, seven surface water samples, and seven groundwater samples (tube-well water samples) collected after a heavy rainy period and chemically as well as texturally analyzed. After the results of these analyzes, it was found that two river water samples, five out of seven surface water samples, and two out of seven groundwater samples have high contamination than other water samples. To understand the available subsurface materials, bore-hole samples which were collected from the National Water Supply and Drainage Board were studied and a 3D model of the distribution of subsurface materials in the area has prepared. When correlating this model with water quality and soil texture analysis data, it is clearly noted that an impermeable clayey layer and a sand layer exist below the locations where the highly contaminated and less contaminated surface water samples were collected respectively. However, the opposite results were observed in groundwater samples, i.e. locations underlain by clay layer recorded low contaminates while the sand layer exists below highly contaminated groundwater samples. Also, it was noted that river water samples are less contaminated. Based on these observations, it can be concluded that because of the existence of an impermeable clay layer contaminated water can not infiltrate easily, and therefore, surface water samples were highly contaminated while groundwater samples were less contaminated. Also, due exists of a permeable sand layer, two groundwater samples were highly contaminated as waste mixed with rainwater can easily infiltrate through that layer. As there is a thick impermeable subsurface. clay layer underlay almost the entire study area except for a small area which consists of a sand layer, there is no serious influence of infiltration of wastewater-contaminated rainwater on groundwater quality.

Keyword

Waste disposal, contaminated, infiltration, impermeable

Meltwater - contamination indicator of industrial areas (Baikal region, Russia)

Evgeniia TSVETKOVA[1]*, independent scientist (e.tsvetkova@igc.irk.ru)
Vera Poletaeva[2], independent scientist
Mikhail Pastukhov[3], independent scientist
Elena Vishniakova[4], inDrive

Abstract

The industrial zone of Usolye-Sibirskoye town (Baikal region) includes enterprises of chemical, processing, and power industries. A priority environmental problem for the Baikal region is environmental contamination caused by the operation of the mercury electrolysis workshop of the chlor-alkali plant. Closure of the plant resulted in a decrease in the flow of pollutants; however, their significant part is accumulated in the soils of the industrial zone and bottom sediments of the collector network. Nowadays, surface runoff and atmospheric transport contribute significantly to the flow of pollutants from the industrial zone into the environment. In the current critical situation, it becomes important to study the migration of pollutants, the final receiver of which is the only runoff of Baikal Lake, the Angara River. In the climatic conditions of the Baikal region are characterized by an abundance of snow precipitation, the perspective markers of pollutant migration ways are meltwater, forming a heavy seasonal surface runoff. The composition of meltwater was the dissolved phase of snow cover with solid particles. Next, meltwater is enriched with elements by contacting with the surface layer of soil.

Studies of the distribution of the trace elements, such as Hg, V, Co, Ni, Cu, Zn, As, Mo, Cd, Pb, and U in meltwater at 56 sampling points showed significant concentration variability. The maximum variation coefficient was determined for V, and then it decreases according to the element row Hg, Pb, U, Cu, Ni, Co, Mo, Zn, As, and Cd. Several concentration coefficients that was calculated in relation to snow water (mean value) - Hg>U>As>Cu>Mo>Ni>Co>V>Pb>Cd>Zn, emphasizing the elements, the enrichment of which from soil is more significant.

The distribution of trace element concentrations (μg/L) in meltwater revealed a logical territorial belonging, which was related to the impact of industrial objects. The most polluted area is the site between the closed wastewater treatment facilities of the chlor-alkali plant and the ash removal ditch of the TPP's ash dump. At this site, the concentrations of the main pollutant of the plant, Hg, as well as U, Ni, Co, Mo, V, and As are significantly higher than their mean concentration. The enrichment of soils and, subsequently, meltwater of the study area with U, Ni, Mo, V, As is determined by their entry with gas-dust emissions from coal-fired TPP. This is confirmed by the dispersion of these trace elements in the dissolved phase of the snow cover in the zone of TPP impact following the predominant northwest winds. Besides, the indicators of the TPP impact are high concentrations of Mo, V, Ni, As, and U in the top meltwater of the ash dump, which then spread through the ash removal ditch. The general trend of the spatial distribution of trace element concentrations in meltwater is a gradual decrease with distance from large anthropogenic objects.

The results showed that the surface runoff of meltwater directly participates in the migration of pollutants from industrial to surrounding areas, including the Angara River, and can be used as the indicators of the condition of natural technogenic systems.

Keyword

meltwater, trace elements, anthropogenic impact, Baikal region

A SPATIO-TEMPORAL RECORD OF MICROPLASTICS DURING THE PAST FOUR DECADES IN A LACUSTRINE SEDIMENTARY SEQUENCE FROM SOUTHERN INDIA

Sandeep KIZHUR[1]*, Central University of Kerala (sandeepk01@gmail.com)
Aravind G H[2], Central University of Kerala
Mahidev R S[3], Central University of Kerala
Abdul Khader Rafaz[4], Central University of Kerala
Sijinkumar A V[5], Central University of Kerala
Anish K Warrier[6], Manipal Academy of Higher Education

Abstract

The present study provides baseline data on the spatio-temporal characteristics of microplastics in lacustrine sedimentary environments in southern India where limited data is available. The study investigated microplastic abundance, their types and polymer composition in surface and sub-surface sediments of Madagadakere (MK) lake situated in the south-western India. The sedimentary sequence (21 cm) which was dated using Cs-137 and Pb-210 methods display variations in the concentration, morphology, and polymer type of microplastics in the sediment profile during the past four decades. The microplastic concentration in the surface sediments of the lake varies from 100 to 450 particles/kg (mean + (standard deviation) = 322.22 (+ 120.91) particles/kg). A gradual increase is documented in the concentration of microplastics (150-1475 particles/kg) during 1975-2010. However, a decrease in microplastics content is documented from 2010 to 2016 (440-225 particles/kg). The fibres are the abundant types of microplastics in both surface and sub-surface sediments. The surface sediment samples are dominantly polypropylene (PP), whereas trench samples contain high-density polyethylene (HDPE) in addition to the former. A small creek joins the lake at north-east part of the lake which act as major source of microplastic influx to the lake. The fluctuations in microplastic concentration in sedimentary profile during the past 44 years can be ascribed to the collective influence of rainfall, fishing activity, and improper waste management practices of plastic materials. Besides, the presence and first appearance of different polymers in lacustrine sedimentary profile from southern India has the potential to be used as a stratigraphic marker during the Anthropocene.

Keyword

Microplastics, Anthropocene, Lake sediments, stratigraphic marker, Pb-210 dating

DEVELOPMENT OF METHODS FOR PHYTOREMEDIATION OF CONTAMINATED SOILS USING TOLERANT PLANTS OF LOCAL NATURAL LANDSCAPES (UZBEKISTAN)

Nosir SHUKUROV[1]*, Institute of Geology and Geophysics named after Kh.M.Abdullaev (nosirsh@gmail.com)
Shukhrat Shukurov[2], Institute of Geology and Geophysics named after Kh.M.Abdullaev
Obidjon Kodirov[3], Ministry of Mining Industry and Geology of the Republic of Uzbekistan
Nodir Rashidov[4], Institute of Geology and Geophysics named after Kh.M.Abdullaev
Shohboz Yoshuzokov[5], Institute of Geology and Geophysics named after Kh.M.Abdullaev

Abstract

Experiments on phytoremediation of contaminated soils were conducted at the Almalyk and Navoi Mining Metallurgical Combines facilities. Field and greenhouse experimental investigations have shown that phytoextraction may effectively remove metals (Pb, Cu, Zn, Cd, As, etc) from the soil. Ideally, phytoextraction requires fast-growing plants with large biomass and the ability to accumulate metal ions in the green mass. A plant's ability to accumulate was determined by the bioaccumulation coefficient (the ratio of the concentration of heavy metals in the shoots to the concentration in the soil). The results of the studies showed that the concentration of heavy metals in tailing wastes from the Navoi and Almalyk MMC is higher than the maximum permissible concentrations, and the anomalies of technogenic distribution occupy a relatively large area. Field experiments on phytoremediation of contaminated soils were conducted on arable lands around the waste storage facilities. At the end of February 2023, seedlings of local species of tree plants (Willow - Salix babylonica; Salix niggra; Salix cocrulea; Poplar - Pópulus álba; Pópulus canadensis; Elaeagnus commutata; Elaeagnus angustifolia) and reed (Phragmites communis) were planted, which are stable in the climatic and geochemical conditions of the area. These tree species also resist drought and saline soil. They can help improve air quality by removing dust and other pollutants. Reed - Tolerant of flooding and salinity, it can help prevent soil erosion and enhance water quality. The results of field experimental studies on the phytoremediation of contaminated soils showed that phytoextraction might become an effective tool for removing metals from the soil. Ideally, phytoextraction requires fast-growing plants with large biomass and the ability to accumulate metal ions in the green mass. A plant's ability to accumulate was determined by the bioaccumulation coefficient (the ratio of the concentration of the toxicant in the shoots to the concentration in the soil). Accumulator plants can absorb certain metals in amounts to several percent of the weight of their dry biomass. The collected plant biomass can be disposed of by burning and disposing of the ash at landfills. The metals with a commercial value can be recovered using an extraction procedure. Plants that produce enough above-ground biomass that can be harvested several times per season to remove toxic elements are the best candidates for phytoextraction. To be most beneficial for phytoremediation, these plants must accumulate harmful elements in plant tissues in 2–5% of dry weight. The results of the experiments showed that some local varieties of trees (Salix babylonica; Salix cocrulea; Salix niggra) and reed

(Phragmites communis) have good indicators of tolerance and accumulation of heavy metals.

Keyword

phytoremediation, soil pollution, mining wastes, heavy metals, Uzbekistan

Lead (Pb) Contamination and Associated Health Risks in the Mining Town of Rosh Pinah, Namibia.

Michelle Uetupa Hailonga[1]*, Geological Survey of Namibia (michelle.hailonga@mme.gov.na)
Giesberta Shaanika[2], Geological Survey of Namibia
Helmi Ipinge[3], Geological Survey of Namibia
Norwel Mwananawa[4], Geological Survey of Namibia
Israel Hasheela[5], Geological Survey of Namibia

Abstract

Lead mining has historically been associated with significant environmental and health impacts, a reality mirrored in the small southern mining town of Rosh Pinah, Namibia. Zinc was first discovered in Rosh Pinah in 1963, with mining operations commencing in 1969. The ore deposit comprises a stratabound stratiform zinc sulfide deposit within the upper volcanoclastic portion of the Precambrian Kapok formation, associated with pyrite gangue and minor copper content. Geo-environmental monitoring surveys conducted in Rosh Pinah in 2007, 2018, and 2023 included comprehensive sampling, analysis, and characterization of water, soil, sediment, tailings, waste rock, and ore samples.

The soil and sediment samples collected in the Rosh Pinah area exhibited elevated levels of lead (Pb), zinc (Zn), and copper (Cu), indicating significant contamination. Lead concentrations ranged from 67 ppm to 17,434 ppm, surpassing Canadian Soil Quality Guidelines (CSQG) thresholds for all land use categories. Similarly, zinc concentrations ranged from 42 ppm to 141,082 ppm, exceeding CSQG values across various land use types. Copper concentrations varied from 30 ppm to 703 ppm, also surpassing CSQG values for agricultural, residential/parkland, commercial, and industrial land uses. In contrast, vanadium (V) concentrations mostly fell below the CSQG threshold of 130 ppm. Comparison with CSQG highlighted significant contamination, raising concerns about health implications, especially for children. Recent Ministry of Health assessments confirmed Pb exposure in children, indicating quantified absorption and associated health risks.

The water results indicate generally satisfactory water quality across the sampled locations, with parameters such as pH, electrical conductivity, and total dissolved solids typically within allowable limits. However, occasional instances of elevated turbidity, particularly in Rosh Pinah Zinc WBH11 and WF000, raise concerns. Although most trace elements meet regulatory standards, slight exceedances are observed, notably in manganese levels in Rosh Pinah Zinc WBH11 and WF60. Despite these localized concerns, the majority of sites exhibit water quality suitable for human consumption, primarily falling within Class A or B classifications of the Namibia Drinking Water Quality Guidelines. The water quality is classified into four groups, in the NDWQG, based on the concentration and limits of various determinants: Group A (excellent quality), Group B (acceptable quality), Group C (low health risk), and Group D (high health risk or unsuitable for human consumption).

The primary source of contamination was identified to be dust fallout from the tailings storage facility and ore stockpiles in the processing area. Urgent action is recommended to conduct comprehensive assessments and implement remedial measures to mitigate the adverse effects of heavy metal contamination on the health of the surrounding community and the environment in Rosh Pinah.

Keyword

contamination, mining, lead (Pb), health effects, water

Overcoming Construction Management Challenges During the Remediation of a Former Gold/Arsenic Mine in Ontario, Canada

MARK William PRIDDLE[1]*, Egis Group (mark.priddle@egis-group.com)
Katharine Faaren[2], Ontario Ministry of the Environment, Conservation and Parks

Abstract

The Deloro Mine Site began its life as a gold mine in the 1860's, but progressed to arsenic extraction and processing. Subsequently a large industrial area with processing of other ores and materials developed. These activities left a legacy of contamination which eventually came under the control of the provincial government. Recently cleanup of the Tailings Area and the Industrial and Mine Area was completed.

The site is unique in Canada for several reasons:

• the Owner (Provincial Environment Ministry) is also the one of the key regulators
• despite no mining of radioactive ores, radioactive materials are present as a result of other industrial processing
• multiple regulators from several levels of governments are involved
• the site is immediately adjacent to a residential area
• an important recreational river flows through the site

These factors presented challenges during the management of the remediation project. The work was successfully completed in 2018 with the "Site Nuclear Licence" being withdrawn as a result of full and effective remediation. All wastes are now consolidated and covered with ongoing management.

This paper will explore the site history and how the challenges at this unique site were overcome over the course of eight years of remediation. These included design changes during construction, dealings with multiple regulators and the requirement for phased construction.

Challenges were overcome with the cooperation of all parties (owner, contract administrator, contractor(s), several regulators and consultation with other stakeholders (public, conservation authority, municipality). Specific examples include:

• Redesign of certain features during construction
• Response to anomalous weather events and subsequent incidents
• Dealing with species-at-risk
• Operating within and then clearance from, the Waste Nuclear Site Licence

The successful completion of this project resulted in an award from the Consulting Engineers of Ontario (Canada).

Keyword

gold mining, arsenic, nuclear, remediation, regulations

Microtechnofossils as a multiproxy record for the human-impacted sediments

Zdzisław M. Migaszewski[1]*, Jan Kochanowski University (zmig@ujk.edu.pl)
Agnieszka Gałuszka[2], Jan Kochanowski University

Abstract

Microtechnofossils encompass technogenic materials reaching 5 mm in diameter. These made-man products include four basic groups that may be used as a proxy for anthropogenic sediment contamination and for precise dating of the present and future human-impacted sedimentary strata. These include: (i) microplastics and their degradation products, (ii) combustion-derived particulates, e.g., metal oxides, aluminosilicates, silicates, spheroidal carbonaceous particles/SCP, (iii) synthetic crystals and mineral-like phases, e.g., boron carbide, tungsten carbide, element-doped garnets, graphene, ballpoint tips, and (iv) a new emerging road dust marker – glass microspheres. In contrast to elements and stable isotopes that require the knowledge of geochemical background for specific environmental settings, microtechnofossils can be unequivocally identified using optical microscopy. Of these four groups, microplastics (worn fragments of major plastic litter, microbeads/plastic glitters, nurdles/plastic pellets, or microfibers) are most widespread in the present environment due to their mass production, low density and easy fluvial and airborne transport. Plastics are known to degrade at the surface, exposed to heat, UV light and oxygen, but as noted, when buried in cold dark anoxic conditions they are likely to be considerably longer-lived, even if the scale of that longevity has not yet been constrained.

The physicochemical properties of glass microspheres, resembling quartz or microtektites, are a prerequisite for a primary marker of sediment contamination primarily with traffic-related dust. Another advantage is their preservation potential for being a chronostratigraphic marker of the human-impacted sediments, irrespective of redox conditions. Glass microspheres have been found in river sediments up to 25 km from city stormwater drains and in lake sediments up to 700 m off the highway 73 in the Świętokrzyskie province, south-central Poland (Migaszewski et al., 2022, 2023), as well as in coastal sediments of the Zuari estuary, southwestern India (Suhas et al., 2019) and the Plymouth Sound (UK) at a depth of 10–15 cm (Turner and Keene, 2023). Primary microtechnofossils and/or in some cases their secondary degradation products, will be the best multiproxy record for the present and future human-impacted sediment strata.

Reference:

1. Migaszewski Z.M., Gałuszka A. 2023. Glass microspheres as a new proxy for the fate and transport of road dust in the environment. The Goldschmidt 2023 Conf. Abstract ID: 14293.
2. Migaszewski Z.M., Gałuszka A., Dołęgowska S., Michalik A. 2022. Abundance and fate of glass microspheres in river sediments and roadside soils: Lessons from the Świętokrzyskie region case study (south-central Poland). Sci. Total Environ. 821, 153410.
3. Suhas S.S., Rudraswami N.G., Nandakumar K., 2019. Anthropogenic spherules in Zuari estuary, South-west coast of India. Mar. Pollut. Bull. 143, 1-5.

4. Turner A., Keene J., 2023. Glass microbeads in coastal sediments as a proxy for traffic-related contamination. Mar. Pollut. Bull. 188, 114663.
This study was supported by the National Science Center, Poland (research grant #2019/35/B/ST10/00821).

Keyword

microtechnofossils, glass microspheres, sediment contamination markers, multiproxy records

On the proper use of geochemical indices in pollution assessment of the road dust

Agnieszka GAŁUSZKA[1]*, Jan Kochanowski University (Agnieszka.Galuszka@ujk.edu.pl)
Zdzisław M. Migaszewski[2], Jan Kochanowski University

Abstract

Road dust is a solid material deposited on a road surface, originating from natural and anthropogenic sources. It contains a mixture of mineral particles from erosion of local rocks, and soils and from abrasion of the road surface, particles emitted from vehicles (e.g., produced during wearing of brakes and tires), plant fragments, technogenic particles, etc. Road dust contains different-size particles. Its composition shows temporal variability in a given location depending mostly on climatic factors, traffic intensity and road maintenance practices. As a consequence of its complex character, road dust is a heterogeneous material which is not comparable to any natural material. Thus, it should not be considered as an analogue to soils or sediments.

Different geochemical indices are used for pollution assessment. The most popular ones include Enrichment Factor (EF), Contamination Factor (CF) and Geoaccumulation Index (Igeo). Different formulas are used for calculation of all these indices, but they are all based on comparison of the results with background concentrations. In most of the recently published papers employing geochemical indices in pollution assessment of the road dust, the background values are understood as values representing shales or the upper continental crust composition. In some cases, the authors use these values for comparison of geochemical indices calculated for different fractions of the road dust. Another example of incorrect approach is the use of Zr as a reference element when calculating the Enrichment Factor in road dust samples. Zr cannot be used as a reference element because it has a substantial share of anthropogenic source in road dust as $ZrSiO_4$, which is commonly used in brake pads. In addition, three-way catalytic converters contain ZrO_2 with an admixture of cerium oxide.

This study reveals common misconceptions related to application of geochemical indices in pollution assessment of the road dust based on the results obtained in the city of Kielce, Poland, and proposes solutions to overcome the existing problems.

This study was financially supported by the National Science Center of Poland (a research grant #2019/35/B/ST10/00821).

Keyword

pollution assessment, geochemical indices, road dust, background concentrations, concentrations upper continental crust composition

METAL ACCUMULATION COMBRETUM IMBERBE, CYNODON DACTYLON AND SPOROBOLUS AFRICANUS AT KLEIN LETABA TAILINGS STORAGE FACILITY, LIMPOPO PROVINCE, SOUTH AFRICA

Phumudzo Gift MUNYAI[1]*, University of Venda (munyaip@gmail.com)
Humbulani Rejune Mundalamo[2], University of Venda
Jason Samuel Ogola[3], University of Venda

Abstract

Gold mine waste is considered as the major source of toxic metals in the environment however these toxic metals can be removed from the mine waste, soil and water by a process called phytoremediation. This process involves the use of plants to remove or extract metals. A mineralogical characterization was conducted at Klein Letaba tailings storage facility to quantify the presence of metals. Previous studies revealed an abundance of metals such as Pb, Cr, Ni and As. However, the extent of remediating metals from the facility has not been investigated. The focus of the study was to investigate the potential of metal extraction from native plant species growing on the tailings storage facility. This is an environmentally friendly remediation strategy for metal extraction and stabilization of the mine tailings using native plant species.

A total of 80 plant and tailings samples were randomly and seasonally collected at Klein Letaba tailings facility for chemical and mineralogical characterization. Five control samples were collected 5 km away from the mine site but within similar geological setting. This helped during comparative study to ascertain that these metals indeed came from the mine due to mining and gold processing. The samples were analysed using X-ray fluorescence spectrometry (XRF) at University of Venda and the second aliquot was digested using microwave digestion technique then sent to Madzivhandila Agricultural Centre for Inductively coupled plasma optical emissions spectrometry analysis. Geochemical data generated was analysed using Microsoft Excel, Arc GIS, and Kriging software. The metal values from the reconnaissance study were used to develop evidential uptake of the dominant plants in the study area. Each composite sample was split into two representative aliquots for chemical and mineralogical analysis.

Three dominant native plant species growing and thriving well on the tailings storage facility were identified, namely, Combretum imberbe, Cynodon dactylon and Sporobolus africanus. There were two more native plant species which were scarcely distributed on the tailings storage facility, Cyperus sexangularis and Phragmites australis. Pb recorded a maximum of 2307.25 mg kg-1 in the roots and Ni recorded maximum metal concertation of 1101.03 mg kg-1 in the roots for the Combretum imberbe plant, whereas Pb had concentration of 1525.8 mg kg-1 in the roots and 1204.3 mg kg-1 in the stem. These values exceed the ground tissues in concentration present in the soil, being greater than 1000 mg kg 1 for Ni, Pb, Cu, Cr, AS, Co. The uptake was high on the Combretum imberbe plant (2307.25 mg kg-1) as compared to the grass species Cynodon dactylon (1525.80 mg kg-1) and Sporobolus africanus (1370.90 mg kg-1).

This is an environmentally friendly remediation strategy for metal extraction and stabilization of the mine tailings using native plant species. Therefore, this remediation strategy will not only be applied in the studied sites but can also be applied in other similar studies.

Keyword

Phytoremediation, Metals, Native Plants, Klein Letaba Tailings Storage Facility

Associated Professor

Jia Duo[1]*, Xinjiang Institute of ecology and geography,Chinese Academy of Sciences, (duojia2017@ms.xjb.ac.cn)

Abstract

The ecological restoration of mines is an important link in the construction of green mines. While rationally developing and utilizing mineral resources to promote economic development, ecological damage and environmental pollution should also be reduced.Fly ash is a powdery particle produced after pulverized coal is burned in a boiler. Fly ash is one of the largest solid waste discharge sources in China. The stacking of fly ash will directly or indirectly cause a series of environmental problems such as atmosphere, soil and river, and cause a great waste of resources. In recent years, the study of soil improvement with fly ash has become a new hotspot. In this paper, fly ash was used to improve the soil in the mining area, and the effects of fly ash compound with different particle sizes and application rates on soil physicochemical properties, nutrient composition and plant growth were studied. The results showed that the use of fly ash with a smaller particle size and 15% application rate had a better effect on soil improvement. The bulk density of soil decreased by 0.13~0.47 g/cm3, the porosity of soil increased by 8.9%~22.8%, the soil water holding capacity increased by 6.7%~17.5%, and the salt content of soil decreased by 25.9%~31.86%. At the same time, the content of soil organic matter increased by 0.64~1.12 g/kg, hydrolyzable nitrogen content increased by 5.3~9.2 mg/kg, and total phosphorus content increased by 0.03~0.06 g/kg, which increased with the increase of fly ash.

Keyword

fly ash, improve, the soil, the mining area

Why is the air humid during wintertime heavy haze days in Beijing?

Jiarui WU[1]*, Institute of Earth Environment, Chinese Academy of Sciences (wujr@ieecas.cn)
Xia LI[2], Institute of Earth Environment, Chinese Academy of Sciences
Ruonan Wang[3], Institute of Earth Environment, Chinese Academy of Sciences
Qian Jiang[4], Institute of Earth Environment, Chinese Academy of Sciences
Guohui Li[5], Institute of Earth Environment, Chinese Academy of Sciences

Abstract

Atmospheric humidity has been shown to promote haze formation, but it remains unclear why the air is humid during heavy haze days in winter. We have identified a substantial increase of water vapor with increasing near-surface PM2.5 concentrations based on observations in Beijing (i.e. the air becomes more humid with aggravation of haze). The observed temperature and wind speed however shows a decreasing trend with near-surface PM2.5 concentrations Water vapor isotopic measurements and analysis at an urban site of Beijing have shown that the combustion derived water (CDW) fraction in the water vapor is about 11 ± 6.2 % on average, and increases with enhancement of near-surface PM2.5 concentrations. Although the wind at the urban site is weak during the study episode and there are almost no strong sources of CDW in upwind area of the sampling site in short distance, the CDW from the intensive emissions surrounding Beijing could also affect the observation site at the urban Beijing by regional transport, which is subject to causing overestimation of the contribution of CDW in Beijing. In future, two or more instruments will be deployed in the northwest and southeast of Beijing, to observe the water vapor characteristics of upwind and separate the regional transported water vapor signals from the local ones.

The more humid air during haze days is mainly caused by the water vapor transported from south or east to Beijing, anthropogenic direct emissions, and interactions between the atmosphere and air pollutants. Model simulations reveal that CDW has a considerable impact on the increasing moisture with aggravation of haze in the urban area of Beijing. The aerosol-radiation interactions (ARI) effect generally decreases the water vapor content with occurrence of haze and only increases the relative humidity when the severe haze occurs. The synergetic effect of CDW and ARI also decreases the temperature, with a reduction of 1.0 °C when severe haze occurs.

Keyword

Humid air, Vapor isotope, WRF-Chem model, Combustion-derived water, Aerosol-radiation interactions

Impacts of changes in land use and land cover between 2001 and 2018 on summertime O3 formation in North China Plain and surrounding areas-A case study

jiaoyang YU[1]*, Institute of Earth Environment, Chinese Academy of Sciences (yujiaoyang@ieecas.cn)
guohui Li[2], Institute of Earth Environment, Chinese Academy of Sciences
weijian Zhou[3], Institute of Earth Environment, Chinese Academy of Sciences
Xia Li[4], Institute of Earth Environment, Chinese Academy of Sciences
suixin Liu[5], Institute of Earth Environment, Chinese Academy of Sciences
ruonan Wang[6], Institute of Earth Environment, Chinese Academy of Sciences
Lang Liu[7], Institute of Earth Environment, Chinese Academy of Sciences
Qian Jiang[8], Institute of Earth Environment, Chinese Academy of Sciences
xuexi Tie[9], Institute of Earth Environment, Chinese Academy of Sciences

Abstract

Changes in land use and land cover (LULC) influence meteorological fields and biogenic emissions, further affecting the atmospheric chemistry and air quality. Combining the satellite measurements and WRF-Chem model simulations, we evaluate impacts of the LULC change between 2001 and 2018 on the summertime ozone (O3) formation in North China Plain and surrounding areas (NCPs). Satellite measurements have revealed that from Taihang to Yanshan Mountain, the fraction of broadleaf and needle forest coverage has increased by 5%-20% and the urban area has increased by up to 25% in the NCP. Additionally, the vegetation density has increased significantly in the NCPs except for urban areas. The LULC change generally enhances biogenic volatile compounds emissions in the NCPs, particularly over Taihang and Yanshan mountain, but the O3 variation is divergent. The maximum daily 8-hours average (MDA8) O3 concentrations are reduced by 1%-7% over Taihang and Yanshan Mountain because the raised vegetation density increases O3 dry deposition velocity to accelerate the O3 loss. The raised vegetation density enhances the evapotranspiration to decrease the near-surface temperature by 0.1 ℃ ~ 1.5 ℃, which also generates a divergence in the low-level atmosphere in the NCPs, causing secondary northerly or easterly winds in the NCP. The O3 enhancement along the coastal areas of the NCP is attributed to the perturbation of wind fields and photolysis induced by the LULC change. The divergent variation of the MDA8 O3 concentrations in the NCP is generally caused by the variations of biogenic emissions and photolysis.

Keyword

land use and land cover, O3, WRF-Chem

Hydrochemical characterization and indicators of anthropic influence on groundwater surrounding Guanabara Bay, Rio de Janeiro, Brazil

Alexis Rosa NUMMER[1]*, UFRRJ (rosanummer@gmail.com)
Nicole Delaunay Souza[2], solteira
Eduardo Duarte Marques[3], casado

Abstract

Guanabara Bay, recognized globally as one of the most eutrophic tropical ecosystems, occupies a position of negative prominence not only at a local but also at a national level. Efficient management of freshwater availability and reducing degradation of its quality are crucial challenges in this region. This study focuses on the hydrochemical analysis of the aquifers surrounding Hydrographic Region V (RHV) of Guanabara Bay, in the Rio de Janeiro State, investigating the interaction of groundwater with geological materials during percolation and establishing a spatial relationship between the zones urban, industrial, and local hydrogeochemistry. In this study, 228 artesian wells were analyzed, resulting in the classification of 38% of the water as chlorinated and 64% as sodium. This predominance of sodic waters can be attributed to maritime influence, given the proximity of Guanabara Bay to the ocean, and to human activities, such as the discharge of industrial and urban effluents, which alter the chemical composition of groundwater. Considering the hydrogeochemical properties, the Inorganic Chemical Index ranged from 0.805 to 99.931, with an average of 56.515, showing a significant variation in water quality. These data suggest a possible correlation between human activities and variations in water quality, highlighting the need for continuous monitoring and the implementation of environmental protection measures. The high variability of the Inorganic Chemical Index may indicate zones of point or diffuse pollution, influenced by effluent discharges, surface runoff and infiltration of contaminants. The classification of waters as chlorinated and sodium suggests that salinization processes are occurring, which can negatively impact aquatic biodiversity and the quality of water for human and agricultural consumption. The results point to the need for integrated water resources management policies, which consider both environmental conservation and economic development, thus ensuring a balance between the use and protection of groundwater in Guanabara Bay.

Keyword

Hydrogeochemical Characterization, Subterranean water, Guanabara Bay, Hydrographic Region

Study of soil contamination in vicinity of the municipal solid waste landfills after recultivation

Irina VASILEVNA Galitskaya[1]*, Sergeev Institute of Environmental Geoscience Russian Academy of Science (IEG RAS) (galgeoenv@mail.ru)
Tatiana Morosova[2], Dubna State University
Starostin Evgenii[3], Dubna State University

Abstract

Currently, the Federal project "Clean Country" is being implemented in Russia. One of the most important directions of the project is the reclamation of municipal solid waste (MSW) landfills or their modernization. A unique opportunity is provided at a significant number of objects to study the spatio-temporal changes in the environmental components contamination in the areas of MSW landfills. The results of soil contamination research at three MSW landfills in the Moscow region are considered. The complex of studies included the following kinds of works: the assessment of soil contamination hazard using various indicators (maximum permissible concentrations, background concentrations, soil clarks, migration indicators); the study of the heavy metals forms; factor modeling. In order to study soils as a secondary source of groundwater contamination, studies have been conducted on the forms of heavy metals: total; water-soluble; easily mobile (extracted with an acetate-ammonia buffer solution); acid-soluble, allowing to assess the level of technogenic soil pollution. As a result of the work carried out, the main trends of spatial and temporal changes in soil contamination were established, a list of polluting components was determined, the features of aerotechnogenic soil pollution and the composition of the forms of chemical elements were revealed. The intensity of soil contamination, the quantitative and qualitative composition of the forms of chemical elements differed significantly in different areas around the landfills. The noted differences seem to be related not only to the impact of the landfill and the wind rose, but also to the specifics of the soil and vegetation cover (the presence of forested, arable, swampy, etc. sites) in the adjacent territories. Significant percentages of exchange forms from their total content (up to 66% in a number of sites) are due to the high ability of soils to form sorbed forms, and the percentages of acid-soluble forms (up to 75% in a number of sites) indicate a high level of technogenic soil contamination, since in background soils the content of acid-soluble forms of these elements is usually not exceeds 1-5% of their total content. The use of the principal component analysis (PCA) method made it possible to identify the complex linear correlation between the concentrations of components and to reveal the main factors affecting the composition of the studied soils in the adjacent territories: the influence of landfill, agricultural activities, motor transport, etc. Based on the results of factor analysis it was concluded that all the factors obtained indicate a predominantly technogenic source of the pollutants in soils. Only some studies have noted factors confirming Fe and Mn natural anomalies. The combination of low groundwater protection in the considered sites and the significant content of mobile forms of a number of chemical elements cause the hazard of groundwater contamination even after the

landfill reclamation, which confirms the need for monitoring studies not only at the sites of the landfill body, but also in the adjacent territories. The research was financially supported by the project of Russian Science Foundation № 22-17-00045.

Keyword

contamination, landfill, soil, heavy metals, monitoring

Characterization and adsorption properties of rectorite/sludge derived biochar composites for Pb(II) removal

huanhuan WANG[1]*, West Anhui University (doublewhh@163.com)
junye ZHANG[2], School of Resources and Environmental Science, Wuhan University

Abstract

Heavy metals enter the environment mainly in water, soil and the atmosphere and migrate between them, contaminating a wide range of areas. Heavy metal ions in water bodies are difficult to biodegrade and can pose a threat to the ecological environment and human health. Therefore, there are many ways to remove heavy metal ions from water, and clay-based adsorbent materials are particularly widely used. Novel rectorite/sludge derived biochar (REC/SDBC) composites have been prepared to absorb Pb(II) in water. SEM images show that rectorite (REC) was evenly dispersed on the surface of sludge derived biochar (SDBC). The maximum Pb(II) adsorption capacity of REC/SDBC compo-sites with REC: SDBC ratio of 3:1 (26.89 mg g-1) was obtained within 120 min and higher than that of REC and SDBC alone. Additionally, it was discovered that pH had a significant impact on the adsorption of Pb(II) upon the compounds. The pseudo-second-order model and the Langmuir isotherm model, respectively, provided good fits for the rates and isotherms of Pb(II) adsorption onto REC/SDBC composites. The reaction mechanism is mainly dominated by chemisorption involving cationic exchange, surface complexation, and surface precipitation, which is also confirmed by X-ray photoelectron spectroscopy (XPS) analysis. The satisfied adsorption capacity combined with cost-effective and environmental-friendly virtues enables REC/SDBC composites promising candidates for removing heavy metallic elements from wastewater

Keyword

Rectorite, Biochar, Adsorption, Mechanism, Kinetics

Seasonal Changes in the Eutrophication Index and Alleviation of Eutrophication with Calcium-Citrate Complex in the Surface Water of Osongji (Osong Pond), Jeonju-si, Korea

Suyeong Noh[1]*, Department of Environment and Energy, Jeonbuk National University, Jeonju-si, Jeollabuk-do, 54896, Republic of Korea (sooyoung9131@naver.com)
Jiyoung KANG[2], Jeonbuk National University
Sung-Wook JEEN[3], Jeonbuk National University

Abstract

Excessive inflow of nitrate and phosphate is a major factor in promoting eutrophication, which can lead to algal blooms. Eutrophication causes soil and water pollution, with potential adverse effects on ecosystems and water quality. This study evaluated seasonal changes in the lake's eutrophication status and assessed the effectiveness of calcium-citrate complex as a reagent for alleviating nitrate and phosphate pollution. In this study, Osongji (Osong Pond) in Jeonju-si, Korea, was selected as an experimental site, and its physicochemical changes were assessed. Changes in the eutrophication status were assessed using the Korean Eutrophication Index (TSIKO), a eutrophication evaluation guidance applying chemical oxygen demand (COD), chlorophyll-a, and total phosphorus (T-P). Three experimental tanks, each with a volume of approximately 255 L (diameter of 50 cm and height of 130 cm), were installed. Calcium-citrate complex was applied either at 2-week intervals (T1; prevention) or as a one-time application (T2; one-time application). Closed (T3) and open (T4) control groups without calcium-citrate complex application were also included for comparison. Seasonal variations in eutrophication status were analyzed every two months from November 2022 to September 2023, while experiments with calcium-citrate complex application were conducted from June to September 2023. Osongji experienced eutrophic conditions from November 2022 to June 2023. It transitioned to a hypereutrophic condition in July 2023 but reverted to a eutrophic condition in August 2023, indicating severe eutrophication during the summer. As precipitation increased during the summer season in July and August, COD, T-N, and T-P also increased. The evaluation of the eutrophication alleviation technique using the calcium-citrate complex showed that in T1, where the complex was applied at 2-week intervals, lower TSIKO values were maintained compared to the control groups without complex application throughout the experimental period. In T2, where complex was applied once, T-P and total nitrogen (T-N) decreased after 2 weeks of application, resulting in a decrease in TSIKO. In conclusion, the application of calcium-citrate complex in a lake environment proved effective in preventing and alleviating eutrophication. This study could contribute to evaluating the eutrophication level in surface water bodies and establishing management strategies for eutrophication alleviation.

Keyword

Eutrophication, Nitrate, Phosphate, Alleviation

Pore-scale simulation of CO2-water-rock Interaction on Rock Permeability and Mechanical Properties

Yang BO[1]*, Jllin university (1090048779@qq.com)
Xu Tian fu[2], Jllin university
Zhu Hui Xing[3], Jllin university

Abstract

CO2 geologic sequestration is currently considered as an effective method to mitigate greenhouse gas emission and climate change. However, the CO2-induced mineral reactions, specifically the CO2-water-rock interactions, has been widely recognized for its potential to compromise the hydrogeological and mechanical properties of porous media, thereby deteriorating their integrity and mechanical characteristics. This further gives rise to concerns regarding the storage capacity and safety of CO2 sequestration project. Nevertheless, the mechanism underlying the influence of CO2-induced mineral reactions on these parameters is still not fully understood, thereby introducing uncertainty into the reliability of predicted outcomes. Direct pore-scale simulation plays a crucial role in deepening the understanding of CO2-water-rock interaction and its associated impacts. The present study proposes a novel simulation model that integrates the lattice Boltzmann (LBM) and finite element methods (FEM) to simulate the dissolution of calcite in a 3D sandstone sample invaded by saturated CO2 solution, aiming to investigate the resulting evolution of hydrogeological parameters (i.e., porosity and permeability) and mechanical properties (i.e., bulk and shear moduli). The reactive transport LBM model is coupled with fluid flow, solute transport, homogeneous reaction, heterogeneous reaction, and pore structure evolution. The subsequent updated skeleton is imported into the FEM model for mechanical calculations. In current study, the injection rates of reactive fluid (i.e., CO2 solution) were varied in the model to simulate different operational conditions of CO2 geological storage project. The simulation results demonstrate that the decrease in injection velocity inhibits the dissolution of calcite in the middle and downstream regions, concentrating it near the inlet. These distinct modes of calcite dissolution result in differentiated permeability and mechanical properties within rocks possessing identical porosity levels. In general, the increase in fluid injection velocity leads to a more pronounced enhancement in permeability and a greater attenuation in bulk and shear moduli under the same porosity. Thus, it is confirmed that the utilization of porosity is inadequate in accurately characterizing the evolution of rock permeability and mechanical properties resulted from mineral reactions. We ascertain that the application of fractal parameters, i.e., succolarity and fractal dimension, can more precisely depict the progression of permeability and bulk/shear modulus, respectively. In general, the parameters analysis and the model proposed above are important supplements for the field-scale study.

Keyword

CO2-water-rock interaction, Reactive transport modeling, Lattice Boltzmann method, Hydrogeological and mechanical properties

Tree stumps as passive sampler for trace metal dust deposition

Shubin ZHOU[1]*, China University of Geosciences, Beijing (shubinzhou@foxmail.com)

Abstract

Significant human activities are leading to the contamination of atmospheric dust with trace metals worldwide. This research evaluates tree stumps as passive samplers of dust deposition and bioindicators for dust contamination in a metal mine impacted environment. Two hundred and thirty tree stumps and adjacent soils from the Bailing Cu-Zn deposit area in northeastern China were analysed in situ using portable X-ray fluorescence (pXRF). Arsenic and Zn concentrations in both tree stumps and roadside soils at each location decreased with increasing distance from the road, following a power-law relationship. This trend suggests that road dust resuspension and redeposition are the primary sources of pollution. Micro-XRF images of vertical slices of tree stumps reveal concentrated As and Zn on the cut surface of tree stumps, indicating atmospheric deposition as a primary contributor to elevated As and Zn concentrations in tree stumps. Considering that natural lithological and geochemical properties of bedrock and soils vary, the presence of naturally occurring mineralization may make it difficult to distinguish polluted from unpolluted areas. The use of tree stumps as passive samplers offers distinct advantages over other methods (e.g., the placement of dust samplers and soil sampling) for analysing trace metal dust deposition, because atmospheric deposition emerges as a primary contributor to trace metals in tree stumps.

Keyword

Atmospheric pollution, dust resuspension and redeposition, soil pollution, in situ pXRF analysis, micro-XRF scanning

Assessment of Ground Water Quality by Statistical Methods in Greater Bangalore, South India

Hemamalini Rajanna R[1]*, Center for Environment , Agriculture And Training (ceadatngo@yahoo.co.in)

Abstract

Water is the vital resource for sustenance of living creatures on the Earth. The groundwater contamination has become a grave problem due to rapid growth of population, industrialization and high rate of urbanization in Bengaluru. Over the last few decades, the land and water use patterns have changed drastically in Bengaluru. Groundwater is an important resource for drinking purpose which contains over 90% of the fresh water resources. The untreated industrial effluents discharged into the surface water sources cause severe groundwater pollution in the industrial belt which requires continuous monitoring of the groundwater quality to evaluate the suitable and sustainable use of groundwater in Bengaluru. This study envisages the assessment of groundwater quality using diverse methodologies: determination of physico- chemical characteristics of groundwater, water quality index, cluster analysis, principal component analysis and determination of darzarrouk parameter.

In the present study, the whole study area was divided into four major grids as North-West, North-East, South-West and South-East. Out of those four major grids for the purpose of accuracy it was further divided into smaller grids having an area of 2x2 sq.km grids. Totally 176 (Bore Well (BW-169, Dug Well/Shallow wells - 7) samples were collected from whole study area and analysed for Chlorides, Sulphate, Nitrate, pH, Total Dissolved Solids, Total Hardness, Specific Conductivity, Calcium, Magnesium, Sodium, Potassium, Iron, Turbidity, Alkalinity and Fluoride. The result show that the groundwater quality is highly polluted in North-West part of Greater Bangalore area due more anthropogenic activities carrying out in those areas, may be due to sewage pollution and eutrophication of lakes and weathering of rocks in sub surface layers.

The present work is aimed at assessing the water quality index (WQI) for the groundwater of study area. The WQI for these samples ranges from 92 to 102. The high value of WQI has been found to be mainly from the higher values of Chlorides, TDS, Total Hardness, Specific Conductivity, Calcium, Magnesium and Sodium in the groundwater. The analysis reveals that the groundwater of the area needs some degree of treatment before consumption, and it also needs to be protected from the perils of contamination. Multivariate statistical analyses such as principal component analysis (PCA) and hierarchical cluster analysis (HCA) were applied to the standardized data set of fifteen groundwater quality parameters collected during the post-monsoon and the summer seasons in order to elicit hydrologic and biogeochemical processes affecting water quality in the unconfined aquifer beneath Bangalore city in southern India. The HCA using Ward's method and squared Euclidean distance measure classified the parameters into four clusters based on their similarities. PCA and HCA allowed interpretation of processes during both post-monsoon and summer seasons, anthropogenic pollution.

The correlation-regression analysis of groundwater quality data of a shallow aquifer system is presented. The correlation coefficients among the various water parameters and their association with total dissolved solids (TDS) were recognized. The Full length paper presents quality, quantity & its Environmental Hazards in the Study area.

Keyword

Contamination, Groundwater Quality/ Quantity, Anthropogenic Activities, Standardization, Environmental Hazards

Mercury in soils near a base metal smelting plant, Plovdiv, Bulgaria

Lora BIDZHOVA[1]*, Geological Institute, Bulgarian Academy of Science (lora.bidzhova@gmail.com)
Svetoslav Velichkov Georgiev[2], Geological Institute, Bulgarian Academy of Science
Galina Radeva[3], Roumen Tsanev Institute of Molecular Biology, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria
Radina Nikolova[4], Roumen Tsanev Institute of Molecular Biology, Bulgarian Academy of Sciences, 1113 Sofia, Bulgaria

Abstract

Mercury (Hg) is a known global pollutant that can be severely damaging to ecosystems and human health. Natural (e.g. volcanoes) and anthropogenic (e.g. artisanal gold mining) activities release mercury to the air, water and on land, part of which is subsequently converted by oceanic and soil bacteria into highly toxic methylmercury (MeHg) species that easily enter the food chain. Because of the high affinity of mercury for organic matter, rich soils retain Hg deposited from natural and anthropogenic sources, and thus represent an important global Hg reservoir. Non-ferrous metal production is estimated to account for 10-15% of global anthropogenic Hg emissions to the atmosphere and 40% of total anthropogenic releases to water. This significant Hg input and related environmental concerns require better understanding of mercury deposition in soils in general and around base metal smelters in particular. Here, we report total Hg contents in surface (0-20 cm) and subsurface (20-40 cm) soils from five sampling sites near the non-ferrous metal smelter KCM-2000, Plovdiv, Southern Bulgaria. Mercury contents, measured by DMA-80 evo at the Geological Institute of the Bulgarian Academy of Sciences, vary between ~20 and ~1000 ppb; these values are below the maximum permissible concentration allowed under Bulgarian Regulation 3/2008. The Hg content in the soil increases towards the location of the smelting plant, and peaks in the immediate vicinity of the smelter. Approximately three kilometers away from the smelting site, Hg contents are within background levels. There is a strong positive correlation between Hg concentrations in the samples and published data for cadmium, lead, and zinc, as well as clay contents. Notably, all surface soils have higher Hg concentrations compared to their subsurface counterparts, a feature that is more prominent within soils closer to the smelter. In addition, the results suggest that the combined effect of heavy metal contamination and the soil physical properties impact the enzyme activities and the abundance of soil bacterial communities. Further research on a larger soil sample population is needed to better characterize the areal extent of Hg contamination in soils near the smelting plant, as well as their effect on enzyme activities and bacterial communities.

Acknowledgements:
The authors acknowledge financial support by grant # КП-06-Н64/2 of the Bulgarian National Science Fund (PI-SVG).

Keyword

mercury, non-ferrous smelting, soil contamination, environment, bacterial communities

SOIL POLLUTION ASSESSMENT IN ALMALYK MINING AREA USING PRINCIPAL COMPONENT AND CLUSTERING ANALYSIS

Nosir SHUKUROV[1]*, Institute of Geology and Geophysics named after Kh.M.Abdullaev (nosirsh@gmail.com)
Timur Sabitov[2], Ministry of Environmental Resources of Uzbekistan
Azimjon Kholikov[3], Institute of Geology and Geophysics named after Kh.M.Abdullaev
Shukhrat Shukurov[4], Institute of Geology and Geophysics named after Kh.M.Abdullaev
Obidjon Kodirov[5], Ministry of Mining Industry and Geology of the Republic of Uzbekistan

Abstract

This study describes the results of principal component analysis and the hierarchical cluster modeling of the chemical and organic properties of soil samples taken from the Almalyk mining industrial area in Uzbekistan. Mine quarries, dumps, and tailings may contain mobile metals, which can act as a sink for tracers introduced to the environment through fly ash, dust, and leachates - the increasing availability of satellite data and field observations, methods to assess these changes and analyze impacts. Field visits can help to obtain vast amounts of data about sites. Soil profiles provide sufficient information about the soil's chemical composition and organic content. Still, sample analysis is hampered by many predictive variables (tracers), which add uncertainty and variability to the data. It is essential to carefully evaluate and interpret tracer concentrations at various sampling sites and environments. Multivariate statistical techniques are of greater value in describing links between sampling sites, concentrations of pollutants, latent factors affecting the data set structure, and pollution sources. Reducing the dimensionality of data increases the accuracy of analysis and helps to focus on the tracers that mainly impact variability in the data set. Such reduction also helps to detect clustering in a multidimensional space, highlighting the properties of collected soil samples and sampling locations. The recent development in the studies of source appropriation has shown that receptor models can help identify the primary sources of contamination in a study area. The models alone, however, are insufficient to conduct an in-depth analysis of the sources, so the redundancy analysis should supplement them to allow a better understanding of the details of land use and factors causing soil contamination, which will help prioritize management goals to minimize the contamination. A multivariate statistical method was used along with redundancy analysis to identify the sources of accumulation of heavy metals in the soils in the Almalyk region, using principal component analysis (PCA) to detect the essential tracers reflecting the variability of data samples. It provides an approach to classification problems through clustering analysis. We isolated variables that affected the variability in the data set using principal component analysis (PCA) and hierarchical clustering (HClust) algorithms. The methods also support cluster visualization in a multidimensional space. The visualization highlights the soil properties and the locations of sampling. The obtained classification displayed the clustering of samples around various sites, resulting from an accumulation of some tracers and distribution by distance from the location of a contaminated zone. Previously, the Almalyk area was analyzed along the transect, and the results

showed that as the distance from the pollution source along the transect increased, the concentrations of metals in soil solutions and exchangeable solid fractions decreased. Studies also showed the effect of airborne pollution caused by metal mining and smelting activity in the areas.

Keyword

Soil pollution, Heavy metals, Principal Component and Clustering Analysis, Almalyk mining industrial area, Uzbekistan

A review of heavy metal contamination around Rosh Pinah area in Southern Namibia

Michael Action EINO[1]*, University of Namibia (einoaction@gmail.com)
Shoopala UUGULU[2], University of Namibia
Collen-Issia UAHENGO[3], University of Namibia

Abstract

The mining industry, pivotal for Namibia's economic growth, concurrently raises environmental concerns, particularly concerning the release of heavy metals into our shared ecosystem. The Rosh Pinah Zinc Mine (RPZM), an underground mine in southern Namibia, mainly mines zinc and lead. The environmental impact of the RPZM was reviewed, focusing on the contamination dynamics of lead and zinc. The review examined the concentrations of zinc and lead in the air, soils, and biota surrounding the mine. The issue stems from the dust fallout, which extends its contamination over a significant portion of Rosh Pinah town. This is due to the positioning of the uncovered tailings dam at an undesirable location, a decision likely made without incorporating insights from local meteorological modelling. Results show that the contaminated area lies in the direction of the prevailing wind. Dispersion modelling for airborne suspended dust particles (TPS) at Rosh Pinah unveiled a noteworthy observation. In the past, the entirety of the tailing dam's surface used to remain desiccated because of water infiltration and evaporation. Despite this, the annual average concentrations of TPS within Rosh Pinah town reached levels ranging from 100 to 300 g/m3. However, a significant change has been observed recently, as approximately two-thirds of the surface of the tailings dam is now covered with water. This alteration has led to a marked reduction in TPS concentrations, ranging from 30 to 100 g/m3. The shift is substantiated by studies conducted on the exposed portion of the grass, which revealed that the lead levels in 52% of the collected grass samples exceeded permissible values for use as dry fodder. Regrettably, this scenario bears adverse consequences for the interconnected ecosystem and environment. Subsequent investigations reveal that the quantity of TSP observed in the air on the tailings dam's surface varies between 8 and 84 mm/m3. The atmospheric composition registers notable concentrations of various elements: zinc (median: 792), lead (median: 412), manganese (median: 163), and copper (median: 42). Comparatively lower levels are detected for arsenic (median: 5) and cadmium (median: 2). The dispersion of dust contamination forms a distinct pattern extending north-eastward, primarily guided by the prevailing wind direction. Concerningly, bio-accessible lead content exceeds acceptable daily intake limits for children. The Namibian Ministry of Mines and Energy confirmed that test results had detected lead in the blood of 18 and 30 children living near a zinc mine at Rosh Pinah. The Rosh Pinah Health Care Clinic's test showed that the blood levels of all children sampled and measured as part of the lead programme in 2020 were above the reference level. The environmental impact assessment of the Rosh Pinah Zinc mine underscores the urgent need for comprehensive measures to mitigate heavy metal contamination, notably lead, to safeguard public health and the surrounding ecosystem from further harm.

Keyword

Rosh Pinah, contamination, heavy metal

Effect of salinity on arsenic mobilization from desulfurized and filtered mine tailings

Rocky KUBUYA KIRO[1]*, UQAT UNIVERSITY-QUEBEC (Pakrockykiro@gmail.com)
Lucie Coudert[2], Prof. UQAT UNIVERSITY

Abstract

Tailings management is one of the most important challenges that mining industry is facing due to potential geotechnical and/or geochemical instabilities. Filtration of mine tailings has been successfully applied on several mine sites, reducing the risks of geotechnical failure. However, the effect of pore water quality (i.e. high salinity) on the geochemical stability of sulfide minerals is poorly documented. Oxidation of As-bearing sulfide minerals, when exposed to air and water, led to the production of As-contaminated mine drainage. Many factors such as the redox potential and pH conditions as well as water quality (i.e. salinity) play a crucial role on the (im)mobilization of As from mine tailings. Many studies have evaluated the mobility of As from mine tailings or pure minerals under several conditions, but few information are available on the geochemical behavior of As from desulfurized and filtered mine tailings. The main objective of the present study was to evaluate the effect of water chemistry on the mobilization of As from desulfurized and filtered mine tailings (DFT). To do so, an exhaustive physico-chemical (e.g., particle size distribution, chemical composition, granulochemical distribution) and mineralogical (e.g., identification of As-bearing minerals and degree of liberation) characterization of a DFT was performed. Four weathering cell tests were performed on washed and unwashed DFT with different water quality (demineralized vs. saline water) to evaluate the effect of salinity on As mobility. DFT, which is mainly composed of fine particles (d80 = 75.5 µm), initially contained 0.1% of As, essentially concentrated in the fine fraction (89.9% of As found in the < 32 µm fraction, which accounted for 55% of the total mass of DFT). Speciation of As revealed that 11% of As was associated to the leachable fraction, while 81% was associated to the residual fraction. Löllingite and arsenopyrite were identified as the main As-bearing minerals. Weathering cells results showed that there is no clear effect of salinity on As mobility from DFT, under the conditions tested ([Cl-] = 1.9-2.5 g/L, [SO42-] = 3.3-3.5 g/L). Indeed, the proportion of As leached after 130 days (2.09-3.59%) and As leaching rates (0.011-0.017 mg/d) were quite similar for all weathering cells.

Keyword

As mobility, Salinity, filtered mine tailings, contaminated mine drainage

Tracing Sources of Zinc Contamination in Groundwater of Industrial Complexes Using Zinc and Sulfur-Oxygen (S-O) Isotopes

Dae-Gyu IM[1]*, Korea University (daegull1995@korea.ac.kr)
Duk-Min Kim[2], Sangji University
Jung-Woo Hwang[3], Korea University
Seong-Taek Yun[4], Korea University

Abstract

Industrial complexes host a variety of industrial categories, including metal, machinery, electronics, petrochemicals, cement, and plating plants, which can be sources of diverse pollutants. This study focuses on groundwater contamination by Zn in the study area, where plating, metal machinery, and cement manufacturing plants are potential sources. Zn and S-O isotopic analyses were conducted to trace sources of Zn contamination. Zn concentrations in groundwater ranged from 24 to 2025 μg/L. Additionally, Cr concentration of 17.3 mg/L in a well inside a plating plant suggested that chemicals from the Cr-plating process were released. The direction of groundwater flow towards a stream southeast of the industrial complex suggested potential impacts on residential areas. Groundwater near the metal machinery plant in the southern part of the industrial complex exhibited Zn isotopic ratios ranging from -0.317 to 0.100 ‰. Concentrations varied across different depths, from shallow groundwater sampled at 18 ~ 30m depth to deep groundwater sampled at 44 ~ 50 m depth (the range of Zn concentration in all groundwater samples from this study area was 0.72 ~ 2025.66 μg/L, with a median value of 33.36 μg/L). Additionally, the Zn isotopic ratio in shallow groundwater ranged from 0.018 to 0.205 ‰, while in deep groundwater, it ranged from -0.317 to -0.052 ‰. These results suggest potentially different Zn contamination sources at shallow and deep groundwater levels. Comparisons of sulfate concentrations and Zn and S-O isotopic ratios indicated that residential areas were primarily affected by cement and plating factories. Groundwater well near the cement plant had concentrations of sulfate, boron, and sulfide of 248 mg/L, 0.11 mg/L, and 0.06 mg/L, with δ34S of 27.6 ‰, suggesting sulfate reduction was induced by organic matter possibly from sewage pipes. The direction of groundwater flow suggested that the plating plant and metal machinery manufacturing plants in the northern part and the cement plant were the primary sources of contamination.

Acknowledgments
This research was partly supported by the Korea Environmental Industry and Technology Institute (KEITI) through the project (Integrated Environmental Forensic Approaches to Trace Sources and Pathways of Subsurface Contaminants) funded by the Korea Ministry of Environment (MOE) (2021002440003). This research was also partly supported by the Development of Source Identification and Apportionment Methods for Toxic Substances in Marine Environments Program of the Korea Institute of Marine Science & Technology Promotion (KIMST), funded by

the Ministry of Oceans and Fisheries (KIMST-20220534).

Keyword

Environmental forensics, Groundwater contamination, Industrial complexes, Zn isotope, S-O isotope

Eco-friendly natural mineral biotite as a cesium adsorbent: Utilizing low-concentration acid and hydrogen peroxide

Sunki KWON[1]*, Pusan National University (rockersunki@hanmail.net)
Donghoon Seoung[2], Chonnam National University
Eunji Jung[3], Gwangju Institute of Science and Technology
Jiyoung Park[4], Korea Atomic Energy Research Institute
Jongmyoung Lim[5], Korea Atomic Energy Research Institute
Byungkyu Park[6], Thermo Fisher Scientific Korea Branch
youngjin Cho[7], Thermo Fisher Scientific Korea Branch
Pyosang Kim[8], Chonnam National University
Hyeonsu Kim[9], Chonnam National University
Yongmoon Lee[10], Pusan National University

Abstract

Biotite, a phyllosilicate mineral, possesses significant potential for cesium (Cs) adsorption owing to its negative surface charge, specific surface area (SSA), and frayed edge sites (FES). Notably, FES are known to play an important role in the adsorption of Cs. The objectives of this study were to investigate the Cs adsorption capacity and behavior of artificially weathered biotite and identify mineralogical characteristics for the development of an eco-friendly geologically-based Cs adsorbent. Through various analyses, it was confirmed that the FES of biotite was mainly formed by mineral structural distortion during artificial weathering. The Cs adsorption capacity is improved by approximately 39% (from 20.53 to 28.63 mg g-1) when FES are formed in biotite through artificial weathering using a low-concentration acidic solution mixed with hydrogen peroxide (H2O2). Especially, the Cs selectivity in Cs-containing seawater, including high concentrations of cations and organic matter, was significantly enhanced from 203. 2 to 1707.6 mL g-1, an increase in removal efficiency from 49.5 to 89.2%. These results indicate that FES of artificially weathered biotite play an essential role in Cs adsorption. Therefore, this simple and economical weathering method, which uses a low-concentration acidic solution mixed with H2O2, can be applied to natural minerals for use as Cs adsorbents.

Keyword

Cesium, Biotite, Artificial weathering, Frayed edge sites (FES), Adsorption

FEATURES OF ANOMALIES OF POLARIZABILITY AND RESISTANCE OF THE INDUCED POLARIZATION METHOD IN THE LIGHT OF PREDICTING GROUNDWATER POLLUTION BY PETROLEUM PRODUCTS

Qodirjon MINGBOYEV[1]*, SE "HYDROENGEO institute" (qodirjon2004@mail.ru)
Rakhimjon TURSUNMETOV[2], SE “HYDROENGEO institute”

Abstract

With the increasing intensity of the oil and gas industry, pollution of the geological environment, including groundwater, is observed. Pollution of the geological environment is an irreversible and dangerous process. Therefore, there is a special requirement for the use of applied methods for detecting oil pollution in the geological environment.

Of greatest interest is forecasting the migration of petroleum products at an early stage. In this aspect, it is of interest to study the subtle mechanism of distribution of petroleum products in a complex geological environment. When studying oil pollution, the method of induced polarization (IP) was mainly used in various modifications.

Petroleum products in the geological environment, other things being equal, despite their different forms of occurrence, gravitate towards the boundaries of the solid and liquid phases in the form of emulsions and films. These boundaries act as capacitive absorbers of oil products. In this case, the volume of oil films (products) is determined by the total specific surface area, which, in turn, is determined by the porosity and permeability of the vapor space. On the one hand, they are polarized in the boundary zone of the liquid and solid phases, and on the other hand, they are distinguished by significant surface conductivity, which leads to a noticeable decrease in the resistivity of the porous medium as a whole.

Consequently, the spread of petroleum products in the geological environment, i.e. pollution of the geological environment, is manifested by a decrease in electrical resistivity and an anomalous increase in the polarizability of the geological environment.

This pattern is confirmed by the results of numerous field studies aimed at identifying oil pollution in the geological environment. Note that the existing calculation algorithm is aimed at assessing the polarizability of the geological medium for two cases (surface and volume polarizability).

Thus, polarization phenomena are mainly determined by volumetric polarization of the geological environment. In this case, the effect of polarization of the medium is due to the presence of scattered disseminated minerals or clay particles, at the boundaries of which a noticeable jump in potentials is not observed. However, these jumps add up in the volume and then a noticeable polarization of the medium as a whole is observed. They also affect the current density distribution.

When petroleum products spread in the geological environment, as noted above, surface and volume polarizations develop in the vapor space. The surface is caused by the fact that the accumulation is accompanied by gas components ΣCH4, CO2, O2, which are potential-setting

compounds of the redox potential.

Based on the formulated models of polarizability and resistance, the results of the IP method were analyzed in areas where the following features of the anomaly of polarizability and resistance were established.

Thus, the established features of the anomaly of polarizability and resistance determined the nature of pollution with petroleum products, on the one hand, and, on the other hand, revealed them at an early stage of pollution.

Keyword

anomaly, electrical resistivity, polarizability, surface conductivity, oil pollution

Tracing iron mining dam collapse pollutants from the Fundão-Mariana accident (2015), using Nd-Sr isotopes in sediments from the Doce River and adjacent marine environment

Claudio de Morisson VALERIANO[1]*, Rio de Janeiro State University
(valeriano.claudio@gmail.com)
Heitor Evangelista[2], Rio de Janeiro State University
Catarina Herdy Ferraz[3], Rio de Janeiro State University

Abstract

This work presents Sm–Nd and Sr isotope TIMS data on the fine-grained fraction (< 74 μm) of iron-rich deposits related to the November 5th, 2015 Mariana accident, caused by the rupture of the Fundão dam, an iron tailings pond operated by SAMARCO Mining. The failure of the Fundão dam provoked the gravitational flow of approximately 62 Mi m3 of quartz and iron oxide-rich slurry composed of water, fine sand and silt that flowed into the Gualaxo do Norte and Carmo rivers, and eventually along the whole Doce River, reaching the shoreline in 15 days.

Samples were collected along the proximal and distal Doce River banks and from the marine shelf environment, including the Abrolhos coral bank, using sediment traps installed on the ocean bottom.

Using the Nd-Sr isotopic fingerprint of the proximal iron-rich mud that flowed out of the ruptured dam, and of the Doce River mouth fine-grained sediment, seasonal patterns of pollutant input in the marine environment are controlled by environmental factors such as stormy weather from advancing cold fronts which cause renewed resuspension of contaminated sediment, and by the seasonal regime of oceanic currents along the eastern-Brazil continental shelf.

Periodic monitoring of the isotopic composition of marine sediment during the last nine years indicates a gradual decrease of the impact of the iron-rich sediment plumes from the Doce River mouth.

Keyword

Mariana accident, Radiogenic isotopes, mining accident, Doce River, Nd-Sr

Examples of the advection mechanism of contaminated groundwater due to VOCs to deep aquifers and the advection of contaminated groundwater in aquifers with different flow directions: wells that diffuse contaminated groundwater deep and wells that do not

Osamu KAZAOKA[1]*, Reserch Institute of Environmental Geology, Chiba
(osamu.kazaoka@gmail.com)
Takeshi Yoshida[2], Reserch Institute of Environmental Geology, Chiba
Shun Kameyama[3], Environmental Living Department, Chiba Prefecture Government
Noboru Narisawa[4], Laboratory of Environmental Geology
Masaaki Uzawa[5], Kanto Natural Gas Development Co., Ltd.
Yoshiyuki Tamura[6], Chiba Prefectural Environment Foundation
Naoto Ito[7], Environmental Living Department, Chiba Prefecture Government
Ayumi Takakura[8], Environmental Protection division of Yachiyo City Government

Abstract

This study was conducted with the aim of effectively purifying groundwater pollution caused by VOCs on the Shimousa upland in the northern part of the Boso Peninsula in central Japan.
At the two targeted groundwater polluted sites, continuous borings were used to understand the detailed hydrogeological structure and vertical strata pollution status, taking into account the pollution sources and the distribution of polluted wells. Next, observation wells installed for each aquifer revealed the direction of groundwater flow and the distribution of polluted concentration in each layer.
As a result, at Site 1, five aquifers exist up to a depth of 100 m, and groundwater pollution exceeding Japanese groundwater environmental standards was found in the first and second aquifers. The source of the pollution is on the Shimousa upland at approximately 25 m height. Pollutants flow into the groundwater at a point 10m westward in an unsaturated zone approximately 10m thick from the pollution source in the surface layer, and then flow northwest through the 1st aquifer approximately 18m thick in a width of approximately 15m. The high concentration polluted water advects in a band along the groundwater flow, and flows out as polluted spring water in a valley 200m away at about 8m height. In addition, since the groundwater head of the 2nd aquifer is approximately 5.2 m lower than the groundwater head of the 1st aquifer, pollutants could pass through the gap between the well pipe and the borehole at the location of a private well. It invaded from the 1st aquifer to the 2nd aquifer. From there, it flowed north-northwest in the second aquifer, reaching another well approximately 150 m away.
At Site 2, three aquifers exist up to a depth of 50 m, and groundwater pollution was observed in the 1st and 2nd aquifers. VOCs penetrated into the unsaturated zone almost vertically from the pollution source, entered the 1st aquifer, and advected east-southeast along the direction of groundwater flow. The groundwater head of the 2nd aquifer is approximately 3.4 m lower than that of the 1st aquifer, so while pollutants flow through the 15 m thick 1st aquifer, there flow into the second aquifer within approximately 100 m. Pollutants were advected to the second aquifer

through the gaps between the well pipes and boreholes of four private wells installed in the 2nd aquifer. The pollutants then flowed west-northwest to west in the2nd aquifer.
Based on the above, pumping wells need to have a structure that prevents the deep diffusion of pollutants such as the following. It is necessary to install a screen in only one aquifer, and to fill the backfill part of other aquifers and impermeable layers with impermeable materials, such as cement slurry. Furthermore, since the flow direction of groundwater differs for each aquifer, in order to take effective purification measures, it is necessary to monitor and take purification measures for each aquifer.

Keyword

groundwater pollution, VOCs, private well, backfill

Identification of *As-III and As-V species in As-contaminated water using cupric acetate monohydrate*

Swati GANVEER[1]*, IIT Kharagpur (ganveerswati95@gmail.com)
Kamal Lochan Pruseth[2], IIT Kharagpur

Abstract

Arsenic contamination in various environmental matrices, including water, soil, and food, poses significant risks to human health. Different arsenic species exhibit distinct toxicities, making its identification essential. Traditional analytical techniques such as chromatography and spectroscopy provide accurate results, but are often time-consuming and require expensive instrumentation. There are several analytical methods for the detection of arsenic. Colorimetry is the simplest of them. Till now in colorimetry, methods such as molybdenum blue, Pyrocatechol Violet Method etc. are limited to the detection of arsenite (*As-III*) only. The use of cupric acetate for arsenic detection can be traced back to older scientific literature and textbooks on analytical or environmental chemistry. Despite the absence of specific references, our experiments involved employing a saturated solution of cupric acetate monohydrate in contaminated water for the detection of both *As-III* and *As-V* in contaminated water. With synthetic solutions of pure *As-III* and *As-V*, we obtained green-coloured and light-blue-coloured precipitates, respectively. Precipitates of intermediate colours were obtained from natural As-contaminated water samples, reflecting the presence of both *As-III* and *As-V* in variable proportions in them. While the total quantity of the precipitate is indicative of the level of As-contamination, digital image processing can be used to quantify the colour components, from which the relative proportions of *As-III* and *As-V* can be estimated. This method holds promise for a cheap, quick and convenient means of determining As speciation in contaminated water.

Keyword

As-III and As-V species, Cupric acetate monohydrate, Contamination, Precipitation

Pb isotopic source tracing and mass balance on heavy metals from East Kolkata Wetland, a Ramsar site of West Bengal, India

KAMALAKANNAN D[1]*, NATIONAL CENTRES OF EXCELLENCE IN GEOSCIENCE RESEARCHES, GEOLOGICAL SURVEY OF INDIA, BANGALORE (kamalakannan.d@gsi.gov.in)
AVIJIT DAS[2], NATIONAL CENTRES OF EXCELLENCE IN GEOSCIENCE RESEARCHES, GEOLOGICAL SURVEY OF INDIA, CHQ, KOLKATA, INDIA

Abstract

The East Kolkata Wetlands (EKW) is a natural ecosystem recognized globally for its bioremediation model of treated sewage water. A detailed analysis was conducted on water samples collected from raw sewage canals, treated pond waters, subsurface sediments, and core sediments. Geochemical analysis showed that the mean concentration (mg/L) of trace metals in untreated pond waters was in the order of Mn > Cr > Fe > Ni > Zn > Cu > As > Pb > Cd, while that for treated pond waters, was Mn > Cr > Ni > Fe > Zn > As > Cu > Al > Pb > Cd. The mean concentration of sediment trace metals was in the order of Fe > Mn > As > Cr > Zn > Ni > Cu > Pb > Cd. The study revealed that the bioremediation of wastewaters containing Al, Cr, Mn, Fe, Pb, Ni, Cu, and Zn varied in different ponds. While reduced concentrations of Mn and Fe were observed in 98% of treated pond waters, 56% of ponds could not remove Zn and As. Mass balance calculations showed that the differential load after microbial treatment of wastewater decreased in the order of Cr > Ni > Cu and Zn. The mean load of trace metals in Core 1, Core 2, and sediments accounted for 17%, 24%, and 26% of the differential load released by wastewater treatment, respectively.

Furthermore, our comparison of the Pb isotopic ratios of EKW sediments and plant samples with potential Pb-rich sources revealed that EKW sediments and plant samples had the isotopic signature of diesel exhausts, coal burning, atmospheric particulates, and anthropogenic sources. The EKW sediments and plant samples exhibited a linear trend in the 207Pb/206Pb vs. 208Pb/206Pb plot, with plant samples having higher Pb isotopic ratios and mostly plotting close to street dust and Kolkata diesel. Sediment samples mostly clustered along the Jharia and Raniganj coals, confirming the sources of contamination.

Overall, our study provides valuable insights into the trace metal concentrations and their removal efficiency in the EKW ecosystem. The findings can serve as a guide for future efforts to enhance bioremediation of wastewaters and minimize the impact of anthropogenic activities on the environment. The results of this study have important implications for the conservation and management of wetlands worldwide.

Keyword

Trace metals, Bio-remediation, mass balance, Pb isotope, East Kolkata Wetland

Urban local body - Farmer partnership for sustainable waste management and organic farming

Kiran D A[1]*, Dayananda Sagar College of Engineering and Indian Institute for Human Settlements, Bengaluru, India (dakiran07@gmail.com)
Pushkara S V[2], Indian Institute for Human Settlements, Bengaluru, India
Ramaraju H K[3], Dayananda Sagar College of Engineering, Bengaluru, India

Abstract

Urban local bodies (ULBs) in India struggle to manage their municipal solid waste (MSW) due to a lack of infrastructure, funds, and the viability of waste processing. Processing MSW is not sustainable since only about 25–30% of the operation cost could be recovered by the sale of recyclables. While some ULBs are processing waste by offering tipping fees or subsidies to waste processing units, many ULBs have not been able to do so. As a result of unprocessed waste, lakhs of tonnes of waste are piled up in landfills, causing harm to the environment. Indian farmers are moving towards the use of chemical fertilisers due to the unavailability, high cost, and inadequate supply of organic compost. The use of chemical fertilisers also has adverse effects on the environment.

Integrating these two challenges, the proposed approach is to demonstrate a simple and scalable waste processing model (Pit composting) to process biodegradable waste and to establish a partnership between ULBs and farmers wherein ULBs will set up composting pits on farmlands and supply biodegradable waste. The farmers will conduct composting operations and recover organic compost after two months.

Pit composting is a method of converting biodegradable waste into organic compost using pits below the ground. Composting pits of about 16 cubic meters are excavated and filled with biodegradable waste. Cow dung slurry is added to the waste material to initiate composting process. Pits are turned every week to provide aeration along with regular monitoring of temperature and moisture content. Water is sprinkled to maintain optimal moisture and temperature and ensure the stability of composting operations. Waste transforms into organic compost in 50-60 days, depending on the nature of waste material and environmental conditions.

A pilot study on this concept was conducted and treated 60 tonnes of organic waste sourced from nearby locality to produce 9 tonnes of organic compost. The capacity of pit composting technique is estimated at a maximum of 10 tonnes of fresh waste. The average yield per batch was approximately 15.35%. The nutrient content of the organic compost produced was checked against the compost quality standards. Implementing this approach of waste-to-composting model helps ULBs manage their waste management challenges and helps farmers by offering free compost, thereby reducing their carbon footprint, and promoting circular economy and sustainability by avoiding the accumulation of waste in landfills.

Keyword

Pit composting, Circular economy, Biodegradable waste, Waste management, Aerobic composting

Characterization of urban aquifers of an Asian megacity (Shenzhen, China) using chemical, antibiotics, and isotope analyses

STEFANO VIAROLI[1]*, University of Pisa (stefano.viaroli@unipi.it)
Xiaoou WEI[2], State Key Laboratory of Environmental and Biological Analysis, Department of Chemistry, Hong Kong Baptist University, Hong Kong, 999077, China
Michele LANCIA[3], Eastern Institute for Advanced Studies, Eastern Institute of Technology, Ningbo, China
Yujie BEN[4], State Environmental Protection Key Laboratory of Integrated Surface Water-Groundwater Pollution Control, School of Environmental Science and Engineering, Southern University of Science and Technology, Shenzhen, China
Viviana RE[5], Department of Earth Sciences, University of Pisa, Pisa, Italy
Roberto GIANNECCHINI[6], Department of Earth Sciences, University of Pisa, Pisa, Italy
Chunmiao ZHENG[7], Eastern Institute for Advanced Studies, Eastern Institute of Technology, Ningbo, China

Abstract

The hydrogeological characterization of urban areas is challenging due to the heterogeneous groundwater dynamics in space and time. Impervious surfaces such as roads and building roofs increase the surface runoff at the expense of the aquifer recharge. The natural groundwater dynamics are also potentially altered by local groundwater withdrawals for domestic or industrial uses, producing long-term modifications in the contaminant transport. Leakage from the water supply network and sewer pipes may trigger unconventional recharge, contaminating the aquifers. In this heterogeneous and challenging context, the urban aquifers of Shenzhen, a fast-growing Chinese megacity (Guangdong, China) with almost 24 million inhabitants, are investigated. The megacity has a subtropical climate with an average rainfall rate of 2000 mm/y with summer rainstorms causing frequent waterlogging and floods.

The groundwater system of the area consists of shallow alluvial and lateritic aquifers, lying on less permeable igneous and sedimentary rocks. The shallow aquifers are vulnerable to contamination because of the exiguous water table depth, generally in the range of a few meters. In this study, groundwater samples from 10 monitoring wells, with a depth ranging between 10 to 50 meters, are collected to assess the groundwater quality. The collection and analysis of urban groundwater have been conducted during the wet and dry seasons. Ion chromatography (major elements) and ICP-MS (trace metals) were used to characterize the hydrogeochemistry of the aquifers. Despite the abundant rainfalls, nitrate levels often exceed the threshold value suggested by the World Health Organization (50 mg/L). To delineate the source of contamination and investigate the presence of denitrification processes within the aquifers, 15N and 18O isotopic analyses were carried out.

Groundwater samples were also tested for 98 types of antibiotics. The samples were analyzed using the LC–MS technique. All groundwater samples are contaminated by a range of 10 to 35 types of antibiotics. In most cases, the concentrations are less than 1 ng/L but some compounds show worrisome levels (up to 19.41 ng/L). The most commonly detected types of antibiotics are

macrolides and quinolones. Roxithromycin and azithromycin had been detected in all samples. The highest concentration is azithromycin, 7.40 ng/L on average. Preliminary elaborations do not highlight correlations with the reconstructed hydrogeological background, supporting the hypothesis of local contaminations. An increment of the urban recharge rate with nature-based solutions and sponge City installations may mitigate the waterlogging and flood risk but, at the same time, further deteriorate the groundwater quality throughout the megacity.

Keyword

Antibiotics, Contaminants of emerging concern, urban recharge, groundwater, nitrate

Exploring Management Practices of Tailings and their Impact on the Downstream Economies and Environment; insights from Uis, Namibia.

Hilya Ndeyapo AMUKWA[1]*, The Geological Survey of Namibia / Federal Institute of Geosciences and natural science (BGR) Ministry of Mines and Energy (hamukwa@gmail.com)
Absai Vatuva[2], University of Namibia

Abstract

The mining industry plays a substantial role in improving the quality of life by creating jobs, skills and knowledge, contributing to the Gross Domestic Products and Foreign Direct Investment, improving infrastructures, public health services, education and government revenues. However, there are volumes of studies on negative socioeconomic (e.g. ghost towns) and environmental consequences of mining which are mostly considered as base in determining the level of sustainability of mining activities. Thus, the information at hand is biased and often mislead the regulators and public at large. The thriving settlement of Uis is here in under study for what seems to be related economic activities of the mining settlement with respect to the Mine Closure Framework of the Chamber of Mines and Ministry of Mines and Energy. The Uis settlement was established in 1958 as workers' settlement to exploit tin deposits. The study is based on a detailed review of available literature and field observation. In addition, a qualitative approach was adopted that included interviewing key stakeholders in the about the extent of their awareness on tailing management/mine closure framework and plans for contribution in the economic growth of the settlement. Positive impacts that can result from sustainable tailings management practices on downstream economies as observed in Uis include the brick making industry where unique processes is used to extract clay from old mine slime dams to produce high strength quality bricks under environmentally friendly conditions. The tailings ensure a stable supply of bricks making raw materials and thus at the same time rehabilitating the mine. The water filled old pits in Uis serve as tourist attraction site and fish farming for local communities. Furthermore, other old tailings can be exploited for critical metals such us lithium that were previously not considers. While the activities in the Uis settlement may be coincidental to the Mine Closure Frameworks, such downstream economic diversification in Uis may be exemplary to establishing smart and thriving mining towns.

Keyword

Tailings, Sustainable Environmental Management, Downstream Economies, Uis Tin Mine, Responsible Mining

The Lower Paleozoic strata in the Baltic Syneclise (NE Poland) – reconstruction of paleoenvironmental conditions based on the distribution of biomarkers

Pawel KOSAKOWSKI[1]*, AGH University of Krakow (kosak@agh.edu.pl)
Adam Zakrzewski[2], AGH University of Krakow
Jan Pańczak[3], AGH University of Krakow

Abstract

The Baltic Basin (BS) is situated along the western edge of the East European Craton and comprises several regional tectonostructural units. The Polish onshore part of BS is called the Peribaltic Syneclise. The thickness of the Early Paleozoic deposits to the east of the basin ranges from 500m, increasing to approximately 4000m in the west, close to the Teisseyre-Tornquist Zone. Geologically, the Baltic Syneclise is a bridge between the East and West European platforms.

The Ordovician and Silurian deposits contain relatively homogeneous type II and I kerogens. In analyzed deposits, the most abundant n-alkanes were n-C17, n-C18, and n-C19. This type of n-alkane distribution is associated with the aquatic phytoplankton-origin organic matter.

To evaluate the content of bacterial and algal input in the analysed samples, a regular steranes/17a hopanes ratio was also calculated. Hopanes are linked to bacterial inputs, and steranes are linked to algal inputs. Hence, the results above 1 indicate an advantage of algal over bacterial input. Redox conditions play a crucial role in preserving the original steranes/17a hopanes ratios. When deposition occurs under anaerobic conditions, the ratio should provide proper results. In cases where aerobic degradation was observed, the ratio might be underestimated, as during the destruction of steroids, the heterotrophic and methylotrophic bacteria produce hopanoids.

In the Silurian deposits, the bacterial input played a greater role than the algae in organic matter origin. Algal input played an integral role in the Ordovician.

Among bacterial phytoplankton, the cyanobacterial presence was noted as 7- and 8-monomethylheptadecanes were marked in all samples. Most of the samples did not contain okenane, isorenieratane, b-carotane diaryl isoprenoids, and aryl isoprenoids, indicating that bacterial input is not linked with sulphur-reducing bacteria. Diaryl isoprenoids were observed only in single samples, suggesting the presence of their within the oxygen-depleted photic zone.

The sterane distribution in the Silurian deposits exhibited a higher content of C29 steranes, which in this case can be linked primarily with a higher content of green algae with potential terrestrial organic matter admixture. Additionally, all Ordovician samples contain cyclohexylalkanes, which might be interpreted as a Gloeocapsomorpha Prisca algae fingerprint.

Organic matter in the Silurian deposits contains potentially little terrigenous input. The presence of retene links e.g., with primitive bryophytes supports this hypothesis. However, it must be noted that retene was also found in Cambrian deposits (sourced from green algae). Moreover, some samples contain perylene, which is typically linked with fungi. All Ordovician and Silurian samples contained dehydroabietate-acid methyl ester (DAME), which is a compound normally

linked to conifers. Its presence is unusual in the Ordovician and Silurian samples. DAME may be a reflection of cyanobacterial activity.
The distribution of biomarkers in the Ordovician rocks can be an indicator of the basal Katian global cooling event in dysoxic bottom water conditions. In turn, the distribution of biomarkers in Silurian rocks indicates that they may reflect a global anoxic phenomenon linked with mass extinctions, e.g., the Ireviken Event.
The studies were financed by the National Science Centre, Poland (no. 2016/21/B/ST10/02079) and AGH University of

Keyword

biomarkers, paleoenvironmental conditions, global cooling event, Lower Paleozoic

Dr

Qian Jiang[1]*, Institute of Earth Environment, Chinese Academy of Sciences (jiangqian@ieecas.cn)
Guohui Li[2], Institute of Earth Environment, Chinese Academy of Sciences

Abstract

The annual average mass concentration of NO2 decreased by only 3% in China, from 29.3 μg m-3 in 2015 to 27.7 μg m-3 in 2019. There is even a trend of worsening pollution in the Pearl River Delta. The reason is that NO2 pollution is related to transportation emissions, whose contribution to NO2 reaches 30-80% in China. The North China Plain (NCP) has densely populated urban agglomerations, with constantly growing populations and increasing traffic volume. Therefore, it is a crucial research area for NO2 exposure risk. The reduction effect of emission control on NO2 concentration is not significant, and the NO2 concentration remains at 48.3 μg m-3 in the 2019 winter in North China Plain. However, as an important factor of respiratory risk, the relationship between NO2 exposure and respiratory outpatient visits has rarely been studied in China. Based on the Generalized Additive Model with the dual pollution lag model, the respiratory outpatient visit dataset is used to evaluate health related risk (RR) and excess risk (ER). The RR value with a 6-day delay is 1.052 (95% CI: 1.038, 1.066) and the ER value is 5.18% (95% CI: 3.75%, 6.63%). There is a highly significant correlation and lag between NO2 exposure and the number of respiratory outpatient visits. Combining the NO2 concentration simulated by the WRF-Chem model explore the temporal and spatial distribution of excess number of outpatient visits. The results show that urban areas exhibit a significant burden of health risks. This study emphasizes the importance of controlling NO2 pollution in urban areas for public health.

Keyword

NO2, GAM, WRF-Chem, Health risk, North China Plain

Estimative engineering geological zoning for the disposal of municipal solid waste

Olga Nikolaevna EREMINA[1]*, Sergeev Institute of Environmental Geoscience RAS (o_eremina@mail.ru)
Irina Vladimirovna Kozliakova[2], Sergeev Institute of Environmental Geoscience RAS
Elizaveta Romanovna Romanova[3], Sergeev Institute of Environmental Geoscience RAS
Aleksandra Gayarovna Khairedinova[4], Institute of Geography, Russian Academy of Sciences
Elena Sulikovna Chutkerashvili[5], Sergeev Institute of Environmental Geoscience RAS

Abstract

Disposal of municipal solid waste (MSW) in the geoenvironment and choosing suitable locations for arrangement of landfills appears to be an urgent global problem. Upon solving this interdisciplinary multi-criteria problem, geological factors are usually underestimated or ignored. The study is aimed at working out the methodology of assessing the geoenvironment favorability for allocation of MSW landfill facilities within ancient geological platforms by the example of the Moscow region, Russia. The method is based on estimative engineering geological zoning and building estimative maps of geoenvrionment favorability. At the first step of research, the geological cross-section in Moscow area was assessed from the standpoint of its ability to provide a natural protective barrier from pollutants generated by MSW landfills. In Moscow region, the geoenvironment protection is mainly ensured by the presence of persistent by strike and thickness,low-permeable strata of preQuaternary (midJurassic clay) and Quaternary (glacial moraine) age. Two types of preQuaternary and three types of Quaternary massif structures were distinguished according to the presence and number of impermeable geological layers, and their observed combinations resulted in 8 types of geological massifs. The generalized lithological columns were built for all ground massif types showing layers of different water permeability to a depth of about 50m. At the second stage, two auxiliary information layers for preQuaternary and Quaternary deposits were compiled in the QGIS code (to a scale 1:200 000) and their superposition permitted us to compile a digital map of typological engineering geological zoning of the studied region in accordance with the developed typification. The next research stage involved ranking the ground massif types according to the categories of suitability for allocation of MSW landfills and performing the special estimative engineering geological zoning and mapping. The estimative zoning of the Moscow region for the disposal of MSW was aimed at ranking the territory according to the complexity of carrying out waste-management measures. We assume that zoning should be based on warnings for the relevant authorities and companies about the problems they may face when placing landfills in a particular area rather than on prohibitions. All ground massifs identified upon typification were classified as favorable, conventionally favorable and unfavorable categories in terms of MSW disposal. The spatial distribution of territories showing different favorability categories was shown on the map of estimative engineering geological zoning for the allocation of MSW landfills. This map gives us an idea of the possible difficulties upon waste disposal in a particular area. Thus obtained cartographic

assessment of territory suitability for MSW disposal, in our opinion, looks easy and understandable. It may be used by decision-makers for the general multi-criterial assessment as an individual informational layer. At the same time, the proposed typification of geoenvironment makes allowance for the main specific features of the geological structure in the considered area.

This study was financially supported by the Russian Science Foundation, project no.22-17-00045.

Keyword

MSW landfills, disposal of municipal solid waste, estimative engineering geological zoning, favorability of geological conditions, natural protective barriers

Spatial Analysis and Probabilistic Risk Assessment of Heavy Metal Contamination in Urban Soils: A Case Study from Seoul, South Korea

Hyunsoo Seo[1]*, Korea University (sallyseo2000@korea.ac.kr)
Kyoung-Ho Kim[2], Korea Environment Institute, Environmental Assessment Group
Jaehoon Choi[3], Korea University
Jin-A Kim[4], Seoul Metropolitan Government Research Institute of Public Health & Environment
Je-Seung Lee[5], Seoul Metropolitan Government Research Institute of Public Health & Environment
Seong-Taek Yun[6], Korea University

Abstract

Urban landscapes have drastically changed due to excessive construction, including excavations and developments below ground. Concurrently, this transformation has led to alterations in the natural state of environmental media, such as soil, predominantly through the emission of various pollutants. Among these pollutants, heavy metals like copper (Cu), zinc (Zn), arsenic (As), and lead (Pb) play a crucial role in environmental assessments due to their lasting impact on both ecological and human health risks. This study aims to provide a detailed evaluation of the source, distribution, and contamination levels of these heavy metals, utilizing analysis data from 2,957 locations within Seoul, South Korea, one of the world's most rapidly expanding metropolitan areas.

Statistical methods such as the additive log-ratio transformation-expectation maximization (EM) algorithm were used to process left-censored data below the limits of detection. Through variogram analysis and ordinary kriging, we mapped heavy metal concentrations on a 100m grid, uncovering specific spatial patterns: elevated concentrations of Cu, Pb, and Zn were predominantly found in the southwestern regions of Seoul, while As levels were additionally higher in the northeastern parts. These findings suggest the significant role of land use in determining heavy metal dispersion in the city.

To investigate the uncertainties of the heavy metal concentration predictions, we conducted Sequential Gaussian Simulation (SGS) a thousand times. This approach gave us a probabilistic perspective on soil contamination levels. Moreover, we mapped the distribution of vulnerable populations (elderly and infants) against the total population to identify exposure risks. Analysis indicated a higher ratio of the elderly population in the northern and southeastern regions, with a higher infant population ratio in the central and southeastern areas of Seoul. Integrating these demographic maps with our heavy metal data and utilizing the USEPA framework, we evaluated potential health impacts through hazard indices for each group.

This comprehensive spatial and probabilistic risk assessment of heavy metal contamination in urban soils provides invaluable insights into the characteristics, distribution, and exposure risks of these pollutants. The results underscore the need for targeted risk reduction strategies in cities, emphasizing the integration of environmental and demographic data for comprehensive urban health risk assessments. This research offers crucial insights for developing informed policies and actions in metropolitan regions, targeting the protection of public health and the environment.

<Acknowledgements> This study was supported by the Korea Environment Industry & Technology Institute (KEITI) through the project ‘Integrated environmental forensic approaches to trace source and pathways of subsurface contaminants (2021002440003)’, funded by the Korea Ministry of Environment (MOE), and the Institute for Korea Spent Nuclear Fuel (iKSNF).

Keyword

heavy metal contamination, urban soil, risk assessment, spatial analysis

Assessment of Current Water Quality Status of Rivers near Two Major Cities in Myanmar

Arkar SAN[1]*, Kangwon National University (arkarsan2013@gmail.com)
Hyunook KIM[2], University of Seoul
Heejung KIM[3], Kangwon National University

Abstract

Water resources in Myanmar are gradually being threatened by localized pollution problems resulting from various economic development activities. The government of Myanmar recognizes the importance of protecting the country's water resources in the development process and some basic policies and regulations relating to water resources management have recently been developed and relevant government ministries are striving for enforcement. When it comes to water quality management of fresh water sources (rivers, streams, etc.), enforcing the regulatory instruments, such as quality standards, requires regular inspection and monitoring of water quality through water quality monitoring network established on major rivers. However, none of the responsible ministries are capable of monitoring river water quality on a regular basis. The scope of the research is mainly focused on assessing current water quality status of rivers near two major cities of Myanmar: Yangon and Mandalay. Based on the water quality data obtained from analyzing water samples collected from those rivers, the research can assess the current status of rivers near Yangon and Mandalay. The research can also make recommendations for taking actions to monitor and inspect changes in water quality to prevent the rivers from pollutions through the establishment of national level water quality monitoring program consisting of a laboratory and monitoring stations.

Acknowledgement
This work is financially supported by the Korea Ministry of Environment (MOE) & Korea Environmental Industry and Technology Institute (KEITI) as "Global Environment Scholarship Program (GESP)". This research was funded by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (grant numbers 2019R1I1A2A01057002 and 2019R1A6A1A03033167)

Keyword

Water resources, Pollution, River Water, Water Quality

CO2 measurement with high spatiotemporal resolution using low-cost sensors in urban Seoul, South Korea

JaeYoung PARK[1]*, Seoul National University (jypark1101@snu.ac.kr)
JeongEun Kim[2], Seoul National University
Jinho Ahn[3], Seoul National University

Abstract

Carbon dioxide (CO2) is the most important anthropogenic greenhouse gas, and is the most prominent cause for the ongoing climate crisis. Urban areas contain a majority of the world's poulation, and this leads to disproportionate utilization of resources and emission of CO2. Due to highly diverse land use of the urban areas, surface CO2 concentration show significant spatiotemporal variability. This can lead to challenges in accurately estimating CO2 emission of cities using a top-down approach. Furthermore, previous studies about bottom-up methods of estimating carbon flux show considerable uncertainties.

In this study, we utilized low-cost NDIR CO2sensors assembly to measure CO2 concentration in high spatiotemporal resolution. Since low-cost NDIR sensors are prone to high degree of deviation from the true concentration, the measured values were subjected to a post-procedure calibrating step for baseline error, humidity, and temperature, using a high-performance NDIR sensor for measuring accurate CO2 concentration. We found that the sensor assembly's data and the smoothed high-performance sensor data correlated well. After correcting the low-cost sensors, we have reduced the average RMS of the sensors to 5ppm.

We also present a visualization of CO2 concentration. By plotting the measurement over the map of the region, locations with high or low CO2 concentrations can be easily spotted. We observed a high concentration of CO2 and heavy fluctuations around traffic junctions and crossings.

Keyword

CO2, Measurement, Data visualization

Regional features of ecological-geological systems of rock massifs in Kamchatka

Violetta SHANINA[1]*, Lomonosov Moscow State University (violettav@inbox.ru)

Abstract

The purpose of the study is to characterize the regional features of the ecological-geological systems of rock massifs in Kamchatka, compiled on the basis of the author's own field research (ten field seasons) and published literature data. The abiotic components of the upper structural layer of the geological section characterize the Quaternary stage of development of the Kuril-Kamchatka island arc and are composed of rocks of Pleistocene-Holocene age, lava flows from basalts to dacites and tuffs of a similar chemical composition. According to their properties, rocks are divided into several groups: 1) massive andesites - dense (2.42-2.51 g/cm^3), with a low density of the solid component (2.64-2.76 g/cm^3) (well consistent with their composition – SiO2 content (62.7-64.1%)); 2) basalts - medium: density (2.23-2.25 g/cm^3), porosity (21-24%), absolute permeability (0.30 mD); 3) porous basalts - low density (0.97-1.73 g/cm^3) and strength (7-12 MPa), maximum: porosity (40-66%); 4) silty tuffs: density 1.40-1.57 g/cm3, density of the solid component 2.70-2.72 g/cm3, porosity 42.2-48 .2%; 5) fine psephitic tuffs are dense (ρ = 1.59-1.80 g/cm3), density of the solid component is 2.72-2.78 g/cm3, porous (33.8-42.7%); 6) pumice tuffs are characterized by the lowest density (ρ=0.98-1.35 g/cm3) and the highest porosity (n=49.8-63.5%). The edaphotope: the ecological and geological systems of rock massifs in Kamchatka include volcanic soils, which are formed mainly under grassy stone-birch forests on volcanic loose layered deposits of varying thickness and composition under conditions of periodic new ash inputs. The thickness of soils located on the tops of positive forms is usually 1.5-3 times less than on their slopes and depressions, which indicates the redistribution of freshly fallen ash along the slope, not yet held together by plant roots. Biotic components: microbial communities are widespread in surface waters, including facultative autotrophic and heterotrophic bacteria, cyanobacteria, sulfate-reducing bacteria, filamentous organisms, and microscopic fungi. The phytocenosis: the vegetation includes about 1,200 species of vascular plants. Including more than 100 species of trees, shrubs, subshrubs, shrubs and other plants with woody stems. Of the trees, the most common species is the Erman birch, or stone birch. The zoocoenosis: the mammal fauna includes more than 40 species; birds - more than 250 species, almost 150 of them are nesting. The poverty of species composition, the absence of a number of families and genera common in neighboring continental territories, as well as endemic species, is due to the history of the Kamchatka Peninsula, characterized by processes that negatively influenced the formation of biodiversity in the past (marine transgressions, relief transformations, active volcanic activity, ice ages and subsequent followed by changes in landscape appearance, etc.). The ecological-geological systems formed on the rock massifs of Kamchatka are a complex formation. The most important features of ecological-geological systems are mainly determined by their lithogenic basis - rocky soils (andesites, basalts and dacites), which have specific properties. The composition and properties of the lithotope largely determine the properties of the edaphotope and

the species composition of phytocenoses and have less influence on the zoocenosis.

Keyword

ecological-geological systems, Kamchatka, rocks, basalts, composed

Spatiotemporal characterization of iron and manganese distribution in a stratified aquifer during in-situ chemical oxidation operation

Seoyoung SON[1]*, Dept. Earth, Environmental & Space Sciences, Chungnam National University (sys3524@cnu.ac.kr)
Sungmin Park[2], Dept. Civil and Environmental Engineering, Hanyang University
Jae-Woo Park[3], Dept. Civil and Environmental Engineering, Hanyang University
Bongho Son[4], GNS Engineering
Wonmi Kim[5], GNS Engineering
Heewon Jung[6], Dept. Geological Sciences, Chungnam National University

Abstract

In-situ chemical oxidation is a remediation method that involves injecting oxidants into contaminated aquifers to remove contaminants by facilitating geochemical reactions such as precipitation, adsorption, and decomposition of contaminants. This study utilized a reactive transport modeling approach to characterize the precipitation of iron hydroxides and manganese sorption during the injection of oxygenated water under various flow conditions. When horizontal flow of the oxygenated water is induced within a highly permeable layer of a stratified aquifer, a relatively small volume of ferric hydroxide precipitation occurs exclusively within the layer. Furthermore, the injected water reaches the withdrawal well before being fully consumed, and it mixes rapidly with the indigenous groundwater containing a high concentration of dissolved iron, leading to the concentrated precipitation of ferric hydroxides near the withdrawal well. In comparison, when wells are positioned at different depths inducing vertical flows, more ferric hydroxides precipitate within the domain due to the larger interfacial area between the injected water and surrounding groundwater. The injected oxygen is consumed completely before reaching the withdrawal well due to enhanced mixing within the aquifer, and hence no substantial precipitation of ferric hydroxides near the withdrawal well is observed. The simulation results also illustrate that reduced pH due to ferric hydroxide formation causes overall desorption of manganese despite increased sorption surface of ferric hydroxides. These simulations result indicate the importance of rigorous consideration of hydrogeochemical processes for the success of in-situ groundwater remediation projects.

Keyword

In-situ chemical oxidation, reactive transport model, heavy metal removal

Assessment of heavy metal pollution in marine sediments around southern waters of Gyeonggi Bay

Hyerim LEE[1]*, Pukyong National University (hyerim_lee@pukyong.ac.kr)
Seonggan Jang[2], Pukyong National University
Seongwoo Jeong[3], Pukyong National University
Minjune Yang[4], Pukyong National University

Abstract

In the marine environment, heavy metals can adsorb and precipitate onto marine sediment particles, resisting degradation in nature. Moreover, these metals have the potential to bioaccumulate through the food chain, posing health threats to humans. This study evaluated heavy metal pollution and environmental risk by analyzing the content of heavy metals in marine sediments in the southern waters of Gyeonggi Bay, South Korea, adjacent to a large-scale industrial complex. Sampling was carried out at 14 sites to measure concentrations of As, Cd, Cr, Cu, Ni, Pb, and Zn. The total heavy metal content was determined using an Inductively Coupled Plasma Mass Spectrometer (ICP-MS, iCAP Pro X, Thermo Fisher Scientific) at the Integrated Analytical Center for Earth and Environmental Sciences after pretreated samples using a mixed acid solution (HF:HNO3:HClO4 in a 4:4:1 ratio). Pollution and risk assessments were conducted using the Geo-accumulation Index (Igeo), the Korea Sediment Quality Guideline (SQG), and the Ecological Risk Index (ERI). The results indicated that the Igeo was less than 1 at all sampling sites, suggesting no contamination. According to the ERI, all elements were classified as having a 'LOW' impact rating on the benthic ecosystem. However, concentrations of Cu and Zn exceeded the Threshold Effects Level (TEL) at five sites (Cu average: 21.9 mg/kg; Zn average: 76.5 mg/kg), slightly surpassing the SQG (Cu: 20.6 mg/kg; Zn: 68.4 mg/kg). These findings confirm the current low level of heavy metal pollution in the study area. Nonetheless, the continuous influx of pollutants from nearby industrial complexes may pose future risks to the marine environment and human health. Thus, sustainable management and continuous monitoring of the marine environment are recommended.

Keyword

Heavy metal, Geo-accumulation Index, Sediment Quality Guideline, Ecological Risk Assessment, Marine sediment

Tracking tobacco-specific nitrosamines (TSNAs) source in fertilizer: an environmental forensic approach

Min-Hui Son[1]*, National forensic service (NFS), Chemistry division (sonmh07@korea.kr)
Hyun Jee Kim[2], National forensic service (NFS), Chemistry division
Yuna Kim[3], National forensic service (NFS), Chemistry division

Abstract

Tobacco-specific nitrosamines (TSNAs) generated from tobacco alkaloids (i.e., nicotine) are one of carcinogens and these are representative compounds shown in tobacco products. Among seven TSNAs including N'-nitrosonornicotine (NNN), 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanon (NNK), N'-nitrosoanabasine (NAB), N'-nitrosoanatabine (NAT), 4-(methylnitrosamino)-1-(3-pyridyl)-1-butanol (NNAL), 4-(methylnitrosamino)-4-(3-pyridyl)-1-butanol (iso-NNAL) and 4-(methylnitrosamino)-4-(3-pyridyl) butanoic acid (iso-NNAC), NNN and NNK are group I carcinogens and it is easily detected in commercial tobacco, e-cigarettes and even mainstream smoke. However, there was no report on measurement of TSNAs in secondary processed products of tobacco dregs and this study was designed to detect TSNAs in that. In a small village in Korea from 2001 to 2017, tobacco-leaf residues were illegally utilized to produce fertilizer and 17 of residents have lost their lives with various forms of cancer during this period. In general, dregs of tobacco leaves cannot be used as a raw material of fertilizer due to the carcinogenicity of TSNAs. Therefore, we tried to track TSNAs source of the fertilizer by investigating 10 different tobacco products produced from 4 manufacturers. In this study, we firstly measured levels of TSNAs in the fertilizer to prove the use of tobacco dregs and contrasted the distributional patterns of TSNAs between fertilizer and tobacco products by applying heat. In conclusion, levels of all TSNA compounds were increased by heating process and the proportion of NNN, NNK and NAB was high, except for NAT.

Keyword

Tobacco-specific nitrosamines (TSNAs), carcinogens, fertilizer, pollution source

The relationship between the intensified heat waves and deteriorated summertime ozone pollution in the Beijing–Tianjin–Hebei region, China, during 2013–2017

Ruonan WANG[1]*, Institute of Earth Environment, Chinese Academy of Sciences (wangruonan@ieecas.cn)
Guohui Li[2], Institute of Earth Environment, Chinese Academy of Sciences

Abstract

Summertime ozone (O3) pollution has frequently occurred in the Beijing–Tianjin–Hebei (BTH) region, China, since 2013, resulting in detrimental impacts on human health and ecosystems. Increasing O3 in BTH has been partially attributed to the mitigation of precursor emissions and deceased particulate matters which slow down the hydroperoxyl radical absorption on aerosol surfaces. However, the contribution of weather shifts to O3 concentration variability owing to climate change remains elusive. By combining regional air chemistry model simulations with near-surface observations, we found that anthropogenic emission changes contributed to approximately 23% of the increase in maximum daily 8-h average O3 concentrations in the BTH region in June–July–August (JJA) 2017 (compared with that in 2013). With respect to the weather shift influence, the frequencies, durations, and magnitudes of O3 exceedance were consistent with those of the heat wave events in the BTH region during JJA in 2013–2017. Intensified heat waves are a significant driver for worsening O3 pollution. In particular, the prolonged duration of heat waves creates consecutive adverse weather conditions that cause O3 accumulation and severe O3 pollution. Our results suggest that the variability in extreme summer heat is closely related to the occurrence of high O3 concentrations, which is a significant driver of deteriorating O3 pollution.

Keyword

ozone pollution, emission changes, weather shift, heat wave

Environmental pollution problems in the mining regions

Elena Nikolaevna LEVCHENKO[1]*, FSBI IMGRE (lev_imgre@rambler.ru)
Igor Gennadievich Spiridonov[2], FSBI IMGRE

Abstract

Intensive economic development entails an inevitable increase in the mineral consumption. In this regard, the increase in mineral production during the last century, a sharp increase in the mining activities contribut-ed to the accumulation of mining waste and man-made pollution of ecosystems. Besides, despite the obvi-ous benefits of mining for the benefit of man, on the other hand, it is also a powerful source of environ-mental hazards.

The mineral deposits' mining alters the basic physicochemical properties of the lithosphere, including its major functions, i.e., geodynamic, geophysical, resource, and geochemical. The study of changes in the ecosystem's parameters during the life period of a mine is one of the key goals of an ecological-geochemical assessment.

The environmental monitoring should be carried out at all stages of the mining area's life, from exploration to mining, and further reclamation of disturbed lands and until the site becomes completely stabilized.

Ecological and geochemical studies make the basis of this paper, including the identification of areas of environmental pollution by toxic substances, assessment of their extent and chemistries; assessment of po-tential geochemical endemicity; zoning of the territory by its pollution level and the degree of environmental hazard, identification of the pollution sources; identification of potential man-made objects; ecological and geochemical monitoring and forecast of the development of negative processes; development of recommendations for the rehabilitation of areas of poor ecological condition; identification of populations with an increased risk of morbidity. The result of these studies is the compilation of ecological and geochemical maps portraying the ecological status of the territory.

The study of the environmental health is carried out in the following main areas:

mapping of the man-made pollution in soil and snow cover; establishment of the response characteristics of the plants to pollution of the soil pollution; geochemical studies of ground / surface water and stream sediments; analysis of the atmospheric air chemistries, precipitation and aerosols, as well as the industrial waste materials as sources of environmental pollution and potential objects for the extraction of secondary raw materials; relationships of environmental pollution and health indicators of the population living in the pollution hot spots.

Keyword

environmental safety, geological risks, public health

Arsenic contamination in ground water, mechanism and role of subsurface sediments for high arsenic concentration, in the Flood Plain of Ghaghara River, Uttar Pradesh. India

Abhinandan SRIVASTAV[1]*, Geological Survey of India (a.srivastava@gsi.gov.in)
Nikhat Naim[2], Geological Survey of India

Abstract

Contamination of groundwater, either from anthropogenic or natural sources with several social impacts, has now turned to be a major environmental concern in different parts of the world. Elevated level of Arsenic in groundwater has been well documented in Chile, Mexico, China, Argentina, USA, and Hungary as well as in several states of India (Smedley and Kinniburgh 2002; Bhattacharya et al., 2002). Arsenic, a well-known carcinogen, is considered as one of the world's most hazardous chemicals (USEPA 2001).

The ground water shows elevated level of Arsenic concentration in the Flood Plain of Ghaghara River, India, collected from shallow (5-15m) and deeper depth (20-45m). The groundwater of the study area is Ca-Mg-HCO3 dominant type and feebly alkaline with average pH value of 7.73. The (Ca + Mg) versus the total cations (Tz) reflects the abundance of Ca and Mg in groundwater. The average (Ca + Mg)/Tz ratio is 0.77 while the average (Na + K)/Tz ratio is 0.22 indicating that the contribution of cations into groundwater from carbonate weathering. Arsenic in groundwater exists primarily as oxy anions representing two oxidation states arsenite and arsenate (Ferguson, 1972; Cullen & Reimer, 1989). In order to investigate the mechanism of Arsenic release, the oxidation–reduction potential of the ground water has also been tested. The present study reveals that the groundwater from Holocene Newer Alluvial aquifers located close to abandoned channels or meander scars, at depth range of 20-45 m are more As-contaminated than the surrounding areas. The ground water, collected from the area exposing Newer Alluvium, mostly shows arsenic concentration above the acceptable limit of 10 ppb and negative ORP value (-7 to -175 mV; reducing condition) both at shallower and deeper depth. In the area which exposes the Older Alluvium the ground water mostly in oxidizing condition showing positive ORP value in the range of +10 to +270 mV and arsenic concentration was within the acceptable limit except at few places. The negative ORP values in ground water in some places were also noted exposing the Older Alluvium. In these area, the ground water does not show high arsenic concentration but mostly reddish in colour. The reducing condition in this area, favors the iron oxidation and change from Ferric oxides (insoluble Fe3+) to Ferrous Oxides (soluble Fe2+). The correlation of Arsenic concentration with the oxidation–reduction potential of the ground water indicates that the reducing environment favors the release of arsenic in the ground water from sediments that remain in sorbed state on the iron oxides surface in these sediments. Arsenic concentration in core sediments varies from 19 ppm to 285 ppm with an average of 124 ppm. XRD analysis indicate presence of lead arsenate Jordanite (Pb14As6S23) at the depth of 9-11 m in nonmagnetic fraction of coarse micaceous sand and Nealite (Pb4 Fe (AsO4)2Cl4) and Arsenolite (As2O3) at depth of

33-35 m in magnetic fraction of coarse sand. Scanning Electron Microscopy of the core sediments shows that the arsenic is mainly occurs in association with oxides of Fe, Si, Al, Mg and Cr

Keyword

Arsenic contamination, Ground water, Ghaghara River Basin, Environmental Hazard, Subsurface sediments

Composition and size distribution of wintertime inorganic aerosols at ground and alpine regions of northwest China

Haijiao Liu[1]*, Xi'an Institute for Innovative Earth Environment Research (liuhj@ieecas.cn)
Xingxing LIU[2], Institute of Earth Environment, Chinese Academy of Sciences
Jianjun Li[3], Institute of Earth Environment, Chinese Academy of Sciences

Abstract

Water-soluble ions (WSIIs) serve as indicators of atmospheric pollution sources, typically constitute 20% to 80% of the total mass concentration within PM2.5. WSIIs play a pivotal role in atmospheric chemical reactions, particularly influencing the formation of secondary particulate matter. Alpine regions experience a distinct atmospheric conditions characterized by low temperature, high humidity, and strong solar radiation, differing from those in lowland areas. A comprehensive grasp of the vertical distribution of WSIIs in atmospheric particles holds immense significance in understanding the diffusion and transportation of these pollutants. This study investigates the WSIIs of PM2.5 and size-segregated particles at the top (~2060 m a.s.l) and foot of Mt. Hua during the winter of 2020. All the measured ions present significant higher concentrations (1.9~6.9 times) at the foot than the top. Cl− and K+ at the foot are more than 4 times of those at the top, whereas Ca2+ and Mg2+ are only 1.3-1.9 times higher. The particle size distribution of NO3−, SO42−, K+ and Cl− demonstrate a single peak distribution (0.7-1.1 μm) at the foot, but with a bimodal distribution (0.7-1.1 μm and 4.7-5.8 μm) at the top. These differences suggest that the aerosol at the alpine region is mainly transported via long-distance from Northwest/North China, but limited influenced by vertical transport through valley breeze. The changes of concentration and size distribution of WSIIs in dust event and non-dust period indicate that the effects of dust event on aerosols at ground surface were weaker than that of the free troposphere of Guanzhong Plain. Notably, our study underscores the dominant influence of NO3− in shaping the gas-particle distribution of ammonia within the winter free troposphere. Our results highlight the significant role of long-range transport on aerosols in the free troposphere in Guanzhong Plain, Northwest China.

Keyword

Water-soluble inorganic ions, Size distribution, Aerosol acidity, Ammonia, Free Troposphere

Occurrence and behavior of per- and polyfluoroalkyl substances (PFAS) and antibiotics in the hyporheic zone

Hyobin LEE[1]*, Kangwon National University (l_hyobin@kangwon.ac.kr)
Eunju Jeong[2], Kangwon National University
Jin-Yong Lee[3], Kangwon National University

Abstract

The release of chemical substances from industrial and domestic wastewater has been increasing over time, which has led to a rise in the presence of per- and polyfluoroalkyl substances (PFAS) and antibiotics in rivers. PFAS are synthetic compounds that have excellent thermal and chemical stability and are used in various applications such as food packaging, textiles, and coatings. Due to their persistent nature, low biodegradability, and high bioaccumulation potential, they can remain in the environment and human's body for an extended period if introduced into rivers. Additionally, antibiotics from pharmaceutical waste contribute to the promotion of antibiotic resistance genes in natural bacteria in rivers, leading to ecological disruption. These chemical substances have recently become a global concern due to their carcinogenicity, toxicity, and persistence. Despite their widespread presence in the environment, our current knowledge of contamination in the hyporheic zone, an ecologically crucial area, is still lacking. This study aims to investigate the distribution and behavior of PFAS and antibiotics in the hyporheic zone, where interactions occur between surface water and groundwater. Samples were collected from different points along the river, including upstream, midstream, and downstream points, as well as from groundwater wells to trace the pathways of contaminants accurately. Experiments were conducted based on seasonal climate conditions, distinguishing between dry and wet periods. This research is expected to have significant implications for sustainable environmental and water resource management and can be used as fundamental data for understanding groundwater contamination.
This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

per- and polyfluoroalkyl substances (PFAS), antibiotics, hyporheic zone, pollutant, groundwater

EFFECTS OF ACID MINE DRAINAGE FROM COAL MINING ON WATER QUALITY IN THE ARARANGUÁ RIVER BASIN

Marlon Hoelzel[1]*, Geological Survey of Brazil - SGB/CPRM (marlon.hoelzel@sgb.gov.br)
Ana Maria Pimentel Mizusaki[2], Federal University of Rio Grande do Sul - URFGS
Anna Alice Couto Gomes[3], Geological Survey of Brazil - SGB/CPRM

Abstract

In the southern region of Brazil, coal mining has been going on for more than a century in the state of Santa Catarina, where the lack of environmental management in mining activities resulted in significant changes to the quality of surface and underground water resources in the local watersheds. Within this context is the Araranguá River Basin, whose substrate is made up of sandstone and pelitic sedimentary rocks of the Rio Bonito Formation, with Permian age. These rocks belong to the gondwanic interval of the Paraná Basin where there are several mining projects, many of them already exhausted, that have left as their legacy the presence of numerous abandoned mines and tailings piles that have caused intense changes in water quality due to the presence of sulphides which oxidize and result in the formation of acid mine drainage. The sedimentary units are usually silicified and are affected by ruptile tectonics resulting from the alkaline intrusion of the Lages Dome. This geological context, combined in part with pillar mining, leads to various episodes of collapses and subsidence of underground mines and intensifies the fracturing of overlying rocks, thus amplifying the processes of interaction between aquifer systems and surface water bodies. In order to improve understanding of the impacts on water quality and underground flow conditions, groundwater samples from nine wells in the Rio Bonito Aquifer System, four wells in the Alluvial Fan Aquifer System and six surface water samples from the same micro-basins where the wells are installed were analyzed. The hydrochemical analyses indicated an original predominance of calcium and sodium bicarbonate waters, which are transformed into sulphate waters when they come into contact with acid mine drainage. The $\delta 2H$ and $\delta 18O$ isotopic values of the samples show similarities with the isotopic composition of current meteoric waters, contributing to the hypothesis of strong interaction between groundwater and surface water.

Keyword

hydrochemistry, stable isotopes, groundwater, acid mine drainage

Dust generated by e-waste processing: Impact of sample treatment and decomposition method on chemical and isotopic compositions

Eva Martinková[1]*, Czech Geological Survey (eva.martinkova@geology.cz)
Ondřej ŠEBEK[2], Czech Geological Survey
Alexandre ANDRONIKOV[3], Czech Geological Survey
Markéta ŠTĚPÁNOVÁ[4], Czech Geological Survey
Leona BOHDÁLKOVÁ[5], Czech Geological Survey
Jan ČUŘÍK[6], Czech Geological Survey
František VESELOVSKÝ[7], Czech Geological Survey

Abstract

The use of electrical/electronic equipment generates an enormous amount of e-waste. The technology of e-waste processing is very complex and technological lines are composed of many individual units. Consequently, a large amount of dust with extreme metal concentrations is produced. It has a very specific matrix and composition that differs from dust generated during other industrial activities and natural processes. The selection of decomposition method and sample processing are crucial for precise and accurate analytical measurements. Thus, the aim of the study was to find the most appropriate decomposition method of e-waste dust and to verify whether: i) sample pretreatment at different temperatures can cause the analyte leak and changes in the isotopic composition, ii) decomposition of samples with the use of different methods can affect concentration and isotopic results.

Samples were exposed to temperatures: i) 110 °C, ii) 550 °C, iii) 1050 °C and subsequently decomposed/leached by: i) aqua regia (HNO3, HCl in a ratio of 1:3), ii) concentrated acids HNO3, HClO4, HF, iii) fusion. Concentration analyses were performed by the ICP-OES Agilent 5110 and lead isotopes were measured by the MC-ICP-MS (Neptune).

In general, the most suitable decomposition methods with the highest yields were either decomposition by a mixture of concentrated acids with temperature pretreatment at 550 °C, or the aqua regia decomposition with temperature pretreatment at 110 °C. Element concentrations were as follows: 0.8 g kg-1 Cd, 24.1 g kg-1 Cu, 14.9 g kg-1 Pb, 24.7 g kg-1 Zn, 3.1 g kg-1 Co, 2.7 g kg-1 Ni, 35.9 g kg-1 Al.

We expected loss of the analyte in high temperature treatments associated with changes in isotopic composition of samples. At a temperature 550 °C with the aqua regia decomposition, only up to 61% Cd, 85% Cu, 45% Pb, 91% Zn were recovered compared to the highest yields. Nevertheless, there was no loss of the analyte during decomposition by concentrated acids and fusion. Similarly, at 1050 °C only up to 18% Cd, 20% Cu, 7% Pb, 9% Zn were recovered and again there was no analyte loss during fusion. We assume that there was no loss of the analyte due to its leak, but the effect of higher temperature resulted in the formation of difficult to decompose phases. Using the three isotope plot (206/207Pb vs 208/207Pb), samples decomposed by aqua regia at a temperature 110 °C and 550 °C were grouped in a separate cluster and differed in isotopic composition (average 206/207Pb, 208/207Pb values were 1.155; 2.437) compared to other values (206/207Pb,

208/207Pb were 1.154; 2.435 on average). Aqua regia (at 110 °C) seemed to be very efficient “decomposer” according to results of concentration analyses, however it probably did not release lead from the whole matrix of dust samples and it decomposed only easily accessible forms of lead. Our results show, that the most appropriate decomposition method is temperature pretreatment at 550 °C with subsequent decomposition by concentrated acids HNO3, HClO4, HF. This will be further verified on Cd and Zn isotopic systems.

Keyword

dust, e-waste, decomposition, concentration analyses, isotopes

State-of-the-art integration of digester, heating system and automation

Atta ur RAHMAN[1]*, Land Information and Management System (LIMS-COE)
(engineer.atta@yahoo.com)

Abstract

Pakistan faces an energy and economic crisis due abrupt increase in the population and mismanagement of available resources. The country is blessed with some energy resources. Beyond these available resources, biomass is a promising resource. Production of biogas from biomass is a famous technology all over the world. However, its adoption in Pakistan is less familiar due to the unavailability of standard design, winter choking, and temperature fluctuations. This study investigated two heating mechanisms in digesters and compared them with conventional (non-heating) digesters in winter. The two heating mechanisms include the PEX coil tubing inside the digester and the external water jacket. The experiment was recorded for one month in winter. Additionally, a low-cost automation system was introduced in both digesters to control the circulated water to maintain the required temperature. Results revealed that the jacketed digester produced 385.1 liters of biogas, the PEX tubing coiled digester produced 313.5 liters of biogas, and the conventional digester produced only 29.7 liters of biogas measured with the water displacement method digesting the same quantity of feedback. The conventional digester stopped after a few days working. The jacketed digester performed better than the other heating systems and was a promising technology for biogas production throughout the year. The study will help in the adoption of biogas technology in rural areas to meet their energy demands.

Keyword

Conventional digester, Heating Digester, Jacketed Digester, PEX Coiling Digester, Winter Biogas

Contribution of Geogenic Radon for Indoor Air Quality using Grey-Box Modeling

Yijune CHOI[1]*, Korea University Earth and Environmental Sciences (cosmos101@korea.ac.kr)
Soonjae LEE[2], Korea University Earth and Environmental Sciences

Abstract

Managing indoor radon concentration is necessary due to a carcinogenic risk of radon. The main pathway of indoor radon pollution is vapor intrusion from the subsurface to buildings and investigating its amount is important for designing effective management strategies. This study assesses the contribution of geogenic radon through a grey-box model approach. Monitoring data encompassing indoor radon concentrations, temperature, relative humidity, and atmospheric pressure were collected over a month. The grey-box model was established by integrating a signal processing system and a physical-based model. Parameters of the grey-box model were optimized to minimize the disparity between monitoring data and physics-based predictions and used for investigating the contribution. The average indoor radon concentration during the monitoring was 1,104 Bq/m^3, significantly surpassing the action level of 148 Bq/m^3. The grey-box model exhibited strong predictive performance for indoor radon concentrations. Investigation into the main factors influencing indoor radon concentration identified ‘advection of gaseous phase’ and ‘volatilization of aqueous phase’ as primary transport mechanisms for geogenic radon. The model’s estimation capabilities demonstrate promise in assessing the contribution of each transport mechanism, facilitating the development of optimized mitigation strategies. This approach offers for optimizing mitigation strategies for individual contributors, enhancing indoor air quality and reducing carcinogenic risk.

Acknowledgement
This work was supported by the National Research Foundation of Korea (NRF) grant funded by Ministry of Science and ICT, South Korea (NRF-2022R1A2C1093405).

Keyword

Radon, Vapor intrusion, Grey-box model, Parameter estimation

Development of Vapor Intrusion Risk Assessment Program for Urban Subsurface Environments

Min Seo BAE[1]*, Department of Earth and Environmental Sciences, Korea University (mstt1@korea.ac.kr)
Soonjae Lee[2], Department of Earth and Environmental Sciences, Korea University
Jae-Hyun Kim[3], Department of Earth and Environmental Sciences, Korea University
Yijune Choi[4], Department of Earth and Environmental Sciences, Korea University

Abstract

Vapor intrusion is the process in which VOC generated from soil contamination by PHC poses risks to the indoor residents/workers via vapor intrusion. In urban settings, risks caused by contaminated vapors are important compared to other pathways related to direct contacts to the contaminated water or soil. In this study, a risk assessment application for urban-specific vapor intrusion pathways was developed. Three major pathways were considered for the risk assessment: damped basement, tunnel dispersion, and volatilization through collector-well. The damped basement and volatilization through collector-well pathways evaluated the cases which contaminated groundwater enters the indoor spaces first through the wall or the collector-wells and then volatilizes. The tunnel dispersion pathway evaluated the dispersion of contaminated vapor from one indoor space to another one through a passage. Input characteristics including the source (e.g. chemical type, contamination concentration), investigated/assumed parameters of the pathways (e.g. volatilization factor, tunnel volume) and receptors (e.g. exposure frequency, length) were submitted. Default input values were offered and the users can change them if necessary, enhancing the user-friendliness of the program. As a result of the risk assessment, ‘cancer risk’, and ‘non-cancer risk’ are calculated, and the comparison of the risk level regarding the screening standards are identified. It is expected that this program can be used to support efficient preliminary contamination control and decision-making (selection of investigation methods and establishment of a remediation plans) in urban areas.

This work was supported by the National Research Foundation of Korea (NRF) grant funded by Ministry of Science and ICT, South Korea (NRF-2022R1A2C1093405).

Keyword

Vapor intrusion, Risk assessment, Damped basement, Tunnel dispersion, Collector well

New insights from landfill microbiome by genome-resolved metagenomics

So-Jeong KIM[1]*, Korea Institute of Geoscience and Mineral Resources (sojkim86@kigam.re.kr)
Wook-Hyun Nahm[2], Korea Institute of Geoscience and Mineral Resources
Min Han[3], Korea Institute of Geoscience and Mineral Resources
In-Hyun Nam[4], Korea Institute of Geoscience and Mineral Resources

Abstract

Landfills constitute a significant source of human-generated methane emissions on Earth. Therefore, there is a need to understand the microbial ecosystem within landfills that causes methane generation. Few studies of microbial ecology in landfills have been analyzed using next-generation sequencing (NGS) technologies, which have advanced dramatically in recent years. In this study, metagenomic analysis was used to investigate the roles and characteristics of microorganisms in landfills. Approximately 600 Metagenome-Assembled Genomes (MAGs) were obtained from samples at 9 different depths of landfill core drilling (16 m). Among bacterial taxa, Firmicutes (149), Bacteroidota (75), and Thermodesulfobacteriota (44) emerged as the predominant phyla, while Euryarchaeota (36) dominated within the Archaea. Notably, genes associated with polysaccharide degradation were predominantly attributed to the phyla Bacteroidota and Firmicutes, whereas genes linked to fatty acid degradation were primarily identified within Desulfobacterota and Planctomycetota. However, in the case of bacteria, the function of decomposing organic compounds was similar, but the dominant genus were different for each sample. On the other hand, in the case of Euryarchaeota, Methanoculleus, Methanoregula, and Methanothrix were found to be dominant. This study could be helpful in management and control of landfill, such as methane generation control, by understanding the microbial ecology within the landfill.

Keyword

landfill, metagenome, methane, methanogen

50 years of Lithologic Mapping and Mineral Exploration from Space

Michael ABRAMS[1]*, NASA/Jet Propulsion Laboratory (mjabrams@jpl.nasa.gov)

Abstract

Geologic remote sensing from space began in 1972 with the US launch of Landsat 1, with its 4-channel multispectral scanner. Early studies demonstrated the advantages of geologic mapping from the space perspective. The launch of Landsat 4 in 1982, with additional spectral bands and improved spatial resolution, meant geologists had a global tool that greatly improved geologic mapping of lithologies and structures. More importantly, the availability of data in two shortwave infrared (SWIR) bands allowed the gross detection of hydrothermal alteration minerals for reconnaissance resource exploration. It wasn't until 1999, when the Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) was put into orbit, that an instrument designed for geologic applications started acquiring global data, with 15-channels and stereo imaging capability for DEMs. The ASTER instrument is a joint project of Japan's Ministry of Economy, Trade, and Industry (METI) and US National Aeronautics and Space Administration (NASA). Since its launch, hundreds of studies have been published documenting the use of ASTER SWIR and thermal infrared (TIR) bands to discriminate and identify rocks and soils based on their mineral composition and makeup, and as an aid in reconnaissance exploration for non-renewable resources, particularly alteration assemblages associated with mineral deposits. ASTER's unique six SWIR bands reveal diagnostic absorption features in the 2-2.5 micron wavelength region. This allows mapping of clays (illite, montmorillonite, kaolinite, dickite), carbonates (dolomite, limestone), and sulfates (alunite, gypsum), and Mg-OH bearing minerals. ASTER's multispectral TIR bands allow discrimination and mapping of quartz content of rocks and minerals, and discrimination of silicate minerals, ranging from felsic to mafic. The next major improvement in spaceborne instruments, first proven with aircraft instruments, was hyperspectral instruments, having 200+ narrow spectral channels in the visible-to-shortwave infrared. Data from these instruments allow mineral identification almost matching laboratory measurements. Chinese HSI scanners have been in space for almost a decade. However, data is unobtainable outside China. The first freely available data were from Italy's PRISMA scanner, launched in 2019. This was followed in late 2019 by Japan's HISUI instrument. Germany's EnMAP scanner was put up in 2022. And the US EMIT instrument was operated onboard the Space Station since mid-2022. PRISMA, HISUI, and EnMAP have almost identical characteristics: 30 m spatial resolution, 30 km swath width, and limited daily acquisition capacity. However, they fulfill the promise of hyperspectral data for mineral identification, if only with limited coverage. NASA is planning the first global mapping mission in 2029 with the Surface Biology and Geology mission. Its VSWIR instrument will have 185 km swath width, and acquire constant, global coverage.

Work by Abrams was done at the Jet Propulsion Laboratory, California Institute of Technology, under contract with the National Aeronautics and Space Administration.

Keyword

remote sensing, mineral exploration, geologic mapping

[Keynote] CURRENT AND FUTURE HIGH-RESOLUTION THERMAL INFRARED- SATELLITE AND AIRBORNE- SENSOR SYSTEMS

Simon John HOOK[1]*, NASA/JPL (simon.j.hook@jpl.nasa.gov)

Abstract

Thermal Infrared (TIR) remote sensing has been used for a wide variety of research and applications from determining how much water farmers should put on their fields to mapping the mineralogy of exposed surfaces. TIR sensors typically acquire data between 8-12 μm in the electromagnetic spectrum. This spectral region is a relatively clear atmospheric window allowing the surface radiation to be observed together with any atmospheric attenuation and atmospheric contributions by the satellite- or airborne- sensor systems. The surface radiation consists of the surface temperature and emissivity, both of which can be extracted from the data using a variety of methods. Of particular use for mineral mapping are the emissivity data that relate to the composition of the surface. In the TIR part of the electromagnetic spectrum spectral features are related to differences in the Si-O bonding of any silicate minerals that may be present. Differences in Si-O bonding are manifest as shifts in the position of the minimum in the emissivity spectra of rocks in the TIR wavelength region. Variations in silicate mineralogy are useful for geologic mapping because they are an important criterion in classifying and interpreting igneous rocks, as well as the sedimentary and metamorphic rocks derived from them. Studies utilizing TIR data have demonstrated that it is possible to distinguish between rock types based on differences in silicate mineralogy. Greater spectral discrimination is possible the more spectral bands that are present in the TIR region. Further, high spectral resolution coupled with high spatial resolution is particularly valuable for mineral mapping where compositional differences occur over short physical distances.

Currently there are three high spatial resolution satellite TIR sensors (ASTER, ECOSTRESS and Landsat), however, only two of these (ASTER and ECOSTRESS) are multispectral having at least three TIR bands. ASTER and ECOSTRESS both have 5 thermal bands with spatial resolutions of 90 and 70 m respectively. There are also several airborne systems which may have many more spectral bands and even higher spatial resolution. Two widely used airborne sensor systems are HyTES and MASTER. HyTES has 256 spectral bands in the TIR and MASTER has 10. The spatial resolution of these systems depends on the flying height of the aircraft which is determined by aircraft capability. Both MASTER and HyTES fly on several aircraft and pixel sizes range from a few meters to less than 50 meters.

Both ASTER and ECOSTRESS are in extended mission with current end of life of 2027 and 2029 respectively. Several space agencies now have similar systems in development. These include TRISHNA, SBG and LSTM scheduled to launch in 2026, 2028 and 2030 respectively. These systems will be followed by Landsat-Next consisting of 3 spacecraft-sensor systems which together image the land surface every 5 days.

This presentation will summarize each of these systems and provide examples of how the current

systems are being used for geological studies.

Keyword

Thermal Infrared, TIR, ECOSTRESS, ASTER, HyTES

A Multiscale Hyperspectral Remote Sensing Approach for Detection of Petroleum Offshore

Carlos Roberto Souza Filho[1]*, University of Campinas (beto@unicamp.br)
Rebbeca Del'Papa Scafutto[2], University of Campinas
Cristina BENTZ[3], Petrobras

Abstract

Petroleum offshore detection is a critical task for environmental monitoring and resource management. This study presents a novel multiscale hyperspectral remote sensing approach tailored for detecting petroleum slicks in offshore environments. Leveraging advancements in hyperspectral imaging technology, our approach integrates data from multiple scales, ranging from satellite to unmanned aerial vehicle (UAV) platforms, to enhance detection capabilities. At the satellite scale, we utilize high spectral resolution hyperspectral images (e.g. EnMap) to capture broad spatial coverage of offshore areas. These images are processed using advanced algorithms to identify spectral signatures indicative of petroleum presence. Additionally, we incorporate data from a field scale leak experiment using UAV platforms equipped with hyperspectral sensors to achieve finer spatial resolution and improve detection accuracy in localized areas. Key components of our approach include preprocessing of hyperspectral data to remove atmospheric and water column effects, spectral unmixing techniques to differentiate between petroleum slicks and background materials, and machine learning algorithms for automated detection and classification. We validate the effectiveness of our approach through comprehensive lab and field experiments simulating offshore environments with varying petroleum concentrations and APIs. Results demonstrate the capability of our multiscale hyperspectral remote sensing approach to accurately detect and differentiate petroleum slicks from natural phenomena and other anthropogenic sources. The proposed approach offers several advantages, including improved detection sensitivity, enhanced spatial resolution, and reduced false alarm rates compared to traditional methods. Furthermore, its scalability and adaptability make it suitable for monitoring large offshore areas and detecting petroleum slicks of varying sizes and concentrations. In conclusion, our study presents a promising multiscale hyperspectral remote sensing approach for effectively detecting petroleum offshore, with significant implications for environmental protection, oil spill response, oil exploration (seepages), and sustainable resource management in marine ecosystems.

Keyword

Petroleum, Hyperspectral, Multiscale, Offshore

The EnMAP hyperspectral satellite: an overview of the mission and its applications in geology and resource exploration

Saeid Asadzadeh[1]*, GFZ German Research Centre for Geosciences (saeid@gfz-potsdam.de)
Sabine Chabrillat[2], GFZ German Research Centre for Geosciences

Abstract

The Environmental Mapping and Analysis Program (EnMAP) hyperspectral satellite was successfully launched into orbit on April 1, 2022. Since the end of October 2022, it has entered the operational phase, collecting on-demand hyperspectral data globally. EnMAP is a German satellite system designed to provide high-quality hyperspectral data for environmental monitoring and sustainable management of natural resources. It covers the spectral range between 420 and 2450 nm by 224 bands, offering a spectral resolution of 8.1 nm in the visible-near infrared (VNIR) and 12.5 nm in the shortwave infrared regions (SWIR) by two individual prism-based push-broom spectrometers. It maintains a signal-to-noise ratio (SNR) higher than 250:1 at a spatial resolution of 30m. In this presentation, we aim to provide an overview of the mission, data levels, and user data access. We also aim to present some application examples of the EnMAP Level 2A orthorectified surface reflectance data in geology and raw materials exploration. These examples range from mapping the outcrops of carbonates, sulfates, and iron oxides in sedimentary basins to mapping the alteration footprints of hydrothermal systems in different geological settings, including porphyry copper deposits, volcanogenic massive sulfides, and Mississippi-valley type deposits, as well as a Rare Earth Element (REE)-bearing carbonatite body. Our presented case studies indicate that EnMAP has superior performance in mapping surface mineralogy over exposed solid earth thanks to EnMAP's high spectral resolution, accurate calibration, and high SNR. The high-quality freely available hyperspectral data offered by EnMAP can be efficiently used to identify, characterize, and map a rich number of spectrally active minerals over the earth's surface facilitating geologic studies and resource exploration in arid to semi-arid regions of the world.

Keyword

EnMAP, Mineral Mapping, Hyperspectral satellite, Mineral exploration, Geology

Characterization of “Sale ‘e Porcu” salty pond (SPp Sardinia, Italy) suitable for CAL/VAL activities using multi sensor approach in the VNIR-TIR range: new optical satellite mission perspective

Maria Fabrizia BUONGIORNO[1]*, Istituto Nazionale di Geofisica e Vulcanologia (fabrizia.buongiorno@ingv.it)
Malvina Silvestri[2], Istituto Nazionale di Geofisica e Vulcanologia,Italy
Massimo Musacchio [3], Istituto Nazionale Geofisica e Vulcanologia,Italy
Enrica Marotta[4], Istituto Nazionale Geofisica e Vulcanologia,Italy
Pasquale Belviso[5], Istituto Nazionale Geofisica e Vulcanologia,Italy
Maria Teresa Melis[6], Università di Cagliari, Italy
Marco Casu [7], Università di Cagliari, Italy
Jan Kanuk [8], Faculty of Science Pavol Jozef Šafárik University in Košice (UPJŠ), Slovakia
Michal Gallay[9], Faculty of Science Pavol Jozef Šafárik University in Košice (UPJŠ), Slovakia

Abstract

The “Sale ‘e Porcu” (SPp) is located in the Sinis peninsula (West Sardinia), and is the largest temporary salty pond in Sardinia. It occupies a flat-bottomed interdunal depression where rainwater is collected. The basin, with a maximum depth of 1 meter and an average depth of 40 cm, is characterized by the absence of tributaries and emissaries, therefore it represents an independent basin from the other ponds present in the area. During the summer period, the strong evaporation causes the fully dry out of the SPp, presenting itself as a large expanse of salt. This characteristic makes this area an almost unique site placed at mid-latitudes in Europe, which could be suitable for Vicarious Calibration and Validation activities (CAL/VAL) for new optical satellite missions. In 2023 remote and proximal data have been collected, covering the VNIR-TIR spectral range, and are currently analysed to obtain a fully characterization of the site. This study includes satellite data with Ground Sampling Distance (GSD) ranging from 90x90 m (Landsat) up to 30 x30m (EnMAP and PRISMA) passing by about 70m of ECOSTRESS. Proximal acquisition ensures the higher GSD reached by using VNIR and TIR sensor mounted on drone and geological and mineralogical analysis. Moreover, hyperspectral thermal infrared data were acquired on the SPp site by the NASA-JPL airborne instrument HyTES in the frame of the 2023 ESA airborne campaign aimed to the characterization of a number of European test sites suitable to evaluate the performances of new optical satellite sensors. In the coming 5-6 years a large number of satellite missions equipped with sensors acquiring data in the range of SWIR-TIR, developed both at National (IRIDE constellation), European (ESA-LSTM) and International (NASA-ASI-SBG) will be deployed. These missions will permit to acquire higher temporal and spectral resolution data increasing the capabilities to monitor large area with different sampling performances. This study highlights the necessity to integrate data coming by several platforms to preliminary analyze the suitability of remote area for CAL/VAL purposes. Indeed, the logistic of the SPp, in terms of accessibility and data availability, permits to define the correct methodology to be exported in far or remote area.

Keyword

optical remote sensing, multisensor-data, new satellite missions, CAL/VAL activities

Active deformation across Indo-Myanmar suture zone, NE India: Insights from integrated RS-GIS-based Geomorphic Investigations

ALEXANDER S KSHETRIMAYUM[1]*, Department of Earth Sciences, National Central University, Taoyuan -32001, Taiwan (alexkshetri83@gmail.com)
Pradeep K Goswami[2], Centre of Advanced Study, Department of Geology, Kumaun University, Nainital -263002 India
Chung-Pai Chang[3], Center for Space and Remote Sensing Research, National Central University, Taoyuan -32001, Taiwan
Wu-Lung Chang[4], Department of Earth Sciences, National Central University, Taoyuan -32001, Taiwan

Abstract

The Indo-Myanmar suture zone, situated on the eastern flank of the Indian plate is characterized by oblique convergence of the Indian plate beneath the Myanmar microplate, which is a part of the Eurasian plate. Recent geodesy-based seismotectonic investigations reveal that the prevailing movements along the region's faults and thrusts at present are predominantly strike-slip in nature, playing a crucial role in accommodating the Indo-Myanmar plate motion. However, the crustal deformation caused by active tectonic movements in the region has not generally been determined across the entire mountain ranges except for a limited studies in some areas of the central part of it. The present study is aimed at understanding the active tectonic movements and associated crustal deformations in a part of the mountain ranges adjoining the tectonic suture zone. The study includes RS-GIS-based delineation of geomorphological indicators that reveal the structures' movements and associated crustal deformation during the Quaternary period. Employing robust geomorphic analyses such as the Normalized Steepness Index (ksn) and Hypsometric Integral (HI), we endeavor to decode the active deformation pattern across the region.

Our findings, underscored by geomorphological markers including entrenched meanders, deflected streams, pronounced straight courses, sharp stream deflections, warping of stream channels, river terraces, and linear ridge features such as pressure ridges and shutter ridges, indicate a combination of active strike-slip and dip-slip movements. These observations suggest that the suture zone is experiencing oblique slip, thereby sustaining the Indo-Myanmar plate motion. Furthermore, the spatial distribution of ksn and HI values suggest distinct deformation patterns across and along the suture zone, with the severity of crustal deformation decreasing from north to south, and from the plate margin to areas farther away from it. This pattern implies variable uplift rates and differential strain accommodation across the suture zone. Such a pattern is likely driven by the interplay of N-S extension and E-W compression as the Indian plate converges beneath the Eurasian plate. Our study highlights varying deformation pattern even in a smaller part of a particular tectonic setting and demands for more directed investigations to understand the intricacies of plate converges during an orogeny.

Keyword

RS-GIS, Active Tectonics, Oblique Slip, Indo-Myanmar suture zone

Remote Measurement of the Earth system with EMIT Imaging Spectroscopy from the International Space Station

Robert Otis Green[1]*, NASA JPL Caltech (robert.o.green@jpl.nasa.gov)
David R Thompson[2], NASA JPL Caltech

Abstract

The NASA Earth Surface Mineral Dust Source Investigation (EMIT) imaging spectroscopy mission was launched to the International Space Station (ISS) on the 14th of July 2022. The EMIT imaging spectrometer is a first-of-its-type F/1.8 full visible to short wavelength infrared (VSWIR) Dyson instrument that incorporates decades of lessons learned, along with advanced device technologies. Since its arrival at the ISS, EMIT has measured high signal-to-noise ratio spectra covering large portions of six continents. These high-fidelity spectroscopic observations enable new science and new applications throughout the Earth system. The EMIT prime mission measurements have been used to map the mineralogy of the Earth's arid land regions and address the prime mission science objectives. In addition, EMIT imaging spectroscopy has delivered detailed measurements of localized sources of methane and carbon dioxide. More than 1000 methane plumes have been identified and made available via the NASA Land Process Distributed Active Archive Center (LP DAAC) and the US Greenhouse Gas Center. These EMIT methane products with uncertainties have been used to advance mitigation of methane emissions into the atmosphere. In 2024, EMIT has entered an extended mission phase, and the target areas for observations below the ISS are being expanded to support new science objectives spanning the disciplines of terrestrial ecology, coastal oceans and inland water, snow and ice hydrology, and geology. A new broad set of applications spanning elements of agriculture, forestry, critical minerals, water quality, wildfires, water resources, and more are anticipated to be supported as well. Looking forward, these imaging spectroscopy measurements, algorithms, science, and applications support preparatory activities for the Surface Geology and Biology Decadal Survey mission with a next-generation VSWIR imaging spectrometer that is part of NASA's Earth System Observatory.

Keyword

Imaging Spectroscopy, EMIT, Geology, Earth System

Assessing Spatio-temporal Changes of climate variables on Diverse Crops in region of Punjab, Pakistan

Waqar YASIN[1]*, Land Information and Management System Centre of Excellence, Pakistan, Institute of Geo-Information and Earth Observation, PMAS-Arid Agriculture University Rawalpindi, Pakistan. (waqaryasin@me.com)

Abstract

Certain crops are climate sensitive in Pakistan such as rice, vegetables, cereals, spices and other grains. Rising temperature and changing rainfall is resulted in the form of shortage of water, which further leads towards the problems of food security due to low productivity especially in cropped food sector. Crop growth in Pakistan is highly dependent upon rainfall, which either fall in the form of rain or snow. Whereas high air temperature reduces the growth of shoots and in turn reduces root growth. High soil temperature is more crucial as damage to the roots is severe resulting in substantial reduction in shoot growth.This study deliberates the effect of changes in rainfall and temperature of Punjab, Pakistan on the production of five major crops viz. wheat (triticum), maize (zea mayes), cotton (gossypium), sugarcane (Saccharum officinarum) and gram (Cicer arietinum).The changes in mean temperature and rainfall from 1951 to 2015 were assessed at region level. Whereas the changes in crop growth were computed through remote sensing and crop reporting data. The variations in crop performance were compared with changes in studied climate variables (temperature and rainfall). It was found that increased in mean annual temperature decreased the crop yield. In addition, the climatic variation imparts negatively on analysed crop production data in the central and southern areas. Although exhibited a positive effect in the northern parts. It is therefore, suggested that various agriculture departments be educated regarding outcomes / conclusions of this study so that formers be trained to take necessary precautions while looking after their crops at different stages of crop cycle regarding these climatic variables i.e. temperature and rainfall.

Keyword

Climatic variables, Crop cycle, Crop growth, Spatio-temporal, Agriculture

Detection of high-geothermal-potential zones in densely vegetated areas through a combination of vegetation and mineral indices derived from hyperspectral satellite imagery

Taiki KUBO[1]*, Kyoto University (kubo.taiki.3n@kyoto-u.ac.jp)
Hiroaki Gonnokami[2], Idemitsu Kosan Co.,Ltd.
Arie Naftali Hawu Hede[3], Institut Teknologi Bandung
Naoya Fukuta[4], Kyoto University
Masahide Kishimoto[5], Kyoto University
Katsuaki Koike[6], Kyoto University

Abstract

Geothermal resources are expected to be increasingly utilized due to their high capacity and sustainability as an energy source for electric power generation. Satellite imagery analysis is one of the effective methods for detecting surface geothermal manifestations in the initial stages of regional resource exploration. However, direct observation of the ground surface becomes challenging in high-potential areas for geothermal resources located in densely vegetated zones. Therefore, we endeavored to identify surface geothermal manifestations through anomalies observed in vegetation. The Patuha geothermal field in West Java, Indonesia, was selected as the study area due to the availability of abundant survey data for validation. For the case study, a single satellite image acquired by the Hyperion sensor was used. We defined a vegetation index to detect spectral features of stressed vegetation: a blue shift of the red edge and an increase in shortwave-infrared reflectance. This index, named as VIBS (Vegetation Index considering Blue shift and Shortwave infrared), proved to be suitable for detecting vegetation stress caused by soil acidification conditions resulting from ascending geothermal fluid. The validity of VIBS was demonstrated through comparison with various local geological structures and geothermal systems. Therefore, VIBS was subsequently applied to geothermal areas in Yuzawa area, Japan. This area has several geothermal power plants operate and it is predominantly covered with vegetation, similar to Patuha. The analysis of the Yuzawa area was performed by utilizing HISUI (Hyperspectral Imager Suite; Iwasaki et al., 2011) imagery. Because the HISUI data analysis process is not fully established, we conducted data preprocessing with parameter validation. The VIBS values showed a clear difference between the northern and southern regions of the target area. In southern part of the study area , high VIBS value zone distributes continuously along faults. This is consistent with the estimated location of the geothermal reservoir and the flow pattern of the geothermal fluid. In contrast, the lower VIBS values in the northern area can be attributed to differences in surface geology. This result is supported by the results of on-site geophysical and geochemical surveys.

Acknowledgment:
This work was supported by the Japan Science and Technology Agency and Japan International Cooperation Agency through “Science and Technology Research Partnership for Sustainable

Development” (SATREPS) [grant number JPMJSA1401] and “Accelerating Social Implementation for SDGs Achievement” (aXis) [grant number JPMJAS2003] programs and by Grant-in-Aid for Scientific Researches (KAKENHI) from the Japan Society for the Promotion of Science [grant numbers 21KK0090 and 22K14105].

References:

Iwasaki, A., Ohgi, N., Tanii, J., Kawashima, T., Inada, H., 2011. Hyperspectral Imager Suite (HISUI)-Japanese hyper-multi spectral radiometer. 2011 IEEE International Geoscience and Remote Sensing Symposium, 1025–1028. https://doi.org/10.1109/IGARSS.2011.6049308

Keyword

Hyperion, HISUI, Indonesia, Japan, resouce exploration

DELINEATION OF MINERAL POTENTIAL HYDROTHERMAL ALTERATION ZONES AND FAULT ZONES USING MULTISPECTRAL ASTER AND LANDSAT 8 DATA OVER SANDUR SCHIST BELT, BELLARY DISTRICT, KARNATAKA, INDIA.

VIJAYAKUMAR MOOLA[1]*, GEOLOGICAL SURVEY OF INDIA (vijaya.moola@gsi.gov.in)
ANJU VR[2], GEOLOGICAL SURVEY OF INDIA

Abstract

Advanced Space borne Thermal Emission and Reflection Radiometer (ASTER) with 3 Bands in visible and near-infrared (VNIR) and 6 bands in shortwave-infrared (SWIR) regions makes its data useful for mapping of Ferric Iron (0.4μm,0.5μm,0.7μm & 0.87μm), Al-OH (2.2μm), Mg-OH (2.3μm) and carbonates (2.16μm, 2.35μm, & 2.55μm), thus making it more suitable for mineral exploration in geological applications. Landsat 8 satellite payload consists of two science instruments—the Operational Land Imager (OLI) and the Thermal Infrared Sensor (TIRS). It has 5bands in VNIR (0.43μm-0.88μm), 2 bands in SWIR (1.57-2.29μm) and 2 bands in thermal infrared region (10.6-12.51μm).

Sandur Schist Belt of eastern Dharwar craton in Bellary District in Karnataka has been taken up for identifying mineral potential areas through processing of multispectral ASTER and Landsat data. Under the present study, hydrothermal alteration minerals such as talc-chlorite (band ratio: (6+9)/(7+8)) and carbonate (band ratio: (7+9)/8) were mapped using Band Ratios, Relative Band Depth (RBD), Matched Filtering, constrained energy minimization (CEM) and Minimum Noise Fraction (MNF) mapping methods from ASTER reflectance data (AST_07_00301142004053445 & AST_07_00301142004053453) acquired on 2004-14-01, by removing vegetation and water by preparing NDVI and NDWI and band thresholding using ENVI software. A new relative band depth, (B1+B4)/B3+2(B4+B6)/B5 in the Landsat OLI data was arrived based on the known mineral occurrence of hematite mineral in the schist belt. Lineaments/ faults were identified using Landsat 8 OLI data, which was acquired on 2020.22.03 (path/row: 145/049)

Two mineral promising areas for gold & base metal, 1. Joga-Vaddu (20 sq km), 2. Lingadahalli (30sq km) were identified, from alteration zone mapping of chlorite and carbonate from ASTER data and lineaments (faults) inferred from satellite imagery (Landsat data) by integrating them with geochemical distribution of MgO, mineral occurrences, structure, lithology and field validations, favourable for mineralisation in the study area. Talc-chlorite alteration zone was identified between Lingadahalli and Shantappa Camp areas from ASTER data, and faults were delineated near Joga from Landsat data.

Ore petrographic studies have indicated the presence of pyrite, pyrrhotite, chalcopyrite and arsenopyrite along quartz-carbonate veins in metabasalt from Joga area. Gold values up to 550 ppb were found in limontised quartz vein in fault zone near Joga. Near Lingadahalli, grey/smoky quartz veins have got up to 115ppm of copper values.

The study has revealed a positive correlation of multispectral hydrothermal alteration zones &

lineaments with the field evidences and mineralization and has resulted in targeting mineral potential zones.

Keyword

ASTER, Spectral Mapping, Landsat 8 OLI

Research on Vegetation Geochemical Anomalies in Uranium Mining Areas Based on Hyperspectral Remote Sensing and Vegetation Spectral Analysis

Yongfei CHE[1]*, .National key Laboratory of Remote Sensing Information and Image Analysis Technology, Beijing Research Institute of Uranium Geology (cheyongfei@163.com)
Minglin ZHANG[2], China Nuclear Geology
Fawang YE[3], National key Laboratory of Remote Sensing Information and Image Analysis Technology, Beijing Research Institute of Uranium Geology

Abstract

Using hyperspectral remote sensing and vegetation spectral analysis technology can extract geochemical anomaly information of plants in uranium mining areas. This paper combines knowledge from multiple disciplines such as remote sensing, botany, plant geochemistry, and petrology to systematically explore the natural landscape and vegetation communities in typical uranium mining areas and non-uranium mining areas. Through hyperspectral technology analysis of common plant spectral characteristics in mining areas and non-mining areas, sensitive feature bands are identified, and the indicative elements of plant geochemical prospecting in uranium mining areas are determined using correlation analysis and cluster analysis. The study found that plants in uranium mining areas are generally enriched in Mo, Th, and U, and there are differences in the enrichment of different elements in different organs. Through the contrast coefficient and barrier coefficient of vegetation element content, Eulalia japonica and Rhus chinensis were selected as effective indicative vegetation, with indicative elements of U and Mo. Finally, combining field spectral data, GF-5 hyperspectral image data, and vegetation geochemical anomaly data above the uranium mining area, the relationship model between vegetation spectral sensitive bands, band ratio, and indicative element content was established, and the spatial distribution characteristics of indicative elements were retrieved. The research results show that the method of extracting mineralization information of uranium deposits in vegetation-covered areas based on hyperspectral remote sensing and vegetation spectral anomalies can better reflect the spatial distribution characteristics of relevant element anomalies in the region, providing new ideas for the prediction of metal deposits in high vegetation coverage areas, and having application value and promotion significance.

Keyword

hyperspectral remote sensing, vegetation spectral analysis, uranium mining area, vegetation geochemical anomaly, spatial distribution characteristics

Computing Sediment Grain Volumes with GIS

Tim Whiteaker[1]*, The University of Texas at Austin (whiteaker@utexas.edu)
Michael L Sweet[2], The University of Texas at Austin

Abstract

When studying sedimentary basins through a source-to-sink lens, we want to track sediment movement into the basin, measuring how it is partitioned between sedimentary environments. We are especially interested in quantifying the fraction of sediment that passes the shelf-slope break into deep water. In this presentation, we introduce a Geographic Information Systems (GIS) workflow for computing the distribution of sediment grain volumes through space and time. Driven primarily by data from well logs, the workflow not only calculates total grain volume, but also considers the partitioning between sand and mud, and deep water deposits from shallow water deposits. Part of the workflow includes using the Sclater-Christie compaction curve to account for changes in porosity with changes in depth, taking into account both depth of sediment and water depth. We exercise the workflow on a case study with Cenozoic depositional systems of the Gulf of Mexico (GOM) Basin, for which we have compiled a rich database of published well logs, seismic data, and datasets derived from publicly available sources. The workflow utilizes Esri ArcGIS desktop software including ArcMap, geoprocessing tools, and ModelBuilder. In this presentation we focus primarily on our GIS methods, and we highlight some key results from the GOM study to demonstrate the utility of the approach.

Keyword

sediment flux, geographic information systems, continental margin

Polish Geological Cartography Platform: fostering geological map data accessibility, enhancing integration and harmonisation for informed decision making

Katarzyna JÓŹWIK[1]*, Polish Geological Institute - National Research Institute (kjoz@pgi.gov.pl)
Urszula Stępień[2], Polish Geological Institute - National Research Institute
Piotr Gałkowski[3], Polish Geological Institute - National Research Institute
Józef Mikołajków[4], Polish Geological Institute - National Research Institute

Abstract

Performing geological mapping and providing accurate knowledge about the geological structure of the country have been priority tasks for the Polish Geological Institute (PGI) for more than a century. Over the years, PGI geoscientists have compiled hundreds of different maps within the framework of domestic, regional, and international projects. Many of these maps are accessible through various national thematic applications, as well as international portals and initiatives such as OneGeology, INSPIRE, EGDI, and IQUAME.

However, based on the results of a questionnaire conducted last year among Polish stakeholders, it is often challenging for them to locate the maps they need. Some stakeholders also lack tools that would enable them to combine and analyze map data within their own systems. The Polish Geological Cartography Platform aims to address these challenges by providing a centralized access point for all geological and geology-related maps, along with an advanced map search engine and a set of specialized tools for spatial data analysis. It is also designed to become one of the fundamental tools supporting the daily duties of the Polish Geological Survey's employees. By replacing some existing internal procedures, the platform seeks to minimize the bureaucratic steps required to access different types of map data.

The platform will facilitate the integration of data from past and ongoing cartographic undertakings and distributed domain systems into a common database. It will also incorporate the results of other projects of the Polish Geological Survey related to the standardization of geological vocabularies, thus enabling further harmonization of map series as well as map data across different scales.

Keyword

Geological maps, Polish Geological Cartography Platform, Map accessibility, Data integration, Stakeholder challenges

Lime phosphates in Senegal: characterization, modelling and predictive mapping for the development of a prospecting guide.

Abdoul Aziz NDIAYE[1]*, ENSMG - University CAD Dakar (UCAD)
(abdoulaziz.ndiaye@ucad.edu.sn)
Mamadou FALL[2], PCSTUI - University CAD Dakar (UCAD)
Mamadou GUEYE[3], ENSMG - University CAD Dakar (UCAD)

Abstract

The first paleogeographic and stratigraphic work carried out within the general framework of mining prospections in Senegal in the years 1943 to 1955 made it possible to highlight deposits and indices of lime phosphates (in the central west of Senegal at Taïba, LamLam and later in the 1980s in Matam in the North East). Since 1962, Senegal has been a producer of phosphate, to the tune of 2.5 million tons in 2021 for proven reserves of 116.5 million tons and probable reserves of 337 million tons. The mining sector, driven by phosphates and gold, plays an important role in the country's economy, producing a value of US$ 2.49 billion.

The general goal of our research work is to sustain these strategic resources for the country. The methodology thus consisted of compiling and reinterpreting data on phosphates in order to provide decision support in the form of a prospecting guide for the development of research projects or the exploitation of new deposits.

An exhaustive compilation of lime phosphate prospecting and exploitation data throughout Senegal, from 1948 to 2023, made it possible to carry out a geological, mineralogical, paleontological and geochemical characterization of the ores.

These same data, supplemented by morpho-structural elements as well as operating data from mining companies, made it possible to construct a GIS with 45 layers of information of various types (drilling points, isolines, faults and discontinuities, etc.) grouped into six categories namely (i) phosphate occurrences, (ii) lithological units, (iii) tectonic structures, (iv) stratigraphic markers, (v) facies types and (vi) multielemental geochemistry.

This GIS allowed modeling of the geometries of the deposits and the creation of a new map at 1:500,000 giving the main characteristics of the Lower Eocene, support of the stratigraphic horizon of phosphates in Senegal.

Subsequently, the combination of data from the 45 layers made it possible to produce predictive maps of potential in phosphate reserves from two approaches, first by “Regionalized PCA” (also called “Analyse Krigeante”) mapping the Phosphate Factor and second by “Directed Pixelation” of information.

The use of these predictive mapping techniques makes it possible to identify areas with potential reserves in the form of probability maps for phosphate presence. These maps will allow either mining companies to optimize their exploration strategy, or the State of Senegal to better guide its mining policy for this very important strategic mineral, in particular by defining promotional zones as authorized by the 2016 Mining Code.

Keyword

Phosphates, Geostatistical modelling, Regionalized PCA, Directed Pixelation, Prospecting Guide

Boosting Europe's Energy Transition: The Pivotal Contribution of a Geological Service for Europe in Delivering FAIR Subsurface Data and Knowledge for Informed Policy and Industrial Decision-Making

Francesco Pizzocolo[1], TNO - Geological Survey of the Netherlands
Julie Alison HOLLIS[2], EuroGeoSurveys
Patrick Wall[3]*, EuroGeoSurveys (Patrick.Wall@eurogeosurveys.org)

Abstract

The world's evolving energy needs demand accurate geoscientific data, information, and knowledge to achieve the energy transition, environmental management, and sustainable development. The Geological Service for Europe (GSEU) project is a strategic initiative funded by the EU, with a mission to provide comprehensive geoscientific data, information, and knowledge harmonized at European scale. The project addresses key challenges associated with the energy transition in the fields of groundwater, minerals, energy, coastal zone management, underlying geoscientific maps and models, and geospatial data delivery, focussing on sustainable development, regulatory improvement, social governance of the subsurface, public participation, derisking of renewable energy projects, and science-informed policy development. The ultimate project goal of establishing a permanent Geological Service for Europe is pivotal in supporting Europe's energy transition, environmental management, natural resource exploration and exploitation, and policy-making.

The transnational nature of geology necessitates collaboration, standardization, and a shared vision. Aligned with the European Commission's vision for a climate-neutral economy, the GSEU project emphasizes the key role of the subsurface in Green Deal and NetZero goals and vital resource exploration and management. Leveraging the network and data of the National Geological Surveys and EuroGeoSurveys – a not-for-profit association representing 37 geological surveys of Europe – GSEU is establishing joint services supporting energy and climate transitions.

Specifically, the GSEU project will deliver:

• pan-European harmonized data services
• an International Centre of Excellence for Sustainable Resource Management
• the European Geological Data Infrastructure and
• a strengthened network of national geological survey organizations and connections with the European Commission and other stakeholders.

These data, information, and knowledge services have the potential to inform:

• Current economy and market dynamics in European Renewables: Assessing geological

characteristics for renewable projects.
• Barriers and improvements to regulatory frameworks: Providing geological insights for effective regulations.
• Social Governance of the subsurface: Fostering transparency and public engagement in decision-making.
• Just Energy Transition and the Green New Deal: Considering socio-economic implications and equity.
• Technical projects with focus on public participation: Advising policymakers on impactful projects.
• Policy developments: Offering valuable lessons from geosciences to accelerate the adoption of renewable energy technologies.

The five-year GSEU project is a stepping stone towards establishing a permanent Geological Service for Europe, providing an ongoing bridge between the geological survey and broader geoscience expert community and policymakers. Our ambition for a permanent Geological Service for Europe is to offer a centralized platform for up-to-date geoscientific data, information, and knowledge harmonized at European scale, building on the existing European Geological Data Infrastructure (EGDI), and linked to national-level data and expertise. Through provision of current geological data, information, and knowledge, and collaborative initiatives, the Geological Service for Europe will allow effective, efficient geoscience-informed decision-making in renewable energy development, contributing to strategic decision-making, responsible subsurface management, public participation, and policy development. The future Geological Service for Europe stands as a cornerstone in ensuring a sustainable and just energy future for Europe.

Keyword

net zero, collaboration, climate action, geological surveys, science for policy

On the issue of developing a methodology for compiling a map for assessing the anisotropy of the natural stress state of dispersed soil massifs

Violetta SHANINA[1]*, Lomonosov Moscow State University (violettav@inbox.ru)
Vladimir MATVEEV[2], Geotechnical Graduate Lab

Abstract

The goal is to develop a methodology for drawing up a map for assessing the anisotropy of the natural stress state of dispersed soil masses, which allows one to obtain a spatial representation of the stress distribution at a given depth from the earth's surface. It is recommended to set the depth corresponding to the most frequently selected depths of the foundations of structures with a high level of responsibility, for example, 5, 10 or 15 m. The difficulty of drawing up a map for large areas consists, as a rule, in the insufficiency of factual material. To describe and calculate parameters, a grouping of soils of the same type, having the same genesis, similar lithological composition and condition, is proposed. The methodology is being developed using the example of soils in the Moscow region. The source material is a field description of soils, as well as the results of laboratory and field studies. The parameters required to construct a map are assessed primarily using empirical formulas, due to the paucity of direct definitions. Formulas are used that are widely used and have high accuracy and stability. In the Moscow region, clay deposits in the upper part of the section belong to the Quaternary, Cretaceous, Jurassic and Carboniferous systems. Among these deposits, overconsolidated ones are often found. Natural pore pressure u is determined by interpolation. Interpolation is carried out in accordance with groundwater data. For depths below the groundwater level, pore pressure is determined by the formula u=γ_w (z-z_0). Pre-compaction stress can be determined by direct methods in key areas according to GOST R 58326-2018, as well as by indirect field methods, for example, by static sounding using an empirical formula. Based on the collected stock data and statistical analysis, it was revealed that the lateral pressure coefficient of cohesive soils does not depend significantly on the lithological composition, condition and genesis, and the age of the deposits and the value of the effective vertical stress are of decisive importance. For Holocene normally compacted soils in the Moscow region, as well as for Quaternary overconsolidated soils with over 200 kPa, vertical stresses predominantly exceed horizontal ones. For Quaternary sediments in the range from 100 to 150 kPa, Mesozoic - from 100 to 350 kPa, the stress state is predominantly isotropic. Overconsolidated Quaternary and Mesozoic sediments at shallow depths (vertical effective stress of 50 kPa or less) are characterized by inversion of principal stresses, horizontal stresses exceed vertical ones. The map for assessing the anisotropy of the natural stress state of dispersed soils shows areas with different lateral pressure coefficients, isolines corresponding to the effective household vertical and horizontal stress, as well as additional information, such as the overconsolidation coefficient. A map for assessing the anisotropy of the natural stress state of dispersed soil masses allows one to obtain a spatial representation of the stress distribution at a given depth from the earth's surface, which contributes to the safety of the construction of underground structures.

Keyword

map, anisotropy, stress, soil, pressure

[Keynote] Bathy-morphological mapping for geohazard assessment

Francesco Latino CHIOCCI[1]*, Sapienza, University of Rome (francesco.chiocci@uniroma1.it)

Abstract

The mapping of the seabed has been a fundamental pursuit in scientific research, dating back to the earliest scientific explorations.

Technological advancements, such as the availability of steel ropes in the 1800s, the introduction of the first echosounders in the early 1900s, utilization of satellite data in the late 1900s, and the development of multibeam echosounders in the present century, have continually expanded our reconstruction of the ocean depths.

Various methodologies are currently used by researchers for seafloor mapping, utilizing light (visible and hyperspectral) for shallow waters and seismic energy (sonar) for deeper seabed. In the latter case, the use of autonomous or remotely-operated vehicles acquiring data in close proximity to the seabed has substantially increased survey efficiency and resolution.

The rapid technological progress, leading to the generation of terabytes or petabytes of data annually, necessitates a concerted effort to standardize and homogenize interpretations, facilitating the production of cartographic products applicable beyond the domain of scientific research.

While subaerial mapping has long addressed these needs for habitat, land use, infrastructure, seismic, volcanic, and hydrogeological risk maps, the marine domain, aside from bathymetric and nautical charts, faces challenges with diverse research groups and end-users adhering to different standards. Lack of standards also hinders the land-to-sea continuity, an important goal for trans-domain mapping of geological features.

Building upon geohazard feature mapping experiences, however applicable to various thematic cartography types, this presentation aims to explore different facets ranging from data acquisition, processing, management, interpretation, to cartographic representation. In Europe, numerous projects, including Mareano in Norway, Infomar in Ireland, Magic in Italy, have contributed to original geohazard maps, while the European Emodnet project serves as a reference for harmonizing existing maps.

The initial unavoidable step involves determining the final scale of representation and the cartography's subject. Despite the apparently obvious nature of these considerations, the resolution of data, ground truthing, interpretative ambiguities, and cartographic representation are intricately interconnected. Misalignments in these aspects can compromise the final product's quality and result in resource wastage. Although multi-scale cartography is often advocated for accommodating diverse-scale products, careful consideration is required for the integration, even conceptually, of data at varying spatial scales.

The crucial involvement of end-users from the outset in defining interpretation and cartographic representation criteria cannot be underestimated. Different users possess specific needs and requirements, and accounting for these from the beginning enhances the final product's quality when it has to be utilized for different purposes.

Finally, a paramount consideration is entrusting the interpretation of mapping data to research groups with expertise in their respective geographical areas. Seafloor mapping tools are inherently limited to morphological expressions of seafloor features, and certain non-homogeneous information (e.g., seismics, sampling, dating) may be essential for accurate interpretation, necessitating the competence in the interpreter's understanding of the area.

Keyword

Collaborative effort, Italy, mapping standards, marine geohazard

A structural map of Italian seas, thematic map derived from collation and harmonization of geological data

Andrea FIORENTINO[1]*, Geological Survey of Italy - ISPRA (andrea.fiorentino@isprambiente.it)
Mauro Agate[2], Department of Earth and Sea Sciences, University of Palermo
Loredana Battaglini[3], Geological Survey of Italy - ISPRA
Anna Del Ben[4], Department of Mathematic and Geosciences, University of Trieste
Martina Busetti[5], Istituto Nazionale di Oceanografia e Geofisica Sperimentale
Dario Civile[6], Istituto Nazionale di Oceanografia e Geofisica Sperimentale
Laura Crispini[7], Department of Earth, Environment and Life Sciences, University of Genova
Michela Dal Cin[8], Istituto Nazionale di Oceanografia e Geofisica Sperimentale
Valentina Ferrante[9], Istituto per le Scienze del Mare – CNR
Veronica Frisicchio[10], Department of Mathematic and Geosciences, University of Trieste
Francesco Frugoni[11], Istituto Nazionale di Geofisica e Vulcanologia
Guido Giordano[12], Department of Sciences, Università RomaTRE
Michele Locatelli[13], Department of Earth, Environment and Life Sciences, University of Genova
Maria Filomena Loreto[14], Istituto per le Scienze del Mare – CNR
Danilo Morelli[15], Department of Earth, Environment and Life Sciences, University of Genova
Simone Orefice[16], Geological Survey of Italy - ISPRA
Camilla Palmiotto[17], Istituto per le Scienze del Mare – CNR
Marco Pantaloni[18], ISPRA
Felicia Papasodaro[19], Geological Survey of Italy - ISPRA
Alessandra Pensa[20], Geological Survey of Italy - ISPRA
Tiziana Sgroi[21], Istituto Nazionale di Geofisica e Vulcanologia
Attilio Sulli[22], Department of Earth and Sea Sciences, University of Palermo
Letizia Vita[23], Geological Survey of Italy - ISPRA
Valentina Volpi[24], Istituto Nazionale di Oceanografia e Geofisica Sperimentale

Abstract

The Geological Survey of Italy – ISPRA, in collaboration with several Italian universities and research institutes, is realizing an update concerning submerged areas of the Structural Model of Italy. The work is carried on in the frame of the European Marine Observation and Data Network (EMODnet) Geology Project.

EMODnet is a long-term marine data initiative funded by the European Union. It provides easy and free access to marine data, metadata and data products and webservices spanning seven broad disciplinary themes (lots): bathymetry, geology, physics, chemistry, biology, seabed habitats and human activities. EMODnet Geology provides full areal coverage of all European regional seas producing maps at a 1:100,000 scale or finer, but also at coarser scales (1:250,000 and 1:1,000,000) to ensure maximum areal coverage. The geology data compiled in the frame of the project are available through the EMODnet Central Portal: https://emodnet.ec.europa.eu/en and include sea-bed substrate, sediment accumulation and erosion rates, Quaternary and pre-Quaternary lithology and age, geomorphological features, coastal behaviour, geological events and probabilities, minerals and submerged landscapes.

The Geological Survey of Italy – ISPRA coordinates the “Geological events and probabilities”

work package concerning submarine landslides, earthquakes, volcanic centres, tsunamis, fluid emissions and Quaternary tectonics. In order to provide a comprehensive and updated product for the Italian contribution to EMODnet Geology, cooperation among marine geology researchers from universities and research institutes has been promoted. Data gathered during this work allowed to realize a structural geology database for the entire Italian submerged territory. Information has been conveyed into a printed map at 1:1,250,000 scale representing an update for submerged areas of the Structural Model of Italy.

The map reports tectonic elements, rocky outcrops, seamounts and earthquake epicenters in Italian seas as revealed by the marine geological researches carried out during the last thirty years that have benefited from the contribution of relevant technological innovations in the field of marine geological surveys (multibeam, sub-bottom profiler, high penetration seismic surveys). The map contains structural data from original surveys as well as data from scientific literature or derived from strategic national research programmes, properly integrated and validated in order to create a harmonized dataset.

Structural and volcanic elements, classified according to the EMODnet terminology (INSPIRE compliant), are characterized by geometric, kinematic and chronological parameters. They are complemented by additional information on heat flow, crustal thickness and thickness of the Plio-Quaternary deposits. The map aims to present in a synthetic but exhaustive way the structural setting of Italian seas, a key region in the geologically very active Mediterranean Sea which is dominated by the geodynamic process of convergence and collision between the European and African plates.

The map provides indications concerning the migration over time and space of the tectonic events, the features that have contributed mostly to the current structure of the Italian seafloor and, among these, those that may originate geohazards. The map represents a solid base for more detailed studies of seismotectonics and applied geology, for territorial management and spatial planning as well as for scientific dissemination.

Keyword

structural geology, geological events, digital maps, EMODnet

Thematic mapping, potential and interactions

Roland Erich OBERHAENSLI[1]*, Potsdam University (roob@geo.uni-potsdam.de)

Abstract

Its the prime property of any map to show data related to a theme. That is why the first known geologic map reports a goldmine in Egypt.
All along data were putt on geographic maps for retracing. Then geologic and tectonic maps were used as such, but also as base maps to put mineralogic or palaeontologic facts in a static manner. It took quite an effort during last century to produce maps related to dynamic phenomena such as landslides, mass movements or hydrology pointing to potential hazard. Similarly the presentation of data related to metamorphism, changed from reporting mineral assemblages to depicting P,T - data accordingly to a facies grid. Such a facies grid is related to geodynamic processes by the concept of thermodynamic calculations of P and T, pseudogetherms and the plate tectonic paradigm. Each geodynamic setting produces its typical sequence of metamorphic facies. When compared to a tectonic maps, where basically tectonic style and transport directions are reported the metamorphic data can add substantially. Especially when gaps in metamorphic conditions occur within a single tectonic unit, then revisions are needed. This was the case for the metamorphic map of the Alps, where co-operation with tectonists lead to a tectonic recompilation published on the same map. Other interactions of metamorphic mapping with paleogeographic maps, which globally base on stratigraphic and sedimentologic data, can led to spatial constraints. A good example of this are the two map sets of the MEBE as well as the DARIUS programs, both reated to reconstruct the Tethyan realm in the Eastern Mediterranean realm. The observation of high pressure relics and the inferred associated subduction processes, especially depth for the formation of eclogites led to implement additional oceanic curst and constrained minimal width of the oceanic basins. Including geophysical data might further enhance the potential of interaction and lead to new insights and interpretation of the geodynamic past.

Keyword

maps, metamorphism, paleogeography, tectonics

Towards an integrated and harmonized geological data model for Europe

Esther HINTERSBERGER[1]*, Geosphere Austria, Dep. of Geological Mapping
(esther.hintersberger@geosphere.at)
Hans-Georg Krenmayr[2], Geosphere Austria
Christine Hörfarter[3], Geosphere Austria
Martin Schiegl[4], Geosphere Austria

Abstract

The initiative of the European Geological Survey Organizations towards a Geological Service for Europe (GSEU project) includes an advancement of the joint infrastructure for various geological data (EGDI). A basic necessity to gather such complex geoscientific data from different partner organizations from all over Europe is a common framework comprising metadata for existing maps and 3D models, an extended multiscale geological data model, and hierarchical and well-defined scientific vocabularies for various topics. Work package 6 of the GSEU initiative is responsible for creating this common framework with special focus on the seamless integration of all parts in order to provide well-structured and easy access to science-based geological information on Europe's subsurface.

This presentation is focused is on scientific vocabularies - developed in a controlled manner according to the principles of Linked Data technology, taking into account the W3C approved SKOS-RDF standard - and the advantages they provide. These vocabularies not only provide definitions for terms in use (and therefore already help better understand the presented data), but also allow storing unstructured information such as geographic description, detailed investigation history, debated theories, etc. In addition, the implementation of Linked Data technology creates a semantic knowledge network beyond the actual database by integrating links to other existing database and information resources, e.g. Wikipedia (DBpedia) and other online controlled vocabularies. Such, let's call them "semantic vocabularies", are also helpful managing transregional or transnational information and data with respect to different languages and across scales. These vocabularies can also build bridges between 2D and 3D visualizations. The implementation of the semantic vocabularies into the EDGI data infrastructure helps to do the step from mere digital data presentation to the construction of a knowledge platform.

As a showcase for the usage of Linked Data vocabularies, we show two examples: Semantic vocabularies have been already implemented in the HIKE European fault database (developed in the GeoERA project, the predecessor of GSEU project), especially regarding the hierarchical nomenclature of faults, semantic harmonization across national (and language) borders, and the linkage between fault geometries at different scales. At Geosphere Austria, the implementation of the Linked Data technology has been widely used for the semantic harmonization of geological units.

Keyword

Geological data model, Europe, Linked Data, vocabularies, GSEU

Geological Map of South America in the twenty–first century

Jorge GÓMEZ TAPIAS[1]*, Servicio Geológico Colombiano (mapageo@sgc.gov.co)
Nohora Emma MONTES RAMÍREZ[2], Servicio Geológico Colombiano
Carlos SCHOBBENHAUS[3], Geological Survey of Brazil
Daniela MATEUS–ZABALA[4], Servicio Geológico Colombiano

Abstract

The Geological Map of South America (GMSA) at a scale of 1:5 000 000 depicts the recent advancements in geological mapping across South America. Information from national geological maps of various countries and regional maps was aggregated and standardized at the 1:5 000 000 scale and subsequently was enriched with geochronological data from indexed journals.

The construction of the GMSA involved eight workshops convened to discuss and define its features. The main workshop took place in Villa de Leyva, Colombia, and included the participation of delegates from multiple countries. During this workshop, the official geological cartography from each South American country was obtained, and agreements were reached to create, revise, and endorse the final map. Subsequent workshops involved groups overseeing the GMSA at the Colombian Geological Survey and the Geological Survey of Brazil, who compiled and integrated the map. The GMSA comprises layers of chronostratigraphic units, faults, folds, basaltic dikes, intrusive and alkaline volcanic rocks, carbonatites, high–pressure metamorphic rocks, impact craters, kimberlites, and volcanoes.

A methodology for integrating geological information from each country was followed as follows. First, a new code was generated for each chronostratigraphic unit according to the proposed legend, using digital layers provided by the geological survey of each country; second, the symbology and colors representative of rock type and ages were created; and third, a map with coded units was prepared at a scale of 1:5 000 000.

The GMSA was printed at a scale of 1:3 000 000 with the new codification to facilitate generalization and manual linking of units. Subsequently, the GMSA was scanned and georeferenced to generalize the geological units, faults, and folds at a scale of 1:5 000 000. Despite the small–scale of the GMSA, the chronostratigraphic units, faults, and folds on the map were adjusted with the aid of shaded relief images (SRTM from NASA) to enhance the agreement between relief and mapped geological units. Harmonization of geology between countries was then carried out. Notably, updates to the GMSA were conducted taking into account data published in indexed journals.

The GMSA is available free in several formats including ArcGIS, PDF, TIFF, ArcGIS web map service, ArcGIS Online, Google Earth, and 3D. The creation of 3D models was accomplished

using Blender 3D software, allowing for schematic representation through objects, elements, shadows, and textures added to an initial 3D surface generated with a DEM (GEBCO). Once rendered, the resulting work yields a 3D image with a 90–meter SRTM resolution.

Keyword

GIS, Geological mapping, Harmonization, CGMW, ASGMI

Spatial relationships between gold deposits, crustal structures, and geophysical fields using GIS and statistical analysis in Central Kyzylkumes, Uzbekistan

Bakhtier NURTAEV[1]*, Institute of geology and geophysics (nurtaev@ingeo.uz)
Oksana TSAY[2], Institute of geology and geophysics

Abstract

The westernmost region of Tien Shan, located in Uzbekistan, is renowned for its world-class ore deposits, which make it one of the wealthiest gold and copper provinces in Eurasia. However, the unique nature of these deposits is still not fully understood. To expand mineral resources, it is necessary to identify deposits that are hidden at a certain depth. Identifying the criteria for searching for these world-class deposits in the Tien Shan belt is a significant geological problem that is of great interest to both academic science and the mining industry.

We have chosen to study the Kyzylkum gold province, which is located in Central Kyzylkum and spans an area of approximately 165,000 km2. In this region, more than two dozen gold and silver deposits have been explored, and over 500 ore occurrences have been discovered. Although most of the mineralization has been found on the surface, there are indications of ore deposits in deeper layers. To identify new large deposits, we need to focus on three regional-scale phenomena that highlight the unique location of the Kyzylkum gold mining region in the Tien Shan belt. These phenomena are morphological features, anomalies of geophysical fields, and mega-scale structures. By examining these phenomena, we can gain a better understanding of the geological basis and uniqueness of this region.

GIS technologies and statistical analysis were utilized in an attempt to develop a methodology for predicting the metal content of a local territory. The research aimed to forecast the mineralization of a gold-bearing territory through data acquisition, data management, and geothematic mapping representation. This process involved conducting a spatial analysis of the geological structure to create a set of features and identify the typical features of mineralization localization.

A database containing geological and geophysical information on geology, geophysical anomalies, mineral deposits, ring structures, fault, and lineament structures has been created in the ArcGIS environment. We have categorized the digitized cartographic information into 4 blocks: geophysics, geology, tectonics, and mineral deposits, presented separately in layers with qualitative and quantitative data (polygonal, linear, and point objects). By using methods of spatial-statistical analysis of heterogeneous cartographic-geological information, we were able to assess the spatial distribution of geological objects and gold mineralization in the study area. As a result, we carried out a spatial analysis of the conditions that localize gold deposits and established their connection with structural, geological, and geophysical characteristics. The work carried out demonstrated the effectiveness of the methods used in large-scale metallogenic studies.

Keyword

spatial analysis, GIS on geology and mineral deposits, geophysical fields, Central Kyzylkumes, data management

Exploratory modeling of Giran Rig- Chah Sangi area (Sistan and Baluchestan Province, Iran)

Elnaz Aghaali[1]*, Research Institute for Earth Sciences, Geological Survey of Iran (elnaz.aghaali@gmail.com)
Mohsen Shirkhani[2], Geological Survey of Iran, Tehran, Iran
Nasim Arab Esmaeili[3], Geological Survey of Iran, Tehran, Iran
Mehdi Zabihi[4], Geological Survey of Iran, Tehran, Iran
Ali Bayatani[5], Geological Survey of Iran, Tehran, Iran
Hassan Kheyrollahi[6], Geological Survey of Iran, Tehran, Iran
Roghiyeh Mosavi[7], Geological Survey of Iran, Tehran, Iran

Abstract

Bazman exploration block is located at the southeastern end of the Urumieh-Dokhtar Cenozoic volcanic arc, which is the result of subduction of the Neotethys oceanic crust under the Cimmerian blocks. Based on geological evidence, this structural zone, as a part of the magmatic arc of the continental-oceanic margin, can be a suitable environment for the formation of deposit types such as porphyry Cu-Mo-Au, epithermal Au, and skarns associated with intrusive bodies. Considering the geodynamic environment, the geological data, high-resolution airborne geophysical data, geochemical data and remote sensing data have been used to prepare information layers and interpret them for prospecting the areas with high potential for porphyry Cu-Mo-Au and epithermal Au mineralization. Mapping the faults, igneous intrusive bodies as heat and fluid sources, suitable host rocks and locating the mineralization indices were the geological information extracted from the geological maps. Magnetic structures, hidden intrusive bodies, potassium alteration zones, demagnetized zones related alteration zones are information layers extracted from high-resolution geophysical data. Mapping the phyllic, argillic, advanced argillic, chloritic, propylitic alteration zones by Aster and Sentinel-1 data are the remote sensing layers. Stream sediment and heavy mineral samples in the area were analyzed for up to 33 elements and identification of different heavy mineral groups, and the geochemical anomaly maps were provided for the elements. The integration of layers in the GIS environment and using the methods of fuzzy integration, index overlap and hierarchical analysis process (AHP) has identified 35 promising areas with an approximate area of 915 square kilometers for more detail follow-up.

Keyword

Exploratory modeling, porphyry system, Giran Rig- Chah Sangi, Sistan and Baluchestan, Iran

The geochronological database of Colombia: Review and new geological perspectives for this sector of the Americas

Daniela MATEUS ZABALA[1]*, Servicio Geológico Colombiano (dmateusz@unal.edu.co)
Nohora Emma MONTES RAMÍREZ[2], Servicio Geológico Colombiano
Jorge GÓMEZ TAPIAS[3], Servicio Geológico Colombiano
Eliana MARÍN RINCÓN[4], Servicio Geológico Colombiano

Abstract

The Geological Map of Colombia (MGC) 2023 is the most recent edition of the geological map of this South American country. Its updating is a missionary function of the Colombian Geological Survey, which publishes periodic versions according to the progress of national mapping and new geochronological data. The map presents chronostratigraphic units grouped according to the age and lithology of the surface materials. For age, the International Chronostratigraphic Chart 2022 was used as a reference. For lithological classification, the rocks and deposits were differentiated according to their formation environment, composition, or metamorphic grade.

Additionally to the Map, the latest update of Colombian mapping includes the geochronological database of Colombia that was created with the country's geochronological ages published in indexed journals until March 2022. This database contains ca. 35000 ages obtained from U–Pb, U–Th–He, Lu–Hf, Ar–Ar, Re–Os, U–Th–Sm, K–Ar, Sm–Nd, Rb–Sr, 14C, and traces of fission isotopic systems. In addition to the identification of each sample, the database presents the stratigraphic unit to which it belongs, the dated mineral, the number of dated grains, measurements and isotopic ratios, errors, and type of errors, published coordinates, cathodoluminescence (characteristics of zircons and dating location), and the interpretation of the data with information such as age, type of age, quality control of dating, observations, discussion, etc.

This database made it possible to update the age of the chronostratigraphic units on the national map and, therefore, separate or group units mapped in the previous edition of the map as a single one. This compilation work raises new questions and confronts the most accepted hypotheses about the formation of the Colombian territory. Also, the timing of main tectonic events that occurred on the western and northern margins of South America since the Proterozoic made the growth of the subcontinent possible.

One of the most relevant updates of the 2023 edition is the demarcation in the MGC of the late Paleozoic magmatic and metamorphic record. Thanks to the advance in detailed geological mapping and the combination with new petrological, geochemical, and geochronological analyses, discontinuous units of the Carboniferous (ca. 333–300 Ma) and Permian (ca. 294–263 Ma) could be defined in the national territory. These crop out from the upper Guajira in the Macuira

mountain range (the Macuira Gneiss), in the north of the country, the Sierra Nevada de Santa Marta (the El Encanto Orthogneiss), and in the Central cordillera (the El Carmen Stock, the Los Guayabos and Belalcázar Gabbros, the La Plata and Ortega Granites).

Magmatic and metamorphic units from the Carboniferous–Permian had already been recognized in other localities in central–southern South America, but not to the north due to lithological similarities with the superimposed Jurassic magmatic record. The record of these Paleozoic periods is relevant at a continental level because it has been considered evidence of the Alleghanian orogen, produced on the western margin of Gondwana by the collision with Laurentia during the Pangea assemblage.

Keyword

isotopic system, geochronology, South America, Gondwana, dating

New edition of the Geological Map of Colombia at a scale of 1:1,5M

Vanessa Rey León[1]*, Servicio Geológico Colombiano (vannerey0722@hotmail.com)
Nohora Emma Montes Ramírez[2], Servicio Geológico Colombiano
Jorge Gómez Tapias[3], Servicio Geológico Colombiano
Eliana Marín Rincón[4], Servicio Geológico Colombiano
Daniela Mateus Zabala[5], Servicio Geológico Colombiano

Abstract

Since 2003, the Geological Map of Colombia research group at the Colombian Geological Survey has been updating, refining, and integrating the most recent surface geological maps of the country and data published in geoscientific indexed journals.

The new edition of the Geological Map of Colombia at a scale of 1:1500000 was created using ArcGIS 10.8.2 and ArcGIS Pro 3.0.3 and includes twelve elements. Of these, the geological maps of the continental and island Colombian areas and the legend stand out. The reverse side of the map contains the references used for updating the map.

Surface materials are represented on the map as chronostratigraphic units. These are shown with colors, numbers, and patterns based on their age and lithology. For the ages and colors, the International Chronostratigraphic Chart 2022 was used as a guide.

Rocks are represented based on their primary classification in igneous, metamorphic, and sedimentary; additionally, volcaniclastic rocks were considered as an additional type. Igneous rocks were classified by their formation environment into volcanic, subvolcanic, and plutonic; these were further subdivided by composition into ultramafic, mafic, intermediate, and felsic. Metamorphic rocks were separated by the degree of metamorphism into very low, low, medium, high grade, and high–pressure rocks, and, due to their economic relevance, marbles.

Sedimentary and volcaniclastic rocks were grouped according to their depositional environment. The first ones were classified as continental, transitional, marine, continental–transitional, continental–transitional–marine, transitional–marine, while the latter were classified as continental, marine, and continental–transitional. Finally, deposits were divided into alluvial, terrace, alluvial fan, paludal, glacial, pyroclastic, dune, swamp, and volcanoclastic.

Despite the cartographic basis consisted mainly of geological maps at scales of 1:100000, 1:50000, and 1:25000 produced by the Colombian Geological Survey, there were numerous challenges in harmonizing the contacts between chronostratigraphic units and keep the continuity of structures because they were made by different authors in different years, therefore, with diverse quality. This is why, in some cases, contacts had to be followed using geomorphology, using Colombia's shaded relief images with a spatial resolution of 30 meters.

As a significant innovation, the map includes the following layers: volcanoes —distinguishing between polygenetic and monogenetic ones—, mud volcanoes, and high–pressure and ultrahigh–pressure rocks.

For the users to have a better understanding of the geology and to reach the greatest number of queries, the map was released in GIS (ArcGIS), PDF, TIFF, PNG, and 3D format, which helps highlight tectonic features more effectively, and Google Earth, as this tool is more user–friendly and widely recognized by the general public. Furthermore, an iOS app was created to display and consult the geological map of Colombia.

Keyword

chronostratigraphic unit, 3D format, Google Earth

Surface and subsurface geological data in Italy: state of the art of the harmonization process.

Marco PANTALONI[1]*, ISPRA (marco.pantaloni@isprambiente.it)
Maria Pia CONGI[2], ISPRA

Abstract

The Geological Survey of Italy - ISPRA serves as the authoritative entity responsible for the comprehensive collection and management of geological data at a national scale. Before the realization of the new 1:50k scale map series, the evolution of the nationwide surface geological mapping in Italy spans from 1877 to 1976, resulting in the production of 277 geological sheets 1:100k scale. This prolonged timeline mirrors the significant advancements in both geological knowledge and cartographic technologies, evident in the diverse terminology used to describe rock formations.

Conversely, information garnered from deep boreholes for oil or geothermal exploration in continental or marine environments falls under the purview of the National mining office for hydrocarbons and georesources (UNMIG-MASE). Following the expiration of industrial licenses, ISPRA has undertaken the task of collating, analysing, and digitizing this information, incorporating it into a dedicated database.

Our aim is to integrate surface (100k scale Geological map) and subsurface (deep boreholes) geological information using a standardized data model, aligning with European and international geological management systems such as OneGeology, EGDI, and EPOS.

The entire dataset from the 100k scale mapping underwent a process of semantic and partial geometric harmonization conforming with the INSPIRE and GeoSciML data models.

The INSPIRE Data Specification and the Implementing Rules are also applied through the support of UML data models developed by INSPIRE's thematic working groups. These models are available in the INSPIRE Geoportal and in the specific GIT-LAB repository.

With these tools, the Geological Survey of Italy started additional harmonization process by applying it to the dataset derived from deep boreholes. The result is an organized dataset that adheres to the GeoSciML data model.

The deep boreholes dataset includes stratigraphic, lithological, structural, and chronostratigraphic data extrapolated from about 1,100 deep wells logs, realized both onshore and offshore.

Given the complexity of the dataset, the simplest standard chosen for this purpose was GeoSciML - Lite, designed for simple map-based applications. This standard is a simplify model aligned with INSPIRE, by complying the interoperability requirements.

Deep well data are provided in Geography Markup Language (GML) format for INSPIRE validation purposes. Other OGC standard formats (e.g. gpkg) have been prepared to simplify the download and the reuse.

The result of our efforts is thematic mapping sharing using OGC standard, semantically harmonized with respect to lithostratigraphic units, chronostratigraphy, lithology, depositional

environment, texture, and layering.
The analysis of deep boreholes facilitates the correlation of stratigraphic and structural features, enabling correlation between geological horizons and the reconstruction of geologically significant surfaces.
The integration between geological map and boreholes datasets is particularly valuable for conducting stratigraphic and structural studies, assessing subsurface resources, and contributing to CO2 capture studies.
The next phases of our work plan involve geometric harmonization of geological map polygons and the integration of the deep boreholes database with newly acquired log registrations. These steps will further enhance the completeness and accuracy of our geological information integration efforts.
This work was developed by ISPRA with the contribution of the EPOS Italia - Joint Research Unit.

Keyword

Italy, geological map, borehole, data harmonisation, INSPIRE

Exploration and Application of High-Precision Inclined Photography and 3D Modeling Technology in Digital Geological Outcrops

Zongqi Lin[1]*, Chengdu University of Technology (846575760@qq.com)
Hanting Zhong[2], Chengdu University of Technology
Jianhua Chen[3], Chengdu University of Technology
Xia Wang[4], Chengdu University of Technology
Bingqian Wang[5], Chengdu University of Technology
Wenfeng Zhou[6], Chengdu University of Technology
Yuqing wu[7], Chengdu University of Technology
Chenyu Wang[8], Chengdu University of Technology
Cai Wang[9], Chengdu University of Technology
Lingxue Gao[10], Chengdu University of Technology

Abstract

With the ongoing evolution of unmanned aerial vehicle (UAV) technology in geology, particularly the emergence of oblique photogrammetry, a novel approach for creating high-precision 3D models of geological outcrops has been introduced. This technique offers a more abundant and detailed perspective compared to traditional orthophotography. To guarantee optimal data collection, an extensive preliminary survey of the surrounding area of the geological outcrop was conducted using satellite imagery. We selected the DJI Mavic 3 drone, equipped with a 4/3 CMOS sensor and boasting an effective resolution of 20 million pixels. The incorporation of a Hasselblad lens significantly enhances the image quality. During the photography process, we meticulously controlled critical parameters such as the overlap rate of images, flight altitude, and the angle of photography. The overlap rate was typically maintained between 60-70%, necessitating systematic photography from macroscopic to microscopic levels and the continual adjustment of the drone camera's tilt to capture intricate details of the outcrop from various angles, enabling the construction of a more detailed and comprehensive 3D model.

Our project has digitally captured and modeled over 120 notable geological outcrops across 12 countries, including China, the United Arab Emirates, Italy, France, Germany, Spain, and Namibia, etc. We have amassed over 240,000 drone photos for 3D modeling, in excess of 7,000 panoramic shots, and more than 800 video segments featuring international experts discussing outcrops, culminating in 8000GB of data. The essence of our work is rooted in precise UAV oblique photography, and through extensive experimentation, we've established a systematic approach, achieving centimeter-level resolution. In terms of further interpretation and processing of the model, we have implemented steps such as automatic stratification, discrimination of paleoflows and determination of occurrence.

Looking to the future, our goal is to further the digitalization of classical geological outcrops, field practice bases, and world geoparks. The data and models we produce are invaluable for geological

research and education, offering a more vivid and intuitive understanding of complex geological phenomena to both the academic community and the public.

Keyword

3D model, drone, geological outcrops, High-Precision, Photography

Geological and Prospectivity mapping of phosphates deposits in the Senegalese sedimentary basin

Mamadou Fall[1]*, UNIVERSITE CHEIKH ANTA DIOP DE DAKAR
(mamadou48.fall@ucad.edu.sn)
Abdoul Aziz NDIAYE[2], UNIVERSITÉ CHEIKH ANTA DIOP / ENSMG
Mamadou GUEYE[3], UNIVERSITÉ CHEIKH ANTA DIOP / ENSMG

Abstract

Lime phosphate exploration work begun in 1943 *resulted in the identification of deposits in the Center West of Senegal at Taïba, LamLam and Matam in the North East as well as the discovery of indices in different points of the sedimentary basin* (*Gossas, Kolda, etc.*). *Senegal produces phosphate around* 2.5 *million tons and have proven reserves of* 116.5 *million tons and probable reserves of* 337 *million tons. The mining sector, driven by phosphates and gold, plays an important role in the country's economy, producing a value of US*$ 2.49 *billion. Consequently, significant prospecting work must be carried out to sustain the reserves. The general aim of the work is to use the geological data available to model known deposits and to develop predictive maps which will serve as decision support in the form of a Prospecting Guide. The work thus consisted of* (*i*) *compiling geological and mining data on all deposits and indices* (*a GIS was created with* 45 *layers of information of varied kinds grouped into* 6 *categories namely phosphate occurrences, lithological units, structures tectonics, stratigraphic markers, facies types and multielemental geochemistry*), (*ii*) *carry out a geological, mineralogical, paleontological and geochemical characterization of the ores*, (*iii*) *model the deposits by producing a new geological map at* 1:500,000 *giving the main characteristics of the Lower Eocene, support of the stratigraphic horizon of phosphates in Senegal and* (*iv*) *produce predictive maps from two approaches namely by the "regionalized PCA"* (*also called Analyse Krigeante*) *which maps the Phosphate Factor and "oriented pixelation" which provides probability maps of phosphate occurrences. These maps will allow either mining companies to optimize their exploration strategy, or the State of Senegal to better guide its mining policy for this very strategic mineral, in particular by defining Promotional Zones as authorized by the* 2016 *Mining Code.*

Keyword

Phosphates, Geostatistical modelling, Regionalized PCA, Directed Pixelation,

Innovative Approaches to 3D Geo-Modeling of Geological Structures: Integration of Laser Scanning and Digital Photogrammetry, case studies from Ukraine

Mariia OLIINYK[1]*, Lviv Polytechnic National University (mariia.a.oliinyk@lpnu.ua)
Ihor Bubniak[2], Lviv Polytechnic National University
Andrii Bubniak[3], Lviv Polytechnic National University
Yevhenii Shylo[4], Lviv Polytechnic National University
Anatolii Vivat[5], Lviv Polytechnic National University

Abstract

In our presentation, we explore advanced techniques of laser scanning and digital photogrammetry as key tools for creating multi-scale 3D geological models, ranging from small minerals to massive rock outcrops. We demonstrate how the integration of these technologies not only improves the accuracy and detail of the models but also ensures high reliability of the results, which is critically important for geological research.

Our presentation includes specific examples from Ukraine, where these methods have been applied to study various geological structures. We highlight their significance for understanding the geological history of the region and for practical applications in areas such as natural resource exploration, ecological planning, engineering geology, natural risk management, and the development of geotourism.

Special attention is given to the data analysis obtained through these technologies. It is crucial to understand how proper interpretation of these data can contribute to accurate reproduction of geological conditions and processes. We also discuss how these innovative methods can be applied across different geological disciplines, underscoring their versatility and effectiveness.

At the same time, we acknowledge the challenges and limitations associated with laser scanning and digital photogrammetry. Including technical and financial aspects, we discuss how these issues can impact geomodeling and what strategies can be used to overcome them.

In conclusion, we focus on the future of these technologies. Discussing potential innovations and development in the field of 3D geomodeling, we attempt to predict how these changes might affect geological science and practice. Particular attention is paid to the role of these technologies in the development of geological research in Ukraine and their impact on the international geological community.

Finally, we emphasize the significance of these advanced technologies in enhancing the level of geological science and practice, particularly in the context of geological research and development in Ukraine. We aim to show how modern geomodeling methods can open new horizons in understanding and utilizing geological resources.

Keyword

3D geomodeling, Laser scanning, Digital photogrammetry, Multi-scale 3D geological models, 3D visualization

Detecting Brittle Structures in Vegetated Landscapes with Sentinel-2 Data: A Case Study of Deep Geological Repository Site Assessment

Jan JELENEK[1]*, Czech Geological Survey (jan.jelenek@geology.cz)
Lucie Koucká[2], Czech Geological Survey
Barbora Kořínková[3], Czech Geological Survey

Abstract

Identifying brittle structures in Central European landscapes, often characterized by dense vegetation and agricultural modifications, presents a significant challenge. Existing methods, such as in-situ mapping and remote sensing via LiDAR or airborne geophysics, can be costly or limited by accessibility. Brittle structures, particularly those hydrologically active, pose a significant limitation for a potential Deep Geological Repository (DGR) site. This study investigates the potential of Sentinel-2 satellite imagery, a freely available multispectral dataset with high spatial resolution and frequent revisit times, for indirect detection of brittle structures through soil moisture variations at four potential DGR sites across the Czech Republic.

The analysis addresses three key challenges: (1) significant crop type variability within the study area, (2) diverse land cover types (fields, pastures, forests) and (3) variations in cloud coverage between the images. To overcome these, we employ newly developed tool, "Moi v2.0," which weights per-pixel occurrences of high moisture content based on a 9-year Sentinel-2 time series. Moi v2.0, built using Python and Google Earth Engine, facilitates efficient processing of large satellite datasets in the cloud. By leveraging weighted time series of spectral indices, the approach successfully mitigates year-to-year variations in land cover and precipitation, standardizing the spectral response across the analyzed area. The resulting map indicates the probability of high soil/vegetation moisture content at each pixel.

Our analysis revealed that, on a larger scale, spatial variability in soil moisture aligns with the location and boundaries of geological units. In particular, the contrast between impermeable clays and permeable granitic sands was clearly visible. On a smaller scale, it was possible to directly identify hydrologically active brittle structures. These were validated using morphological lineaments and existing tectonic map.

This study demonstrates the potential of freely available multispectral satellite data, like Sentinel-2, for aerial geological mapping, even in landscapes with high vegetation cover. This offers a cost-effective and accessible method for preliminary assessments in DGR site selection and other geological investigations.

Further research is needed to validate its applicability across diverse geological settings, also using new ground-truth data.

Keyword

Brittle structures, Sentinel-2, Spectral indices, Soil moisture, Deep Geological Repository

(Open)GeoSGB: State of the art of Transition to an Open Source, semi-automated, FAIR-ready Geological Spatial Data Infrastructure of the Geological Survey of Brazil

CARLOS EDUARDO MIRANDA MOTA[1]*, Geological Survey of Brazil/SGB (carlos.mota@sgb.gov.br)
Flavia Renata Ferreira[2], Geological Survey of Brazil/SGB
Alvaro Gomes Sobral Barcellos[3], Geological Survey of Brazil/SGB
Americo dos Santos Junior[4], Geological Survey of Brazil/SGB
Pietro Laba Menezes[5], Geological Survey of Brazil/SGB
Edgar Shinzato[6], Geological Survey of Brazil/SGB
Hiran Silva Dias[7], Geological Survey of Brazil/SGB

Abstract

The Geological Survey of Brazil (SGB) is under a digital transformation process. One of the pillars of this process involves speed, scalability, security and availability of data produced. Furthermore, CPRM is creating a favorable environment for the adoption of cloud-based architecture. This paper aims to present an overview of a new developed Geological Spatial Data Infrastructure for the SGB. The GeoSGB is the main source for internal mapping, infographic and dashboard applications. It will assimilate legacy services, that runs on isolated map servers, such as self hosted node of OneGeology OGC Services. The solution adopted is GeoNode 4.2, which brings together map, data services, metadata catalog and spatial database. It is free and open source software with a very active community. In addition, GeoNode has a good content management system, a rich API, and it's fully customizable. To meet data access demands, it was customized to run in Kubernetes-based environments and each mapped area produces its own geoservice, exportable to different formats, such as shapefile and geotiff. However, it became necessary a complete separation between the production and publishing environments. SGB's production pipeline is composed by internally developed data management software. Some of these systems are being modernized, with updates on business rules, frameworks and security. GIS work is carried out in ArcGIS Enterprise®, with some exceptions in QGIS and GeoServer. With this background, it should be considered as a hybrid GIS model. About database structures, a process of harmonization was necessary, mainly those produced from proprietary GIS. For legacy reasons, the proprietary structures were maintained, as long as possible to export to OGC WKT or WKB. Exported geometries are analyzed for compliance with Simple Features Standard (OGC/ISO19125). The information eligible for publication were consolidated in database views and is literally replicated to GeoSGB, by script. The metadata production for continuous databases is carried out semi-automatically – templated - in accordance with the mapping program. This is possible by integrating GeoNode's APIs with internal databases, delivering associated metadata and resources directly to the authors. The contact with (meta)data authors were managed by GeoNode. The symbolization of thematic layers involved the development of interoperable libraries, based on SVG glyphs inserted in OpenType fonts (ISO/IEC 14496-22:2007), with near

equal rendering among different multi-platform GIS software. Data and metadata pipelines were implemented using Python scripts, with specific libraries associated with GeoNode APIs. Apache Airflow manages the entire process of extracting internal bases, quality tests, structure analysis and loading on the GeoSGB database server, including being responsible for notification activities. So, GeoSGB now is a continuous development platform, with focus in increase quality in delivered data to customers. The future perspectives involve the transformation itself into research line in geotechnologies and high-performance IT services. It shoud envolve plug-in development for data management, processing and visualization including use of artificial intelligence. In operational terms, adoption of OGC APIs, data internationalization and harmonization, associated with adoption of OGC specific standards, such as GeoSciML and WaterML contributes to become SGB a global supplier of geoscientific data.

Keyword

spatial data infrasctructure, geonode, ogc, geosgb

Rapid Geological Modelling for Surat Basin Based on Well Logs

GUOXU CHEN[1]*, Hefei University of Technology (chenguoxu1983@hfut.edu.cn)
Suzanne Hurter[2], The University of Queensland
Wanchang Liu[3], Hefei University of Technology
Fang Lv[4], Hefei University of Technology

Abstract

Resources estimation and numerical simulation of coalbed methane reservoirs depend on precise 3D geological models. The various properties of coalbed methane reservoirs (such as coal thickness, buried depth, coal quality, gas content, porosity, permeability, etc.) are heterogeneous in 3D space, which affect the occurrence, migration and development of coalbed methane. Lauren is one of the critical coalbed methane–producing fields in Surat Basin, Australia. Take Lauren coalbed methane field as the experimental area, a rapid modelling method of coalbed methane reservoirs based on well logs was studied in this paper. Firstly, by analyzing and using the data of remote sensing, DEM, and well logs, the integrated geosciences structure model of the aboveground and underground was created rapidly. Then, a multi-linear regression mathematical model for interpreting properties of coalbed methane reservoir was generated based on geophysical logs and laboratory analysis data. Furthermore, the 3D geological structure model was segmented into voxels, and the 3D high-resolution property models were achieved by interpolating the log interpretation data in 3D space. The 3D high-resolution property models, such as coal quality, coal faces, porosity, permeability and gas content, can characterize the high-resolution property characteristics of coalbed methane reservoirs, which can provide decision supports for the development of coalbed methane resources.

Keyword

coalbed methane reservoir, 3D rapid geological modelling, well log interpretation, 3D high-resolution structure model, 3D high-resolution property model

GEODEATLAS.nl; A web-based GIS resource atlas showing multiple geo-energy uses to support subsurface planning

Susanne NELSKAMP[1]*, TNO-GSN (susanne.nelskamp@tno.nl)
Suzanne Atkins[2], TNO-GSN
Kike Beintema[3], EBN B.V.
Esmée Boter[4], EBN B.V.
Rory Dalman[5], TNO-GSN
Sabine Korevaar[6], EBN B.V.
Marloes Kortekaas[7], EBN B.V.
Michael Nolten[8], EBN B.V.
Edward Wiarda[9], EBN B.V.

Abstract

The subsurface of the Netherlands has been the focus for oil and gas exploration for decades. With exploration and production of hydrocarbons decreasing, the need to safeguard, consolidate and make existing data and knowledge publicly available for future use became more and more apparent. In this light the GEODE project was set up with the aim to create an easily accessible, web-based GIS environment where play-based exploration (PBE) data can be displayed and downloaded for the main hydrocarbon and potential CO2 aquifer storage (sub)plays of the Dutch subsurface. The PBE process is an industry best-practice to document and evaluate subsurface data and systematically determine the value of remaining reserves. Within the context of this project, we are extending the use of this approach from pure hydrocarbon-focused exploration to including other relevant use cases such as CO2 saline aquifer storage and hydrogen storage.

The initial components of the PBE for hydrocarbon exploration include risked assessments of the presence and quality of a source rock, reservoir, seal, and trap. Common Risk Segment Maps (CRS) were made using a traffic light system identifying areas with high, medium, and low potential. To assess the subsurface potential for saline aquifer CO2 storage, additional subsurface analyses/deliverables were needed, such as injectivity, relative storage capacity density as well as geological containment potential. The gross thickness and permeability of the aquifers were used as a proxy for CO2 injectivity in the subsurface. The relative storage capacity density was estimated using gross reservoir thickness, average porosity and reservoir depth, as well as a set of rock and fluid properties. Overpressure and fault fracture likeliness maps were included to highlight the compartmentalization of the aquifers and indicate potential containment/vertical leakage risks. Due to limitations in the available input parameters as well as the availability of field data for calibration, the current maps can only be used for qualitative screening purposes.

For the first time a combined resource atlas is built, using a coherent database of subsurface data which gives the possibility to assess and evaluate potential synergies but also to identify conflicts of use and therefore aid in the planning and decision making process for subsurface energy

projects. The PBE results for the Triassic, for example, show significant overlap in areas with historic gas production and aquifers for potential CO2 injection, suggesting possibilities in infrastructure re-use but also potential containment issues.

Keyword

Play based exploration, Decision support, CCS, Subsurface use, North Sea basin

The Landslide Whisperer: An Intelligent and Efficient Framework for wrapped Interferogram Detection of Potential Hazards

Ruixuan Zhang[1]*, Chang'an University (rx.zhang@chd.edu.cn)
Wu Zhu[2], Chang'an University
Qian He[3], Chang'an University

Abstract

The Multi-Temporal Interferometric Synthetic Aperture Radar (MT-InSAR) technology shows significant advantages in identifying potential landslide hazards. However, the process is invariably affected by unwrapping errors and Atmospheric Phase Screen (APS), resulting in less accurate identification. Additionally, unwrapping operations incur substantial time costs, hindering real-time responsiveness. Hence, why not consider completing the identification task before unwrapping? In this work, leveraging the ISSLIDE dataset and data-driven convolutional neural networks (CNNs), we design and propose an intelligent framework for more efficiently identifying potential landslide hazards from wrapped interferograms. The framework consists of three main parts. The first part involves reprocessing the ISSLIDE dataset, where we read phase, cosphase, and sinphase in a more computer vision-oriented manner. The second part focuses on the network structure design. The model is divided into three sections: firstly, the phase, cosphase, and sinphase information is abstracted into high-dimensional semantic features through three weight-sharing, parallel encoding processes; secondly, features of the same dimension at each encoding level are fused via a feature fusion mechanism; finally, five different dimensions of the fused features are loaded into the decoder to complete the final decoding process. The third part addresses the integration of extracted results from interferograms across different time periods. We also take this opportunity to discuss "How to Train a Segmentation Network to Unearth Deformation Regions in Wrapping Interferogram with Unparalleled Precision?" This includes examining the impact of channel numbers, input methods, loss functions, and feature fusion techniques on segmentation results. Ultimately, our goal is to generalize the trained high-precision model to real-world scenarios. To validate our method, we use data from the publicly available LiCSBAS platform and conduct experiments in the lower reaches of the Jinsha River in China. The results demonstrate that our proposed intelligent framework shows promising performance in practical applications.

Keyword

InSAR; Wrapped Interferogram; Deep Learning; Landslide detection

The f(utility) of GIS-based landslide susceptibility: a review approach

Mihai Niculiță[1]*, Alexandru Ioan Cuza University of Iași (mihai.niculita@uaic.ro)

Abstract

The landslide susceptibility approach is very used today in landslide research. While the utility of this type of approach, especially in the context of hazard-risk workflows, other uses of the methodology are problematic. To understand the evolution and the progress of the susceptibility approach we realized an intensive critical review of the literature pinpointed both the utility, but also the futility of such an approach. The utility in the context of the hazard-to-risk evaluation is clearly shown in the literature, but even in this context, very often there are issues with the landslide inventories, with the lack of the optimization criteria, and with the utility in a practical context. The literature review analyzed the papers since 1980 when the approach was born, to the present day. After 2010 the increase in the number of papers is exponential. In the review, we analyzed the typology of the papers (theoretical, applicative), the data sources (in terms of landslide inventory, DEM, landslide factors), the methodologies (geomorphological, empirical, statistical, physical), validation strategy, the complexity of the scenario, the typology of the landslide, and applicability. The results show that the majority of the literature is applicative, with the theoretical approaches in the minority, although a certain number of these theoretical studies drive the trend of number increase. After 1990 the majority of the papers rely on GIS and statistical models, and on DEM variables for factors. The typology is variate (natural, anthropic-induced, co-seismic), but very often there is a lack of analysis of mechanism type differentiation (falls, slides, and flows considered together). The validation strategy is in majority based on ROC, and only a few papers deal with multi-temporal inventories that allow robust validations. The scenario of landslide triggering and evolution is limited to point-based GIS and statistical approaches, but there is a minority of papers considering run-out modeling. The applicability is the area where there is a general lack of specific applications of the results. As a conclusion of the analysis we have synthesized the results on the criteria mentioned and we have outlined the desired directions of the study in order to improve the utility of the GIS-based landslide susceptibility.

Keyword

landslide susceptibility, GIS, DEM, statistics, modelling

InSAR analysis for monitoring Cultural Heritage threatened by multiple risk and anthropogenic hazards: the seaport quarter in Valparaiso (Chile) case study.

Federica Ferrigno[1], ISPRA Geological Survey of Italy
Gabriele Leoni Leoni[2], ISPRA Geological Survey of Italy
Francesco Menniti[3], ISPRA Geological Survey of Italy
Daniele SPIZZICHINO[4]*, ISPRA Geological Survey of Italy (daniele.spizzichino@isprambiente.it)

Abstract

Valparaiso is a colonial city located on central Chile's Pacific coast, of which the historic seaport district has been declared as UNESCO World Heritage Site in 2003 for its rich history, unique architecture, and remarkable landscapes. However, the area is threatened by multiple natural risks, including slope instability, seismic hazard, tsunami, and man-induced hazards such as fires and subsidence. Slope superficial instabilities are caused by the thick layer of weathered rock from the Paleozoic and Mesozoic batholit and plutons along the hill slopes and subsidence is due mainly due to the compaction of soft sediments of the recent coastal deposits.

The current work shows the application of the InSAR (Interferometric Synthetic Aperture Radar) technology able to estimate, with millimeter precision, slow and non-catastrophic morphological processes, both long-term and seasonal, triggered by a great variety of causative factors. These kind of Aanalysis allows the planning of mitigation strategies.

More in detail, a specific InSAR data processing has been performed in the UNESCO buffer area of the historic district i of Valparaíso, additionally, a direct field survey to test the InSAR results has been carried out (November 2023).

SAR images acquired from Sentinel-1 constellation (C-band radar sensor) have been processed to generate multi temporal ground displacement measurement points using an A-DInSAR method, and to analyze their spatial distribution and correlation with slope instability and historical remains damages, thus allowing to verify the evolution of recent ground deformation phenomena (from January 2020 to August 2023).

The initial results show clear deformation patterns in different areas in both descending e ascending geometry, but any cluster of moving measurement point has been detected. Only some isolated points have been identified, and the analysis of their time series suggests that the movement (ca about 3mm/y) is probably due to small and local deformation instead than medium or large slope instability phenomena over the whole investigated area.

In conclusion, the results of the Sentinel-1 data provided useful information for detecting and monitoring the potential interaction between ground displacements and structures and to define potential unstable areas over the time, detecting anomalies and accelerations of the ground displacement, offering a powerful tool for the prevention of damage to cultural heritage related to the slope instability and subsidence.

The proposed research activity was developed within implementation of the FPCUP programme.

More in detail the actions aims to promote the uptake of Copernicus data and services in Central and South America (C&SA) focusing on Natural and Anthropogenic hazard and vulnerability assessment

Keyword

Copernicus, InSAR, Hazard, Cultural Heritage, UNESCO

Multi-frequency SAR time-series analysis of ground subsidence at coastal reclaimed land in Busan

Jeong-Heon JU[1]*, Pusan National University (jh.ju@pusan.ac.kr)
Sang-Hoon Hong[2], Pusan National University

Abstract

Synthetic Aperture Radar (SAR) is a remote data acquisition method that exploits microwaves to interact with the Earth's surface, enabling the retrieval of distance and scattering characteristic information about the Earth. With technological advancements, many satellites equipped with SAR payloads with different system characteristics, such as radar wavelength, revisit period, and incidence angle, have been launched and are being operated. Multi-temporal interferometric SAR (MT-InSAR), a technique utilizing multiple observations acquired over a long period, effectively removes residual phase errors in SAR observations and enables the precise estimation of time-series ground displacement. In the golden age of spaceborne SAR, characterized by the availability of numerous SAR sensors, exploiting multi-frequency SAR imagery for MT-InSAR research is indispensable. Ground subsidence, a phenomenon where surface materials sink due to natural or anthropogenic factors, can cause significant damage to human and material resources. Continuous monitoring is necessary to manage the devastating disaster of ground subsidence, and multi-frequency spaceborne SAR offers a promising solution. In this study, we aim to observe ground subsidence occurring at coastal reclaimed land in Busan, located in the southeastern region of South Korea, using multi-frequency space-borne SAR. We utilized X-band COSMO-SkyMed, C-band Sentinel-1, and L-band ALOS-2 PALSAR-2 SAR observations acquired from 2015 to 2019, comparing and analyzing results to measure ground subsidence and its causes accurately. In each result, there were differences in coverage by frequency, but similar distributions of subsidence were observed. The average subsidence rates in the research area were -1.99 mm/year from COSMO-SkyMed, -0.64 mm/year from Sentinel-1, and -1.10 mm/year from ALOS -2. In contrast to previous multi-frequency studies aimed at extending the observation period, this study demonstrated the potential to identify suitable SAR images through comparisons between SAR images from similar periods.

Keyword

SAR, Ground subsidence, Multi-frequency, Busan

Coastal Change from Space: Geohazard Assessment using S1-SAR and S2 datasets

Xavier MONTEYS[1]*, geological Survey Ireland (xmonteysv@gmail.com)
Salvatore Savastano[2], isardSAT UK
Jara Martinez Sanchez[3], IHCantabria
Paula Gomes Da SIlva[4], IHCantabria
Yeray Castillo[5], National University of Ireland Maynooth
Arnau Garcia Tort[6], IHCantabria
Andres Payo[7], British Geological Survey

Abstract

Coasts are continually evolving and remote sensing from satellites has the potential to both map and monitor coastal change at multiple scales for geohazard management. Experts in Earth Observation and end-users responsible for coastal monitoring from 5 different countries jointly developed the project Coastal Erosion from Space funded by the European Space Agency (ESA, 2020-2023) with the aim of assessing the ability of satellite derived products to detect coastal changes. This study presents the application of shorelines extracted from S1 SAR combined with S2 optical datasets, from publicly available satellite imagery, to map and capture intra-annual to inter-annual shoreline variability. This is assessed in three distinct settings areas from Ireland, Spain and the UK that represent coastal segments with different backshore environments: low-lying dunes and marsh; steep, rocky cliff; and urban environments. We have found that SAR derived shorelines consistently corresponded to positions above the high-water mark across all three sites. In a low-lying coastal setting, the annual change rate derived through SAR presents a high degree of alignment with the known reference values derived from optical satellite analysis. We further discuss the influence of the scene geometry, meteorological and oceanographic conditions, and backshore environment and provide a conceptual interpretation for the satellite-derived shorelines. The present study contributes with validation to our understanding of the poorly constrained knowledge of using shorelines derived from publicly available SAR satellite missions. It outlines a quantitative approach to automatically assess their quality with a novel automatic detection method that is transferable to shoreline evolution assessments worldwide.

Keyword

Satellite, SAR, shorelines, Coastal Change, geohazard

Geospatial Analysis of Coastal Dynamics and Development Strategies: A Case Study of Nagapattinam District, Tamil Nadu, India

Isai RAMACHANDRAN[1]*, Post Doctoral Fellow (isairamachandran@gmail.com)
Kannan Perumal[2], Research Scholar
Babu BALAKRISHNAN[3], Research Scholar
Natarajan GOVINDARAJU[4], Research Scholar

Abstract

This research delves into coastal zone management and planning for Nagapattinam District in Tamil Nadu, South India, leveraging Geospatial technology. Through meticulous analysis of various spatial distribution thematic maps encompassing rainfall patterns, geology, geomorphology, shoreline changes, and land use/cover utilizing collateral and satellite data, critical insights have been unearthed. Notably, areas such as Vanjiyur, Nagore, and Nagappattinam stations exhibit high rainfall, contributing to flooding and sediment deposition in estuaries, as evidenced by the annual average rainfall map. Geologically, flood basin deposits dominate, covering a substantial 1608 km2 area, with direct implications for coastal dynamics. Vulnerability assessments underscore regions of fluvial origin as particularly susceptible, where saltwater intrusion imperils agricultural lands and groundwater. Shoreline analysis spanning from 1971 to 2013 highlights significant accretion primarily attributed to major cyclones, notably Cyclone Nisha in 2008 and Cyclone Thane in 2011. Detailed land use/cover mapping delineates a gradual increase in human-made aquaculture ponds and salt pans until 2008, stabilizing thereafter, alongside a steady rise in built-up areas. Moreover, strategic development sites for tourism, transport networks, ferry services, sand harvesting, and resorts have been identified, emphasizing the holistic approach towards sustainable coastal development. This comprehensive research serves as a pivotal resource for informed decision-making and proactive management of coastal resources, fostering resilience and prosperity in the region.

Keyword

Coastal zone management, Geospatial technology, Geomorphology, Vulnerability assessment, Shoreline changes

Multitemporal Monitoring of Landslides using Remotely Piloted Aircraft (RPA) and Structure from Motion–Multi View Stereo (SfM-MVS): Case Studies in Brazil

Camila Duelis VIANA[1]*, Universidade de São Paulo (camila.viana@usp.br)
Rebeca Durço Coelho[2], Universidade de São Paulo - Institute of Geosciences
Vivian Cristina Dias[3], Universidade de São Paulo - Institute of Energy and Environment
Lucas Pedrosa Soares[4], Spatial Analysis And Modelling Lab (SPAMLab) IEE-USP
Guilherme Pereira Bento Garcia[5], Spatial Analysis And Modelling Lab (SPAMLab) IEE-USP
Carlos Henrique Grohmann[6], Universidade de São Paulo - Institute of Energy and Environment

Abstract

Landslides are among the most frequent and destructive natural hazards, representing one of the main causes of disasters. In Brazil, mass movements are geological processes that result in the highest number of fatalities. According to data from the Institute of Technological Research of the State of São Paulo (IPT), between 1988 and 2022, these processes led to 4,146 deaths in 16 Brazilian states. Thus, the automation of landslide mapping and monitoring is crucial for a better understanding of these processes, ensuring a swift response in disaster scenarios, and enhancing landslide susceptibility models.

The development of remote sensing technologies in the last decade has led to a significant growth in the information available about the Earth's surface. Among these advances, high-resolution orbital images capable of generating Digital Elevation Models (DEMs), airborne or terrestrial Light Detection and Ranging (LiDAR), and, more recently, the application of Structure from Motion–Multi View Stereo (SfM-MVS) technique to sets of images obtained by Remotely Piloted Aircraft (RPAs) can be mentioned.

The combination of such technologies, especially RPAs and SfM-MVS, provides a low-cost solution and the possibility of greater control over the temporal and spatial scales of surveys, making it particularly valuable in the study of landslides. In Brazil the use of RPAs to study landslides is still incipient and particularly challenging considering the diversity of scenarios within the country. To illustrate these differences, we selected two study areas in São Paulo State, southeastern Brazil, and evaluated multitemporal monitoring of landslides using RPA and SfM-MVS.

The first area is located in the São Sebastião municipality, in the coastal area of the State. The region is mainly prone to shallow landslides and debris flow. The most recent disaster event was registered in February 2023, resulting in significant human and economic losses. The studied area consists of a vegetated hillslope with a shallow landslide measuring approximately 250 x 100 m. Historical satellite imagery shows that the first ruptures of the landslide occurred around 2002. We conducted fieldwork for RPA surveys in October 2019 and May 2021, 2022 and 2023.

The second area is located in the northern part of the São Paulo municipality. Unlike São Sebastião, São Paulo is highly urbanized and the fourth-most populous city in the world, posing some challenges to the use of RPAs. The study area is locally known as CEU Paz, where urban

communities have developed in steep slopes since 2004, causing recurrent small landslides.
For both areas, images were acquired by a DJI Phantom 4 Pro V2 RPA and the SfM-MVS workflow was processed in Agisoft Metashape Pro. For each area, we compared the multiple digital surface models using Geographic Information System and the point clouds using CloudCompare. The analysis revealed the suitability of the chosen method for landslide monitoring while also highlighting limitations to consider. This research demonstrates the potential of RPAs and SfM-MVS for landslide monitoring in diverse Brazilian landscapes, contributing to improved risk assessment and mitigation strategies.

Keyword

landslides, monitoring, Remotely Piloted Aircraft, São Paulo

Utilizing PSInSAR and Open-Source Software for Monitoring Slow-Moving Landslides: A Case Study from Southern Taiwan

Abhishek Ravindra LAKHOTE[1]*, Institute of Earth Sciences (abhi.lakhote1994@gmail.com)
Yu-Chang Chan[2], Institute of Earth Sciences
Chiao-Yin Lu[3], National Science and Technology Center for Disaster Reduction

Abstract

Slow-moving landslides pose significant threats to the stability of mountainous regions, affecting both human settlements and infrastructure. This study focuses on the southern part of Taiwan, specifically at the Hsinfa village in the vicinity of Laonong River, where slow-moving, deep-seated landslides have been identified as a significant geohazard since the 2009 Morakot Typhoon. This study presents a detailed analysis of monitoring slow-moving deep-seated landslides utilizing PSInSAR techniques, complemented by the integration of open-source software tools. Utilizing the temporal and spatial information provided by these techniques; this study aims to characterize the movement along the slope of the identified deep-seated landslides in the Laonong River region. The integration of StaMPS with ISCE environment facilitates the identification of persistent scatterers and the detection of ground deformation associated with slow-moving landslides. The datasets used for this research focused on the Sentinel 1 datasets from 2018 to 2023, which contribute to a better understanding of the dynamics of slow-moving deep-seated landslides in the southern part of Taiwan. The findings from the PSInSAR techniques provide valuable information, such as that the slope is characterized by EW (horizontal) and NS (vertical) velocity values ranging from 1.5 mm/yr to 6.5 mm/yr movement for the observed period. The results observed along the slope also corroborate the present inclinometer stations at the site-specific areas. This observation surely helps in developing early warning systems and implementing effective mitigation strategies to reduce the impact of such geohazards on local communities and infrastructure. Furthermore, the study highlights the significance of remote sensing technologies in monitoring and managing landslide-prone areas for sustainable development and risk reduction.

Keyword

Laonong River, PSInSAR, Slow-moving Landslide, Horizontal (EW) velocity, Vertical (UD) velocity

Fostering New Talent: Exploring Innovative Approaches in Geoscience to Meet 21st Century Societal Needs

Courtney Elaine Jermyn[1]*, ESM Foundation (c.jermyn@earthsciencematters.org)

Abstract

The escalating challenges posed by climate change, resource scarcity, and the need for skilled labour in a sustainable economy are pressing global issues that must be addressed. Earth's role is central to many of these challenges, necessitating increased societal awareness and innovative, science-driven solutions that harmonize the demands of our planet with those of its inhabitants. The commitment of UN member states to the Paris Agreement underscores the urgency of transitioning to a low carbon economy. The competition for essential metals between renewable industry scaling and technological advancements further complicates this transition. To navigate these complexities sustainably, leaders require access to comprehensive information underpinned by Earth Science expertise, which is currently at risk of depletion. Addressing the decline in Earth Science education and expertise is crucial for overcoming these obstacles and fostering a sustainable future.

As the geoscience field faces the challenge of an aging expert population, the question arises: how do we ensure the continuity of knowledge and inspire a new generation of Earth scientists? Could advancements in GIS and remote sensing be the vehicle to bridging the gap geoscience education?

Through an open discussion format, we will delve into this pressing issue, and examining the current trends experienced by geoscience professionals. During the presentation session we aim to engage the audience to collaboratively seek solutions to sustain and invigorate geoscience programs, ensuring that our understanding of the Earth remains robust to meet society's needs in the 21st century and beyond.

Keyword

Geoscience, Education, Innovation, Challenges, Geomatics

Landslide susceptibility assessment using Mahalanobis Distance-based class imbalance strategies: A comparison of under-sampling, over-sampling, and hybrid sampling techniques

Kounghoon NAM[1]*, Andong National University (geonamsoil@gmail.com)
Jongtae Kim[2], Nature and Tech Inc, Korea
Hojin Lee[3], Korea Water Resources Corporation, Korea
Shuai Zhang[4], Institute of Geomechanics, Chinese Academy of Geological Sciences, China
Chang-Oh Choo[5], Andong National University, Korea
Gyo-Cheol Jeong[6], Andong National University, Korea

Abstract

This research investigates the effectiveness of different resampling methods—under-sampling, over-sampling, and hybrid sampling—within the Random Forest (RF) framework for enhancing landslide susceptibility modeling in Hokkaido, Japan. The region, severely impacted by 5,625 landslides triggered by the 2018 Iburi earthquake, serves as the study site. The primary aim is to mitigate the challenges posed by class imbalance in landslide susceptibility assessment (LSA) and to refine the predictive accuracy. The study leverages multiple data sources to define conditioning factors and employs a novel strategy for selecting absence data based on Mahalanobis distance to address the issue of unlabeled samples. The RF model is utilized to compute susceptibility scores and produce LSA maps, which are assessed using the Area Under the Receiver Operating Characteristic curve (AUROC) and the Precision-Recall curve (AUPRC). These metrics facilitate the evaluation and interpretation of the model's predictive capabilities in the context of imbalanced datasets. Findings indicate that resampling methods, especially when combined in a hybrid approach and supplemented with Mahalanobis distance-based absence data selection, significantly enhance model performance and reliability in LSA. The study underscores the potential of these strategies to improve the precision and stability of machine learning models in landslide risk reduction efforts. Acknowledgment: This study was carried out with the support of R&D Program for Forest Science Technology (Project No. 2023476C10-2325-BB01) provided by Korea Forest Service(Korea Forestry Promotion Institute).

Keyword

landslide, class imbalance, mahalanobis distance, hybrid sampling, random forest

Opportunities of Advanced Remote Sensing for Rock Mass Classification on Inaccessible High Alpine Rock Slopes

Nicole OYSMUELLER[1]*, University of Natural Resources and Life Sciences in Vienna
(nicole.oysmueller@students.boku.ac.at)
Christian Zangerl [2], University of Natural Resources and Life Sciences in Vienna
Christine Fey [3], University of Natural Resources and Life Sciences in Vienna
Erik Kuschel [4], University of Natural Resources and Life Sciences in Vienna

Abstract

In order to describe and classify rock slope failures and to estimate the slope stability for an area of interest, it is important to perform several in-situ investigations with various methods. Thereby, a special focus is laid upon the structural inventory of a rock mass, as its discontinuities can provide kinematic feasibility for rock slope failure.
Investigations in areas exposed to natural hazards can be challenging to perform or generally be unfeasible due to its inaccessibility for humans.
Thus, the application of advanced remote sensing techniques may be crucial, in order to derive important rock mass parameters, such as the discontinuity network. However, the method still needs to be validated with in-situ data.
The study area 'Kühtaier Längental' with its high alpine terrain is located in the Oetztal Nappe of the Austrian Alps. Its well-exposed, fractured, metamorphic rock mass offers great potential for our investigations.
During a four-week field campaign detailed in-situ investigations were performed.
A total number of 675 discontinuities were recorded and evaluated, which led to a proper rock mass characterization of the rock slope.
The study area was additionally examined remotely both with a UAV system and a terrestrial laser scanner (TLS) from different positions, making it possible to gather a 3D terrain-model of the inaccessible areas. This provided the basis to compare the in-situ measurements with the advanced remote sensing data, derived by UAV and TLS. Furthermore, the results of the manual recording of discontinuities can be compared with the structural inventory derived from the TLS and UAV point-clouds.
In our study, we present a comparison of the data by highlighting advantages and disadvantages of the respective techniques.
As a conclusion, this study is intended to make a qualitative statement as to whether semi-automatic recordings can be suitable for engineering geology issues. In our study we demonstrate the opportunities and limitations of deriving a fracture network by advanced remote sensing in inaccessible high alpine terrains.

Keyword

rock mass characterization, remote sensing, discontinuity network, high alpine rock slope

A Study on the Utilization of GNSS Data for Monitoring the Stability of the Yangsan Fault

Heeun KIM[1]*, Korea Meteorological Administration (khu0716@gmail.com)
HaSeong LEE[2], Korea Meteorological Administration
Jimin LEE[3], Korea Meteorological Administration
Sun Cheon PARK[4], Korea Meteorological Administration

Abstract

In recent times, major earthquakes, including those in Gyeongju and Pohang near the Yangsan Fault, have occurred on the Korean Peninsula, highlighting the need for monitoring studies on the ground movements around the Yangsan Fault Zone. This study utilized GNSS (Global Navigation Satellite System) observational data to conduct monitoring by analyzing the displacements and calculating strain stresses in the vicinity of the Yangsan Fault. The analysis methods employed in this study involved, firstly, analyzing the global movements of the ground around the Yangsan Fault based on the IGS (International GNSS Service) reference station. Secondly, analyzing the strain stress around the Yangsan Fault using domestic GNSS data. Data processing was carried out using the Bernese GNSS Software. The Bernese GNSS Software is a scientific, high-precision, multi-GNSS data processing software developed at the Astronomical Institute of the University of Bern (AIUB). The analysis period spanned from July 2018 to December 2023. The results indicate that the ground movements around the Yangsan Fault corresponded to the annual average of the Korean Peninsula in terms of magnitude and direction. Additionally, the stress levels around the Yangsan Fault were relatively stable compared to the period of the Tohoku Earthquake. However, continuous monitoring using GNSS is deemed necessary due to the persistent seismic activity in the region.

Keyword

GNSS, Strain Stress, Yangsan Fault, Bernese, Earthquake

Geological Risk Mapping in the Largest City in Brazil: From Paper Reports to Artificial Intelligence

Thais Feitosa TREVISANI[1]*, São Paulo City Hall - Civil Defence Coordination (thaistrevisani@gmail.com)
Camila Duelis Viana[2], Universidade de São Paulo - Institute of Geosciences
Natália Leite de Morais[3], São Paulo City Hall - Civil Defense Coordination
Caroline Gevaert[4], University of Twente - Faculty of Geoinformation Science and Earth Observation

Abstract

São Paulo ranks in the top 20 most populous cities, with over 11 million inhabitants in the municipality alone. While it is the wealthiest city in Brazil, it is also highly unequal. Approximately 26% of its inhabitants are low-income, leading to many of them living in areas prone to mass movement processes.

Although the urban expansion from the center to the periphery, with the occupation of land with lower construction aptitude and areas of protection for water sources, began in the 1930s and consolidated from the 1970s onwards, it was only in the late 1980s that geological risk areas began to be mapped, after a landslide killed 14 people, including 12 children.

Until 2015, risk mapping was carried out by hiring companies, atlarge time intervals: 1989/1990, 1996, 2002/2003, and 2009/2010. The reports and maps were produced using different mapping methods, were delivered in printed form, and were based on different cartographic bases. This resulted in discrepancies between them, making it impossible to perform spatialized comparative and quantitative analyses.

Starting in 2018, an effort began to initially organize all the mapping updates in a geographic information system (GIS), and then to digitize the risk sectorization of previous mappings in the same system. The digitization work was essentially manual, with consultation of several historical maps and reports, cartographic bases, and current high-resolution images, as well as the correction to the official datum of the country, to faithfully preserve the boundaries of the various risk sectors.

The unification of the various mappings in a GIS environment allowed for the quantitative evaluation of the spatialization and evolution of geological risk areas. Such data also allows for verifying whether the implemented risk mitigation and prevention actions for the occupation of new risk-prone areas are satisfactory, pointing out shortcomings or successes in the city's risk management.

In 2023, a new phase began, with the final goal of using artificial intelligence to help monitor the more than 480 areas at risk of geological hazards, many of them representing low-income neighborhoods. Using the GIS database, orthophotos with a resolution of up to 10 cm produced from two airborne lidar surveys (2017 and 2020), and orthomosaics produced using remotely piloted aircraft and photogrammetry, it is expected to achieve the segmentation of elements that may alter the risk classification (e.g., leaning trees, exposed soil, wooden houses), and which are

not always visible during field inspections. To this end, the Segment Anything Model (SAM), a new AI model from Meta AI that is a promptable segmentation system with zero-shot generalization to unfamiliar objects and images, without the need for additional training, will be tested. Such an automatic workflow has the potential to harmonize risk classifications and increase the ability to monitor changing risk profiles across São Paulo.

Keyword

risk mapping, landslides, São Paulo

2023 Multi-temporal Surface Deformation and Activity Evaluation of Deep-Seated Landslide Sites

Suet-Yee AU[1]*, National Taipei University of Technology, Taipei Tech (asybibi@gmail.com)
Rou-Fei CHEN[2], National Taipei University of Technology, Taipei Tech
Chen-Yu CHEN[3], Agency of Rural Development and Soil and Water Conservation, MOA
Ya-Zhu YU[4], Agency of Rural Development and Soil and Water Conservation, MOA
Tsung-Ting CHEN[5], National Taipei University of Technology, Taipei Tech
Yi-Chung CHEN[6], National Taipei University of Technology, Taipei Tech
Chih-Yu Kuo[7], Research Center for Applied Sciences, Academia Sinica (RCAS)

Abstract

The Taiwan main island, with 47% of its land situated above 1000 meters, has consistently experienced slopeland disasters caused by intensified typhoons and torrential rains triggered by the extreme climate. To prevent and mitigate potential landslide hazards, relevant government agencies have been proactive and dedicated to conducting large-scale landslide monitoring and analyses. After evaluating the scale of disaster-affected areas, potential risks, and preservation targets, the Agency of Rural Development and Soil and Water Conservation, Ministry of Agriculture (hereinafter referred to as the ARDSWC) has further planned a landslide activity assessment for 306 potential large-scale landslide sites this year. At the current stage, to acquire extensive ground surface deformation data, the use of the all-weather and high-resolution Interferometric synthetic aperture radar (InSAR) technique with continuous spatial coverage is essential to provide long-term and quantified information for potential large-scale landslide areas.
This project has adopted the imagery of the ALOS-2 satellite released by the Japan Aerospace Exploration Agency (JAXA) in 2014, along with the Temporarily Coherence Point InSAR (TCP-InSAR), to analyze the ground surface deformation data of potential large-scale landslide areas. In the meantime, the aerial Lidar-derived Digital Elevation Model (DEM) is utilized for geomorphometric analysis and value-added algorithms to further obtain cartographic information, such as the slope, openness, curvature, and roughness. This information can facilitate the statistical, quantitative, and image analysis of surface terrain features in potential large-scale landslide areas. In light of this, leveraging multi-variant and multi-scale observations effectively contributes to managing disaster-prone areas, thereby serving as a valuable reference for subsequent detailed planning and engineering management of slopes.

Keyword

Potential Large-scale Landslide, Interferometric Synthetic Aperture Radar (InSAR), Multivariate and Multi-scale Observations, Activity Assessment, Corner Reflector

Remote Sensing Technology Applied to the Potential Analysis of Engineering Geological Disasters

Tsung ting CHEN[1]*, National Taipei University of Technology (fggd0721@gmail.com)
Rou Fei CHEN[2], National Taipei University of Technology
Chris LI[3], CECI Engineering Consultants, Inc. Taiwan
Huei HUANG[4], CECI Engineering Consultants, Inc. Taiwan
Chia Shin Chang[5], CECI Engineering Consultants, Inc. Taiwan
Suet Yee AU[6], National Taipei University of Technology
Yi Chung CHEN[7], National Taipei University of Technology
Chih-Yu Kuo[8], Research Center for Applied Sciences, Academia Sinica (RCAS)

Abstract

With the rapid development of Taiwan's economy and the increasing construction of infrastructure, it is important to prevent the planning and construction of road corridors from being affected by potential hazards, which may lead to subsequent environmental loads or extreme events that may disrupt the structural stability of the transportation facilities. This project integrates multiple remote sensing techniques to interpret underlying geological structures, detect regional slow ground deformation in a larger scale, and assess rainfall and hydrological information at different scales. This project aims to analyze the potential environmental hazards in the early stages of planning and design, and provide early warning when road facilities from being subjected to the amount of cumulative deformation on the ground surface or exceeding a certain limit, which may threaten the normal operation of the transportation network or even cause major incidents. Taking the national highway as an example, several collapses on the dip slopes along the northern coast of the Keelung River and the effects of the regional structure on the Zhongliao Tunnel highlight the importance of understanding the regional geological structure, and conducting landslide activity assessment and environmental monitoring in selecting the infrastructure site and planning road corridor at the early design stage, and the subsequent environmental impact assessment. At the same time, regular deformation monitoring of infrastructure is essential for timely detection of potential safety hazards and ensuring their safe operation.

The project has accomplished the following achievements: (1) Conducting topographic metric analysis using airborne LiDAR to interpret the topography and geomorphology of the eastern sections of National Highway 7 and Provincial Highway 86 with a focus on prominent gullies and structural features (e.g., terrain slope, openness, curvature, and roughness); and further identify factors along the road corridors that potentially contribute to slope disasters. (2) Collecting and pre-processing of radar satellite images, including 66 ALOS-2 raw images spanning from 2015 to 2022; and, based on the InSAR ground surface deformation analysis results, pinpointing key road sections with significant ground surface deformation rates on National Highway 7 and Provincial Highway 86. (3) The time-series profile analysis of cumulative ground surface deformation, coupled with rainfall data, reveals that ground surface deformations in specific areas of both road

sections are influenced by typhoons, heavy rainfall, and seismic events; and the limestone segment of the Dasha Formation in the Fengshan section of National Highway 7 experiences a pronounced trend of ground surface deformation triggered by the erosive effect of rainwater. Therefore, in regions with relevant topographic and geological conditions along these two highways, a careful evaluation of hydrological and geological conditions is advised. Moreover, since Provincial Highway 86 is situated in proximity to the Longchuan Fault zone and features an exposed mud volcano, it is recommended to assess exposed mud diapirs during the eastward extension project of Provincial Highway 86 and prevent the infrastructure from being affected by mud diapirs and fault activities.

Keyword

InSAR, Engineering Geological, Potential Safety Hazards

Assessing Landslide Vulnerability in Sindhudurg District, Western India: Integrating Stakeholder Perspectives and Geospatial Analysis

AMIT VIJAYKUMAR SHIRKE[1]*, Research Scholar, Department of Geology, Savitribai Phule Pune University, Pune (amitshirke2311@gmail.com)
Bhavana Umrikar[2], Professor, Department of Geology, Savitribai Phule Pune University, Pune

Abstract

Landslides pose a significant threat in the Western Deccan Volcanic Provinces, particularly in the Western Ghats region of India, where unique weathering properties, rugged terrain, heavy rainfall, and human activities converge to heighten susceptibility. This study concentrates on pinpointing landslide-prone areas within Sindhudurg district, Western India, by amalgamating stakeholder insights with geospatial analysis. A structured questionnaire was administered to 208 stakeholders, including local government officials and public representatives from various villages in the district, considering factors such as Deccan Trap typology, heavy rainfall, seismic activity, and anthropogenic influences. Statistical methodologies, encompassing mean, standard deviation, and factor analysis, were employed to extract pivotal influencing factors from stakeholder responses. Geospatial datasets, incorporating digital elevation model (DEM), slope, aspect, geology, geomorphology, road network, and drainage density, were assimilated into the analysis. The Analytic Hierarchy Process (AHP) facilitated the weighting of influential parameters, contributing to the formulation of a landslide vulnerability map. Findings unveiled that stakeholders' perceptions were shaped by a myriad of factors, including heavy precipitation, seismic events, and human interventions. This research underscores the significance of integrating stakeholder perspectives into disaster management strategies. Validation of the landslide vulnerability map was performed through alignment with stakeholders' observations of hazardous areas. The outcomes furnish valuable insights into landslide vulnerability dynamics and serve as a foundation for informing policymakers and district disaster management authorities. By prioritizing resources and deploying targeted mitigation measures, authorities can effectively mitigate the adverse impacts of landslides, promoting resilience and sustainable development. This interdisciplinary approach, blending stakeholder engagement with geospatial analysis, provides a robust framework for assessing landslide vulnerability and enhancing disaster preparedness in analogous geographical contexts.

Keyword

Disaster, AHP, Landslides, Statistical Analysis

Research on Precipitation Prediction and Geological Disaster Warning Based on Infrared Remote Sensing and Deep Learning

jingyi zhang[1]*, School Of Earth Sciences, Zhejiang University (Zjingyi@zju.edu.cn)
linshu hu[2], School Of Earth Sciences, Zhejiang University

Abstract

Precipitation is a natural phenomenon, which has great significance in human production and life. Its complex relationship with agriculture, water resources, and the overall ecological balance highlights the urgent need for accurate prediction and effective management of precipitation. This article utilizes large-scale infrared remote sensing technology to capture high-precision, near-real-time precipitation data and analyzes and processes the remote sensing data to make it more suitable for precipitation estimation. This enables a deeper study of the subtle differences in precipitation dynamics, decoding the local spatial and temporal patterns of precipitation, and revealing the complex and high-order spatial and temporal characteristics of large-scale weather systems. Through research, we can deepen our understanding of precipitation mechanisms, patterns, and evolution trends to make better decisions and strategic plans. The paper uses deep learning methods to build a precise and real-time short-term precipitation prediction model, considering three geological disasters that are greatly affected by rainfall: collapses, landslides, and debris flows. When the precipitation forecast reaches a certain threshold, disaster warnings will be issued to reduce losses of life and property and enhance the ability to predict and respond to precipitation-related challenges. By utilizing advanced remote sensing technology, we can obtain information on dynamic changes in precipitation and improve the resilience and sustainability of the human life support system.

Keyword

Remote Sensing, Spatiotemporal Prediction, Deep Learning, Precipitation, Geological Disaster

Geological Hazard Mitigation Portal of Indonesia

Ahmad BARNES[1]*, Geological Agency (barnes.esdm@gmail.com)
Gentur Dwi Teguh Santoso[2], Geological Agency
Hery Kuswandarto[3], Geological Agency

Abstract

Located along the “Pacific Ring of Fire”, Indonesia faces high seismic, tsunami, landslide and volcanic risk. As the government-mandated agency to perform geological hazard mitigation, CVGHM has duty to do monitoring, evaluating, reporting, mapping, perform analysis and providing technical recommendations of geological hazards in Indonesia. We continuously strategizing and establishing an efficient and optimal infrastructure and data management system to improve mitigation that allow contingency planning, effective emergency preparedness, timely assessment, warning and action during crisis. Multi-hazard disaster mitigation action requires functioning disaster mitigation information systems that can provide reliable and timely data, statistics and analysis. For this reason, we created geological hazard mitigation portal, an open access interactive graphical user interface allowing users to search and download various geological hazard maps (earthquake, tsunami, landslide, volcanic), volcano geological maps and and rain-induced landslide susceptibility maps. This map can be visualize interactively based on area of interest following administrative boundary and kept up-to-date with the most recent recommendation. Given that we are also dealing with large amounts of volcano monitoring data that are complex and of various types and formats, a robust and efficient data management platform is crucial for CVGHM. We are using PostgreSQL, an open-source relational database management system emphasizing extensibility to GIS-based data type and SQL compliance. To make an efficient data archiving, we developed a system that able to automatically input low-rate processed data into the database. This system also allows data display in near real-time through web application. All of these efforts aimed for quick assessment, timely evaluation, and better decision to provide early warning to the community.

Keyword

geological hazard, mitigation, database, GIS, web portal

Integration of ISAR and GNSS for Monitoring the Stability of Artificial Slope: a Case Study of Lijiang, China

Yinjie CAO[1]*, Tongji University (james008@tongji.edu.cn)
Lei ZHANG[2], Tongji University

Abstract

China, with a vast territory, complex terrain, diverse climate and unique geology, frequently experiences landslides that result in heavy casualties and property losses. In southwest China, where extensive construction of highways and high-speed railways is taking place, the creation of high and steep artificial slopes has become common. However, due to the complex geological structure in southwestern areas, these artificial slopes are prone to sliding or even collapsing after one or two rainy seasons. Such occurrences not only disrupt the progress of construction projects but also pose a potential threat to the infrastructure safety operation management. Therefore, it is crucial to establish an automated real-time monitoring and warning system for various geological hazards, particularly focusing on the artificial slope sliding, which assumes paramount practical significance in guaranteeing the safe operation of infrastructure.

Nowadays, traditional methods employed for monitoring artificial slope sliding include leveling instruments, GPS ground stations, and crack meters, among others. However, these traditional methods exhibit limitations in terms of their ability to effectively monitor proven landslide points within a restricted area, resulting in low efficiency, high costs and susceptibility to external conditions. Furthermore, they fail to accurately reflect the overall deformation characteristics and trends of the sliding forms at regional scale, particularly with regard to the hidden landslides in inaccessible areas. The emergence of spaceborne synthetic aperture radar (InSAR) technology has effectively addressed the deficiency associated with traditional technologies, rapidly establishing itself as a prevalent geodetic method due to its extensive coverage, high precision, high resolution and independence from weather and lighting conditions. However, the low temporal resolution of InSAR technology remains limited, precluding the extraction of real-time surface deformation information.

In this project, we amalgamate the space-borne Interferometric Synthetic Aperture Radar (InSAR) and Global Navigation Satellite System (GNSS) technologies to monitor the stability of artificial slopes formed during the construction of Huali Highway in Yunnan Province (Huaping to Lijiang section of National Highway G4216). Initially, we employ the TCPInSAR technology to extract deformation information in Lijiang, utilizing a set of 17 PALSAR-2 images acquired between 2014 and 2019. Then we select 8 artificial slopes situated along the highway as our designated monitoring areas, where we deploy GNSS ground monitoring stations. The optimal deployment of these stations will be guided by the InSAR historical deformation census. The effectiveness and practicality of this integrated InSAR and GNSS monitoring system will be verified through this project. This integrated system has successfully found three deformation areas with more than ten times warning messages during past two years.

Keyword

InSAR, GNSS, Slope stability, Deformation monitoring

Multi-Sensor Remote Sensing Data and Deep Learning for Time-Series Analysis of Caldera Lake Dynamics at Mt. Changbai: Monitoring Volcanic Activity

EURU LEE[1]*, University of seoul (eurulee22@uos.ac.kr)
Ha Seong Lee[2], Korea Meteorological Administration
Ji Min Lee[3], Korea Meteorological Administration
Sun Cheon Park[4], Korea Meteorological Administration
Hyung Sup Jung[5], University of seoul

Abstract

To mitigate and minimize the damages caused by volcanic eruptions, continuous monitoring of pre-eruptive signs is essential. In the case of the active volcano Mt.Changbai, changes in the area and water level of the caldera lake, Cheonji, serve as reliable indicators of volcanic precursory phenomena (Shibata and Akita., 2001). However, due to the extensive area of caldera landscapes and the accessibility limitations in high mountain regions, satellite imagery becomes indispensable for monitoring Cheonji water body and level (KMA2022). Deep learning technologies have demonstrated superior performance in detecting changes in water body and level compared to traditional methods, robustly adapting to various conditions and environmental changes, thereby enhancing the accuracy and efficiency of volcanic monitoring. This study employs SAR-EO sensor satellite imagery alongside deep learning techniques to monitor volcanic activity at Mt. Changbai. Utilizing images captured between 2014 and 2022 during the thawing period of August to December, we developed an algorithm with an F1-score of 0.996 for estimating the water body area and level using 129 Sentinel-1 SAR images, 45 Sentinel-2 optical images, and Copernicus DEM data. The developed algorithm facilitated the analysis of multi sensor satellite time-series data on water body area and level, allowing for the assessment of seasonal effects and discrepancies between satellites. To achieve precise volcanic activity monitoring that incorporates heterogeneous satellite imagery, we acquired regional meteorological data near Mount Changbai and developed and applied an Long Short Term Memory model that corrects for time-series weather distortions and inter-satellite biases. The study did not identify any significant volcanic activity in Cheonji during the research period, aligning with the results of other studies on Mt. Changbai's volcanic activity. The consistency of our findings with other research suggests that, when used in conjunction with other Mt. Changbai volcanic activity monitoring techniques, our approach can contribute to a more

precise surveillance system for the volcano.

Keyword

Volcanic activity, Monitoring, Artificial Intelligence, Electro-Optics, Synthetic Aperture Radar

Assessing the Potential of Novel Remote Sensing Techniques in Landslide Monitoring and Susceptibility Mapping

Dylan GORDON[1]*, University of Pennsylvannia (dylan44514@gmail.com)

Abstract

Landslides are a major hazard that can cause significant damage to property and infrastructure. Traditional methods for identifying landslide conditions and demarcating landslide susceptibility are often time-consuming and labor-intensive. In recent years, there has been a growing interest in the use of remote sensing to improve these methods. Continuous satellite-derived data and imagery can provide a wealth of information about landslide conditions, including changes in land surface elevation, vegetation cover, and soil moisture. This information can be used to identify areas that are at risk of landslides and to track the development of landslide conditions over time. By comparing and contrasting differences between commonly used methods of continuous landslide monitoring and identification, an assessment of the results can determine the most viable and/or successful method to identify areas susceptible to landslides. The use of satellite-derived data and imagery in continuous landslide monitoring is still in its early stages, but it has the potential to revolutionize the way that landslide hazards are assessed. There is significant potential in novel remote sensing techniques in landslide monitoring and susceptibility mapping. By providing a more accurate and timely assessment of landslide hazards, recent advancements in remote sensing can help to save lives and property.

Keyword

landslides, remote sensing, geophysics

Mitigating decorrelation noises and atmospheric delays in InSAR

Jun HU[1]*, Central South University (csuhujun@csu.edu.cn)
Jihong LIU[2], Central South University
Yuqi TANG[3], Central South University

Abstract

Decorrelation noises and atmospheric delays pose significant challenges in achieving high-accuracy surface displacement measurements using Interferometric Synthetic Aperture Radar (InSAR). Decorrelation noises, which manifest randomly in both temporal and spatial domains, hinder the recovery of interferometric phases. Traditionally, optimization of interferometric phases relies on statistically homogeneous points throughout the observation period, leading to inadequate recovery of decorrelated phases and potential use of incoherent phases in optimization, consequently compromising measurement accuracy and density. To tackle this challenge, we propose incorporating a strain model to capture the spatial correlation between displacements of adjacent points. By leveraging this spatial constraint relationship, homogeneous points of target pixels can be identified on an interferogram-by-interferogram basis, effectively suppressing decorrelation noises and achieving precise interferometric phase optimization.

In contrast, atmospheric delays exhibit spatial correlation and temporal randomness. Methods to mitigate these errors typically fall into two categories: those based on external information and those using data-driven techniques. External methods rely on sources like GNSS-derived tropospheric models and meteorological data but often lack the necessary spatial resolution. Conversely, data-driven techniques directly utilize InSAR data, addressing stratified and turbulent components separately. However, this separation may lead to biased estimates due to the interdependence of these components. To overcome these challenges, we introduce DetrendInSAR, a novel data-driven method that simultaneously models and mitigates turbulent and stratified delays. Leveraging their spatiotemporal characteristics, DetrendInSAR models turbulent delays as a slowly changing spatial process and stratified delays as linearly related to local terrain height. These components are integrated into a mathematical model using a pixel-by-pixel window-based strategy, with additional constraints provided by the assumed temporally smooth displacement signals in InSAR observations.

Validation using both simulated and real SAR data demonstrates the efficacy of the proposed methods in mitigating decorrelation noises and atmospheric delays. Case studies include investigating surface displacements in the Geysers geothermal field and postseismic displacement after the 22 May 2021 Maduo earthquake in China. Results reveal the enhanced accuracy of the proposed methods in displacement measurement compared to traditional methods. The ground surface deformation in the Geysers is slowdown after the construction of two fluid injection projects in 1997 and 2003. Moreover, analysis of postseismic displacements highlights the contribution of poroelastic rebound to near-field deformation, in addition to afterslip reported in earlier studies.

Keyword

InSAR, decorrelation noises, atmospheric delays, data-driven, Maduo earthquake

High-Density and High-Temporal-Frequency Monitoring of Reservoir Landslides with InSAR based on Environmental Prior Information

Qian SUN[1]*, Hunan Normal University (sandra@hunnu.edu.cn)
Aoqing GUO[2], Central South University
Wanji ZHENG[3], Central South University

Abstract

The creep of rock and soil masses along the slopes of reservoir banks occurs due to fluctuations in water levels, leading to sudden and destructive landslides that can rapidly slide into the reservoir in just a few dozen seconds, generating huge waves and posing a significant threat to the safety of people's lives and property. Monitoring the evolution of historical surface deformation using Interferometric Synthetic Aperture Radar (InSAR) technology can predict the risk of premature instability in landslides. However, current InSAR deformation monitoring for reservoir bank landslides still faces technical barriers in terms of precision and temporal frequency. Regarding monitoring precision, factors such as steep terrain and seasonal decoherence can limit the detection of deformation characteristics within blind spots. In terms of temporal frequency, SAR satellites typically operate at relatively low orbit altitudes, resulting in limitations in InSAR deformation monitoring due to fixed revisit cycles and low temporal resolution, which cannot meet the need for continuous monitoring of geological disasters. To address these issues, we have proposed a new InSAR method that leverages the spatiotemporal characteristics of landslide deformation as prior information to effectively enhance the density and accuracy of temporal monitoring of landslide deformation in low-coherence regions. This method combines independent component analysis (ICA) with the identification of temporary coherent points. Additionally, we have developed a high-temporal frequency landslide deformation estimation method that incorporates hydrological observations, such as rainfall and reservoir water levels, as prior information, significantly improving the temporal resolution of InSAR temporal monitoring of landslides. By utilizing the characteristics of our new methods, which yield products with high spatial density and temporal frequency, we have conducted detailed high-temporal frequency deformation monitoring of the Xinpu landslide in the Three Gorges Reservoir Area. The application of our new methods has revealed previously undetected potential small-scale movement units, detected significant seasonal signals, and identified accelerated deformation triggered by the rainy season in 2020. Furthermore, our methods have increased the temporal resolution of landslide deformation monitoring along the reservoir bank to one day. Our proposed methodological framework has advanced the development of landslide deformation detection, monitoring, and disaster risk prediction, paving the way for more accurate and timely assessments of landslide hazards and the mitigation of potential risks.

Keyword

InSAR, landslide, deformation, high-density, high-temporal-frequency

Identification of lithium deposits information based on two Chinese satellites

Nannan ZHANG [1]*, Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences (znn_0802@163.com)
Li CHENG[2], Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences
Hao ZHANG[3], Xinjiang Institute of Ecology and Geography , Chinese Academy of Sciences

Abstract

Currently the worldwide development and utilization of lithium has gained significant attention, as its demand remains inflexible in both military and civilian applications. The search of lithium ore remains a critical research focus in geological prospecting, as consumption continues to rise. Remote sensing has been used for mineral and lithology identification for years, but the identification of lithium ore is still in its infancy. Using China's Gaofen-5 hyperspectral data, this study has conducted research on identifying Li-rich pegmatite in the high-altitude and high-cold West Kunlun region of Xinjiang. Additionally, the study has analyzed the spectral characteristics of Li-rich and Li-poor pegmatite in the 509 mining area of the large-scale lithium mine in China. Finally, the study has determined the identification factors of Li-rich pegmatite based on ground spectral data and the Gini coefficient. In the Gaofen-5 remote sensing image, various factors have been identified, indicating that the method has a significant impact on the identification of Li-rich pegmatite. Furthermore, the sensitive feature bands for Li-rich pegmatite identification are determined using a genetic algorithm. These bands are then combined with geological maps to distinguish between Li-rich and Li-poor pegmatite using a random forest algorithm. The classification results are evaluated based on overall classification accuracy (OA) and the kappa coefficient. The evaluation of inversion and recognition accuracy of Li-rich pegmatite on remote sensing images has been completed, with the highest recognition accuracy of Li-rich pegmatite achieving an F1-score of 0.771. This study demonstrates the effectiveness of the "genetic algorithm + Gini coefficient + random forest" approach in identifying Li-rich lithology in remote sensing images, offering a novel technology and perspective for discovering lithium deposits in alpine cutting areas.

Keyword

lithium, Li-rich pegmatite, GF-5, Random forest, Gini coefficient

Exploration Information System (EIS): Open-Source Toolkit & QGIS Plugin for Mineral System Modelling and Mineral Predictive Mapping

Andreas KNOBLOCH[1], Beak Consultants GmbH
Vesa Nykänen[2]*, Geological Survey of Finland / Geologian Tutkimuskeskus
(vesa.nykanen@gtk.fi)
Emmanuel John Carranza[3], University of the Free State
Niko Aarnio[4], Gispo Ltd
Timo Aarnio[5], Gispo Ltd
Johanna Torppa[6], Geological Survey of Finland / Geologian Tutkimuskeskus
Bijal Chudasama[7], Geological Survey of Finland / Geologian Tutkimuskeskus
Nikolas Ovaskainen[8], Geological Survey of Finland / Geologian Tutkimuskeskus
Pyry Lehtonen[9], Geological Survey of Finland / Geologian Tutkimuskeskus
Ina Storch[10], Beak Consultants GmbH
Michael Steffen[11], Beak Consultants GmbH
Bernd Torchala[12], Beak Consultants GmbH
Dipak Nidhi[13], University of Turku / Turin Yliopisto
Fahimeh Farahnakian[14], University of Turku / Turin Yliopisto
Luca Zelioli[15], University of Turku / Turin Yliopisto

Abstract

The "Exploration Information System" (EIS) project, funded by the European Union (EU) Horizon Europe research and innovation funding programme, aims to discover new sources of critical primary raw materials within the EU. Therefore, EIS intends to develop and utilize a unique combination of the mineral system approach and mineral predictive mapping (MPM) tools in the open-source geographic information system (GIS) software of Quantum GIS (QGIS).

Since the beginning of the EIS project in May 2022, the “EIS Toolkit” and the “QGIS EIS Plugin” have been successfully designed and developed. The “EIS Toolkit” is a Python library of functions customized for mineral prospectivity mapping (MPM) and analysis. The “QGIS EIS Plugin” consists of two parts: The “EIS Wizard” and the “EIS Processing Toolbox”. The EIS Wizard is a user interface guiding through different steps of mineral system modelling and prospectivity analysis. It provides the possibility to organize data for the different mineral system components and proxies and track the processing workflow of the prospectivity modelling. The “EIS Processing Toolbox” is the QGIS interface to the “EIS Toolkit” functions, and it can be used outside the “EIS Wizard” for building custom prospectivity analysis workflows in QGIS, for instance, with the QGIS model builder.

The beta release of the “EIS Toolkit”, dated 6th November 2023, can be found on GitHub under: https://github.com/GispoCoding/eis_toolkit. The first release will be available by the end of April 2024. The EIS QGIS Plugin can be found on GitHub under: https://github.com/GispoCoding/eis_qgis_plugin. The beta release is scheduled for April 2024, while the first release is planned for October 2024. Both software products – “EIS Toolkit” and “QGIS EIS Plugin” - are published with a free and open-source EUPL 1.2 license, which is a GPL-compatible copy left license.

Keyword

mineral systems modelling, mineral prospectivity mapping, , geographic information systems

Characterization of mineral systems in northern Finland using autoencoders- and self-organizing maps-based deep learning architecture.

Bijal Chudasama[1]*, Geological Survey of Finland (bijal.chudasama@gtk.fi)

Abstract

The northern Finland province is comprised of several tectonic domains and geological divisions. The geological characteristics of these regions are similar to the highly mineralized belts of Australia and Canada. For instance, the Palaeoproterozoic belts such as the Central Lapland belt and the Peräpohja belt are known to host mineral deposits of ferrous metals (Fe, Ti, V, Cr), precious metals (Au, Pd, Pt), base metals (Ni, Co, Cu), and critical metals (REE, Ta). Out of the 47 metallogenic areas identified in Finland, more than half are located within the northern Finland province comprising genetically diverse mineral deposits encompassed in different mineral systems. Studies have shown that a single geological province can host different mineral systems yielding several mineral deposit types because of the presence of shared mineral system components such as sources for metals and energy or the pathways. This feature can be attributed to the presence of a favourable geodynamic architecture, that over the history of geological evolution of the region could sustain different mineral systems through repeated reactivations.

In this study we characterize the signatures of different mineral systems existing in the metallogenic areas of northern Finland using advanced machine learning methods. Two unsupervised methods, namely, self-organizing maps and autoencoders are combined in a deep learning architecture to jointly implement representation learning and clustering of regional scale geoscientific datasets. Unsupervised machine learning methods are deployed to gain insights into the structure of the data, identifying features in latent space and subsequently, the sparsely labelled training data facilitates characterization of these features to genetically different mineralization styles and systems. Additionally, the implementation of supervised machine learning based mineral prospectivity analysis is generally constrained because of lack of sufficient training data that represent mineral deposits. Class balancing method such as SMOTE (Synthetic Minority Oversampling Technique) is used for data augmentation to generate additional feature vectors representative of mineral deposits for subsequent supervised classification and predictive mapping.

Keyword

mineral systems, self-organizing maps, autoencoders, mineral exploration, exploration information system

Sparse spectral unmixing applied to hyperspectral satellite imagery for accurate identification and mapping of hydrothermal alteration minerals

Masahide KISHIMOTO[1]*, Kyoto University (kishimoto.masahide.75z@st.kyoto-u.ac.jp)
Taiki Kubo[2], Kyoto university
Katuaki Koike[3], Kyoto university

Abstract

Remote sensing using Earth observation satellites has been widely applied to detect signs of metallic deposits and hydrothermally altered minerals, because it can detect them in wide areas. With many observation wavelength ranges (bands) and a large amount of information, Hyperspectral satellite imagery can identify surface materials accurately. However, not all bands of hyperspectral data are optimized for the analysis method. In this study, we apply feature selection methods used in machine learning, and propose a high-accuracy mineral content estimation method that combines sparse spectral unmixing method with band importance evaluation based on two criteria: class separability performance and linear separability performance. The proposed estimation method was verified by laboratory experiments using several hydrothermal alteration minerals and hyperspectral Hyperion and HISUI data of the Cuprite field, west Nevada, USA. The Cuprite field is a suitable site for testing the proposed method, as it has been extensively studied by geological surveys and remote sensing techniques that reveal the surface minerals, especially hydrothermal alteration minerals like alunite and kaolinite. In the analysis of laboratory experimental data, the actual and estimated contents matched well. Also, from the HISUI image taken on 1st October 2021 and Hyperion image taken on 19th September 2011 with zero cloud cover, mineral distribution maps were created by the proposed method, and a mineral distribution map that corresponded well with the geological map was obtained. Furthermore, kaolinite distribution was able to be discriminated and delineated despite similarity of the reflectance spectrum to alunite.

Keyword

Satellite remote Sensing, hyperspectral image, Sparse spectral unmixing, Cuprite field (USA)

Spectral Geological mapping in Kuhi area, Maharashtra, with AVIRIS-NG Airborne Hyperspectral Data

Trina Vishal VYAS[1]*, Geological Survey of India (trina.royburman@gsi.gov.in)
Debjani Sarkar[2], Geological Survey of India
P. Balaji[3], Geological Survey of India

Abstract

The Advanced visible infra-red imaging spectrometer - Next Generation (AVIRIS-NG) data of many mineralized belts in India has been acquired from aerial platforms over the Indian subcontinent during October-November, 2015, January-February, 2016 and March-April 2018 under ISRO-NASA collaboration. The Kuhi area is a part of the north-western limb of the Sakoli synclinorium. The Sakoli Group of rocks are Archean to Lower Proterozoic metasedimentary sequences of chlorite-quartz-sericite schist, tourmaline schist, graphite schist, sericitic quartzite, marble, migmatites, potash feldspar porphyroblasts bearing mica schist, lepidolite bearing mica schist, phyllite, pegmatite with or without tourmaline quartz vein, milky and smoky quartz veins, silicified zone. Tourmalisation and brecciation in the schistose rock are commonly associated with greisenization. Hematitization is also associated at places with greisen zones.

For the extraction of end members, the Minimum Noise Factor images are subjected to Pixel Purity Index (PPI) module followed by the n-Dimensional Visualization technique. The spectrally purest pixels of tourmaline were identified using PPI. The n-dimensional visualization method serves as an interactive tool for multidimensional analysis and identification of spectral endmembers. To determine the greisen zone this set of end member signatures is used in the spectral feature fitting (SFF) techniques to find the most spectrally pure or spectrally unique pixels within the dataset. Tourmaline and hematite-rich areas are hence demarcated and the result indicates that the SFF algorithm is very effective in differentiating subtle spectral features and obtaining accurate mineral information.

The standard USGS mineral spectra, AVIRIS-NG image spectra, and field-lab spectra of samples collected from muscovite schist, greisen zone, ferruginous alterations areas in quartz, azurite-malachite staining have been compared and the diagnostic spectral characteristics confirm the presence of these rocks, minerals and zone.

Keyword

AVIRIS NG, Hyperspectral, Greisen, Kuhi

Approaches and Technologies of the Digital Twin of Russia's Mineral Resources: possibility of using the experience of the Karpinsky Institute for the development of information systems in geological surveys and institutes

Olga KOVALEVA[1]*, A.P. Karpinsky Russian Geological Research Institute
(olya_pavlikova@mail.ru)
Eugene Petrov[2], Federal Agency of Mineral Management
Pavel Khimchenko[3], A.P. Karpinsky Russian Geological Research Institute
Maksim Tkachenko[4], A.P. Karpinsky Russian Geological Research Institute
Victor Snezhko[5], A.P. Karpinsky Russian Geological Research Institute
Eugene Kovalenko[6], A.P. Karpinsky Russian Geological Research Institute
Olga Snezhko[7], A.P. Karpinsky Russian Geological Research Institute
Sergey Gornostaev[8], A.P. Karpinsky Russian Geological Research Institute

Abstract

The concept of the Digital Twin of Russia's Mineral Resources implements the transition from the accumulation of static data to the creation of a dynamic, constantly updated multidimensional model of Russia's mineral resources based on the integration of information flows obtained during geological exploration, regional geological study of mineral resources and scientific studies. The combination of technical solutions and resources of the Digital Twin will provide analysis and modelling of geology, identification of new patterns, their verification and refinement in virtual space.

The technology of the Digital Twin of Russia's Mineral Resources provides

- Automated process of integration, updating, processing and spatial analysis of results of geological studies at various scales of geological mapping, creation of a unified geological mapping model of the country;
- Dynamic integration of up-to-date data from state information systems of licensing and exploration, accounting systems of mineral deposits, promising areas and licensing;
- Use of structured digital data arrays for complex processing and interpretation of geological information, assessment of exploitability of geological features and settings, prediction and exploration of mineral deposits;
- Creation of a reliable and up-to-date information base for management decisions in geological exploration, development of the mineral resource base and its use at the federal and regional levels.

The Digital Twin resource developed at the Karpinsky Institute includes more than 130,000 maps, 200,000 natural mineral and man-made features, 2.1 million primary data, as well as tens of thousands of geochronological determinations and reference geological features.

The technologies of the Digital Twin of Russia's Mineral Resources have been developed on the basis of standard software and hardware solutions and can be used for arranging digital geological information by various geological surveys and national geological institutes.

Keyword

Digital Twin, GIS, web services

[Keynote] Assessment of Machine Learning Techniques for Prospectivity Modeling and Vectoring of IOCG Mineralizations

Carlos Roberto Souza Filho[1]*, University of Campinas (beto@unicamp.br)
Elias PRADO[2], University of Campinas / Geological Survey of Brazil

Abstract

The progression of mineral exploration, with an emphasis on bolstering mineral resource availability while mitigating environmental ramifications, is integral for fostering a robust and sustainable socio-economic development within society. The current era witnesses a rapid surge in mineral extraction and consumption owing to escalating human populations, heightened economic activity, and the shift towards new technologies. Addressing this mounting demand necessitates the mineral industry to tackle significant challenges such as discovering new mineral resources, optimizing production efficiency and safety, and minimizing the environmental impacts of mining activities. Promising solutions to these challenges are found in the adoption of artificial intelligence techniques, big data analysis, and other Industry 4.0 technologies.

Here, we introduce innovative approaches to mineral exploration targeting, specifically focusing on the application of cutting-edge machine learning algorithms for mineral prospectivity mapping and ore grade estimation utilizing spectral data. These methodologies are exemplified through the exploration of Iron-Oxide Copper Gold (IOCG) deposits, which are reservoirs of economically vital commodities like copper (Cu) and rare earth elements (REEs), currently experiencing high and escalating demand.

The methodologies developed herein encompass two primary stages of mineral exploration: the identification of new mineralized zones and the extraction of known deposits. Given the pioneering nature of these methodologies, the essence of this work revolves around various facets including data processing, algorithm optimization, model architecture, and hyperparameter tuning of machine learning algorithms. Specific details regarding the mineral prospectivity mapping approach and ore grading estimation are also explained.

Machine learning techniques were tailored to process geological and geophysical data from the Carajás mineral province in Brazil, with the aim of modeling the prospectivity of IOCG mineral deposits in the region. The results demonstrate that the synthetic minority oversampling technique, utilized for dataset balancing, markedly enhances the performance of machine learning algorithms for mineral prospectivity mapping. These models, developed employing machine learning algorithms, exhibit superior classification and spatial performance compared to traditional data-driven methods such as the weight of evidence approach. Hence, these methodologies are poised to become prominent in the field in the forthcoming years.

Additionally, a novel approach is introduced where deep learning algorithms are employed to forecast Cu grades at the Olympic Dam deposit in Australia, utilizing hyperspectral data. The outcomes indicate that this approach holds promise for application in automation systems for identifying mineralized zones, enabling selective mining. This has the potential to reduce costs

and environmental impacts while enhancing the efficiency of mining operations.
The findings of these studies indicate that machine learning techniques surpass traditional methods used for prospectivity modeling and vectoring of IOCG mineralizations. These developed methodologies can seamlessly be applied to explore other mineral deposits. Furthermore, the techniques proposed in this study, integrating Industry 4.0 technologies into the mining industry, contribute to a solid and sustainable development of mineral exploration.

Keyword

Mineral Prospectivity, IOCG deposits, GIS, machine learning, hyperspectral

Enhancing Mineral Prospectivity Mapping for Cu-Pb-Zn in Faraj Abad, Qom, Iran: A Comprehensive Integration of Geology, Geochemistry, and Remote Sensing Data Using Fuzzy Analytical Hierarchy Process Models.

Kamyar KESHAVARZ[1]*, Shahid Beheshti University of Tehran (kamyar.ksh@gmail.com)
Aida Mohebi[2], Geology Survey of Iran

Abstract

Faraj-Abad is an area of about 600 square kilometers in Qom, Iran. The Urmia-Dokhtar volcanic belt passes through this region, leaving mineral deposits comprising metals such as copper, lead, zinc, iron, and manganese dating back to the Eocene. The exploration trend of the area was initially established through the application of exploratory modeling within a Geographic Information System (GIS) framework. This approach leveraged geological, geochemical, aerial geophysics, and remote sensing data, spanning multiple scales, to effectively analyze the region. In this regard, each of the aforementioned data sets underwent a unique processing methodology. Geological maps were used to determine lithological units and faults, while ASTER and ETM satellite images were used for the same purpose. Satellite imagery was also useful in locating alteration zones. Additionally, drainage sediment data and heavy mineral data were used to identify geochemical anomaly locations at various scales.

Within the Faraj-Abad region, two distinct types of copper mineralization can be found. The first type is referred to as porphyric, and it is exemplified by the Narbaghi mines. The second type is known as epigenetic polymetallic mineralization, where copper is commonly associated with lead and zinc. The Kuh-Pang Mine serves as an example of this second type of mineralization. Iron in this region is present in two forms: hematite accompanied by manganese of the oxalate type, and magnetite associated with ultramafic bodies.

In this exploratory modeling, all the aforementioned factors were thoroughly examined and evaluated using the fuzzy Analytic Hierarchy Process (AHP) methodology. Based on these evaluations, various data sets were assessed and valued. Consequently, mineral potential maps were prepared for each factor. Additionally, the areas with potential mineralization underwent field visits and geological sampling. Ultimately, a total of 45 geochemical samples were collected from these areas and subjected to analysis using the ICP-MASS method. The mineralized regions were then presented in the form of maps and tables, providing a comprehensive overview of their mineralization potential.

Keyword

Mineral prospectivity mapping, Cu-Pb-Zn mineralization, Geochemistry, fuzzy Analytic Hierarchy Process (AHP), Iran

Identification of High-grade Ni Laterite Ores Using Hyperspectral Imaging and Deep Learning

Koichi FURUKAWA[1]*, Hokkaido University (furukawa.koichi.m5@elms.hokudai.ac.jp)
Natsuo Okada[2], Hokkaido University
Ryosuke Kikuchi[3], Hokkaido University
Yoko Ohtomo[4], Hokkaido University
Tubasa Otake[5], Hokkaido University
Youhei Kawamura[6], Hokkaido University

Abstract

Nickel (Ni) laterite deposits account for ~60% of the world Ni ore supply. They form by chemical weathering of ultramafic rocks, consisting of multiple weathered layers such as laterite and saprolite. Although Ni grades in the ores are generally higher in the saprolite than in laterite layers, they tend to be heterogeneous depending on various geological and geographical factors, which makes efficient mining and processing difficult. This study aimed at using visible-light to near infra-red range (450 – 950 nm) hyperspectral (HS) imaging to classify Ni ores (e.g., laterite and saprolite ores from bedrocks) as well as the Ni grades (low (<1.8 wt% Ni), medium (1.8~3.0 wt% Ni), high (>3.0 wt% Ni)) at the site. While the visible-light range has an advantage on the cost, it is usually more difficult to distinguish the constituting minerals than when an infra-red region is used. Therefore, we also employed machine learning, particularly Convolutional Neural Network (CNN), aiming at rapid and automatic classification by letting the Al model learn from many training input data. The study focused on Ni laterite deposits in the Sulawesi and Halmahera Islands in Indonesia. Indonesia has the largest Ni ore reserve in the world formed by intensive chemical weathering under tropical climatic conditions. We compared rock chip and pulverized samples as training data to investigate the effect of sample forms on the quality of classification. The obtained HS data from the laterite and saprolite ores as well as the bedrocks from different mines in Sulawesi and Halmahera Islands showed peculiar peak shapes depending on the weathering layer. Nevertheless, there appears to be no difference among variable Ni grade samples. A comparison of the sample forms demonstrates that training both forms yielded better results. The Al model successfully classified different weathering layers (i.e., laterite and saprolite layers) from the bedrocks with high accuracy (79 – 100%) even with untrained test samples. However, the classification of Ni grades in the saprolite layer samples was found to be more difficult, and their accuracy was variable (5.3 – 99%). This is likely due to variations in major chemical and mineralogical compositions of the saprolite samples rather than the Ni grade, which would make the Ni grade difficult to reflect in the HS data. Further improvement of the Al model such as pre-screening based on the bedrock type or Ni host mineral will be needed for the more accurate classification of Ni grade.

Keyword

Ni laterite deposit, Saprolite, Indonesia, Hyperspectral imaging, Convolutional Neural Network

Advancing Mineral Resource Prediction through Distributed Cloud Computing and Remote Sensing: A Case Study in Namibia

Tianyi LI[1]*, Zhejiang University (lity@zju.edu.cn)
Linshu Hu[2], Zhejiang University

Abstract

Mineral resources, as a vital material foundation for human societal development, involve the scientific analysis and assessment of the location and potential of industrially valuable minerals within the Earth's crust. Typically, mineral deposits exhibit distinct alteration zone distributions, including widespread occurrences of hydroxyl minerals, carbonate minerals, and iron oxides, which become more prominent under long-term weathering effects. Utilizing remote sensing technology, particularly through the analysis of remote sensing data from the visible to the shortwave infrared spectrum, effectively extracts this alteration information. In recent years, significant advances in cloud computing technology have made it feasible to process large-scale, continental remote sensing data. By shifting mineral resource prediction work from traditional single-machine operations to a cloud environment, we can scale up data processing and more efficiently apply complex and precise prediction models, thereby enhancing the accuracy and efficiency of predictions. In this study, we selected Namibia as a case study area, employing distributed cloud computing technology for continental-scale surface erosion index analysis. We developed a remote sensing image processing workflow based on parallel computing theory and utilized the powerful computational capabilities of a cloud spatiotemporal database to compute and analyze vast amounts of remote sensing data, ensuring high scalability of the system. Through in-depth analysis of Namibia's entire ASTER remote sensing imagery, we successfully identified potential mineralization areas and analyzed their distribution characteristics. This research provides crucial reference material for local mineral resource management, development, and utilization, and also demonstrates the feasibility and advantages of distributed cloud computing in the field of remote sensing image processing, offering a concrete example of such technology applied in this domain.

Keyword

Cloud Computing, Remote Sensing, Mineral Alteration, Aster

Hydrothermal Alteration Mapping using Remote Sensing and GIS in parts of North Purulia Shear Zone (NPSZ), Purulia District, West Bengal, India

Anirudh CHAKRABORTY[1]*, University of Mumbai (anirudhchakraborty@gmail.com)

Abstract

According to Sarkar et al. (1998), the North Purulia Shear Zone (NPSZ) is a significant brittle-ductile shear zone with an E-W to ENE-WSW strike. It starts more west of Kotshila, travels via Sindri, Chas Road, Tetuldih, and Dubrajpur, and ends in the east by defining the northern edge of the Osthosite Massif. This shear zone has not been thoroughly investigated or defined. This shear zone roughly delineates the northern boundary of anorthosite rock, separating it from the surrounding high-grade rocks. It runs well within the Chotanagpur Gneissic Complex (CGC) rocks on a regional scale. The CGC's anorthosite-granulite rocks are undergoing shear deformation along the NPSZ, resulting in the production of mylonite fabrics. Along with some pegmatites, the lithological assemblage includes the following rocks: syenite, enderbite, anorthosite, amphibolites, khondalite, quartzite, biotite gneiss, calcsilicate granulite, basic granulite, etc. Objectives of the present study is to use the widely regarded ASTER data to distinguish the litho units and map the alteration zones from their host rocks, as prospective potential locations for mining important minerals can be identified and also to study the structural lineaments of the study area using remote sensing. The results were field validated. Remote sensing methods such as False Color Composites, Band Ratios, Principal Component Analysis and Spectral Classification proved useful in detecting alteration zones for potential mineral deposits.

Keyword

NPSZ, Remote Sensing, ASTER, Alteration Zones, Mineral Exploration

Evolution of a Sand Spit in Ujeon Tidal Flat at Sinangun, Jeollanamdo, Korea's West Coast

Junho Lee[1]*, Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology (leejh@kiost.ac.kr)
Huigyeong Ryu[2], Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology
Hoi-Soo Jung[3], Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology
Joo-Hyung Ryu[4], Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology

Abstract

Jeungdo Island, a unique and valuable location, is home to the Ujeon tidal flat. This island has been recognized and protected for its exceptional environmental importance. It was designated a UNESCO (United Nations Educational, Scientific and Cultural Organization) convention concerning the protection of the world cultural and natural heritage in 2021, a Ramsar Wetland in 2011, and a Wetland Protection Area in 2010. However, the intertidal zones along the West Coast, including our study area, have experienced significant environmental changes due to human activities such as the construction of fish farms and large tidal embankments for reclamation projects. The Taepyeong salt farm, the largest salt field in South Korea, was also established on Jeungdo Island in 1953. The Ujeon tidal flat, a significant part of Jeungdo Island's ecosystem, now features a sand spit that stretches about 800 m in a north-south direction. Our research indicates that this sand spit has formed and grown as a direct result of the construction of the Taepyeong salt farm. This development, coupled with the spit's formation, has led to a profound change in the sedimentary environment of the Ujeon tidal flat In this study, we present a model of these sedimentary environment changes and further predict the potential closure of the Ujeon tidal flat highlighting the urgent need for action. This study delves into the long-term effects of human activities on tidal environment processes, shedding light on a crucial aspect of coastal conservation. It significantly contributes to our understanding of the effects of human activities on coastal sedimentary environments, providing vital information for the development of effective management and conservation strategies for coastal areas, including the Ujeon tidal flat. Its findings are not just academic, but also practical, offering a roadmap for sustainable coastal development.

Keyword

Coastal areas, Salt farm, Sand spit, Tidal Flat, UNESCO

Guided sampling method of diffusion model for cloud area restoration from tidal flat satellite images

Donguk LEE[1]*, Korea Institute of Ocean Science & Technology (ldu3833@kiost.ac.kr)
Hyeong-Tae JOU[2], Korea Institute of Ocean Science & Technology
Geun-Ho KWAK[3], Korea Institute of Ocean Science & Technology
Jingyo LEE[4], Korea Institute of Ocean Science & Technology
Joo-hyung RYU[5], Korea Institute of Ocean Science & Technology

Abstract

With recent advances in the Earth observation technology, satellite imagery is being used in a wide variety of applications, but satellite observations are often hampered by clouds. To address this, various methods have been developed to remove cloud regions from images.

Early methods used only neighborhood information and were simple to apply, but difficult to apply to complex terrain. Later methods were proposed that utilized both temporal and spatial information, and were able to successfully restore complex areas using previous acquisitions. However, because tidal flats change rapidly with the tides, selecting prior information to use for restoration is much more difficult than on land.

In this study, we applied a restoration method using a diffusion model to automatically restore cloud regions without the need for prior selection. Diffusion models store image characteristics in the form of distributions, and images can be generated from the distributions. Since the characteristics of all acquired images are included in the distribution, it is possible to generate images of any desired shape as long as the image characteristics are provided.

To restore clouds in the tidal flats satellite image, we used images of cloudless areas. It was considered that images of cloudless areas have information about the tides themselves, and it was possible to generate an image from the distribution that best fits the tides in the image. To this end, we proposed a gradient-based guided sampling method to restore the cloud-covered areas without any prior selection of information.

The restoration results were validated by qualitative and quantitative analysis using synthetic data. The qualitative analysis confirmed that the clouds were successfully restored, and the quantitative analysis confirmed that the range of pixel values in the generated image was reasonable. In addition, the validity of the restored images was indirectly verified by comparing the land-water boundaries extracted from the satellite images with those extracted from the high-resolution DEM.

This method allowed us to restore the cloud-covered area by providing only the surrounding information without any prior selection process, which is expected to contribute to the development of automated systems for real-time monitoring of tidal flats and as training material for artificial intelligence models. In addition, as a direct application example, it is expected to reduce the time required to generate satellite-based tidal flat topographic maps using restored images.

Keyword

Tidal flat, Cloud removal, Diffusion model

Performance comparison of waterline based topographical mapping of tidal flats with different spatial interpolation methods

Jingyo LEE[1]*, Korea Institute of Ocean Science and Technology(KIOST) (jingyo@kiost.ac.kr)
Keunyong KIM[2], Korea Institute of Ocean Science and Technology(KIOST)
Geun-Ho KWAK[3], Korea Institute of Ocean Science and Technology(KIOST)
Yeongjae JANG[4], Korea Institute of Ocean Science and Technology(KIOST)
Joo-Hyung RYU[5], Korea Institute of Ocean Science and Technology(KIOST)

Abstract

Tidal flats are highly sensitive to change due to repeated erosion and deposition caused by tidal energy and seasonal factors. Recent emphasis on the ecological value of tidal flats has led to the need for precise tidal flat topographic maps as a basis for tidal flats ecosystem protection and restoration. Because tidal flats are inaccessible due to the tidal cycle, remote sensing data that can be surveyed periodically using non-accessible methods are often utilized. Satellite-based waterline method is one of the most common methods used to map tidal flats using remote sensing data. To ensure high performance, it is important to collect imagery at different tide levels. However, remote sensing data is limited by clouds and weather conditions, and it is difficult to acquire images evenly at different tides due to tidal cycles and acquisition cycles. To solve this problem, spatial interpolation has been applied to improve the accuracy of tidal flats topographic maps produced by the waterline method. However, no study has analyzed the effect of the mean tide interval on the spatial interpolation of tidal flat topographic maps, considering the availability of images. In this study, considering the limitations of the above-mentioned existing studies, a case study was conducted on the Hwangdo tidal flats in Taean, Chungnam, using a total of 21 Landsat-8, 9 and Sentinel-2A/B images. In order to improve the accuracy of tidal flat topographic maps, spatial interpolation methods such as TIN, IDW, Spline, and Kriging were compared, and the average tide intervals of the acquired images were comprehensively compared. The results of the case study showed that the spatial interpolation method actually decreased in performance as the tide interval increased, compared to the conventional waterline based tidal flat topography, but outperformed the denser tide interval. Based on these interpolated results, it was possible to significantly improve the accuracy of tidal flat topography by utilizing a minimum number of images, and can provide guidelines for applying interpolation to tidal mudflat topography in cases where a large number of images are difficult to acquire.

Keyword

tidal flat, remote sensing, waterline method, interpolation method

Airborne Sensor system for monitoring Tidal Flat

Hyunsoo Hur[1]*, Geostory (caebc44@gmail.com)
MinYoung KIM[2], Geostory
Kahyeon KIM[3], Geostory
HYEYOUNG JEONG[4], Geostory

Abstract

Tidal flat is challenging area to survey for both land based survey method and shipborne based survey method. Development of Tidal flat survey system is essential to monitor tidal flat thoroughly and accurately. Thus, multi purpose integration sensing system based on Airborne Bathymetry LiDAR will be used for capturing tidal flat. Multi sensor integration system is consisted with ABL and Hyperspectral sensor and Digital camera. Each sensor maximizes performance through mutual complementation.

General Topography LiDAR firing near infrared Laser to survey land area. However, Airborne Bathymetry LiDAR uses more powerful visual wavelength of green laser that penetrate water surface and we can get the sea bottom data. With this technology. We can survey land side and waterside simultaneously. This Characteristic is Key feature for capturing Tidal flat. Airborne Bathymetry LiDAR is best for surveying shallow water as well. It took only about 10% of time to survey shallow water than shipborne survey.

Hyperspectral sensor is another important component of the Multi sensing integration system. Hyperspectral imagery which captured with Airborne Bathymetry LiDAR simultaneously can improve Turbid water penetration ability as well as tidal flat environment monitoring.

In this research project we are planning to build multi sensing integration system and collecting tidal flat elevation data and environmental data using Airborne Bathymetry LiDAR and Hyperspectral sensor.

Keyword

Airborne Bathymetry LiDAR, Hyperspectral Sensor, Tidal flat

Exposure Duration and Geochemical Influences on Surface Sediment Properties for Monitoring Approach at Hwangdo Tidal Flat, Taean, Cheonsu Bay, Korea's West Coast

Junho Lee[1]*, Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology (leejh@kiost.ac.kr)
Hoi Soo JUNG[2], Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology
Huigyeong RYU[3], Marine Domain & Security Research Department, Korea Institute of Ocean Science & Technology
Yeongjae JANG[4], Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology
Keunyong KIM[5], Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology
Joo-Hyung RYU[6], Korea Ocean Satellite Center, Korea Institute of Ocean Science & Technology

Abstract

This research explores the Hwangdo tidal flat, a significant intertidal zone within Cheonsu Bay, Taean-gun, Chungcheongnam-do, along Korea's western shoreline. The area's unique topography, characterized by water channels, sandbars, small islands, and tidal flats, is situated in a semi-enclosed bay on the eastern perimeter. Data collection involved tide gauge readings from Hwangdo Bridge and ellipsoid height determinations via a real-time kinematics global positioning system (RTK-GPS). A digital elevation model (DEM) was also developed from processed Matrice 300 drone imagery. The study also examined geochemical sediment attributes and tidal flat exposure times influenced by environmental conditions. Sediment samples (n = 107), collected from October 25 to 28, 2022 were used to classify sediment particles according to Folk and Ward (1957). Sedimentary facies ranged from coarse sand (sand : mud ratio = 9 : 1) to sandy silt (sZ) followed by muddy sand (mS) and slightly gravelly sandy mud ((g)sM). The investigation into total organic carbon (TOC) was informed by particle-size analysis. Tidal height variations recorded at Hwangdo Bridge, with a significant mean change of ~7.53 m (minimum: –3.86 m, maximum: +3.67 m), underscored the dynamic nature of the tidal flat. Based on the Boryeong's sea level measurement tide data in 2022, the tidal area in the drone images ranged from 6.360 square meters (0.006 square kilometers) at DEM +4.0 to 4,841,100 square meters (4.8410 square kilometers) at DEM –4.0 m, indicating an increase in the tidal-flat area according to the tidal level of up to ~800-fold. The daily average exposure time was 9.0 h (minimum: 1.5 h, maximum: 17.9 h). Multivariate analysis, incorporating exposure durations and geochemical data, delineated four distinct zones: upper, middle, and lower intertidal areas, alongside regions enriched in organic matter. Spatial analysis revealed that sediment composition shifts, attributed to community dynamics, predominantly influence the environmental makeup of the Hwangdo tidal flat. This study's findings articulate the complex interplay of marine environmental characteristics across the tidal flats, with sedimentary transitions, more so than exposure duration, marking the variances across different zones as a trend poised to persist.

Keyword

Exposure time, Geochemical factors, Hwangdo tidal flat, Monitoring approach, Total organic carbon

Land Subsidence Observation using InSAR Time-Series Analysis of Bangkok and Samut Prakan, Thailand

Raisa Najma Najma Sakina[1]*, Kangwon National University (raisaarifinn@kangwon.ac.kr)
Wahyu Luqmanul Hakim[2], Kangwon National University
Muhammad Fulki Fadhillah[3], Kangwon National University
Chang-Wook Lee[4], Kangwon National University

Abstract

Climate change has become a critical issue due to its impact particularly on coastal cities. Bangkok is such a coastal city already facing the impact of climate change, notably the rise of sea level leading to flooding and posing a danger situation of submerging land in Bangkok Area. This situation is intensified by the land subsidence phenomenon caused by excessive groundwater extraction causing damage to buildings. This study provides a time-series analysis using Synthetic Aperture Radar (SAR) undertaken for Bangkok and Samut Prakan, both of which are part of Bangkok Metropolitan Region (BMR) that located on coastal area in Thailand, aimed at constructing the susceptibility map. In this study, 183 SAR data obtained from Sentinel-1 radar satellite in ascending direction were used ranging from 2017 to January 2024 which can be show the current situation of the subsidence of Bangkok through time-series analysis. The result of time-series measurements in this study were compared with the GPS data measurements to obtain the correlation between time-series InSAR deformation map and ground data measurements. According to the result, the land subsidence in Bangkok and Samut Prakan occurred mostly along the Chao Praya River, which has a geological composition that prone to land subsidence. Another cause of land subsidence in Bangkok and Samut Prakan is over-exploitation groundwater in the urban areas. The susceptibility map then can be generated for future research, enabling the identification of the additional locations susceptible in order to anticipate the risk of land subsidence in the future.

Keyword

Land Subsidence, Bangkok, Samut Prakan, Time-series InSAR, Susceptibility Map

Identification of slope failure by random forest using topographic characteristics changes

Mitsunori UEDA[1]*, Osaka Metropolitan University (so22000t@st.omu.ac.jp)
Tatsuya NEMOTO[2], Osaka Metropolitan University
Venkatesh RAGHAVAN[3], Osaka Metropolitan University

Abstract

Slope failure is one of the events of erosion and sedimentation. This event is a phenomenon in which rocks are weathered due to physical and chemical processes and the weakened slopes slide down due to rainfall, earthquakes, melting of snow and volcanic eruption. Therefore, generation of slope failure inventory map is extremely important for solving geologically related problems such as land development, disaster prevention planning, and environmental conservation. Also, to understand the slope failure morphology and structure, it is necessary to clearly classify between the erosion area which is the sliding area, and the sedimentation area which is the moving body. Therefore, in this study, slope failures were identified using a distribution map of slope failures (head scarp and main body) caused by heavy rain. Random Forest (RF), a machine learning method, was used to recognize slope failures, and the importance of features was also investigated. Topographical data were collected from aerial LiDAR survey and aerial photographs for data before and after the slope failure. The topographical data used the slope angle and slope direction of the terrain, the topological classification, and the terrain convergence index. We used Change Vector Analysis (CVA) to investigate changes due to erosion and sedimentation. CVA is a vector representation of changes between two time periods. You can investigate changes over time by plotting two input variables for two periods on the x-axis and y-axis, respectively, and calculating the changes between the data as the magnitude and direction of the vector. Here, we analyzed changes in slope angle and various topographical parameters using data before and after the slope failure. The y-axis is the slope angle and the x-axis is the other terrain features. The aerial photographs were used as learning data by calculating the Vegetation Index (VI). VI used the Modified Photochemical Reflectance Index (MPRI) calculated from red band and green band of the photographs.

As a result, the magnitude of CVA tended to be suitable for separating slope failure and non-slope failure and the direction of CVA tended to be suitable for separating scarp and main body within slope failure areas. The topographical features that contribute to learn were the slope angle, vector magnitude of CVA and MPRI. Also, the identification failure areas by RF were in good agreement with the slope failure distribution map. the extraction accuracy exceeded 0.8 per pixel within the slope failure area. By using topographic features and their changes, it has become possible to identify slope failures by dividing them into head scarp and main body. In particular, head scarp tended to be clearly extracted. However, the range of sediment movement along the area of erosion that occurred in the river downstream of the collapsed area was misidentified. In addition, parts of the slope that were not affected by the event were also interpreted as Slope failures, in

reality they were non slope failure areas. In future, it will be necessary to build a highly accurate model that can only extract collapsed areas.

Keyword

Slope Failure Identification, Random Forest, Change Vector Analysis, Topographical Changes

Integrating InSAR Time-Series Machine Learning Optimized and Susceptibility Assessment for Monitoring Land Subsidence in the Iron Mining Site Musan

Muhammad Fulki Fulki Fadhillah[1]*, Kangwon National University (fulkifadhillah@kangwon.ac.kr)
Raisa Najma Sakina[2], Kangwon National University
Chang Wook Lee[3], Kangwon National University

Abstract

The combined use of interferometric Synthetic Aperture Radar (SAR) and disaster susceptibility mapping has become an important approach to identifying, understanding, and managing disaster risk in mining areas. Interferometric SAR (InSAR) is a monitoring method that utilizes SAR satellite imagery and interferometric principles to produce information about changes in the earth's surface. Notably, the progression of the InSAR time-series technique has advanced to encompass the utilization of artificial intelligence algorithms, thereby enhancing data processing capabilities and ensuring the retention of critical information amidst extensive datasets.

On the other hand, disaster susceptibility mapping utilizes spatial and attribute data combined with InSAR time series results to determine the susceptibility of an area to various types of natural disasters and disasters caused by human activities. The synergy between remote sensing data and spatial information presents a valuable framework for assessing disaster susceptibility within mining sites.

This research explores how a combination of InSAR technology and disaster susceptibility mapping can improve the understanding of disaster risk in Musan mining areas. By integrating InSAR-derived data from the Sentinel-1 C-band SAR satellite, which provided insights into land deformation conditions in the study area. Then, the disaster susceptibility analyses can delineate environmental change patterns and evaluate potential disaster risks, including landslides, land subsidence, and infrastructure collapse.

The research results show that the use of machine learning algorithms can provide an optimization impact on the final results of time-series data on mining sites. Furthermore, the disaster susceptibility mapping model, facilitated by machine learning algorithms, has yielded a ROC value exceeding 0.8, indicative of robust performance. This integrated approach facilitates risk mitigation planning, informed decision-making, and the formulation of adaptation strategies to curtail disaster ramifications within mining precincts. Moreover, the combination of InSAR technology and disaster susceptibility mapping fosters sustainable development, bolstering disaster risk management endeavors and upholding environmental conditions within mining areas.

Keyword

InSAR, Mining Sites, Susceptilibilty Map, Machine learning

NSDI Implementation at the Ministry of Mines and Energy in Namibia

FREDDY MUYAMBA[1]*, GEOLOGICAL SURVEY OF NAMIBIA
(Freddy.Muyamba@mme.gov.na)
Paulina Pokolo[2], GEOLOGICAL SURVEY OF NAMIBIA

Abstract

The National Spatial Data Infrastructure (NSDI) is a framework that aids the management, use, sharing, and integration of spatial data and related services in Namibia. This is the policies, standards, technologies and institutional arrangements that enable an easy access and utilization of spatial information by the various stakeholders, which includes government agencies, private sector organisations, and the public.

The NSDI implementation at the Ministry of Mines and Energy (MME) in Namibia is a major advancement in improving the management, accessibility, and utilisation of spatial information in the country's mining and energy industries. This effort is in line with worldwide patterns in utilising spatial data for making informed decisions, managing resources sustainably, and promoting economic growth.

The main objectives of implementing NSDI at MME are to: Create a centralised and standardised repository for spatial data. Facilitate interoperability among various spatial datasets, enabling seamless data sharing and integration within MME. Provision of current, up-to-date, and easily accessible spatial information for effective and efficient decision-making in planning and management of resources. Strengthen and enhance collaboration with relevant stakeholders being other government agencies, private sector entities, and research institutions in an all-inclusive geospatial ecosystem.

The NSDI implementation at MME involves a phased approach, encompassing the following key elements: Data Standardisation: Development and uptake of standardised data formats, metadata, and quality assurance to ensure consistency and reliability within the spatial datasets. Infrastructure Development: Establishing a robust and secure spatial data infrastructure to host, manage, and disseminate spatial information efficiently. Capacity Development: Providing training sessions to prepare MME employees with the essential skills for managing, analysing, and using spatial data. Inter-Agency Collaboration - This is to be done through collaboration with other government departments, non-governmental agencies and even the private sector to create a network of shared spatial resources and expertise. Public Outreach: Public outreach programs to create awareness among the public on the benefits of NSDI implementation and mobilising communities to ensure responsible use of spatial data.

Expected Outputs: The implementation of NSDI at MME is expected to result in the following outputs: Improved access to current and accurate spatial data, efficient and cost-effective data sharing and management practices, standardised datasets, Strengthened capacity for spatial data analysis and utilisation. Boost collaboration and data sharing among relevant stakeholders in the country.

Conclusion: The implementation of the NSDI in the Ministry of Mines and Energy in Namibia represents a nation-driven strategic initiative that aims at harnessing the power of spatial data to underpin sustainable development. It seeks to position MME as a leading ministry in leveraging spatial information by adopting a comprehensive approach that includes development of infrastructure, capacity building, and collaboration through standardised data use in the mining and energy sectors.

Keyword

NSDI, Spatial Data, Standards, MME

New opportunities with Earth Science data platforms in Europe: fostering next-generation cross-domain research and decision-making

Marc URVOIS[1]*, BRGM - French Geological Survey (m.urvois@brgm.fr)
Matthew HARRISON[2], UK Environmental Data Service
Christelle LOISELET[3], BRGM - French Geological Survey
Jørgen TULSTRUP[4], GEUS - Geological Survey of Denmark and Greenland
Carmela FREDA[5], EPOS ERIC, European Plate Observing System European Research Infrastructure Consortium

Abstract

European-level data is co-created by research communities and National Geological Survey Organisations (NGSOs), and there has been a focus on creating platforms to enable open access. Here we will argue that there is also an opportunity and duty for these groups to contribute to the overall governance surrounding geoscience data and information at a global scale. This is through ensuring geoscience data is discoverable and reusable in recognised formats for onward analysis, validation and research (the FAIR principles). Also that a European geoscience voice and perspective is recognised and listened to in the development of geoscience standards beyond the boundaries of the European Continent.

As a result of a decade of design and implementation, two major and complementary geoscientific data platforms are now online making available harmonised and quality-controlled subsurface data to support both research and policy-making. The European Plate Observing System (EPOS, www.epos-eu.org) brings together national research infrastructures across 26 countries in Europe. The delivery framework of this unique Solid Earth Research Infrastructure currently includes more than 260 data and product services from ten domain-specific communities accessible through the metadata-driven web-enabled EPOS Data Portal. The contents proposed by these thematic services cover a wide range of geoscience disciplines (e.g., seismology, geodesy, geology and remote sensing).

The geological information and modelling data services are exposed to EPOS by the European Geological Data Infrastructure (EGDI, www.europe-geology.eu). Through the collaboration of 37 European NGSOs, EuroGeoSurveys established the EGDI as the framework to capitalise and disseminate project results as well as national and pan-European inventories. A wealth of more than 800 datasets cover a broad spectrum of geoscientific areas relevant to policy such as groundwater, geohazards, minerals, coastal zone management, carbon and hydrogen potential.

This actual connection between these two platforms brings to life the operational level of interoperability standards and best practices for the benefit of the end-users: researchers, citizens and policy-makers. The synergy of contents at their fingertips fosters the analytical possibilities to produce added-value information and knowledge. EPOS and EGDI are timely, taking advantage of the maturity of the necessary standards defined by OGC, IUGS-CGI and INSPIRE. The FAIRness of the numerous data sets exposed by the platforms is constantly being improved, and now part of the Open Science and national and international research framework programs.

One of the initial ambitions of these pan-European platforms has been successfully achieved, which was to federate high-quality data and information produced by research centres and national survey organisations. This supply-driven process providing robust infrastructures and rich contents now evolves towards a demand-driven approach. Awareness and training sessions are organised to further develop the confidence of a wide range of users in using EPOS and EGDI, create advanced product services to generate next-generation research and decision-making.

Keyword

geoscience information, open science, FAIR, data services, Europe

International geoscience terminology management and governance

Mark Rattenbury[1]*, GNS Science, New Zealand (m.rattenbury@gns.cri.nz)

Abstract

International terminology standards are important for communication of geoscience information across borders and between countries, particularly for addressing multinational and global issues such as climate change, resilience to natural hazards and sustainable resource extraction.

The Commission for the Management and Application of Geoscience Information (CGI), an International Union of Geological Sciences (IUGS) commission, develops, manages and publishes geoscience data models and vocabularies, amongst other standards. CGI's Geoscience Terminology Working Group has members drawn from most continents and regions, and their collaboration results in agreed, published geoscience vocabularies that are used internationally. To date these vocabularies have been developed to support the GeoSciML and EarthResourceML data models but their application has been wider.

CGI as an IUGS commission has both a unique position and an opportunity around governance of global geoscience terminology standards. Through its enduring status, CGI is not bound by finite and funding-constrained projects. Projects can accelerate terminology standards development but sustaining these standards after project cessation can be difficult and this is where CGI can assist.

CGI has predominantly managed and governed standards it has developed or co-developed. The opportunity for CGI going forward is to take more of a leadership role across IUGS as well as internationally-focussed societies and agencies in assisting to host, manage and/or promote their terminology standards. With growing expectations of FAIR Principles adherence across the global geoscience community, CGI can help enable their implementation by providing a platform for enduring, authorised, geoscience information standards and services.

Keyword

geoscience terminology, vocabularies, standards

A Framework for Smart Geological Mapping Using Data and Knowledge Hybrid-drivenFAIR

Yongzhi WANG[1]*, Jilin University, China (iamwangyongzhi@126.com)
Yuhao DONG[2], Jilin University, China
Yangchun LI[3], Development Research Center of China Geological Survey, Beijing, China
Dongjie ZHAO[4], Development Research Center of China Geological Survey, Beijing, China

Abstract

Traditional geological mapping is mainly conducted by geoinformatics experts using GIS software under the instruction of geoscientists. This professional work still has few disadvantages such as (1) *geoscientists lead the work while information experts can't finish the task on their own*, (2) *most of works are repeated and time-consuming*, (3) *many complex processes and manual actions affect data quality of the final map. Thus, cut-edging technologies are utilized to solve these problems and result in new methodology for geological map compilation and in which big data, cloud computing, artificial intelligence are widely used. Geologic mapping work mainly includes data management, data preprocessing, generalization, symbolization & rendering and output. So, this paper proposes a new data and knowledge hybrid-driven methodology for geological map compilation in vector format semi-automatically. The novel geological data generalization mechanism for compilation concentrates on the knowledge of geologists. It aims to deal with various geologic features and corresponding property values using both data-driven and knowledge-driven method. Geologists retrieve the geological knowledge of the region in research from related unstructured geologic reports and saves them into a structured database. The geologic knowledge data includes original and final status attributes of geological body such as strata, geological era, importance, etc. The data-driven approach promotes geologic data transferring from raw data to target map data after some procedures. Of course, it would follow predefined rules and inherit property data from the specific scale digital geological survey databases or perform other vector data processing. The knowledge-driven method employs geologists' knowledge and GIS analysis and even AI algorithms to drive the generalization of different geological features in all areas or interests respectively. For example, during geological map compilation from large-scale to small-scale, geological bodies can be generalized by some generalization operations such as dissolve, elimination, simplification, smoothness, exaggeration, various merged methods, and so on. Although the method names are similar as GIS algorithms, they are all customarily*

developed based on geologists' knowledge and GIS architecture, changed geometry shapes and property values of geologic bodies, lines, or points simultaneously. In addition, the upperscript and subscript, color and legend of geologic features can be performed automatically based on geological knowledge and mapping rules. This framework integrates types of data, mapping model, geologic knowledge, intelligent algorithms together, uses knowledge as core driving force to complete compilation task supported by generalization in interactions with back-end algorithms. The proposed framework powers geologist's knowledge to update spatial data and property data separately or integratedly. It needs geologist's less time, fewer repeated works, and it works much quicker and easier with higher quality than before. Now, it has been developed and used in several national and regional geological mapping projects in China.Results show that it is a new powerful tool to help geologists in the compilation work.

Keyword

data-driven, knowledge-driven, geological map compilation, geological mapping

Geoscience Information in the 2020s

Leonard Harvey Thorleifson[1]*, University of Minnesota (thorleif@umn.edu)

Abstract

Geoscientists deliver research, which is conceptual, mapping, which is spatial, monitoring, which is temporal, and dynamic modeling, which assembles the foregoing, to guide management. Current international geoscience information arrangements are meant to accelerate research, and serve the needs of society regarding energy, engineering, hazards, minerals, and water. To better serve global society, we must optimize adoption of standards, and commit to FAIR principles for publications and databases – findable, accessible, interoperable, and reusable. Publications are being made accessible to machine methods. Concurrently, authoritative, ideally-jurisdiction-wide, indefinitely-updated, evergreen databases are being built, as observations in part assembled through data sharing and appropriate crowdsourcing, and as inferences increasingly as fully categorized, machine-readable, multi-resolution seamless 3D geological mapping that is coordinated with other mapping. To access and utilize information, there are increasing roles for methods such as large language models and knowledge graphs, and appropriate roles for artificial intelligence and machine learning. Modeling, in some cases indefinitely sustained with iterations, inputs, and outputs and thus a digital twin, is permitting gradually increasing implementation such as jurisdiction-wide groundwater modeling and management to ensure sustainability, and other applications such as managing the energy transition and optimizing sourcing of materials. International coordination of earth science information is facilitated by broader mechanisms such as the Committee on Data (CODATA) of the International Science Council (ISC), standards organization such as Open Geospatial Consortium (OGC), the International Union of Geological Sciences (IUGS) Commission for the Management and Application of Geoscience Information (CGI), influential initiatives such as Deep-time Digital Earth (DDE), and highly active partners.

Keyword

geoscience, information, FAIR

EarthResourceML 3.0

Michael Graham SEXTON[1]*, Geoscience Australia (michael.sexton@ga.gov.au)
Jouni Vuollo[2], Geological Survey of Finland (retired)
Oliver Raymond[3], Geoscience Australia (retired)
Daniel Cassard[4], Bureau de Recherches Géologiques et Minières (retired)
Ernst Schetselaar[5], Natural Resources Canada
Mark Rattenbury[6], GNS Science
Ursula Michael[7], Department for Energy and Mining

Abstract

EarthResourceML (https://earthresourceml.org/) is the international logical data model and data standard for mineral occurrences, mines, and mineral resources. The release of EarthResourceML (ERML) 3.0 represents the first significant update to the standard since 2018. ERML 3.0 makes the transition to Open Geospatial Consortium (OGC) standard GeoSciML 4.1 (http://geosciml.org/) as its foundation. The standard undergoes a major revision to the Earth Resource and Mineral Occurrence feature types and their related features, enabling future extension of the model to incorporate other earth resources unrelated to mining and minerals. A new Mine Status type defines the time-series data for the lifecycle of a mine from feasibility through to operation and closure. The reporting of reserves and resources is now collected under a single Ore Measure Observation feature type. New feature types for Processing Plants and Processing Activities capture downstream mineral processes related to refining and smelting. The Mining Waste Measure data type is extended to include new attributes which better describe the composition, size, and mineral commodities for tonnages and volumes of mining waste. Mining Waste features are related to Processing Plants to capture waste outputs such as slag and fly-ash. Simplified features containing the minimum set of necessary attributes for simple map-based applications and basic data exchange are defined in ERML Lite 2.0.1 for Mineral Occurrences, Commodity Resources, Mines, Mining Activities, Processing Plants and Mining Waste. Simple Knowledge Organisation System (SKOS) vocabularies (https://cgi.vocabs.ga.gov.au/vocab/) for the new ERML 3.0 types are provided by the Commission for the Management and Application of Geoscience Information (CGI) Geoscience Terminology Working Group (GTWG). These include the new vocabulary for the deposit classification naming system developed by the Critical Minerals Mapping Initiative (CMMI), collaboration between Geoscience Australia (GA), the Geological Survey of Canada (GSC) and the United States Geological Survey (USGS). These extensions to ERML provide a sustainable data framework for important areas of modern research, including critical minerals and environmental, social, and governance (ESG) decision-making.

Keyword

data standards, vocabularies, mineral resources, data modelling

Building a Digital Framework for Europe's Geology: GSEU and the Significance of Data Modelling and Vocabularies

Kristine E.C. ASCH[1]*, Federal Institute for Geosciences and Natural Resources (BGR)
(Kristine.Asch@bgr.de)
Hans-Georg Krenmayr[2], GeoSphere Austria
Kris Kris Piessens[3], Royal Belgian Institute of Natural Sciences - Geological Survey of Belgium,
Zoltán Németh Nemeth[4], State Geological Institute of Dionýz Štú
Cécile Le Guern[5], Bureau de recherches géologiques et minières - BRGM

Abstract

Amongst the objectives of the GSEU project is the provision of harmonized data and information. Such data are needed to coordinate and ensure sufficient and sustainable provision of natural resources, efficient use of the subsurface, sustainable management of our landscape and the protection of the environment. They all have in common that they need to rely on, and to work with, basic geological data representations, such as digital map data sets and 3D models. A comprehensive and flexible (e.g. regarding scale) digital framework, able to take up these data sets and models is therefore a central objective of GSEU.

In this context, the development of a commonly agreed data model is necessary for the compilation of interoperable, harmonised, multiscale geolscientific data sets in 2D and 3D. It will be based on the Structural Framework (developed within the GeoConnect[3]d-project) but also on standards developed by OneGeologyEurope, INSPIRE, HIKE or at national level.
Scientific vocabularies and hierarchic nomenclatures are being improved or newly created to be used for the following geoscientific thematic map layers (spatial data):

- lithology – essential to describe the geological subsurface;
- anthropogenic deposits – an actual theme, important to describe human impact on the subsurface;
- lithotectonic units – tectonic structures and geological units, important for understanding regionally significant rock frequences and structures, their evolution and their potential to contain mineral reserves.

As a testbed for the data model and newly created vocabularies, the 1 : 5 Million International Geological Map of Europe and Adjacent Areas (IGME 5000) will be be used which is the only existing, harmonized, pan-European geological map data set.

Keyword

data model, vocabularies, lithology, anthropogenic units, lithotectonic units

REASSESSMENT OF DETAILED LITHOLOGICAL MAPPING USING A MACHINE LEARNING ALGORITHM: A CASE STUDY ON THE BOA VISTA SHOSHONITIC STOCK IN NORTHEASTERN BRAZIL

Mariana Izabel Tomaz de LIMA[1]*, Federal University of Rio Grande do Norte (UFRN) (marianalima506@gmail.com)
Frederico Castro Jobim VILALVA[2], Federal University of Rio Grande do Norte (UFRN)

Abstract

Contemporary approaches to "visual" integration for geological mapping from geophysics are notoriously challenging, often influenced by user assumptions and characterised by significant time demands. The use of a supervised machine learning method, such as Random Forest, applied to airborne geophysical datasets, emerges as a viable alternative for the rapid generation of interpretative maps. These maps can then be submitted for validation through geological mapping, resulting in more efficient and reliable processes. The geophysical and geological data used, which is widely available at an adequate resolution, is provided by the Geological Survey of Brazil. The use of this data made it possible to carry out a predictive lithological analysis for the Boa Vista Shoshonitic Stock and for the region's crystalline basement, represented by the Caicó Complex. This process made it possible to identify areas that need to be revised for a more precise refinement of the lithologies in the field. After selecting the areas for reassessment, detailed lithological mapping was carried out, resulting in a more precise distinction of the lithological contacts and rock formations present. Based on the most recent geological data, which was described in detail in the field, a new predictive lithology analysis was carried out for the Stock. Of the 10400 samples available, 322 were selected as training samples for the random forest algorithm to predict the desired area. These training points had associated geological and geophysical information, which was incorporated into the ArcGIS software. This analysis resulted in a compatibility rate of 86.9 percent. However, it is important to emphasise that some factors may contribute to this percentage of incompatibility. One of these factors could be the discovery of new correlations between geological and geophysical data, which could be exploited to improve the current geological map. In the context of the Boa Vista Stock, the predicted lithological analysis revealed a notable decrease in the presence of other lithologies within the crystalline basement. Due to the diversity of the lithological unit in question and its similar characteristics to the lithologies of other units, it is possible that some sites were mistakenly interpreted as belonging to the Caicó Complex. A new correlation identified in the first lithological forecast was confirmed during field exploration, with the rocks of the Caicó Complex being affected by the Stock thermal halo, undergoing a process of migmatization. In addition, it was observed that the intrusive body itself did not show major geometric changes. This conclusion was supported by the body's geophysical response and confirmed during field exploration. Using the new predictive lithological map of the region, an updated geological map was drawn up, incorporating the corrections derived from field exploration and identifying specific areas for detailing the facies

found in the Stock. The lithological forecast emerges as a crucial tool not only for improving existing lithological maps, but also as an essential starting point for mapping regions lacking in lithological information due to the lack of significant outcrops.

Keyword

geological mapping, machine learning, lithological analysis, predictive mapping, field exploration

Serverless Computing Powered Efficient Remote Sensing Image Processing: A Case Study on Potential Sand Source Identification in the Yarlung Zangbo River Middle Reaches

Qing LAN[1]*, School of Earth Sciences, Zhejiang University (lanqing@zju.edu.cn)
Linshu HU[2], School of Earth Sciences, Zhejiang University
Sensen WU[3], School of Earth Sciences, Zhejiang University
Zhenhong DU[4], School of Earth Sciences, Zhejiang University

Abstract

Currently, remote sensing image processing faces the ever-growing challenge of big data tasks, and cloud computing provides a viable solution for efficient processing of these massive datasets. However, traditional cloud computing solutions still encounter challenges in resource provisioning, scheduling, and scalability. In this context, serverless computing architecture has emerged as a new paradigm for delivering cloud services, allowing users to upload only the functional code and delegate the underlying server management tasks to service providers. This opens up new possibilities for remote sensing image processing. This study, using the potential sand source identification in the middle reaches of the Yarlung Zangbo River as a case, aims to explore the integration of serverless computing architecture with traditional remote sensing data processing while investigating potential changes in sand sources in the research area. Therefore, we constructed a remote sensing image analysis tool based on a cloud computing platform, utilizing serverless technology to endow it with high scalability. We efficiently analyzed 30 years of remote sensing images of the middle reaches of the Yarlung Zangbo River, extracting potential sand sources and studying their change patterns. This research provides essential references for local sand control and ecological conservation. Simultaneously, the study demonstrates the feasibility and advantages of serverless computing in the application of remote sensing image processing, offering a practical example for its implementation in the field.

Keyword

Serverless Computing, Remote Sensing, Big Data, Cloud Computing

Enhancing Environmental Understanding with Spatio-Temporal Knowledge Activation in Large Language Models

Xinhua FAN[1]*, Zhejiang University (fanxhgis@zju.edu.cn)
Zhenhong Du[2], Zhejiang University

Abstract

This paper proposes a methodology for activating spatio-temporal knowledge within large language models to enhance understanding of environmental phenomena. We extract scene knowledge and derive spatio-temporal rules from remote sensing data, integrating them into large language models for improved analysis. Our methodology combines remote sensing image processing with natural language processing techniques. Initially, we preprocess remote sensing images to extract meaningful features representing various environmental phenomena, capturing spatial patterns and temporal variations. These features are then encoded and embedded for ingestion by the large language model, allowing it to capture rich spatio-temporal information. Within the large model, algorithms are developed to extract scene knowledge by identifying and classifying environmental entities and their relationships based on the encoded features. Spatio-temporal rules are derived to discover patterns and trends in the temporal evolution and spatial distribution of these entities. Integrating spatio-temporal knowledge into the large model enables it to generate more accurate insights about environmental phenomena, potentially enhancing environmental monitoring, analysis, and decision-making processes. This paper contributes to the emerging field of integrating remote sensing and large language models for environmental studies, demonstrating the feasibility and effectiveness of leveraging spatio-temporal knowledge from remote sensing data within large models to enhance understanding of complex environmental systems.

Keyword

Large Language Models, Spatio-Temporal Knowledge, Remote Sensing

Unraveling Seismic Patterns: A Deep Dive into Earthquake Sequences and Swarms in Northeastern Algeria through a Dual Method Approach

Sofiane Taki-Eddine Rahmani[1]*, CRAAG (sofianerah1@outlook.fr)
Issam Abacha[2], CRAAG
Oualid Boulahia[3], CRAAG
El-Mahdi Tikhamarine[4], UFAS 1
Khaled Roubeche[5], CRAAG

Abstract

In nature, there are two main types of seismic sequences: the first involves mainshocks followed by aftershocks, exhibiting a temporal decay in line with the Omori-Utsu law, typically with the mainshock initiating the sequence. The second type consists of earthquake swarms, deviating from Omori-type decay, where events of significant magnitude often occur in the middle or towards the end of the sequence. In the northeastern region of Algeria, seismic sequences often involve more than two main earthquakes, featuring both temporal and spatial migrations (Rahmani et al., 2023; Abacha et al., 2022; Boulahia et al., 2021). Clarifying and categorizing these sequences is crucial for understanding the triggering mechanisms governing this seismicity.

In the current study, two methodologies were employed. Firstly, we determined spatio-temporal ETAS model parameters for the entire region, incorporating a bootstrap approach to assess uncertainties. Subsequently, using these parameters, the region was divided into grid cells of dimensions 0.2 x 0.2, and transformed time was calculated in each grid cell. Finally, the '1σ criterion' introduced by Nishikawa et al. in 2017 was applied. A total of 21 clusters were identified, encompassing 312 swarm events.

For the second method, skewness and kurtosis of the moment release time series (Mesimeri et al., 2019) were computed for each cluster after identification using the CURATE method ((Jacobs et al., 2013). In total, 621 events exhibited swarm-like behavior. The two swarm catalogs were merged, as both techniques are independent of each other. In all, 762 events were accepted as swarm after applying additional criteria, such as ensuring the difference between the largest event and the second largest event in each cluster is less than 1. From this catalog, interpretations were made based on the tectonic setting of the region and the geological area to understand the factors responsible for these earthquake swarms.

List of references

Abacha I., Yelles-Chaouche A., Boulahia O., 2022. Statistical study of earthquake swarms in northeastern Algeria with special reference to the Ain Azel swarm; Hodna Chain 2015. CAJG 2019. Advances in Science, Technology & Innovation. Springer, Cham.

Boulahia O., Abacha I., Yelles-Chaouche A., Bendjama H., Kherroubi A., Mohammedi Y., Aidi C., Chami A., 2021. Recent seismic activity in the Bejaia-Babors Region (Northeastern Algeria): the case of the 2012–2013 Bejaia Earthquake sequences. Pure appl. Geophys., 178, 1253–1279.

Jacobs, K.M., Smith, E.G.C., Savage, M.K., Zhuang, J., 2013. Cumulative rate analysis (CURATE): a clustering algorithm for swarm dominated catalogs. J. Geophys. Res.Solid Earth

118, 553–569.
Mesimeri M., Karakostas V., Papadimitriou E., Tsaklidis G., 2019. Characteristics of earthquake clusters: application to western Corinth Gulf (Greece), Tectonophysics, 767, 228160.
Nishikawa, T., & Ide, S. (2017). Detection of earthquake swarms at subduction zones globally: Insights into tectonic controls on swarm activity. Journal of Geophysical Research: Solid Earth, 122(7), 5325–5343.
Sofiane Taki-Eddine Rahmani, Issam Abacha, Oualid Boulahia, Abdelkarim Yelles-Chaouche, Cristina Crespo-Martín, Khaled Roubeche, Time-dependent and spatio-temporal statistical analysis of seismicity: application on the complete data set of the 2010 Beni–Ilmane earthquake sequence, Geophysical Journal International, Volume 236, Issue 3, March 2024, Pages 1246–1261

Keyword

Earthquake swarms, fluid, ETAS, spatio-temporal patterns, seismic moment

Estimation of earthquake hazard parameters of delineated sources of the Shillong Plateau, Northeast India and adjoining regions

MOHD SHAHABUDDIN[1]*, Indian Institute of Technology Kharagpur India (mohdshahabuddin@iitkgp.ac.in)
William Kumar Mohanty[2], Indian Institute of Technology Kharagpur
Eleftheria E. Papadimitriou[3], Geophysics Department, Aristotle University of Thessaloniki, GR 541 24 Thessaloniki, Greece

Abstract

The Shillong plateau is one of the most seismically active regions of world and it experienced many major to great earthquakes in the past. Earthquake hazard parameters such as seismicity rate (λ), b value and maximum magnitude (Mmax) from the G-R relationship are the essential input for the seismic hazard assessment. The seismicity rate or the mean return periods of earthquakes with magnitudes greater than or equal to a given threshold value are considered for the evaluation of the seismicity of the region. We have estimated the earthquake hazard parameters namely Gutenberg–Richter b-value, beta (β=b*ln(10)=2.303*b), Maximum magnitude (Mmax), and earthquake mean activity rate (λ) of the twenty one seismic zones delineated based on spatial distribution and level of seismicity, seismotectonic properties, historical earthquakes, focal mechanisms and geology of the region. Earthquake catalogue compiled in the present study is used for these estimations. We applied Kijko Sellevoll Bayes technique (Kijko, 2004) to assess the essential earthquake hazard parameters for each seismic zone. Return period versus magnitude, annual probability of exceedance versus magnitude, Hazard curves have been made for each seismic zone. It is observed that λ, b value and Mmax range from 0.355 to 2.816, 0.86 to 1.50, and 5.67 to 9.21, respectively.

Keyword

Mmax, b value, Mean activity rate, Shillong Plateau, Return period

Using eathquake time series to characterize seismicity in the Mount Cameroon

Delair Dieudonne NDIBI ETOUNDI[1]*, Institute of Geological and Mining Research
(del_ndibson@yahoo.fr)
Eddy Ferdinand Mbossi[2], Institute of Geological and Mining Research
Sofiane Taki-Eddine Rahmani[3], CRAAG
Bekoa Ateba[4], Institute of Geological and Mining Research

Abstract

Mount Cameroon is an active volcano rising to almost 4100 m above the sea level on Cameroon south-western coast on the Gulf of Guinea. Over the past century,it has experienced 7 major volcanic eruptions, the most recent of which occurred in 1999 and 2000. Its volcanic eruptions are usually preceded by major seismic crisis, with seismicity rising from an average of 30 events in the quiescent period to over 100 events per month as an eruption approaches. At the end of the year 2010, over a period of almost 3 months, we witnessed an increase in seismicity, with a peak of just under 200 events reached in September,yet no eruption followed. In order to better understand the physical phenomena behind this crisis, we therefore proposed to use a seismological statistical approach, in this case the non stationary ETAS model and the analysis of magnitude distribution to characterize this seismicity. The b value, considered as one of the important parameters representing the nature of earthquake occurrence and characterizing the state of stress in the crust was found to be high. The background rate, obtained from the inversion of non-stationary ETAS parameters, reveals a slow transient deformation with gradual onset. The computation of the forcing rate show so far that almost 55 % of the seismicity is due to an external process like fluid extrusion.

Keyword

Mount Cameroon, Volcanic eruption, seismicity, ETAS model

A regional insight on the tectonic and geometric configuration of the Bengal Basin for hosting predicted mega earthquakes

MIR FAZLUL KARIM[1]*, Geological Survey of Bangladesh (Formerly) / Presently Retired/ Address - 700 Massachusetts Avenue, Boxborough, MA 01719, USA (geologist.karim@gmail.com)
Daya Shanker[2], Department of Earthquake Engineering, IIT, Roorkee-247667, Uttarakhand, India

Abstract

Bangladesh is tectonically active and experiences often moderate to significant damage during earthquakes. Due to rapid socioeconomic and infrastructure development it is essential for a rational understanding of seismic risks factors for engineering design and hazard management in this region. Bangladesh occupies a major part of Bengal Basin, folded hills of Indo-Burma Range (IBR), a broadly N-S trending arcuate fold-thrust, close to the Indo-Burmese subducting plate boundary. This plate-boundary is an arch part and extends southward to the Andaman-Nicobar Island arc. The geological and tectonic setting of the region is extraordinarily complicated due to a juxtaposition of multiple tectonic plate margins. The Bengal Basin is covered by extensive sediment thickness of 10 - 17 km. It is formed during the separation of Antarctica from India in the early Cretaceous. Shillong plateau is over thrusting the Bengal Basin from the north, thereby depressing the Sylhet Basin. The Bengal Basin has experienced two massive earthquakes in the past (1923, M7.0, and 1918 M7.1). In recent geoscientific research based on hypothetical simulation models Steckler et al. (2016) suggested that the Indo-Burmese subduction slabs are locked, and Bangladesh is likely to host mega-earthquakes of magnitude Mw 8.2-9 soon. The prediction is highly conjectural due to lack of sufficient geological evidence. Therefore, for a thorough understanding and reliability of the prediction we investigated the geometry and stress field of the subduction zone. It is found that a stress value of the order of 30–40 MPa is estimated in the Bengal basin, Meghalaya region, and some parts of the Burmese region and Himalayan region. Based on detailed scrutinization of regional and local field geology, magnetic, gravitational anomaly maps and subsurface data published by the Geological Survey of Bangladesh we postulated the tectonic and geometric configuration of Bangladesh. Further, we did not find any megathrust structure to host any mega earthquake in the Bengal Basin.

Keyword

Bengal Basin, Tectonics, Mega Earthquake

Recent Earthquakes along the Ogcheon Fold Belt in the Korean Peninsula

Won-Young KIM[1]*, Columbia University (wykim@ldeo.columbia.edu)
Minseong Seo[2], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea.
Jun Yong Park[3], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea
YoungHee Kim[4], School of Earth and Environmental Sciences, Seoul National University, Seoul, Republic of Korea

Abstract

The tectonic map of the Korean Peninsula, published in 2019 by the Korea Institute of Geoscience and Mineral Resources (KIGAM), revised the extent of several tectonic provinces in the Korean Peninsula. Notably, the Imjingang belt in the central Korean Peninsula has been extended to include the western edge of the Precambrian Gyeonggi Massif and down to the Ogcheon fold belt (OBF) and is named the Hongseong-Imjingang belt (Permian collisional and accretionary feature). Another prominent tectonic province, the Ogcheon fold belt, a ~60 km wide and about 450 km long geologic unit that runs diagonally from southwest to northeast in the middle of the southern Korean Peninsula, had its northern border moved by about 30 km to the south. The newly defined northern and southern boundaries of the Ogcheon fold belt show a remarkable correlation with recent significant earthquakes (magnitude > 3.5) in the southern Korean Peninsula. The focal mechanisms of these earthquakes are predominantly east-west trending strike-slip faulting – nearly perpendicular to the OFB boundaries. In the framework of plate tectonics, OFB is thought to be produced by the collisions of the North China-Korea block and the South China block with the proto-Korean Peninsula.

Recent earthquakes in and around the Korean Peninsula since 1996 suggest that 1) the boundaries of the tectonic provinces may act as the zone of weakness that accommodates the occurrence of earthquakes. 2) seismogenic faults, however, appear to be stray faults trending perpendicular to the boundary faults of the tectonic provinces. These may be typical seismogenesis in stable continental regions. We will show important examples to support these arguments.

Keyword

Korea, Ogcheon fold belt, Seismicity

HIGH RESOLUTION P AND S WAVE VELOCITY STRUCTURES OF THE EASTERN SINO-KOREAN CRATON

Yanbing LIU[1]*, Yonsei Univerisity (liuyanbing@yonsei.ac.kr)
Tae-Kyung HONG[2], Yonsei Univerisity
Junhyung Lee[3], Yonsei Univerisity
Seongjun Park[4], Yonsei Univerisity
Jeongin Lee[5], Yonsei Univerisity
Byeongwoo Kim[6], Yonsei Univerisity

Abstract

This study investigates the eastern North China Craton (ENC), Korean Peninsula, and Bohai and Yellow Seas. These areas are located in the convergence region of ancient Asian Ocean, Tethys Ocean, and Pacific Ocean, collectively constituting the eastern Sino-Korean Craton (SKC). The areas currently undergo a significant craton destruction process. However, the precise boundaries of major geological units and their stress conditions are still inadequately understood. A velocity tomography of the entire eastern Sino-Korean Craton (SKC) demands refinement, particularly at the China-South Korea border, where the resolution is relatively poor due to the absence of collaborative works based on seismic data from both Chinese and South Korean stations.

The study integrates a comprehensive dataset, combining 87,260 earthquakes recorded at 680 Chinese seismic stations since 2008 and 5,400 earthquakes recorded at 483 South Korean seismic stations since 2017. A joint inversion method, VELEST, is employed to determine 1D minimum velocity models and hypocenters, then the events location are further refined by using the double difference method, HYPODD. All the seismic events are relocated, and the 1D minimum velocity models are improved. Different regions with diverse geological backgrounds undergo separate relocation procedures. The P and S arrival times for events in the South Korean region are determined through both the machine learning method, PHASENET and the manual picking process. The machine learning model has been trained to adapt to the Korean dataset, and the picking capacity appears to have improved after transfer learning. The arrival times of events located in the Bohai Sea and Yellow Sea regions, recorded by South Korean stations, are manually picked. Subsequently, the TOMODD tomography method is employed to image the P-wave and S-wave velocity structures for events with magnitudes of ML 2 or higher.

The seismic rays, with their cross-coverage extending over the Yellow Sea and Bohai Sea, enhance the tomography resolution of the boundary regions between mainland China and South Korea. The inverted models reveal the P and S wave velocity structures of the eastern SKC, featuring pronounced anomalies and low-velocity layers intricately connected to the ongoing craton destruction process. This research contributes new insights into the tectonic evolution and seismic activity of this dynamic region.

Keyword

Velocity Tomography, Korean Peninsula, North China Craton, Bohai Sea, Yellow Sea

The 2022 Goesan earthquake of the moment magnitude 3.8 along the buried fault in the central Korean Peninsula

Hobin LIM[1]*, Korea Institute of Geoscience and Mineral Resources (HBL@kigam.re.kr)
Chang Soo Cho[2], Korea Institute of Geoscience and Mineral Resources
Minkyung Son[3], Korea Institute of Geoscience and Mineral Resources

Abstract

On October 28, 2022, a moment magnitude (Mw) 3.8 earthquake occurred in Goesan, South Korea, typically characterized as a stable continental region. Herein, we analyze 42 earthquakes, including the Mw 3.8 earthquake, the largest foreshock (Mw 3.3), which preceded the mainshock by 17 s, and the largest aftershock (Mw 2.9). The primary aim of this study is to identify interactions among the seismic events. To this end, we utilized the permanent seismic networks with the closest station at 8.3 km from the epicenter, and the temporary network deployed eight hours after the mainshock's occurrence. Relocation results delineate that the mainshock occurred at the southeastern tip of the hypocenter distribution of three foreshocks, trending west-northwest–east-southeast. The aftershocks form an overall spatially diffused seismic pattern that propagates toward both ends of the inferred lineament in the downdip direction. The rupture directivity of the mainshock, along with waveform similarity across the mainshock and foreshocks, confirms the inferred geometry, corresponding well with the focal mechanisms of the mainshock and the largest foreshock. We demonstrate that the change in Coulomb failure stress (ΔCFS) by the largest foreshock was positive where the mainshock occurred and that the mainshock generated ΔCFS capable of triggering the propagation of the aftershocks.

Keyword

stable continental region, earthquake interaction, Coulomb Failure Stress, foreshock, aftershock

Resolving rupture properties of small earthquakes in the southern Korean Peninsula using direct and reflected phases

Min-Seong SEO[1]*, Seoul National University (36wnfgodfkd@snu.ac.kr)
Sangwoo HAN[2], Seoul National University
Won-Young KIM[3], Lamont-Doherty Earth Observatory
YoungHee KIM[4], Seoul National University

Abstract

While finite-fault earthquake source inversions have become a standard method for studying the kinematics of earthquake ruptures, detailing small earthquake (usually magnitude < 4) ruptures still remains challenging due to limited resolution. This limitation is pronounced in stable continental regions (SCRs), such as the Korean Peninsula, where the infrequent occurrence of moderate-to-large earthquakes impedes routine analysis and hinders a comprehensive understanding of earthquake rupture processes. This study, therefore, undertakes a systematic analysis of 28 small earthquakes (ML 2.0 – 4.1) in the southern Korean Peninsula (SKP) since 2019, taking advantage of a dense seismic network deployed in the past decade. Employing nearby smaller events as empirical Green's functions, we retrieve relative source time functions (RSTFs) of target earthquakes using direct P and S phases from stations within 100 km of the epicenter. We further obtain RSTFs from P and S phases down-going from the source and arrive as reflected from Moho, which ensures the acquisition of source pulses with up- and down-going takeoff angles. The diverse takeoff angles in the RSTFs are pivotal for resolving the vertical component of rupture propagation, which has often been overlooked in previous studies due to the absence of close-in stations. By utilizing a Bayesian framework to model RSTF durations with a simple line source model, we successfully invert for key rupture parameters — direction, length, velocity, and degree of asymmetry — thereby facilitating robust quantification of uncertainty and trade-offs between parameters.

Our results demonstrate that approximately 85% of the analyzed events can be effectively modeled using the line source model. We find that the rupture direction can be reliably inverted, thus defining the actual fault plane. Remarkably, the majority (~70%) of the events reveal asymmetric rupture propagation with varying degrees of asymmetry, while only ~15% exhibit nearly symmetrical rupture. The strategic use of Moho-reflection phase RSTFs is indeed effective in substantially reducing parameter uncertainties by tightly constraining the vertical component of rupture. Additionally, our findings reveal a positive correlation between rupture length and magnitude, aligning with the previously suggested scaling relationship for SCR earthquakes. Furthermore, well-resolved rupture velocities range from 0.56 to 0.94 times the shear wave velocity (VS), encompassing the range reported for large crustal earthquakes (0.7 – 0.9VS).

Keyword

Earthquake rupture, Rupture directivity, Korean Peninsula, Microearthquake, Bayesian inference

Constraints on crustal seismic properties of the southern Korean Peninsula using Virtual Deep Seismic Sounding

Young Oh SON[1]*, Seoul National University (sonofson@snu.ac.kr)
YoungHee KIM[2], Seoul National University
Chunquan YU[3], Southern University of Science and Technology

Abstract

The southern Korean Peninsula (SKP) preserves complex history of geologic processes in the Northeast Asia including Permian–Triassic collision between North China Craton (NCC) and South China Craton (SCC), as well as the formation of the island arcs of Japan in the Neogene. Traces of these events are manifested by series of tectonic units trending NE–SW to NNE–SSW, such as Yeongnam Massif and Gyeongsang Basin in SE of SKP, Gyeonggi Massif in NW, and Okcheon Belt in between. Knowledge of the average P-wave velocity (Vp), thickness (H) and P-to-S velocity ratio (κ) of the SKP crust can provide key information on its composition, isostasy, and state of thermal interaction with the upper mantle. In this study, we constrain these properties of the continental crust of the SKP by performing a joint analysis of Virtual Deep Seismic Sounding (VDSS) and P-wave receiver function (PRF). For VDSS, we inverted for H and Vp by fitting traveltimes and phases of direct S and SsPmp recorded by 192 stations (107 broadband seismometers and 154 accelerometers) in SKP. Inherent large amplitude of SsPmp, along with removal of source-side scattering effects via deconvolution of S-type waves separated by particle motion analysis, facilitates robust waveform fitting.

Estimates of Vp and H range within ∼6.0–6.7 km/s and ∼23–34 km, respectively, whereas values of κ, computed from differential arrivals of direct and multiple P-to-s conversions in the PRF combined with Vp and H from VDSS, lie mostly within ∼1.66–1.82. Independent calculation of H and κ from H–κ stacking fed by variable Vp from VDSS shows similar trend overall, supporting the validity of our results. Comparison of crustal constituents inferred from obtained Vp and κ with those from the rock samples indicates abundance of typical metamorphic rocks and granites, with composition transiting from felsic to intermediate as it goes southeast. Vp over 6.4 km/s in the southern province of Yeongnam Massif and Gyeongsang Basin might reflect magmatic underplating in the Cretaceous, induced by the subduction of Izanagi Plate. Similar value in the southwestern portion of Okcheon Belt seems to be the result of rifting between Precambrian massifs in the Paleozoic. Shallow Moho (∼23–25 km) along the eastern coast shows evidence for the opening of the East Sea of Korea (Sea of Japan). Vp in the Yeongnam Massif and Gyeongsang Basin shows similarity to NCC, while those are significantly lower in the Gyeonggi Massif at similar latitudes. This discrepancy, together with lower κ in the Gyeonggi Massif, implies its possible origin linked to SCC.

Keyword

Crustal structure, Body waves, Virtual Deep Seismic Sounding

Focal Mechanism Solutions and Crustal Stress Field around the Korean Peninsula

Dong geon KIM[1]*, Yonsei University (kdg3290@yonsei.ac.kr)
Junhyung LEE[2], Yonsei University
Tae-Kyung HONG[3], Yonsei University

Abstract

The Korean Peninsula is located in the eastern margin of the Eurasian plate surrounded by the Okhotsk, Pacific, and Philippine Sea plates. The crustal stress field is mainly influenced by the regional tectonics. We collect the focal mechanism solutions of 473 earthquakes around the Korean Peninsula. We also determine the focal mechanism solutions of additional 93 regional earthquakes using a long-period waveform inversion and P phase polarity analysis. The strike-slip earthquakes are dominant in the region around the Korean Peninsula. Reverse faulting earthquakes occur in the western East sea (Sea of Japan). Normal faulting earthquakes are observed in the central Yellow Sea. We investigate the regional crustal stress field in the continental margin around the Korean Peninsula and Japanese islands. The regional stress field was inferred from the focal mechanism solutions of 13334 regional earthquakes using a damped stress inversion technique. We present a detailed stress map. The dominant compressional stress is directed ENE-WSW around the Korean Peninsula, NW-SE in the central Japanese islands, and N-S around the northern Nankai trough. The dominant compression direction changes between the Korean Peninsula and Japanese islands. The lateral variation in stress field may be due to the relative motions of surrounding plates. The stress field may provide information on potential earthquake mechanisms and vulnerability of faults in local regions.

Keyword

Korean Peninsula, focal mechanism solution, crustal stress field, regional tectonic

Fault complexity revealed by focal mechanisms of small earthquakes in Gyeongju, South Korea: effective use of S-wave polarizations retrieved from the high-density seismic array

Sangwoo HAN[1]*, Seoul National University (sangw876@snu.ac.kr)
YoungHee KIM[2], Seoul National University

Abstract

The southeastern part of Korean Peninsula is the most seismically active after the 2016 Mw 5.5 Gyeongju earthquake. This earthquake sequence involves foreshocks, mainshock, and aftershocks which appear to occur on multiple segments of the Naenam fault. We here investigate detailed fault structures with the focal mechanisms of small earthquakes recorded by the 200 broadband seismic stations that cover a 50 km by 50 km zone of the earthquake sequence.

We developed a method that utilizes S-wave polarizations to increase the accuracy of focal mechanism solutions of small earthquakes (ML<3). S waves recorded within epicentral distance of 13 km were used to exclude non-linear particle motions due to free-surface interactions at incidence angle greater than critical angle of S-to-P conversion. Through rigorous synthetic tests, we assessed focal mechanisms using three different datasets: P-wave first-motion polarities, S/P amplitude ratios, and S-wave polarization directions, with varying levels of measurement errors. Results indicate that utilizing the S-wave polarization directions with correction of S-wave splitting effectively reduces the minimum required number of stations. Considering realistic noise levels for a ML 2.6 event, the solution could be derived with only two stations with mean error of 15° in the 3-D rotation angles. Lastly, we applied our method to determine focal mechanisms of small earthquakes that occurred within the network since 2019 in Gyeongju. We obtained ~90% strike-slip and ~10% reverse faulting mechanisms having spatially different distributions depending on their focal depths. We also found that reverse faulting mechanisms are mostly concentrated at shallower depths. Our analysis results suggest that the location of earthquakes can be improved by using seismic waveforms rotated to the direction of S-wave polarization constrained by the focal mechanism.

Keyword

Focal mechanism, S-wave polarization direction, Small earthquake

Do Subducted Seamounts Act as Weak Asperities?

Sungho LEE[1]*, KIGAM (slee29@memphis.edu)
Eunseo Choi[2], University of Memphis
Christopher H. Scholz[3], Columbia University

Abstract

The additional work of ploughing makes seamounts more resistant to subduction and more strongly coupled than smoother areas. Yet there is a school that believes that seamounts have weak coupling and slip aseismically. This idea is primarily based on the claim that a seamount being subducted in the southern Japan Trench behaves this way. The key element in this assertion is that large M~7 earthquakes that abut the leading edge of the seamount require that the seamount be aseismically sliding to initiate them. More recent observations which were found by ocean-bottom seismometers deployed in the southern Japan Trench show instead that the surrounding region is aseismically sliding while the seamount acts as a stationary buttress. Here we re-examine this case and model it with both weak and strong asperity assumptions. Our modeling results show that only a strong asperity model can produce this type of earthquake. Strong asperities also rupture the seamount in great earthquakes with long recurrence times. This provides the previously unknown source for a series of great tsunami earthquakes that have occurred along the southern Japan Trench, the most recent being the 1677 M8.3–8.6 Enpo Boso-oki tsunami earthquake. The ‘weak asperity’ hypothesis is thus found to be false in this foundational example.

Keyword

Japan Trench, Seamounts, Asperity, Numerical modeling

Crustal Structure in the Southeastern Korean Peninsula Using a Receiver Function Analysis

Jeongin Lee[1]*, Yonsei University (jeongin6422@yonsei.ac.kr)
Tae-Kyung Hong[2], Yonsei University
Seongjun Park[3], Yonsei University
Junhyung Lee[4], Yonsei University
Byeongwoo Kim[5], Yonsei University

Abstract

The southeastern Korean Peninsula (Yeongnam region) is a region with a population of 12 million and 19 nuclear power plants in operation. Recent moderate-size earthquakes, including the 2016.9.12 ML5.8 Gyeongju earthquake and the 2017.11.15 ML5.4 Pohang earthquake, occurred in the southeastern Korean Peninsula. Small to moderate-size earthquakes (≥ ML 3.0) constantly occur in the region. The southeastern Korean Peninsula is composed of two geological provinces of Yeongnam Massif and the Gyeongsang Basin. In the Gyeongsang Basin, complicated fault structures developed by tectonic processes during the Miocene. High-resolution crustal structures may provide information on tectonic processes and seismic hazard potentials. We investigate the crustal structures of the southeastern Korean Peninsula using a receiver function analysis. We collect seismic records in 182 stations for 138 teleseismic events with magnitudes of ≥ MW 6.0 and distances of 30°–90° since 2019. We calculate the receiver functions and shear-wave velocity models using a time-domain iterative deconvolution method and iterative least-squares inversion method. The shear wave velocity distribution is generally consistent with geological features. Low velocities are observed in the Cenozoic sedimentary region in the east of the study area. The crustal thickness and VP/VS ratio are estimated using an H-K staking analysis. The Moho depths range mostly from 28 to 34 km, becoming shallower on the east coast of the peninsula. The western study area, corresponding to the Yeongnam Massif, presents a crustal thickness greater than 34 km. The VP/VS ratios vary between 1.68 and 1.86, with higher values around the coast and fault zones.

Keyword

Receiver function, Crustal structure, Yeongnam region

Comprehensive Earthquake Parameter Determination using the AI and Bayesian Inference Techniques: Case Study on the Southeastern Korean Peninsula

Jongwon Han[1]*, Korea Institute of Geoscience and Mineral Resources (jongwony@korea.ac.kr)
Seongryong Kim[2], Dept. of Earth and Environmental Sciences, Korea University
Dabeen Heo[3], Division of Earth Environmental System Science, Pukyong National University
Tae-Seob Kang[4], Division of Earth Environmental System Science, Pukyong National University
Dong-Hoon Sheen[5], Dept. of Geological Environment, Chonnam National University

Abstract

To investigate the seismic source characteristics and the safety of nuclear power plants (NPPs) due to ML5.8 Gyeongju earthquake, 200 broadband seismic stations (Gyeongju Hi-density Broadband Seismic Network) were deployed over a 60 * 60 km area centered around the epicenter. During the investigation, signs of various seismogenic faults developing in the study area were discovered, and it was confirmed that several faults exhibit complex segmentation. When seismogenic faults are segmented, it is necessary to analyze the 3D structure of the faults and the possibility of rupture propagation. Securing an earthquake catalog with statistical completeness down to the lowest possible magnitude earthquakes is essential in this process. In this study, deep learning (DL) based techniques were used to build a comprehensive earthquake catalog more efficiently with the massive amount of dataset. Training models were optimized for the research area using fine-tuning and transfer learning techniques, and as a result, microearthquake catalog with better statistical completeness than previous studies were suggested. Additionally, various earthquake parameters such as phase picking, association, signal discrimination, and event declustering were provided through DL (or machine learning) based analysis. Focal mechanisms were automatically determined using a DL based P-wave polarity determination model, and the spatiotemporal background stress distribution in the research area was elucidated using a Bayesian inference-based stress inversion algorithm. The earthquake distribution derived from this study was used to confirm various 3D fault structures and secure segments of seismogenic faults. Furthermore, the potential for fault rupture and propagation was analyzed through the derived stress field distribution. The results of this study are expected to be utilized in assessing the safety of NPPs, including estimating the maximum potential earthquakes at seismic sources, the characteristics of seismic attenuation between sources and NPPs, and calculating the maximum ground motions at NPPs.

Keyword

Earthquake catalog, Deep learning, AI, Bayesian inference, Stress inversion

Utilization of Regional Lg Wave in Precise Epicentral Relocation and Source Characterization of Two 2021 Earthquake Sequences in Gunsan Basin, Yellow Sea

JUN YONG PARK[1]*, Seoul National University (zip1900@snu.ac.kr)
YoungHee Kim[2], Seoul National University
Won-Young Kim[3], Lamont-Doherty Earth Observatory, Columbia University
Xuzhang Shen[4], Sun Yat-sen University

Abstract

The Yellow Sea encompasses the tectonic boundary of China Blocks and the Korean Peninsula. Despite its regional importance, seismogenic faults and ruptures remain insufficiently investigated due to the lack of close-in stations and station coverage. In this study, we examined seismogenic faults and distinct rupture processes of two intraplate earthquake sequences using Lg-wave observations in the Gunsan Basin, situated in the middle of the Yellow Sea, characterized by low seismicity.

The first sequence initiated with a Mw 4.7 event on January 18, 2021, followed by five aftershocks until March 9, 2021. The second sequence began with a Mw 4.2 event on December 3, 2021, accompanied by two aftershocks within 13 hours. Focal mechanisms of the mainshocks indicate strike-slip faulting along steeply dipping nodal planes striking NW (~305º) and SW (~215º) at a depth of 10 km. While the focal mechanisms are similar to other events in the Yellow Sea, the fault planes of these events have been rarely investigated. Furthermore, event location uncertainty in the sequences hinders the definition of fault planes due to weak Pn/Sn signals despite the alignment of the two mainshocks in the NW-SE direction. We utilized Lg waves, characterized by strong amplitude and travel through the continental crust beneath the Yellow Sea with a group velocity centered at 3.3 km/s, to relocate epicenters of aftershocks.

Epicentral relocation was determined through differential travel times (Δt) measurements using the Lg-wave cross-correlation technique. The measured Δt exhibited sinusoidal features against azimuth, even in event pairs of different sequences and small events. Consequently, both earthquake sequences exhibited an NW-SE trend fault along one of the nodal planes of the focal mechanism. Additionally, we investigated rupture processes using the Lg-wave source spectrum, revealing distinct rupture processes between the two mainshocks. The Mw 4.7 event displayed bi-lateral or circular rupture, while the Mw 4.2 event exhibited a uni-lateral rupture strongly directed to the SE, supporting the epicentral relocation of aftershocks. Our results indicate that the stress field in the Gunsan Basin is similar to the overall Yellow Sea, governed by the same tectonic sources. This also suggests the possibility of defining fault and rupture directions of other events in the Yellow Sea for future studies.

Keyword

Yellow Sea, Intraplate Earthquakes, Lg-wave, Epicentral Relocation, Source Characterization

[Keynote] Lithosphere structure from comparative tomographic study: Implications for deformation mechanisms of the Tibetan Plateau

Xiaodong SONG[1]*, Peking University (xdsong@pku.edu.cn)
Xuezheng Zhang[2], Peking University
Jincheng Ma[3], Peking University
Xuewei Bao[4], Zhejiang University
Jiangtao Li[5], Wuhan University

Abstract

Several geodynamic models have been proposed for the deformation and growth of Tibetan Plateau (TP) without consensus, including continuum, rigid block, and channel flow models. In the meanwhile, numerous models of the lithosphere structure of the TP have been developed over the decades with different methods and datasets in various studies. These models show apparent discrepancies as well as consistencies. In this study, we compare these models and synthesize robust model features to explore the deformation mechanisms. The results show complex but distinct features in the crustal thickness and the velocity and anisotropy of the crust and the uppermost mantle. The results suggest a lithospheric-scale deformation of continuous shortening as well as localized faulting, which is affected by the strength of the lithosphere blocks of the TP. The thickened mantle lithosphere can be removed, which facilitates the formation of middle-lower crustal low-velocity zone and flow. However, such flow is likely a consequence of the deformation rather than a driving force for the outward growth of the TP. We propose an episodic growth model for the TP, in which heterogeneous crustal thickening was a primary driver at the early stage and the weakened middle-lower crust flowed locally at a later stage.

Keyword

Tibetan Plateau, Seismic tomography, deformation mechanism

Teleseismic constraints on the crustal structure beneath Gyeongju, S. Korea from high-density seismic array data

Minkyung KIM[1]*, Seoul National University (shinyjade@snu.ac.kr)
Hobin LIM[2], Korea Institute of Geoscience and Mineral Resources
YoungHee KIM[3], Seoul National University
Junkee RHIE[4], Seoul National University
Tae-Seob KANG[5], Pukyong National University
Kwang-Hee KIM[6], Pusan National University
Jin-Han REE[7], Korea University

Abstract

The southeastern Korean Peninsula (SeKP) is known as one of the most seismically active regions in South Korea. The previous studies suggested that the SeKP experienced complex tectonic processes influenced by the subduction of the paleo-Pacific plate in the Cretaceous and the East Sea (Japan Sea) opening in the Cenozoic. The Gyeongju Hi-density Broadband Seismic Network (GHBSN) deployed in an area of 50 km by 50 km consists of 200 broadband stations that densely cover the region where aftershocks of the 2016 moment magnitude 5.5 Gyeongju earthquake occurred. The GHBSN covers two major fault systems such as the Yangsan Fault (YSF) and the Ulsan Fault (USF) from west to east, encompassing the Gyeongsang basin to the west and the Miocene basin to the east with respect the Yeonil tectonic line situated in close proximity to the USF. We calculated the receiver functions (RFs) using 647 teleseismic events in distance of 30°–90° in 2018–2023 to retrieve detailed crustal structure and seismic properties.

As the first-order crustal structure obtained by two different stacking methods, the Moho is deepest in the west (33.5 ± 0.35 km) and shallowest in the east (25.6 ± 0.42 km). Rather than gradual change in Moho depth, we find two step-like changes beneath the YSF with its vertical offset of ~6 km and the USF with ~3 km offset, which could be related to the formation of extensional basin in SeKP. The P-to-S wave velocity ratio (Vp/Vs) for the crust as a good proxy for rock types is estimated as 1.817. Slightly higher Vp/Vs estimate, exceeding 1.8 in the eastern side of the USF and the western side of the YSF, could be affected by mafic crustal composition related to Cretaceous to Cenozoic magmatic activities. The P-to-S converted phase at Moho (Pms) of the radial and tangential RFs shows systematic backazimuthal phase shift, indicating the presence of seismic anisotropy in terms of fast symmetric axis (FSA) and delay time (DT). Overall trend of the FSA shows the clockwise rotation from west to east. In the west of the YSF, the azimuth of the FSA is ~325°; it becomes ~355° between the YSF and USF and > 30° in the east of the USF. Lastly, the average DT is 0.32 s, which corresponds to the degree of anisotropy of ~4%. Our crustal anisotropy measurements suggest that the crust might have experienced sufficient deformation attributed to the east sea opening in the Cenozoic.

Keyword

crustal structure, teleseismic receiver function, Gyeongju

The intricate fault interactions: source parameter estimation of the 2017 Pohang, Korea, earthquake and its aftershocks

Minkyung SON[1]*, KIGAM (kersti@kigam.re.kr)
Esteban J Chaves[2], OVSICORI-UNA
Chang Soo Cho[3], KIGAM

Abstract

In 2017, the Korean Peninsula experienced its second-largest recorded earthquake, a moderate-magnitude (M 5.4) event near fluid injection sites in Pohang. We analyzed the waveforms of this earthquake and seven aftershocks to elucidate their occurrence and subsequent triggering mechanisms. An empirical Green's function approach provided apparent source time functions and stress drop estimates, isolating the effects attributed to earthquake source characteristics from the influence of propagated waves through the Earth. Our findings revealed that the mainshock ruptured in multiple stages along a central segment of the fault system, contrasting with the relatively simpler processes observed in most aftershocks. Notably, one aftershock, occurring within the mainshock slip zone, also exhibited multi-stage patterns, and its hypocenter coincided with a potential fault jog of the mainshock segment. Stress drop estimates indicated that aftershocks occurring outside the mainshock slip zone released higher stresses than those within. Particularly, the aftershock at the shallowest depth released the highest stress, following the upward-progressing aftershock sequence. We posit that the mainshock swept out much of the stress accumulated within its slip zone, prompting the upward migration of aftershocks and stress buildup along the fault system edges. Furthermore, we observed that the migration head corresponded to a fluid diffusion curve, suggesting a fault-valve mechanism. Stress transfer along the upper part of the northern fault segment, connected to the mainshock fault at depth, could have caused the highest stress-drop event at the top. Our investigation, highlighting the intricate interplay of earthquakes, may improve seismic hazard assessment and mitigation strategies by further understanding earthquake genesis.

Keyword

2017 Pohang earthquake, stress drop, empirical Green's function approach, fluid-fault interaction, rupture process

Seismic Properties of Upper-mantle 410- and 660-km Discontinuities Beneath the Korean Peninsula Using P-wave Receiver Functions

Juhyung LEE[1]*, Seoul National University (juhyung@snu.ac.kr)
Hyunsun KANG[2], University of Florida
YoungHee KIM[3], Seoul National University

Abstract

Fundamental questions relevant to the mantle transition zone concern the nature of phase transition, distribution of chemical heterogeneities, temperature gradient, as well as degree and extent of hydration and melting. One particularly important question is how the slab stagnation may be influenced by hydration or/and basalt enrichment in the mantle transition zone. To help answer these questions, we aim to retrieve upper mantle seismic discontinuity properties, such as the shear-wave velocity contrast, the density contrast, the transition sharpness and the gradient using high-quality receiver functions (RFs) using dense seismic data in South Korea, which is located in the immediate vicinity of the stagnant slab near northeast China.

We retrieve P-to-S converted phases from the 410- and 660-km discontinuities as well as their reverberated phases, as these phases are sensitive to the shear-wave velocity contrast and density contrast across the discontinuities. Nearly 20-year data (2003-2022) recorded by 151 broadband stations are used to compute the RFs; we further stack the RFs in a distance interval of 0.5° in order to enhance RF amplitudes of the converted phases. We plan to conduct amplitude analysis of direct converted waves and multiples from the 410- and 660-km seismic discontinuities to detail seismic properties of the mantle transition zone and to discuss the role of slab stagnation in the deep mantle structure.

Keyword

Upper mantle transition zone, Teleseismic P receiver function, Stagnant Pacific slab, Korea permanent seismic network

Constraining crustal composition of the continental China by three-dimensional Vp/Vs model

Guifang ZHANG[1]*, University of Science and Technology of China (guifangz@mail.ustc.edu.cn)
Haijiang zhang[2], University of Science and Technology of China
Guifang Zhang[3], University of Science and Technology of China
Hailiang Xin[4], Geophysical Exploration Center, CEA, China

Abstract

The ratio (Vp/Vs or k) between seismic compressional wave velocity (Vp) and shear wave velocity (Vs) is directly related to Poisson's ratio. In the continental crust of the continental China, Vp and Vs models have been obtained using an improved method of joint inversion of body wave and surface wave data. However, the Vp/Vs ratio model directly derived from these models may contain some artifacts due to an inherent inconsistency between the resolution and uncertainty of the models. In this study, a high-resolution three-dimensional Vp/Vs model is directly inverted based on body wave arrival time data collected from the regional seismic network in continental China during the period from 2008 to 2018. Following Fang et al. (2019), Vp/Vs is directly determined by P and S arrival times by constructing sensitivity of S arrival times with respect to Vp/Vs. Resolution analysis reveals that the spatial resolution of the obtained Vp/Vs model is approximately 1.5° across most regions of mainland China, reaching depths of up to 150 km. Overall, the Vp/Vs anomalies of the upper crust correlate well with surface geological features. With the Vp/Vs model, we can further estimate the SiO_2 content of the crystalline crust because it is related to Vp/Vs ratio. The spatial distribution of SiO_2 content as a whole shows a strong correlation with major geological provinces, offering new insights into the composition and evolution of the continental China.

Keyword

Vp/Vs ratio model, SiO2 wt%, crustal composition, continental China

Intraplate lithospheric structures near plate margins: comparison between northeast India (Eastern Himalayan Syntaxis) and southern Korean Peninsula

ABHISHEK KUNDU[1]*, Yonsei University (kunduabhishek@yonsei.ac.kr)
Tae-Kyong Hong[2], Yonsei University
Devajit Hazarika[3], Wadia Institute of Himalayan Geology
Jeongin Lee[4], Yonsei University
Seongjun Park[5], Yonsei University

Abstract

Lithospheric structures near plate boundaries are highly deformed by tectonic activities. Various signatures and byproducts are imprinted in the lithosphere that provide valuable information on tectonic evolution in the plate margins. We investigate the intraplate lithospheric structures of India and the Korean Peninsula using a receiver function analysis. The lithospheric structures beneath the Eastern Himalayan Syntaxis (EHS) at the northeast corner of the indenting Indian Plate (i.e. Lohit Valley and Siang Window) have been studied using the P-wave receiver function (PRF) analysis of teleseismic earthquakes. The three-component waveforms recorded by broadband seismological networks have been utilized in this study for PRF analysis. We present fresh insights into the lithospheric features using the common conversion point (CCP) stacking and 1-D velocity models generated through the inversion of PRFs. The signature of the Main Himalayan Thrust (MHT) or dècollement which separates the underthrusting Indian plate from the Himalayan wedge above, is observed at a depth of around ~22–26 km beneath the Lohit Valley. The signature of MHT is not prominent beneath the Siang Window. The absence of the prominent MHT beneath the Siang Window can be attributed to the large-scale crustal deformation due to window formation and antiform folding. The crustal and intra-crustal structures along with the lithospheric deformation patterns at the eastern part of the Eurasian plate in the Korean peninsula will also be investigated utilizing the concept of CCP stacking and 1-D inverted velocity models using PRFs. The seismic velocity characteristics of the Precambrian massif blocks along with the intervening fold-thrust belts and basins of the Korean peninsula will be studied using high-resolution subsurface imaging and different passive seismological experiments which can provide some new important information regarding the geodynamic evolution of the Korean peninsula. The comparative study on the lithospheric configurations and deformation patterns carried out at the eastern parts of the Indian (EHS) and Eurasian (Korean peninsula) plates can reveal some interesting facts about global tectonics.

Keyword

Receiver function, Lithospheric structure, Tectonics

Deploying a Temporary Seismic Network for the 2022 Goesan Earthquake Sequence and its Integration with the Deep Learning Model EQTransformer

EunJin LEE[1]*, Pusan National University (eunjinlee@pusan.ac.kr)
Yu Jin Sohn[2], Pusan National University, Department of Geological Science, Busan, South Korea
Su young Kang[3], Institute of Geologic Hazard & Industrial Resources, Pusan National University, Department of Geological Science, Busan, South Korea
Hyeong-Tae Jou[4], Korea Institute of Ocean Science and Technology, Busan, Republic of Korea
Kwang-Hee Kim[5], Pusan National University, Department of Geological Science, Busan, South Korea

Abstract

In the morning on October 28, 2022, the Goesan region in Korea experienced a light earthquake with a ML 4.1 mainshock with a preceding ML 3.5 foreshock. Responding to the seismic activity and considering azimuthal coverage with nearby stations, PNUGL (Pusan National University Geophysics Laboratory) deployed nine temporary seismic stations within an 8 km radius of the main earthquake epicenter and operated them for the next 7 months until May 31, 2023. The temporary seismic network comprised one broadband seismometer and eight short-period seismometers. We detected 386 events by manual inspection. In the first 13 days of the aftershock monitoring, 330 events were detected. Most aftershocks following the Goesan earthquake were recorded in the period. The number of aftershocks per day decreases over time. Event locations were determined using the earthquake location program, HYPOELLIPSE, and the double-difference method, HypoDD. The distribution of relocated aftershock epicenters aligned along the fault trace at the surface, with hypocenters predominantly located at depths of 12 to 15 km. We utilized the P-wave polarities of microseismic events and the mainshock to derive a representative composite focal mechanism solution. We observe the effects of ambient noise on earthquake detection by examining Power Spectral Density (PSD) Probability Density Functions (PDF) at each temporary seismic station. Comparing the mode PSD value of GE09 (most noisy station) with that of GE03 (most quiet station) revealed a difference of approximately 20 dB at 0.1 ~ 2s period bands, suggesting varying observation conditions. The thickness of soft sedimentary layer also affects ambient noise levels and signal-to-noise ratios. We also applied the Deep Learning model EQTransformer (EQT) for simultaneous detections of events and phase pickings. Four models were used to compare and observe differences and improvements in predictions. A model, trained exclusively with earthquake data from the study area and non-earthquake signals, demonstrated improved prediction accuracy for P- and S-waves compared to results using the EQT original model.

Keyword

Goesan earthquake, Temporary seismic array, Ambient noise level, Deep Learning, HVSR analysis

Upper crustal azimuthal anisotropy and seismogenic tectonics of the Hefei segment of the Tan-Lu fault zone from ambient noise tomography

LI CHENG[1]*, Anhui University of Science and Technology (licheng@aust.edu.cn)

Abstract

The Tan-Lu fault zone is a large NNE-trending fault zone, which has a significant effect on the development and earthquake disaster prevention of eastern China. Aiming at the upper crustal azimuthal anisotropy structure and seismogenic tectonics in the Hefei segment of this fault, we collected continuous ambient noise phase velocity dispersion data of fundamental mode Rayleigh waves from ~400 temporal seismographs in the area about 80 km×70 km along the fault zone. The period band of the dispersion data is 0.5~10 s. We inverted for the upper crustal 3-D shear velocity model with azimuthal anisotropy from surface to 10 km depth by using a direct 3-D azimuthal anisotropy inversion method. The inversion result shows the spatial distribution characteristics of the tectonic units in the upper crust. Meanwhile, the evolution of Tan-Lu fault and its conjugated fault systems can be inferred from the anisotropy model. Especially, the faults that kept active from early and middle Pleistocene, control the anisotropic characteristic of the upper crustal structure in this area. The direction of fast axes anisotropy near the fault zone area in the upper crust is consistent with the direction of the faults which kept active from early and middle Pleistocene. While for the region far away from the fault zone, the direction of fast axes is consistent with the direction of regional principal stress caused by plate movement. Combined with the azimuthal anisotropy models in the deep crust and uppermost mantle from Pn wave and surface wave, the different anisotropic patterns caused by the Tan-Lu fault zone and its conjugated fault system nearby are shown in upper crust and lower crust. Furthermore, by using the double-difference method, we relocated the Lujiang earthquake series, which contain 32 earthquakes with the depth shallow than 10 km. The result shows these earthquakes are mainly located in the transition zone between high and low velocities. Together with the tectonic characteristics from azimuthal anisotropy results, we constructed a seismogenic model for these upper crustal earthquakes in this area.

Keyword

ambient noise tomography, azimuthal anisotropy, seismogenic model, the Tan-Lu fault zone

Determination of moment magnitude of earthquakes in the Korean Peninsula from 2017 to 2022.

Yoontaek HONG[1]*, Chonnam National University (ythong@jnu.ac.kr)
Dong-Hoon Sheen[2], Chonnam National University

Abstract

The accurate determination of earthquake magnitudes is crucial for seismic hazard assessments. In South Korea, a local magnitude scale using the peak amplitude of S waves has been proposed (Sheen et al., 2018). However, at the time of the previous study, there were a limited number of observations within 50 km of the epicenter. Therefore, it is difficult to consistently determine the magnitude of small earthquakes that are observed only at short distances, using the previous scaling relationship. Additionally, the local magnitude scale underestimated for small earthquakes due to the limitations of the Wood-Anderson response (Hanks and Boore, 1984). In contrast, the moment magnitude is proportional to the seismic moment, which quantifies the energy of an earthquake in physical units. In this study, we determined the moment magnitude of earthquakes in and around South Korea, occurring from 2017 to 2022. For this, we collected seismograms within 100 km of the hypocenter of 647 earthquakes ($M \geq 2.0$). We adopted the source spectrum approach for moment magnitude determination, and the source spectrum was calculated for the S-wave using the multitaper method to avoid spectral leakage. To reduce the impact of outliers, we selected the spectrum with a signal-to-noise ratio greater than 3.0. For source parameter estimation, we employed MCMC (Markov chain Monte Carlo) to fit the Brune source model (1970). It is expected that the moment magnitudes of earthquakes in the peninsula determined in this study can be used for seismic hazard assessment.

Keyword

earthquake, moment magnitude, source spectrum, Brune source model, multitaper method

Recent seismicity in the Haenam and Suncheon regions using template matching method

Bohyun KIM[1]*, Chonnam National University (kbobo41@naver.com)
Dong-Hoon Sheen[2], Chonnam National University

Abstract

According to the Korea Meteorological Administration, 48 microearthquakes occurred persistently in the Suncheon region of southwestern Korea over the years from 2009 to 2024. However, 76 earthquakes occurred in the Haenam region in southwestern Korea, apart from 98 Km from Suncheon, between April 26, 2020, and June 11, 2020, and few earthquakes have occurred intermittently, suggesting a distinct seismic pattern from Suncheon. Previous studies on Haenam (Son et al., 2021; Han et al., 2021; Hong et al., 2021) and Suncheon (Kwak et al., 2022) have shown that microearthquakes in both areas have occurred more frequently than cataloged by the KMA. However, these studies only utilized data up to 2020, leaving us unaware of the detailed seismic activity in both areas beyond that period. This study applies the template matching (TM) method to detect recent microearthquakes in both areas. TM is a detection method based on the idea that colocated earthquakes with the same focal mechanism have similar waveforms. We performed TM on data from both regions for the period up to 31 May 2023. For Haenam, we used 77 template events reported by the KMA and detected 1340 earthquakes, of which 1273 were not cataloged. Most of the earthquakes occurred between April 25 and May 8, 2020, with only 68 earthquakes occurring intermittently in several years after this period. For Suncheon, using 28 cataloged events resulted in the detection of 753 earthquakes, of which 723 had been undetected. In contrast to the Haenam region, we found that all the 753 earthquakes detected in the Suncheon region were evenly distributed over the entire period. Based on these results, we generated a catalog that is completeness guaranteed even at the low cutoff magnitude, so using this catalog we were able to calculate b-values as 0.77±0.02 for Haenam and 1.01±0.06 for Suncheon. Furthermore, we analyzed several quantitative factors proposed by Bachura et al. (2021) and determined whether the earthquakes in the two regions were earthquake sequence or swarm. We found that they were more likely to be earthquake sequence. To investigate the spatiotemporal distribution of earthquakes in both regions, we relocate earthquakes in the catalog with high correlation coefficients using hypoDD, which is based on a double-difference relocation algorithm.

Keyword

template matching, microearthquake, Haenam earthquake sequence, Suncheon earthquake sequence

Determination Focal Depth of the 2014 ML 5.1 Offshore Gyeongyeolbi Island Earthquake Using Depth Phase

Hyeonjun LEE[1]*, CHONNAM NATIONAL UNIVERSITY (hyunj@jnu.ac.kr)
Dong-Hoon Sheen[2], CHONNAM NATIONAL UNIVERSITY

Abstract

The focal depth is an important factor in analyzing the overall cause and process of earthquake occurrence, and therefore, accurately determining the focal depth is crucial. Since a routine earthquake location method is based on the arrival times of the seismic phases, the number of data and the distribution of the stations are critical. Determining the focal depth requires additional constraints than determining the epicenter, and in particular, the acquisition of near-field S-waves is crucial for constraining the focal depth (Gomberg et al.,1990). However, regional earthquakes are challenging because of the difficulty of acquiring near-field S-waves and the relatively small amount of data available, leading to large uncertainties in the results. Determination of the focal depth of offshore earthquakes is under the same conditions. Seismic stations are usually installed on land, making it difficult to obtain near-field observations for offshore earthquakes. The focal depths of offshore earthquakes usually show large variations. (up to 17 km depth deviation). As an alternative, depth phase, which can be observed in seismograms, was used in this study. It is reported that the regional depth phase (sPg, sPmP, sPn) and its reference phase can well constrain the focal depth (Ma, 2010). To identify these depth phases, after extracting the depth phase from the seismograms, we compared the shape and arrival time of the propagable depth phase obtained through waveform modeling. This allowed us to use the differential time between the depth phase and the reference phase with depth to constrain the focal depth. In the Yellow Sea, small- to moderate-sized earthquakes have been occurring continuously, and it is analyzed that they have a significant variation in their focal depth. In particular, numerous earthquakes have occurred around Gyeongreolbi Island in the Yellow Sea in the past, but their focal depths have large uncertainties. The reason for this is that the seismic network is sparse in the area, and the epicentral distance to the nearest station is about 100 km, making it difficult to determine the focal depth. Therefore, in this study, we aimed to increase the understanding of the seismicity in the Yellow Sea by determining the focal depth the magnitude 5.1 (ML) Offshore Gyeongnyeolbi Island earthquake that occurred on 31 March 2014 using depth phase.

Keyword

offshore earthquake, depth phase, focal depth

Introduction to Research using the Unified Model for Subsurface Fault and Velocity Structure in the Korean Peninsula

Kyungmin MIN[1]*, Korea Meteorological Administration (mkmzx@korea.kr)
Mikyoung CHOI[2], Korea Meteorological Administration
Yeongjae CHOI[3], Korea Meteorological Administration
Ah-Hyun BYUN[4], Korea Meteorological Administration
Eun-young JO[5], Korea Meteorological Administration
Sun-Cheon PARK[6], Korea Meteorological Administration

Abstract

The Korea Meteorological Administration (KMA) is conducting a project to develop a unified model of 3-D subsurface fault and velocity structure in the Korean Peninsula to determine the causes of earthquakes and improve the accuracy of earthquake information. This project, targeting the Korean Peninsula and its surrounding seas, involved research conducted in the Seoul metropolitan region and the Youngnam region from 2018 to 2021. As a result, we have developed initial models of subsurface fault and velocity structure. We are various research are being conducted to utilize and apply this initial model. First, we apply the DD-RT procedure, which uses cross-correlation and double-difference methods, to rapidly relocate new earthquakes in the Seoul metropolitan region and the Youngnam region. The DD base catalog is computed from a simultaneous relocation of all events, involving the cross-correlation of waveforms between each event and all neighboring events within select regions. The new events are relocated relative to a selected number of reference events in the DD catalog. Secondly, the hypocenter determination system was established using the initial 3D velocity structure model(Ver.1). We utilize the nonlinloc program that can apply the 3D velocity structure model for the hypocenter and construct a system to determine the hypocenter through the Antelope database. Finally, we are conducting research on accurately calculating 3D elastic wave propagation using the spectral-element method implemented in the SPECFEM3D Cartesian software package.

Keyword

Subsurface fault structure, 3D velocity model, Earthquake, Unified Model, Korean Peninsula

Analysis of the three earthquakes with moment magnitudes greater than 4 in the Gunsan Basin, Yellow Sea, Korea, 2021

Miji KIM[1]*, Korea institute of Geoscience and mineral resources (miji61759@gmail.com)
Minkyung SON[2], Korea Institute of Geoscience and Mineral Resources
Chang Soo CHO[3], Korea Institute of Geoscience and Mineral Resources
Tae-Seob KANG[4], Pukyong National University

Abstract

Three earthquakes, with magnitudes exceeding 4, occurred in the far sea of the Yellow Sea on January 18, August 21, and December 3 (UTC), respectively, according to the Korea Meteorological Administration (KMA). The academic annual report of earthquakes from the Korea Institute of Geoscience and Mineral Resources (KIGAM) indicates that the epicenters of the January and December earthquakes were located on the eastern highlands of the Gunsan Basin, near the Haema Platform. We relocated these two nearby earthquakes based on the fact that depth differences in nearby hypocenters affect travel time differences for Pn phases rather than Pg phases. The seismic stations located along the coast of the Yellow Sea, including station RCN in the Shandong, China, region, enabled us to approximate the vertical slowness of the Pg to zero. Furthermore, we estimated corner frequencies, rupture radii, and stress drops of the three earthquakes by approximating S-wave displacement spectra of the three earthquakes to the Brune's source model. The time-domain moment tensor inversion also provided moment magnitudes along with variance reduction values, searching the best solution with varying hypocenter depths. The relocation results showed that the difference in focal depths among the two nearby earthquakes was 1.9 km, and the epicenter of the December earthquake was located 3.3 km southeast from the epicenter of the January earthquake. The corner frequencies estimated from the curve fitting to the Brune's model were 2.5 Hz and 3.0 Hz for the January and December earthquakes respectively. Assuming an S-wave velocity of 3.5 km/s, the estimated corner frequencies yield the rupture areas of 520 m and 440 m, respectively. The rupture areas of the two nearby earthquakes do not overlap on the map for the relocated hypocenters. The moment magnitudes are 4.6, 4.1, and 4.1 for the January, August, and December earthquakes, respectively, and the direction of maximum compressive stress is ENE-WSW for all three earthquakes. This direction corresponds to the current compressive stress environment on the Korean Peninsula and its surrounding sea, which is known as the ENE-WSW to E-W.

Keyword

Yellow Sea, earthquake, relocation, corner frequency, moment tensor solution

[Keynote] What determined the Rupture Extent of the 2023 Mw7.8 Kahramanmaraş Earthquake

Ali Ozgun KONCA[1]*, Bogazici University (ozgun.konca@boun.edu.tr)
Hayrullah Karabulut[2], Bogazici University
Yasemin Korkusuz Ozturk[3], Bogazici University
Sezim Ezgi Guvercin[4], University of Southern California

Abstract

2023 Eastern Turkey earthquakes were the largest earthquakes experienced during the instrumental period. Mw7.8 ruptured 350 km portion of the 600 km long East Anatolian Fault (EAF). The second Mw7.6 earthquake ruptured 9 hours later northwest of the first earthquake along the Çardak fault, which is another E-W trending left-lateral fault. The 2023 Mw7.8 is a remarkable earthquake due to its implications about seismic cycle, interesting sequence of foreshocks and rupture dynamics. Based on paleoseismogical studies and fault slip-rate on the fault the 2023 Mw7.8 earthquake cannot be explained by the last seismic cycle and implies that to understand these earthquakes multiple seismic cycles must be considered. We also study the foreshock sequence of the Mw7.8 earthquake and show that there was increasing seismic activity in the vicinity of the epicenter which started about 6 months before the mainshock. Finally we study what determined the slip distribution of this earthquake and whether the rupture would have propagated in a similar way had it started on the EAF rather than Narli fault. In that regard, we first calculate dynamic rupture models that mimic the Mw7.8 earthquke. Then we change the rupture initiation point to the main fault. We show that with a similar rupture initiation patch the earthquake might not have propagated bilaterally if it had started on the main fault. The results indicate that dynamic stresses which cannot be predicted from static stress are a very important factor in determining the rupture extent of these large earthquakes.

Keyword

earthquake, foreshocks, rupture dynamics, seismic cycle

[Keynote] The East Anatolian Fault System: An Overview on Active Tectonic Setting of the February 6, 2023, Kahramanmaraş Earthquake Sequence, Türkiye

OMER EMRE[1]*, Fugro Sial (o.emre@fugro.com)
TAMER Y. DUMAN[2], Fugro Sial

Abstract

The East Anatolian Fault (EAF) is a complex continental transform fault system in the Eastern Mediterranean, accommodating westward extrusion of the Anatolian block along with the North Anatolian fault. On February 6, 2023, two large earthquakes, Mw 7.8, and Mw 7.6 occurred on the EAF system nine hours apart, resulting in multi-segment surface ruptures spanning a total of 517km. The ruptures largely followed the previously mapped Holocene fault traces but also triggered previously unmapped fault splays. Available data on the fault characteristics along the entire EAF provided valuable insights understanding the nature of the multi-segment rupturing and fault interactions in the earthquakes.

The EAF consists of a 580 km-long main strand extending between Karlıova and Amik triple junctions, and the northern strand as known the Sürgü-Misis fault system bifurcating from the main strand. The 160 km-long southwestern section of the main strand overlaps with Dead Sea Fault (DSF). The main strand is divided into seven fault segments, ranging in length from 31 to 112 km, separated from each other by releasing and restraining jogs. The eastern part of the northern strand comprises the Sürgü and Çardak faults, and the Nurhak fault complexity, which is a fault junction on a regional scale between the Çardak, Sürgü, Malatya, and Doğanşehir faults.

The slip rate decreases from northeast to southwest along the main strand, with approximately 10 mm/year on the Karlıova-Çelikhan section, decreasing to 5.6-7 mm/year on the Erkenek and Pazarcık segments, and further to 4-4.5 mm/year on the Amanos segment. The change in the slip rate west of the Çelikhan reveal slip partitioning between the main and the northern strand, as well as between the Amanos segment and DSF. The estimated slip rate of 2-3 mm/year on the Çardak fault suggests a slip partitioning ratio of approximately 1/3 with the main strand.

Historical earthquakes along the EAF have resulted in surface rupturing in the 19th and 20th centuries. Recurrence intervals of 350-400 years have been suggested for the Palu segment, and 510 years have elapsed since the 1513 earthquake on the Pazarcık segment. The timing of the last event on the Pütürge segment was unknown. Historical records indicate large earthquakes in AD 521 and AD 1893 on the Amanos and Erkenek segments, respectively. The Pütürge, Pazarcık, and Amanos fault segments, along with the northern strand, were considered seismic gaps of the EAF system prior to the 2020 Doğanyol earthquake. The 2020 earthquake of Mw:6.8 originated from the Pütürge seismic gap. 2023 earthquakes ruptured the fault segments in these seismic gaps and the Erkenek segment. Additionally, the Narlı segment of the DSF and Doğanşehir faults, and previously unmapped two fault splays involved in the rupturing. Thus, the entire main strand of

the EAF have been ruptured in the last two centuries except for the Gökdere bend. However, we infer that the earthquake potential of Sürgü fault and the westerly fault segments of the northern strand has been increased due to stress loading onto them by the 2023 earthquake sequence.

Keyword

East Anatolian fault, fault geometry, segmentation, slip rate and recurrence.

[Keynote] The earthquake deformation cycle along the East Anatolian Fault deduced from space geodesy; implications for rupture propagation and arrest

Ziyadin CAKIR[1]*, Istanbul Technical University (ziyadin.cakir@itu.edu.tr)
Semih Ergintav[2], Bogazici University, Kandilli Observatory
Ugur Dogan[3], Yildiz Technical University

Abstract

The initiation of ruptures in large and major continental strike-slip earthquakes typically occurs near the lower part of the seismogenic crust, propagating both upward and laterally until encountering geometric or mechanical obstacles that impede further propagation. Historically, the existence of fault creep has been considered one of these potential mechanical barriers. However, the challenge lies in experimentally identifying the parameters controlling rupture arrest due to the absence of significant earthquakes on well-monitored creeping strike-slip faults during the instrumental period. This difficulty arises from the rarity of creeping faults with a well-constrained geodetic history displaying hybrid creep and seismic rupture. Moreover, major earthquakes have not occurred near these locations in recent decades.

Utilizing Envisat and Sentinel-1 SAR data along with GPS measurements, we have meticulously mapped the inter-, co-, and post-seismic velocity fields along the East Anatolian Fault (EAF), where the January 24, 2020 Mw6.8 Elazig and the February 6, 2023 Mw7.8 Kahramanmaras earthquakes occurred. Our study unveils a key observation—the coseismic rupture of a substantial strike-slip earthquake being halted by shallow creep during the January 24, 2020 Mw6.8 Elazig and February 6, 2023 Kahramanmaras earthquakes in Turkey. Contrary to conventional earthquake scaling laws and to the surprise of many, no surface rupture was evident in the field fallowing the former earthquake. This absence is attributed to the fault exhibiting creeping behavior from the surface to shallow depths before the earthquake, as discerned from Envisat and Sentinel-1 data. The rupture, abruptly arrested by the shallow creep, subsequently propagated aseismically upward as afterslip following the earthquake. Similarly, the eastward progression of the rupture during the February 6, 2023 Mw7.8 Kahramanmaras earthquake was impeded by a creeping section on the EAF, creating a gap of approximately 20 km long between the two earthquakes that is also currently exhibiting afterslip. Geology along the EAF suggests that creep is most likely promoted by the presence of minerals with low friction within the ophiolitic and metamorphic rocks along the fault zone. This study highlights the significant finding that creeping faults can halt earthquakes, even if the creeping is partial and limited to shallow depths, thereby holding crucial implications for seismic hazard analyses.

Keyword

2020 Elazig Earthquake, 2023 Kahramanmaras Earthquake, creep, rupture arrest, East Anatolian Fault

Establishing and Operating the AFAD Earthquake Clearinghouse for Reconnaissance Efforts After the 6 February 2023 M7.7 and M7.6 Eastern Türkiye Earthquakes

RECEP CAKIR[1]*, Izmir Institute of Technology, Izmir, Turkiye (cakir.ray@gmail.com)
ORHAN TATAR[2], The Disaster and Emergency Management Presidency of Türkiye
HASAN MANDAL[3], The Scientific and Technological Research Council of Turkey
DUYGU ÇELİK[4], The Scientific and Technological Research Council of Turkey
FILIZ T KADIROGLU[5], The Disaster and Emergency Management Presidency of Türkiye
DORUK M SENTURK[6], The Disaster and Emergency Management Presidency of Türkiye
AYKUT AKGUN[7], The Disaster and Emergency Management Presidency of Türkiye
HASAN SOZBILIR[8], Dokuz Eylul University, Izmir, Turkiye

Abstract

The devastating Mw7.7 and Mw7.6 earthquakes that struck eastern Türkiye on February 6, 2023, prompted a rapid establishment of an earthquake clearinghouse at AFAD (The Disaster and Emergency Management Presidency of Türkiye) in Ankara. Within a week, AFAD and TUBITAK (The Scientific and Technological Research Council of Türkiye) coordinated efforts to mobilize reconnaissance teams, funded by TUBITAK and comprised of approximately 577 researchers from 61 universities across Türkiye. Collaborating under the umbrella of the earthquake clearinghouse in Ankara, AFAD and TUBITAK teams worked together to rapidly pull the field observations from reconnaissance teams. Additionally, the Earthquake Engineering Research Institute (EERI) contributed invaluable tools and forms, including the EERI mobile application and field forms, to bolster reconnaissance efforts. Following thorough evaluation of available resources, a decision was swiftly reached to utilize ESRI-ArcGIS Enterprise mobile application over the EERI's application. This choice was mainly based on ArcGIS Enterprise's seamless integration with AFAD's IT policy and the comprehensive technical and software support provided by ESRI- Türkiye.

The collected reconnaissance data, which encompassed crucial information on liquefaction, landslides, surface rupture, and structural damage, was promptly archived, transferred to the AFAD server, and disseminated to national agencies and ministries of Türkiye. This effort contributed to the rapid formulation of recovery plans and provided supportive information for the selection of new settlement sites in the affected region. Despite its establishment following the Kahramanmaras, eastern Türkiye, earthquakes, the first earthquake clearinghouse of Türkiye proved to be highly effective, serving as a central hub for international reconnaissance teams. Moving forward, the AFAD Earthquake Clearinghouse will continue to play a pivotal role, facilitating collaboration among stakeholders and leveraging archived data for further research and investigations. This concerted effort will not only enhance recovery efforts but also strengthen earthquake mitigation plans and preparedness for future potential devastating earthquakes in Türkiye.

Keyword

Earthquake, Clearinghouse, AFAD, Reconnaissance

A Comprehensive Analysis of Türkiye's Earthquake Disaster Response and Recovery Efforts Following the Devastating 6 February 2023 M7.7 and Mw7.6 Kahramanmaraş-Elbistan Earthquakes

Orhan TATAR[1]*, The Disaster and Emergency Management Presidency of Türkiye, Ankara, Türkiye (orhan.tatar@afad.gov.tr)
Recep CAKIR[2], Independent Researcher, Olympia, WA, USA
Hasan SOZBILIR[3], Dokuz Eylül University, Izmir, Türkiye
Aykut AKGUN[4], The Disaster and Emergency Management Presidency of Türkiye, Ankara, Türkiye

Abstract

Türkiye, located in a seismic hotspot, faces recurrent seismic challenges, with earthquakes holding a central position in disaster and emergency management. Boasting the largest earthquake monitoring network in Europe, The Disaster and Emergency Management Presidency of Türkiye (AFAD) Earthquake Department records approximately 22,000 earthquakes annually through its 1,187 seismic stations as of 2024. On February 6, 2023, Eastern Anatolia experienced the devastating impact of the Mw7.7 and Mw7.6 earthquakes. The aftermath prompted an immediate state of emergency in Kahramanmaraş, extending its reach to Hatay, Gaziantep, Malatya, Diyarbakır, Kilis, Şanlıurfa, Adıyaman, Osmaniye, Adana, and Elazığ. This disaster zone expanded further to include Bingöl, Kayseri, Mardin, Tunceli, Niğde, and Batman. Official reports document a staggering toll of 53,537 lives lost, 107,204 individuals injured, and 38,901 buildings collapsing. This earthquake catastrophe highlighted the paramount importance of effective earthquake risk management, with a distinct emphasis on emergency response and recovery strategies. The enacted National Earthquake Strategy and Action Plan (UDSEP-2023) in 2011 aimed to establish a prepared and resilient society capable of reducing seismic risks. This collaborative initiative, involving public, private, and academic sectors, executed 80 distinct actions focused on mitigating earthquake risks, particularly emphasizing emergency response and recovery.

In the aftermath of the February 6, 2023, earthquakes, the AFAD Earthquake and Risk Reduction General Directorate conducted comprehensive seismological studies and field observations, well-documented efforts aimed at reducing potential damages from future seismic events. These efforts also elucidate the instrumental role of robust emergency response and recovery strategies following such catastrophic events, with a focus on preparedness and collaboration in mitigating the impact of earthquakes on communities and infrastructure.

Keyword

AFAD, Response, Risk Reduction, Seismic Network

Near-Fault and Off-Fault Field Observations of The 6 February 2023 Mw7.8 and Mw7.6 Kahramanmaraş and 20 February 2023 Mw6.4 Antakya earthquakes

Hasan SOZBILIR[1]*, Dokuz Eylul University, Izmir, Turkiye (hasan.sozbilir@deu.edu.tr)
Ercan AKSOY[2], Fırat University, Elazig, Turkiye
Mustafa SOFTA[3], Dokuz Eylul University, Izmir, Turkiye
Caglar OZKAYMAK[4], Afyon Kocatepe University, Afyonkarahisar, Turkiye
Volkan KARABACAK[5], Eskisehir Osmangazi University, Eskisehir, Turkiye
Fikret KOÇBULUT[6], Sivas Cumhuriyet University. Sivas, Turkiye
Elif AKGUN[7], Fırat University, Elazig, Turkiye
Orhan TATAR[8], The Disaster and Emergency Management Presidency of Türkiye, Ankara, Türkiye

Recep CAKIR[9], Independent Researcher, Olympia, WA, USA
Ozkan C OZDAG[10], DAUM, Dokuz Eylul University, Izmir, Turkiye
Mehmet UTKU[11], Dokuz Eylul University, Izmir, Turkiye
Ahmet DEMIR[12], The Disaster and Emergency Management Presidency of Türkiye, Ankara, Türkiye
Gokhan ARSLAN[13], The Disaster and Emergency Management Presidency of Türkiye, Ankara, Türkiye

Abstract

On February 6, 2023, at 04:17 local time, four fault segments (Narlı, Erkenek, Pazarcık, Amanos segments) on the southern branch of the Eastern Anatolian Fault (EAF) ruptured within 78 seconds, causing a 300 km long surface rupture. Approximately nine hours after this Mw7.8 main shock, two fault segments (Çardak and Doğanşehir segments) on the northern branch of the EAF ruptured within 60 seconds, creating a 150 km long surface rupture. Fieldwork began within a day after the earthquakes, spanning a two-month period. Meticulous observations were conducted along the surface ruptures, capturing damages inflicted on both natural landscapes and human-made structures using drone footage.

While fieldwork in the earthquake area was ongoing, another earthquake occurred on February 20, at 20:04 local time, centered in Defne (Antakya). In this Mw6.4 earthquake, the northern segment of the Antakya Fault was ruptured. In the earthquake region, where aftershocks exceeded 100,000, over 53,000 lives were lost, and thousands of buildings were destroyed or damaged. Our findings indicate that the leading factors influencing the loss of life and property can be classified into seven key categories: (1) construction on active faults, (2) construction on ground susceptible to liquefaction, (3) construction along lake shores, (4) construction along rivers, (5) flawed project design, (6) substandard workmanship, and (7) utilization of inappropriate materials in building construction.

Our observations on surface ruptures revealed that a significant portion of the February 6 earthquakes exploited pre-existing surface fractures. In the first Mw7.8 earthquake, a lateral

displacement of 7.3 meters was identified, followed by a lateral displacement of 6.3 meters in the subsequent Mw7.6 earthquake, and a vertical displacement of 20 cm in the third Mw6.4 event. Various deformations were observed on structures along the surface rupture. Particularly in regions with observed surface fractures and liquefaction hazards, high damage levels were noted. In areas distanced from the surface rupture, the dynamic behavior of the ground became prominent, and a notable degree of damage was observed.

The extent of destruction and damage is much higher, especially in buildings constructed before 1999. Additionally, even modern buildings constructed in compliance with the latest earthquake regulations suffered destruction or damage. Evaluating the interplay between ground conditions, building structures, and active faults, it has been ascertained that irrespective of the ground type and the inventory of buildings and structures, a specific degree of deformation occurs along the surface fracture, resulting in a consequential loss of life and property. Hence, it is crucial to control or avoid construction on active faults with the potential to produce devastating earthquakes in the near future.

Keyword

Earthquake, Rupture, Active Fault, Damage, Eastern Anatolian Fault

The Role of Stress Transfer in Earthquake Nucleation and Inhibition in the 2023 Kahramanmaraş, Türkiye, Earthquake Sequence

Shinji TODA[1]*, Tohoku University (toda@irides.tohoku.ac.jp)
Ross S Stein[2], Temblor Inc.

Abstract

We here explore the interaction of large earthquakes on the East Anatolian Fault Zone, site of four M≥6.8 earthquakes since 2020 and then forecast the subsequent one-year aftershocks. Regarding the 2023 Kahramanmaraş sequence, we find that the 2023 M 7.8 Pazarcık shock promoted the subsequent nine-hour later M 7.7 Elbistan quake, largely through unclamping of the epicentral patch of the future rupture. Unclamping effect on upcoming rupture plane is also reported in other earthquakes such as the 1987 Superstition Hills, 1997 Kagoshima, and 2019 Ridgecrest sequences, so this may be common. The M 7.7 Elbistan earthquake, in turn, is calculated to have reduced the shear stress on the central Pazarcık rupture, producing a decrease in the aftershock rate along that section of the rupture. However, the M 7.7 event ruptured through a Çardak Fault section on which the shear stress was decreased by the M 7.8 rupture, and so rupture propagation was not halted by the static stress decrease. The 2020 M 6.8 Elazığ earthquake, located beyond the northeast tip of the M 7.8 Pazarcık rupture, locally dropped the stress by ~10 bars. The 2023 M 7.8 quake then increased the stress there by 1-2 bar, leaving a net stress drop, resulting in exceptional seismic dormancy in the 2023 Pazarcık aftershocks. This seismic hole is also explained by the Monte Carlo time sequence simulation of earthquake nucleation incorporating rate/state friction. We find that many lobes of calculated stress increase caused by the M 6.8-7.8 earthquakes during the period of 2020-2023 are sites of aftershocks, and we calculate 5-10 faults in several locations off the ruptures brought closer to failure. The earthquakes also cast broad stress shadows in which most faults were brought farther from failure, and we observe the beginnings of seismicity rate decreases in some of the deepest stress shadows. Some 42 M≥5 aftershocks have struck since the M 7.8 mainshock. But based on these Coulomb interactions and on the rapid Kahramanmaraş aftershock decay, we forecast only about 1-2 M≥5 earthquakes during the 12-month period beginning 1 March 2024, which is fortunately quite low.

Keyword

stress transfer, Coulomb stress, active fault, East Anatolian fault

Stress perturbation induced by precedent earthquakes and its implications for the 2023 Kahramanmaras earthquake sequence

Junhyung LEE[1]*, Yonsei University (aqualung@yonsei.ac.kr)
Tae-Kyung Hong[2], Yonsei University

Abstract

The 6 February 2023 Mw7.8 Pazarcik and Mw7.5 Elbistan earthquakes (Kahramanmaras earthquake sequence) occurred in southern Turkey near the northern border of Syria. The 2023 Kahramanmaras earthquake sequence occurred in the East Anatolian Fault zone, located in a region known for active seismicity. Stress perturbation in the fault zone plays an important role in the occurrence of earthquakes. Understanding the stress changes in the fault zone is crucial for mitigation of seismic hazards. We investigate the influence of stress perturbation caused by precedent large earthquakes in the East Anatolian Fault zone, where the earthquake sequence occurred. The static stress perturbation is assessed by stacking the induced Coulomb stress changes by the large earthquakes. The Coulomb stress changes are calculated for 64 earthquakes with magnitudes greater than or equal to 6.0 since 1900 when the instrumental earthquake monitoring began. The cumulative Coulomb stress changes vary between -218 and 123 bar around the East Anatolian fault zone. The negative cumulative Coulomb stress changes were generally dominant, suggesting that loaded stresses were released after large earthquakes. We observe laterally heterogeneous stress fields with stress contrasts of tens to hundreds of bars along the East Anatolian Fault zone. The Kahramanmaras earthquake sequence occurred in regions with large lateral gradients in cumulative Coulomb stress changes by precedent large earthquakes. This observation suggests that lateral heterogeneity in static stress fields may induce large earthquakes. Heterogeneity in the stress field may play an important role in nucleation of large earthquakes.

Keyword

Kahramanmaras earthquake sequence, East Anatolian Fault, cumulative Coulomb stress changes, stress perturbation

Understanding the 2023 Mw 7.8 Pazarcık (Kahramanmaraş) Earthquake by integrating multi-parameter paleoseismological data from the Pazarcık segment of the East Anatolian Fault

Gülsen Ucarkus[1]*, Istanbul Technical University (ucarkus@itu.edu.tr)
Erdem Kırkan[2], Istanbul Technical University
Cengiz Zabcı[3], Istanbul Technical University
Kürşad Kadir Eriş[4], Istanbul Technical University
Murat Ersen Aksoy[5], Mugla Sıtkı Koçman University
Mehmet Köküm[6], Fırat University
Demet Biltekin[7], Istanbul Technical University
Dila Doğa Gökgöz[8], Istanbul Technical University
Dursun Acar[9], Istanbul Technical University
Camila Ringvelski[10], Istanbul Technical University
Furkan Hoser[11], Istanbul Technical University
Havva Neslihan Kıray[12], Istanbul Technical University
Serdar Akyüz[13], Istanbul Technical University
Sinan Akçiz[14], California State University, Fullerton

Abstract

Continental transform faults create broad zones of deformation with multiple strike-slip faults, making it challenging to determine earthquake recurrence intervals due to geometric complexities and variable slip. Collecting datasets related to history of surface faulting and slip distribution to understand spatial and temporal seismic behavior of these faults is crucial yet challenging. The February, 6, 2023 Mw 7.8 Pazarcık (Kahramanmaraş) Earthquake triggered a 300-kilometer-long, multi-segment failure along the East Anatolian Fault Zone (EAFZ), presenting another challenge to this phenomenon. Prior to this large earthquake, our focus was on the seismically silent Pazarcık segment of the EAF, aiming to understand its role on the earthquake cycle of EAF. Due to limited paleoseismological dat along the EAF compared to the North Anatolian Fault (NAF), we initiated a project employing both subaqueous and on-land paleoseismology techniques to assess earthquake recurrence along the Pazarcık segment comprehensively. The Gölbaşı basin, the second-largest basin along the EAF, includes three shallow lakes, with Gölbaşı Lake serving as a segment boundary between Pazarcık and Erkenek segments. In September 2022, we collected sediment gravity cores from Gölbaşı and Azaplı Lakes and excavated a 17-m-long, 2.7-m-deep trench along the Gölbaşı basin section of the Pazarcık segment. The Çelik-1 trench revealed a fault zone with four branches, showing diverse infills and divergent sediment packages on the southeast and northwest sections of the fault zone, indicative of the strike-slip character of the fault. Four months later, the Çelik Trench was offset by ~5.3 m during the 2023 Mw 7.8 earthquake. This event enabled us to evaluate both the penultimate large earthquake and the recent surface rupture along the

Pazarcık segment. Physical and geochemical analyses of the gravity cores provided evidence of earthquake-triggered sediment deposits. Pb-210 and Cs-137 dating results from sediment cores, indicate that these seismic deposits are associated with historical earthquakes in AD 1513 and AD 1114, as well as other events dating back to 1498 BP and 2168 BP. Following the Mw 7.8 earthquake, we obtained new sediment cores and excavated two new trenches, with findings to be compared with the observations of previous field campaign.

The surface rupture of the 2023 earthquake along the Pazarcık segment spans 85 km, with max. sinistral slip of ~7 m. Slip decreases towards the Karaburun and Gölbaşı sections, reaching around 1.2 m. Near Gölbaşı lake, Near Gölbaşı lake and its town, where the most severe destruction occurred due to intense liquefaction and wide lateral spreading, the deformation zone widens, and slip decreases to less than 1 m. Gölbaşı lake serves as the junction between Pazarcık and Erkenek segments. In the Ozan section of the Erkenek segment, slip increases again to a maximum of 3.5 m. A notable feature in this area is the 10 km-long surface rupture with an average slip of 2 m along an unmapped fault branching off north-east from Pazarcık segment towards Yaylacık village.

The overall characteristics of the surface rupture, along with our ongoing multi-proxy paleoseismology project, offer insights into fault behavior and earthquake recurrence along the EAF.

Keyword

East Anatolian Fault, Pazarcık Segment, Kahramanmaras Earthquake, Surface Rupture, Paleoseismology

The 2023 Kahramanmaraş, Tu¨rkiye, earthquake doublet as the most powerful continental earthquake doublet: magnitudes, rupture process, triggering mechanism, and aftershocks

Xiaodong SONG[1]*, Peking University (xdsong@pku.edu.cn)
Yue Han[2], Peking University
Zengxi Ge[3], Peking University
Yijian Zhou[4], University of California, Riverside

Abstract

The 2023 Kahramanmaraş, Tu¨rkiye, earthquake doublet, which caused massive damages and casualties, has attracted wide attention and intense studies. Here we report our studies on the doublet magnitudes (Jiang XY et al., Earthq. Sci., 2023), rupture process and triggering mechanism (Ren CM et al., Science, 2024), and aftershocks (Ding HY et al., Earthq. Sci., 2023) in collaborative efforts. The magnitudes and the relative sizes of the two events are essential information for scientific research and public awareness. There are obvious discrepancies among the results that have been reported. We applied a recently developed long-period coda moment magnitude method with minimum influence from Earth structure and source complexities. The moment magnitudes were determined to be about 7.9 and 7.8 for the two events, respectively, which appear the largest continental earthquake doublet ever recorded. The first mainshock, which matches the largest recorded earthquakes in the Turkish history, is slightly larger than the second one by 0.11±0.035 in magnitude or by 0.04 to 0.18 at 95% confidence level.

To investigate the rupture process over multiple fault segments, we performed a comprehensive analysis of local seismic and geodetic data and determined supershear ruptures on the initial branch and the Pazarcık and Erkenek segments and subshear ruptures on the Amanos segment of event 1. The bilateral rupture of event 2 also presents distinct sub- and supershear velocities. The dynamic stress of the branch fault rupture triggered the Pazarcık segment initial rupture at a point 9 kilometers west of the junction of these two faults, boosting the supershear rupture of the Pazarcık segment of the main fault. The geometry and prestress level of multiple segments controlled the rupture behaviors and influenced the ground shaking intensity.

We also built a high-resolution early aftershock catalog using a workflow that sequentially performs phase picking, association, location, and matched filter (PALM) for continuous data, containing 29,519 well-located events in the two mainshocks rupture region during 2023-02-01–2023-02-28. From the catalog, the Eastern Anatolian Fault (EAF) that generated Event 1 is overall near-vertical, whereas complexities are revealed in a small-scale, such as subparallel subfaults, unmapped branches, and stepovers. The seismicity on EAF is shallow (<15 km) and concentrated in depth distribution, indicating a clear lock-creep transition. In contrast, the Su¨gu¨

Fault (SF) that is responsible for Event 2 is shovel-shaped for the nucleation segment and has overall lower dip angles (~40°–80°). Aftershocks on the SF distribute in a broad range of depth, extending down to ~35 km. A clear complementary pattern between the distributions of aftershocks and coseismic slips was found for both events. Two voids of aftershocks on the central Seg P of Event 1 and the western portion of Event 2 (Fig. 2C), which seems related to supershear rupture behavior. No immediate foreshocks within ~5 days preceding Event 1, and no seismic activity on the SF before Event 2.

Keyword

2023 Kahramanmaraş earthquakes, Tuŕkiye, earthquake doublet

[Keynote] Rupture Geometry and Segmentation associated with the 6 February 2023 Pazarcık (Mw 7.8) and Elbistan (Mw 7.6) Earthquakes: East Anatolian Fault, Southeastern Türkiye

Tamer Y. DUMAN[1]*, Fugro Sial (t.duman@fugro.com)
Omer Emre[2], Fugro Sial

Abstract

On February 6, 2023, two large earthquakes with magnitudes of Mw 7.8 and 7.6 occurred on the East Anatolian Fault (EAF), causing 54k fatalities and an economic loss of over 100 billion USD. Both earthquakes occurred in previously identified seismic gaps within the EAF zone and collectively resulted in 517-km-long surface ruptures. Nearly all the ruptures followed the mapped Holocene fault trace. The first earthquake, Pazarcık, originated from the southwestern half of the main strand of the EAF at the junction with the northernmost tip of the Dead Sea Fault (DSF). Nine hours later, the second earthquake, Elbistan, occurred on the Misis-Sürgü Fault, forming the northern strand of the EAF.

The Pazarcık earthquake resulted in a 302-km-long rupture along the main strand of the EAF, spanning between the Yarpuzlu double bend to the northeast and the Amik triple junction to the southwest. During this event, Erkenek (62-km), Pazarcık (82-km), and Amanos (112-km) fault segments entirely ruptured, separated by releasing step-overs. Additionally, a 40-km-long section of the Narlı fault at the northernmost tip of the DSF and a 15-km-long western part of the Tut fault were also included in the rupturing. While a maximum slip of 7.1m was observed in the Pazarcık segment, the highest and average slip values successively decreased in the Pazarcık, Erkenek, and Amanos segments. This variable slip was assessed based on the slip rate and the elapsed time since the penultimate event on each segment. The epicenter's location suggests that the event was initiated on the Narlı fault. We speculate that initial dynamic stress loading during the event triggered the Pazarcık segment on the main strand of the EAF, which experienced a high-stress state due to the long-term elapsed time since the penultimate events. Subsequently, the rupturing propagated bilaterally on the Pazarcık segment and transferred to the Erkenek and Amanos segments.

The Elbistan earthquake was likely triggered by the Pazarcık earthquake. This event nucleated at the eastern tip of the Çardak fault, which is connected to the Nurhak fault complex. The rupturing propagated bilaterally towards the west and east. In the east, the rupture was directed toward the Doğanşehir fault zone through the Kapıdere double bend, instead of the Sürgü fault. In the west, a previously unmapped north-east-striking Sisne fault with a 20-km-length was included in the rupturing. The surface rupture of the Elbistan earthquake is 142-km-long, with a maximum slip of 8.2m. The rupture passed through the Nurhak complex but terminated in the Göksun releasing

bend. The maximum and average slip on the Doğanşehir fault is half of that on the Çardak fault. Despite having a smaller magnitude than the initial event, the Elbistan earthquake caused greater maximum and average slips on the Çardak fault compared to the Pazarcık earthquake. We consider that this difference is attributed to a longer elapsed time.

Keyword

East Anatolian fault, fault segmentation, surface rupture, slip distribution, Feb 6th Kahramanmaraş earthquakes

In the light of fault geometry, segmentation and slip distribution data an assessment of the February 06 2023 Pazarcık (Kahramanmaraş) earthquake (Mw 7.8), East Anatolian Fault Zone, Turkey.

Akın KÜRÇER[1]*, General Directorate of Mineral Research and Exploration (MTA)
(akurcer@gmail.com)
Hasan Elmacı[2], MTA
Can Güven[3], MTA
Ersin Özdemir[4], MTA
Tayfun Güler[5], MTA
İrem Avcu[6], MTA
Şeyda Olgun[7], MTA
Hasret Ozan Avcı[8], MTA
Hakan Aydoğan[9], MTA
Ali Atalay Yüce[10], MTA
Ferhat Emre Çetin[11], MTA
Aydın Ayrancı[12], MTA
Zeycan Akyol[13], MTA
Ömer Akif Soykasap[14], MTA
Selim Özalp[15], MTA

Abstract

A catastrophic earthquake with magnitude Mw 7.8 and followed by a series of triggered earthquakes occurred on the East Anatolian Fault Zone (EAFZ), on the 6th of February 2023. The earthquake caused severe damage to 11 cities in eastern Turkey and settlements in northern Syria, killing more than 50.000 people. Surface rupture mapping and slip measurements was initiated immediately after the earthquake and continued until the end of March 2023.

In addition to ground observations, HGM-KURE orthophoto and MTA-UAV images were used in surface rupture mapping and slip measurements. The amount of displacement was measured at a total of 410 points on the 6 February 2023 Pazarcık (Kahramanmaraş) earthquake surface rupture. In contrast to previous studies, a total of 375 km of surface rupture was mapped in this study.

According to the field studies, Yarpuzlu restraining double bend and Erkenek, Pazarcık and Amanos segments of EAFZ have been ruptured during this earthquake. In addition, Tetirlik, Serinyol, Kazkeli faults and Gölbaşı splay fault, which were identified for the first time in this study, also ruptured during this earthquake. Although no surface rupture occurred on the fault south of the Tetirlik segment during the earthquake, the distribution of aftershocks points out that also this fault may have ruptured at depth. The maximum displacement associated with this event was measured as 7.2 ± 1 m on the Pazarcık Segment of the EAFZ.

The most important geological causes of loss of life and structural damage were determined as earthquake magnitude, duration, focal depth, directivity of earthquake waves, soil-related liquefaction, lateral spreading and ground amplification effects, and construction on faults.

The 2023 Pazarcık earthquake showed that the EAFZ can also produce multi-segment surface faulting like the North Anatolian Fault Zone (NAFZ). The EAFZ is one of the most active transform fault zones in the eastern Mediterranean region. This earthquake sequence may have transferred stress to faults kinematically linked to the EAFZ, such as unbroken segments of the northern strand of EAFZ, northern segments of DSFZ, western segments of Southeast Anatolian Thrust Zone, Yedisu Segment of NAFZ, Kahramanmaraş Fault Zone, Engizek Fault Zone and Malatya Fault.

Keyword

East Anatolian Fault Zone, February 06, 2023 Pazarcık (Kahramanmaraş) Earthquake (Mw 7.8), Slip distribution, Surface rupture mapping, Dead Sea Fault Zone

Rupture geometry and slip characteristics of the Doğanşehir Fault Zone rupture associated with the February 06, 2023 Ekinözü Earthquake (Mw 7.6), Eastern Anatolia, Türkiye

Hasan ELMACI[1]*, GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA) (hasan.elmaci@mta.gov.tr)
Akın Kürçer[2], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Hasret Ozan Avcı[3], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Hakan Aydoğan[4], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Ali Atalay Yüce[5], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
İrem Avcu[6], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Tayfun Güler[7], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Şeyda Olgun[8], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Can Güven[9], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Ersin Özdemir[10], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)
Selim Özalp[11], GENERAL DIRECTORATE OF MINERAL RESEARCH AND EXPLORATION (MTA)

Abstract

The second main shock, the Ekinözü Earthquake (Mw 7.6) of the February 6, 2023, Kahramanmaraş earthquake sequence, nucleated on the eastern tip of the Çardak fault, on the northern strand of the East Anatolian Fault Zone (EAFZ). The earthquake produced a 167-km-long surface rupture on the Çardak fault segment of the northern strand of the EAFZ and the Doğanşehir Fault Zone (DFZ), which is connected to the northern strand at the Nurhak fault complexity west of the Sürgü fault. Following the main shocks, fieldwork and drone surveys were conducted to map the surface rupture in detail and document the slip measurements. Our observations revealed that the easternmost section of the surface rupture associated with the Ekinözü earthquake was directed onto the DFZ east of Nurhak fault complexity. Left lateral strike-slip surface faulting, 44 km long, extended on the DFZ, generally trending N50°E. The rupture locally displays normal and reverse components, depending on step-overs and bends in fault geometry. The DFZ surface rupture consists of two distinct sections: the main body of the rupture zone between the Sürgü fault to the south and Işıklı village to the north, and the Eskiköy splay. Approximately 39 km long, the main body of the rupture, extending in the N50°E direction, comprises small-and-large scale subsections in a right-stepping pattern in general. Observed

maximum and average slips on the main body of the rupture zone were 1.96±0.20 m and about 1.00 m, respectively. A 5 km long left lateral strike-slip Eskiköy splay extends conjugate to the main body of the rupture zone. Although a short splay bifurcates from the main body of the rupture zone, the amounts of the maximum and average slips were measured to be larger than those of the main body of the rupture zone, with 2.18±0.20 m and 1.11 m, respectively. The splay rupture, with a strike of N70°W, has a north-dipping reverse component characterized by a 1.80 m vertical offset. The southern section of the surface ruptures nearly followed the previously mapped Doğanşehir Fault Zone; however, there is not any Holocene fault previously mapped in the north of Doğanşehir. There are no clear geomorphic manifestations indicating Holocene activity of the fault, except for a lineament along this section of the surface rupture. However, aftershocks clustered along the northern continuation of the Doğanşehir fault zone towards Malatya city. We infer that the heavy damage in Malatya city might have been related to the directivity of the rupture propagation along the DFZ. We also infer that the second shock of the Kahramanmaraş earthquake sequence transferred stress onto the Malatya fault that had not ruptured for ~2550 years with a recurrence interval of 2275±605 years according to literature.

Keyword

Surface rupture, slip distribution, Doğanşehir Fault Zone, February 6 2023 Ekinözü Earthquake

Rupture Propagation Paths and Probabilities Considering Fault Continuity and Geometry in the 2023 Kahramanmaraş, Türkiye Earthquake

Yuki HARA[1]*, Tohoku University (yhara@irides.tohoku.ac.jp)
Shinji TODA[2], Tohoku University

Abstract

In the assessment of the activity of large-scale faults, considerations at segmented levels defined based on geometry and paleoseismic history are typically conducted. While occurrence of multi-segment rupture led to broader and more extensive damage, there are cases where only a part of that segments is ruptured (e.g., Okada et al., 2015). Therefore, probabilistic assessment for fault rupture propagation is necessary.

Initiation, termination, and propagation of the rupture are significantly influenced by the fault geometry such as bends and steps. For instance, Wesnousky (2008) suggested that fault rupture consistently ceased at fault step of 5 km or more in strike-slip faults. On the other hand, at fault step from 1 to 4 km, fault rupture ceased in 33-50% of cases, indicating a non-binary relationship with 5 km as a threshold. Recently, Biasi and Wesnousky (2021) proposed a method for predicting total rupture lengths based on empirical propagation probabilities at steps and bends (Biasi and Wesnousky, 2016; 2017). However, there have been no examples conducting the validation of these methods for the recent large-scale fault ruptures.

In this study, we developed an objective method using QGIS and Python to semi-automatically measure the fault geometry and extract rupture paths, and then applied the empirical rupture propagation probabilities reported by Biasi and Wesnousky (2021). Furthermore, to validate the method, we applied our code to the detailed active fault data (Emre et al., 2018) and surface rupture trace (Reitman et al., 2023) in the 2023 Kahramanmaraş, Türkiye earthquake. We assigned the rupture initiation point on the intersection of East Anatolian Fault with the Narlı Fault, and calculated rupture propagation probabilities to the northeast and southwest.

Initially, we discretized fault lines into 5-km-long and calculated rupture propagation probability. As a result, unrealistic probabilities, below 10^-5%, were obtained at active fault trace corresponding to the endpoints of the 2023 earthquake rupture. Considering the global frequency of long surface rupturing earthquake exceeding Mw7.8 (Five earthquakes since 2000), this result may lead significant underestimation of the probabilities. The potential flaw is attributed to the automatic definitions of bends or steps every 5 km even in relatively linear sections. Therefore, we approximated the fault traces by extracting points of change in strike using the Douglas-Peucker algorithm. Additionally, we obtained at most ~200 rupture paths from the initiation point to northern or southern end, and then calculated complementary probabilities of any of these paths enabling to pass through. As a result, probabilities exceeding 0.01% were obtained at the fault trace to the termination of the 2023 rupture, although it is necessary to appropriately evaluate a single parameter, tolerance, of the Douglas-Peucker algorithm, as increasing tolerance leads to increasing probability. In comparison with the Gutenberg-Richter (GR) distribution obtained from

earthquake databases (AFAD) from 1990 to 2020, the probability of Mw≥7.8 earthquake occurrences fall below the rate from the GR law. However, the probability gain for Mw≤7 events exceeding the GR law is up to about tenfold.

Keyword

Geometry, Probability, Rupture Propagation, East Anatolian Fault

Preliminary Study on Surface Rupture Displacement Analysis of the 2023 Kahramanmaraş(Turkey) Earthquake Using High-Resolution Optical KOMPSAT-3(A) Satellite

Chaehyeon CHOI[1]*, Active Tectonics Research Center, Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources (cjc6918@gmail.com)
Jin-Hyuck CHOI[2], Active Tectonics Research Center, Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources

Abstract

A high-resolution map of the coseismic surface ruptures provide an opportunity to understand relations between tectonic faults and earthquake characteristics. Along the surface rupture of the 2023 Kahramanmaraş (Turkey) Earthquake, we have acquired imagery from the Earth observation satellites KOMPSAT (Korean Multi-purpose Satellite) 3 (launched in 2013) and 3A (launched in 2015), operated by the Korea Aerospace Research Institute (KARI). The panchromatic band's Ground Sampling Distance (GSD) of these satellites is approximately 0.7 meters, boasting high resolution alongside WorldView and Pleiades satellites. We perform Optical Image Correlation (OIC) using images acquired by KOMPSAT-3(A) both before and after the earthquake, focusing on two specific areas: 1) the Hatay Airport area, which experienced surface rupture due to the Pazarcık Earthquake (Mw 7.8) along the East Anatolian Fault, and 2) the epicenter area of the Elbistan Earthquake (Mw 7.6). Digital Surface Models (DSMs) were produced from images captured under stereo conditions, and each image was orthorectified using DSMs. These pre-processed optical images were then used to calculate the horizontal displacement field using the MicMac. MicMac, along with COSI-Corr, is the software extensively used for earthquake displacement analysis, providing the tool of mutually matching optical images taken before and after the earthquake. We intend to interpret the three-dimensional movement of faults and discuss distributed deformation (such as off-fault deformation) that are difficult to quantify through field observations.

Keyword

2023 Kahramanmaraş Earthquake, Surface Rupture, Off-fault deformation, High resolution satellite, Optiacal Image Correlation

Advanced seismic imaging of subsurface structures using wavelet-based decoupled wavefields on small aperture dense arrays

Hongfeng YANG[1]*, The Chinese University of Hong Kong (hyang@cuhk.edu.hk)
Jia Zhang[2], Shenzhen Research Institute, The Chinese University of Hong Kong

Abstract

Imaging subsurface structure holds important implications for underground space development, resource exploration, seismic hazard assessment, and so on. In recent years dense seismic arrays have been widely used in various environment, enabling high-resolution images of the subsurface structure. However, small-scale subsurface heterogeneities may cause strong scattering on waveform recordings at dense arrays, posing challenges in a reliable investigation of crustal structure using waveform tomography. To overcome, we develop a wavelet-based method to separate the teleseismic P wave and local scattered wave. We apply our technique in the waveforms recorded by two small-aperture dense across-fault arrays in Binchuan, northwestern Yunnan, China. The resulting common-conversion-point (CCP) images of decomposed tele-P wave receiver functions (RFs) depict a flat Moho at ~52 km in depth and a remarkable middle crust interface at a depth of ~30 km. Besides, seismic imaging using the decomposed local waves illustrate clear shallow low velocity zones (LVZs) beneath the Chenghai Fault (CHF), , which extend to ∼1.5 km in depth beneath the southern segment of the CHF, indicating complicate sediment distribution under the combined impact of regional east–west crustal extension and clockwise rotation of microblocks. Our results demonstrate the wave decomposition method can effectively separate different wave segments, enabling utilization of small-aperture temporary arrays to reveal reliable, high-resolution crustal structure.

Keyword

Wavefield decoupling, dense array, fault zones

Subsurface structure imaging robustness enhancement with multiple processing methods on a dense seismic array

Lanbo Liu[1]*, Pusan National University (lanboliu77@gmail.com)
Kwanghee Kim[2], Pusan National University

Abstract

Dense seismic array technique has been widely used in both natural earthquake seismology and exploration seismics. One of our research topics is using dense seismic array to image geological and tectonic structures in the depth range up to several hundred meters from the surface. Imaging subsurface structures in this depth range must face a number of challenges. The most significant one is that shallow subsurface usually contains significant lateral variation, caused by both natural processes such as buried sand channels, heterogeneous and undulating weathering layers etc., and man-made artificial objects such as buried infrastructures and pipelines, especially in highly developed urban areas. In this talk we focus on subsurface structure imaging robustness in this depth range by examining the impact of a number of factors. For using passive seismic sources originated from ambient noise, these factors include station spacing, array aperture, frequency range, noise type and spatial distribution, observation duration etc. For using active sources generated by man-made ground impacts, the factors include source energy level, source impulse width, level of background noise, ground condition, data processing methods etc. We will illustrate our viewpoints with numerical simulation and validate them using real-world examples. Field practice suggests that by the combination of both passive and active seismic data and analyses we may significantly enhance image robustness of the reconstructed subsurface targets.

Keyword

dense array, passive seismic noise, active source, shallow subsurface, image robustness

Seismic velocity changes observed on a dense array of nodal seismometers reveal soil moisture changes in the Critical Zone

James HAMMOND[1]*, Birkbeck, University of London (James.hammond@bbk.ac.uk)
Kevin Davidson[2], Birkbeck, University of London
Victoria Lane[3], SEISUK, University of Leicester
Lucy Finch[4], SEISUK, University of Leicester
J-Micheal Kendall[5], University of Oxford
Chris Ogden[6], University of Leicester
Cunrui Han[7], Birkbeck, University of London
Jia Chen-Wu[8], Birkbeck, University of London
Dominic Ryan[9], Birkbeck, University of London
Ken Doherty[10], Stryde
Nick Tratner[11], Stryde
Tom O'Toole[12], Stryde

Abstract

The Critical Zone (CZ) is the "living skin" of our planet, extending from the bottom of the water table to the top of the tree canopy. Processes occurring in the CZ are subject to a complex and dynamic interplay between soil structure, temperature, pressure, precipitation, and water content. Geophysical methods can be used to image the subsurface portion of the CZ but typically offer a point-in-time snapshot view which does not constrain changes over time. The development of ambient noise seismology allows us to exploit continuous recordings of the seismic wavefield to detect small changes in seismic velocity over time, which may be indicative of changes in the subsurface. In December 2022, in partnership with Stryde, we deployed a "large-N" array consisting of ~1600 seismic nodes at spacings between 5m and 10m for one month at a site in Dumfries, southwest Scotland. The site was chosen as it hosts a Critical Zone observatory, recording real-time data on soil moisture and temperature along with other meteorological data. Ambient noise recordings from this array are cross-correlated to retrieve the Green's function. We perform coda-wave interferometry to detect velocity changes across the array are able to observe relative seismic velocity changes of < 1% at a temporal resolution of 30 minutes. The time series of relative velocity variation are compared with measurements of soil moisture and temperature to establish relationships and correlations between changes in seismic velocity and environmental factors, and constrain the extent to which external hydrological factors influence seismic velocities. Our study shows the strongest correlations are with soil moisture content ($r \sim 0.6$-0.7). Heavy rainfall events leading to soil saturation temporarily disrupt the correlation trend, which then recovers as water content returns to field capacity. The correlations between velocity and soil moisture are negative, with velocity decreasing as water content increases. We attribute this to a change in the properties of the soil, whereby the density increases with added water content but the shear modulus remains the same. Other environmental factors such as soil temperature show a weaker correlation with soil moisture; however, the relationship between various factors is complex and cannot be considered in isolation. This study shows the potential benefits of newly-

developed nodal seismometer technology in the emerging field of Critical Zone seismology.

Keyword

Critical Zone, Ambient Noise, Large-N, Nodal, Seismic

Unravelling crust-to-upper-mantle structures around the central Korean Peninsula using combined tomographic analyses

SEONGJUN PARK[1]*, Yonsei University (seongjunpark@yonsei.ac.kr)
TAE-KYUNG HONG[2], Yonsei University

Abstract

Public concern on potential seismic hazards has arisen due to recent successive major earthquakes in the Korean Peninsula. The subsurface structures may provide information on the seismic and tectonic nature, which is crucial for seismic hazard mitigation. The central Korean Peninsula is composed of complex geological structures that were formed by a series of tectonic events. We investigate the seismic velocity structures of the lithosphere in the region using the ambient noise tomography and earthquake-based Eikonal tomography based on dense seismic networks consisting of 529 stations. Interstation Green's functions for 31,532 station pairs are calculated from crosscorrelation of one-year-long noise records in 2022. We determine the Rayleigh-wave group velocities at periods of 1-15 s from the Green's functions. Additionally, we analyze the Rayleigh waves from 337 MW 5.5-8.1 global earthquakes in 2018-2022, determining Rayleigh-wave phase velocities at periods of 20-80 s using the Eikonal tomographic inversion. The integration of the two tomographic analyses enables us to examine the Rayleigh-wave dispersion curves over a wide period range of 1 to 80 s. We finally determine a 3-D shear-wave velocity model up to a depth of 200 km from the Rayleigh-wave velocities using a linearized iterative inversion with the Markov-chain Monte-Carlo technique. The shear-wave velocities generally increase with depth, presenting high lateral variations. The shear-wave velocities illuminate geological and tectonic structures that may be associated with present and paleotectonic activities. The observations may contribute to understanding seismic and tectonic processes in the region.

Keyword

seismic tomography, seismic velocity structure, Korean Peninsula

Lithospheric Structure Beneath the Upper Indus Basin and its Adjacent Regions from Inversion of Surface Wave Dispersion

G. Suresh[1]*, Ministry of Earth Sciences (g.suresh@imd.gov.in)

Abstract

Lithospheric Structure Beneath the Upper Indus Basin and its Adjacent Regions from Inversion of Surface Wave Dispersion
G. Suresh
National Center for Seismology, Ministry of Earth Sciences, New Delhi.
* Corresponding Author: G. Suresh
E-mail address: g.suresh@imd.gov.in, gsureshimd@yahoo.com.

Abstract
We evaluated the crustal and upper mantle lithospheric structure down to 160 km depth across the Upper Indus Basin (UIB) and its neighboring area through inversion of surface waves (Rayleigh and Love waves) group velocities for periods ranging between 5 and 120 s using broadband seismograms of fifty eight regional earthquakes recorded at 60 seismological stations located in the southern neighborhood of UIB. The study region is further divided into western (A), central (B), and eastern (C) clusters as per ray paths coverage. The observed group velocities are then inverted by Genetic Algorithm (GA) to obtain the lithospheric velocity structure along each of the three cluster wave paths. The crustal thickness decreases westward with the maximum thickness of 59.8 km (Cluster A) in the eastern part, 59.5 km (Cluster B) in central UIB, and 56.1 km (Cluster C) in the western part. The average structure (UIB) has also been obtained through inversion and the estimated average crustal thickness is 65.3 km. The crustal thickness estimated along clusters A and B is thicker in comparison to crustal thickness observed along cluster C, which may indicate the subduction of Indian plate under the Eurasian plate. This study reveals the presence of a Low Velocity Zone ~128 km beneath each wave path cluster, characterized by a shear wave velocity (Vs) of around 4.67 km/s.
Keywords: Surface wave Dispersion, Lithospheric structure, Low Velocity Zone (LVZ), Upper Indus Basin (UIB).

Keyword

Surface wave Dispersion, Lithospheric structure, Low Velocity Zone (LVZ),, Upper Indus Basin (UIB)

Lateral variation of the Mantle Transition Zone Beneath Southern Tibet inferred from receiver function analysis

YiBin WU[1]*, INSTITUTE OF GEOLOGY AND GEOPHYSICSCAS
(wuyibin21@mail.iggcas.ac.cn)
Xiaobo Tian[2], INSTITUTE OF GEOLOGY AND GEOPHYSICSCAS

Abstract

The subduction of the Indian plate beneath southern Tibet plays a vital role in the evolution of the Tibetan Plateau. Previous studies suggest that the Indian lithospheric slab has torn into sections with different subduction angles and the high-angle Indian lithospheric slab is more likely subducting into the deep mantle. However, the locations of these slab sections and the depth extent of the subduction Indian plate remain controversial. Here, we used newly collected data from a linear array in southern Tibet to study the structure of the mantle transition zone (MTZ) by adopting the receiver function methods. Our results show there is an MTZ thickening region that is approximately 15 km thicker than the global average beneath the east of the Lhasa terrane, the thickened MTZ correlates well with high P-wave velocity anomalies in the MTZ. We interpret the thickened MTZ beneath the plateau as evidence of the presence of a cold Indian slab. An obvious low-velocity layer (LVL) atop the MTZ is also observed, indicating the MTZ is hydrous, the average estimated value for water content in MTZ is +0.5wt%. We suggest the subducted Indian plate has subducted to the MTZ and disturbed the hydrous MTZ, the hydrous upwelling further weakened the overlying lithosphere and promoted continental rifting.

Keyword

subduction, MTZ, low-velocity layer, hydrous upwelling, water

Pn-wave receiver function method

LiangYu ZHANG[1]*, State Key Laboratory of Lithospheric Evolution,Insitute of Geology and Geophysics, Chinese Academy of Science (zhang_ly06033@163.com)
XiaoBo TIAN[2], State Key Laboratory of Lithospheric Evolution, Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

Receiver function (RF) method is the most widely adopted method for imaging crustal structure using teleseismic data. However, through attenuation during long-distance propagation, high-frequency components are scarce in teleseismic waveforms, resulting in low resolution of RF. Although regional earthquakes are always considered very complex, containing multiple seismic phases, they do contain more high-frequency components because of their short epicentral distances. Thus to improve the resolution of crustal structure study and to derive more detailed shallow crustal structures, we propose the Pn-wave receiver function method. Among those variable regional seismic phases, Pn-wave can be approximately considered as a plane wave in the crust beneath seismic stations, and interference from other phases can be avoided at epicentral distance of 5-15°. After choosing an appropriate time window to exclude interferences of other regional seismic phases, and rotating three-component of waveform record to polarization direction of P wave and S wave, Pn-wave RFs (PnRFs) can be calculated by deconvolving S wave component with P wave component. PnRFs calculated from both numerical synthetic data and observational data at broadband seismic stations show that all converted waves present in PnRFs at the predicted time according to the theory of plane wave, and the amplitudes of converted wave in PnRFs are 2-3 times larger than those in teleseismic RFs, because of larger incident angle of Pn-wave in the crust. PnRFs calculated from observational data of a dense nodal array (DNA) clearly show not only the converted wave from Moho, but also the converted wave from crustal interface which is too weak to be observed in tele-RFs due to the fact that Pn-wave has larger incident angle and higher frequency than that of teleseismic P-wave. Cooperating with DNA observation, the Pn-wave receiver function method has potential to image crustal structure with high-resolution closing to the deep seismic reflection method.

Keyword

Pn-wave, Receiver Function, High Resolution

Detailed crustal structure beneath the epicentral region of 2016 Mw 5.5 Gyeongju earthquake: preliminary results of teleseismic receiver functions from the Naenam Fault Array

Hobin LIM[1]*, Korea Institute of Geoscience and Mineral Resources (hbim76@gmail.com)
Minkyung KIM[2], Seoul National University
YoungHee KIM[3], Seoul National University
Junkee RHIE[4], Seoul National University
Tae-Seob KANG[5], Pukyong National University
Kwang-Hee KIM[6], Pusan National University
Jin-Han REE[7], Korea University

Abstract

We probe fine crustal seismic structure and properties from radial and tangential receiver functions (R-RFs and T-RFs, respectively) using two teleseismic earthquakes recorded by a linear dense geophone array, called the Naenam Fault Array (NFA), during a month. The NFA was deployed subperpendicular to the NNE–SSW striking Naenam fault and Yangsan fault (YSF) over the ~15 km distance. The Naenam fault is causative fault of the 2016 moment magnitude 5.5 Gyeongju earthquake in southeastern Korea.

We retrieve the isotropic and anisotropic subsurface structure based on the forward modeling of the R- and T-RFs, respectively. First, the R-RFs show clear P-to-S converted phases of the Moho (Pms) at 3.6 s and its first multiple (PpPms) at 12 s, indicating the depth of Moho at ~28 km. Additionally, we observe lateral (west-east) variation in positive amplitudes before the Pms, indicating the presence of a mid-crustal discontinuity at depths of ~12-13 km. In the west of the YSF, we observe a dip of ~10°, shallowing towards the east. An abrupt change in its depth from 12 km to 8 km is observed near the YSF. In the east of YSF, its depth ranges from ~8 km to 4 km.

Second, the T-RFs show polarity changes in their amplitudes before and after the Pms, indicating the presence of seismic anisotropy in the lower crust and lithospheric mantle. Although constraining parameters of anisotropy is challenging with only two usable events in one-month period, our analysis results show a fast symmetric axis azimuth of 100±20° and a plunge of <10°. Our observations require the presence of seismic anisotropy ~4% in the lower crust and ~8% in the lithospheric mantle.

Keyword

crustal structure, teleseismic receiver function, dense geophone array

The Seismogenic Processes of Main Faults in Sichuan-Yunnan Based on Time-varying Repeating Event Waveforms

Boyang WANG[1]*, University of Chinese Academy of Sciences (wangboyang21@mails.ucas.ac.cn)
Yuanze ZHOU[2], University of Chinese Academy of Sciences

Abstract

The Sichuan-Yunnan region is located at the southeast edge of the Tibetan Plateau, with intense crustal tectonic activity, high rates of crustal deformation, large deformation volumes, and the development of a large number of faults, making it one of the regions with the highest frequency of strong earthquakes and the most serious disasters in mainland China. Small and medium-sized earthquakes occur frequently in this region, and the distribution of seismic stations/arrays is dense, thus accumulating a large amount of high-quality seismic waveform data. The NE-oriented Zhaotong-Ludian fault zone, located in the eastern section of the Sichuan-Yunnan border, is an active tectonic zone with a relatively low level of seismic research. Since the Ms 6.5 earthquake occurred in Ludian on August 3, 2014, the Zhaotong-Ludian fault zone has gradually received attention from active tectonic researchers. The aim of this study is to investigate the seismic activity in this region in depth using the method of repeating earthquakes. We collected and organized the three-component continuous seismic data recorded by the Zhaotong station network in Yunnan from 2018 to 2021; identified seismic events from the seismic records using the PALM program; and localized the seismic events by Hypoinverse and Hypodd to determine the seismic source location and depth of the seismic events. In total, we obtained 105 seismic events. These seismic events are distributed in the range of 27°~27.5°N, 103.5°~104.1°E, and the magnitude is about ML 1.5. Based on the waveform similarity and source parameter similarity criteria, we identified three groups of repeating earthquakes, each containing two seismic events. By analyzing the waveforms of these three groups of repeating earthquakes, we can obtain important information about the pregnant earthquake of the Zhaotong-Ludian rupture as well as the fault activity; together with the local precipitation data, we can further analyze the effect of precipitation on the velocity structure of seismic waves. Through an analysis of the correlation between precipitation and seismicity, we can better understand the influencing factors of seismic wave propagation mechanism and provide geophysical data support for earthquake early warning and disaster prevention and mitigation. The results of this study are of great significance for a deeper understanding of the mechanism of seismicity in the

Sichuan-Yunnan region, for predicting seismic risk, and for providing a scientific basis for earthquake early warning and disaster prevention and mitigation.

Keyword

Sichuan-Yunnan region, Repeating Earthquakes, Zhaotong-Ludian fold belt, Precipitation, Seismogenic Processes

The Characteristics of Regional Seismicity before the 2008 Mw 7.9 Wenchuan Earthquake

Xinzhong YIN[1]*, Institute of Geology CEA (yinxinzhong@ies.ac.cn)
Jiuhui Chen[2], Institute of Geology CEA

Abstract

The 12 May 2008 Mw 7.9 Wenchuan earthquake occurred on the Longmenshan Fault (LMSF) zone, the eastern margin of the Tibetan Plateau, in Sichuan province, China. This earthquake is the largest intra-plate high-angle thrust earthquake recorded by digital seismometers. Field observations revealed that the primary rupture was along the LMSF extending up to ~330km long. The results of geological and geodetic studies indicate that no obvious anomalies were found in the epicentral area before the Wenchuan earthquake. The temporary Western Sichuan Seismic Array (WSSA, 297 broadband stations; 10–30 km spacing; operational from 2006–2009) covered the central and southern part of the LMSF. We use the neural network and REAL method to pick and associate the Pg/Sg phase respectively. Then, we use the NonLinLoc and the double-difference relocation method to relocate all the events before the Wenchuan mainshock.

Our preliminary results can be summarized as follows: 1Regional seismicity is mainly distributed along the Xianshuihe fault, Longriba fault, Miyaluo fault and Xiaoyudong fault, coinciding with secondary plates boundaries; 2) Seismic activity relatively intensified along the Xiaoyudong fault before the Wenchuan mainshock; 3) Based on these observations, we speculate that long-term reginal tectonic movement led to the stress accumulation around the mainshock zone, possibly serving as the regional dynamic mechanism triggering to the the Wenchuan earthquake.

Keyword

Wenchuan Earthquake, AI, seismicity

Characterizing the shallow subsurface of the Bukpyeong Basin, Korea, by the HVSR method

SU YOUNG KANG[1]*, Pusan National University (sukang@pusan.ac.kr)
Kwang-Hee Kim[2], Pusan National University
Hee-Cheol Kang[3], Pusan National University
Young-Cheol Lee[4], Pusan National University

Abstract

We present a dense seismic observation approach to characterize the shallow subsurface of the Bukpyeong Basin in Korea, employing the Horizontal-to-Vertical Spectral Ratio (HVSR) technique on ambient noise data. Situated in Donghae, Gangwon Province, Korea, the study area experienced an unusual series of micro-earthquakes in May 2023. Our hypothesis posits that faults reactivated during this seismic sequence played an important role in the formation of the Miocene Bukpyeong Basin. The basin is marked by several significant fault zones, including the Osipcheon fault and inferred basin boundary faults. Using a three-component seismometer, we conducted background noise observations at 149 sites in and around the basin. The HVSR method calculates resonance frequencies by spectrally dividing the vertical component of ambient noise from the horizontal components. The resulting data is directly linked to the depth of major impedance contrasts between bedrock and the overlying sediment beneath the observation site. The basin model proposed in this study is constructed based on 149 resonance frequencies, ranging from 0.87 Hz to 55.8 Hz. The model reveals lower resonance frequencies in the central part of the Bukpyeong Basin, suggesting a thick sedimentary cover. To validate our findings, we compared HVSR results with Bouguer Gravity anomaly (BA) data and depth measurements to bedrock available from the Geotechnical Information Database System. By integrating HVSR results, BA data, and geotechnical observations, we identify potential fault locations for further investigation. This comprehensive approach enhances our understanding of the subsurface dynamics of the Bukpyeong Basin and provides valuable insights into the geological processes and fault activity in the region.

Keyword

HVSR, subsurface structure, microtremor, Bukpyeong Basin

Fragmented Plates in Sumatra-Andaman Subduction Zone Revealed by Distinct Mantle Anisotropic Directions

BHASKARARAO ILLA[1]*, Tata Institute of Fundamental Research (bhaskar.illa1992@gmail.com)
PRAKASH KUMAR[2], CSIR-National Geophysical Research Institute

Abstract

Mega-thrust subduction zones are tectonic plate boundaries where one tectonic plate is being forced beneath another, known for producing some of the most powerful earthquakes in history. Understanding the structural heterogeneity at a regional scale in the mega-thrust subduction zone is crucial for deciphering the rupture dynamics that control earthquake generation. The rupture dynamics of earthquakes in the Andaman-Sumatra region are primarily hindered due to the lack of velocity and anisotropy information at the lithospheric level. To map lithospheric velocity and anisotropy in the mega-thrust subduction zone of Andaman-Sumatra, we generated compression wave (Pn) tomography by inverting 41,354 Pn arrivals from 5,725 regional events recorded at 316 stations. Our findings reveal a significant variation in velocity and fast polarization directions (FPDs) across the entire study region, which could be an essential factor for earthquake nucleation. The intriguing observation is the abrupt change in fast polarization directions from the Andaman to Sumatra and Sumatra to Java regions along the arc. We suggest that there exist well-defined plate boundaries between Indian-Capricorn rather than the diffused one as thought earlier. The nature of plate boundaries significantly influences stress accumulation and release, impacting the occurrence and characteristics of earthquakes in the region. Our observation is also supported by the lower spreading rate and higher crustal age in the Andaman region compared to the north Sumatra region. We further argue that the mega events of 2004 and 2005 occurred along the Indian-Capricorn plate boundary. Our results also indicate the presence of low Pn velocity anomalies in the west of the Andaman Sea, suggesting the existence of a magma reservoir pouring out lava through the steep and torn subducted Indian oceanic slab.

Keyword

Andaman-Sumtra Subduction Zone, 2004 (Mw 9.1) Sumatra-Andaman Earthquake Rupture, Pn waves - Uppermost Mantle, Seismic Anisotropy, Magma - Subducting Indian Oceanic Slab

Ambient Noise Tomography with a Short-Period Dense Array: Case of Sedimentary Basin

Hyejeong CHO[1]*, Student (ezyo0101@snu.ac.kr)
Sang-Jun Lee[2], Professor
Seongryong Kim[3], Professor
Junkee Rhie[4], Professor
Tae-Seob Kang[5], Professor

Abstract

Ambient noise tomography (ANT), extracting empirical Green's functions by cross-correlation of noise records, has been a prevalent method to constrain a shear wave velocity distribution beneath the surface. The method does not require earthquakes or explosions, which makes itself applicable anywhere receivers have been installed and cost-effective. Usually, ANT has been conducted in a 3–10 s period range, in which a major noise source is the most energetic, so broadband data is needed. Although many recent studies have shown that high-frequency ANT can work for tens of kilometer areas with any type of receiver, it is still challenging to measure dispersion curves in high frequency, especially in the case of sedimentary basin regions due to their complex structure. Thus, in this study, we tested parameters for achieving high-frequency ANT with a short-period array while employing ANT to the Santa Clara Valley, which is a sedimentary basin area in the San Francisco Bay region, bearing 2 Tertiary basins covered by Quaternary alluviums up to 500 m. As a result of the test, it is found that long-period energy recorded by short-period instruments should be eliminated to calculate empirical Green's functions stably. Also, the relationship between Gaussian alpha and interstation distances for frequency-time analysis is determined as 50 for 60 km, 25 for 30 km, and 12.5 for 10 km to obtain dispersion curves in 0.7–7 s. In resulting shear wave velocity models, two low velocity anomalies are found. The location of the anomalies corresponds to 2 Tertiary basins of the study area, and their basement is reaching to 2.5–3 km, which is consistent with the previous models. Therefore, it shows that high-frequency ANT can succeed in imaging sedimentary basin regions with careful processing.

Keyword

Ambient noise tomography, Dense array, Short period sensor, Sedimentary basin

Deep Learning-driven ambient noise surface wave dispersion data selection along linear array

Yan WANG[1]*, University of Science and Technology of China (wy57@mail.ustc.edu.cn)
HaiJiang Zhang[2], University of Science and Technology of China

Abstract

Passive seismic surface wave tomography utilizes ambient noise data to first obtain surface wave dispersion data, and then derives the subsurface velocity structure through inversion. Passive seismic surface wave tomography based on linear seismic array acquisition has now been widely used due to its efficiency in deployment. However, due to the temporal and spatial variations of high-frequency noise sources that are useful for imaging near-surface structure, the surface wave dispersion curves extracted from ambient noise may not be reliable, thereby affecting the tomography imaging.

To improve the quality of surface wave dispersion data along linear arrays, in general the acquisition time is increased. However, simply superimposing all time-lapse data cannot remove the interference of noise sources located in non-steady regions. To eliminate the interference of non-steady noise sources, we propose a data screening and superposition method based on deep learning. First, we trained a ResNet-50 deep learning network by actual dispersion data manually selected from a real dataset. Then we use the trained ResNet-50 deep learning network to evaluate and screen the quality of different time-lapse dispersion data. Lastly, we only superimpose the data segments judged as high-quality dispersion data. We have applied the developed dispersion data screening and superposition technique to a real linear array dataset. This not only significantly improves the signal-to-noise ratio of the dispersion spectrum, but also greatly reduces data processing time.

Keyword

Deep Learning, ResNet-50, Dispersion Spectrograms, Noise data selection, Noise Source Distribution

Extraction of body waves from seismic ambient noise recorded by a dense seismic array at the Zhangbaling segment of Tanlu Fault Zone, China

Mingze Du[1]*, University of Science and Technology of China (d17752@hotmail.com)
Ji Gao[2], University of Science and Technology of China
Haijiang Zhang[3], University of Science and Technology of China

Abstract

The Tanlu Fault (TLF), the largest strike-slip fault in eastern China, exhibits significant segmentations in both structural characteristics and seismic activity. The Jiashan-Feidong segment of TLF, situated between the Sulu and Dabie orogenic belts, is particularly complex due to the presence of the Zhangbaling uplift and Hefei basin on its eastern and western flanks, respectively. This complexity extends to both structural and sedimentary features, thus a detailed velocity model is needed.

In recent years, ambient noise tomography has been widely used to determine the Vs model by extracting seismic surface waves from ambient noise. However, surface waves are mainly sensitive to the Vs structure and also have limited depth resolutions. In comparison, body waves can provide complementary information to the surface waves. In this study, we have developed a procedure to extract body waves from ambient noise recorded on a dense seismic array and applied it to elucidate the upper crustal structure of the Zhangbaling segment of TLF by utilizing direct P waves extracted from ambient noise by a dense array comprising 192 receivers spaced at a minimum interval of 5 km.

Our analysis procedure includes two primary components: body wave extraction and travel time tomography. Firstly, we employ the Wavelet Phase Cross-Correlation (WPCC) technique to obtain robust cross-correlation functions of receiver pairs. Subsequently, we subdue the Rayleigh wave component by summing the imaginary parts of the ZR and RZ components of the cross-spectrum tensor for each receiver pair. Additionally, a selection filter is applied to isolate time segments exhibiting relatively high Signal-to-Noise Ratios (SNRs) indicative of potential direct P wave arrivals. Furthermore, we utilize the Adaptive Covariance Filter (ACF) to enhance the coherent signal and suppress incoherent noise within each trace, resulting in the extraction of clear direct P wave signals from all available receiver pairs.

Utilizing the extracted P wave signals, we further perform 3-D travel time tomography to estimate P wave velocities in the study area. Our results demonstrate the feasibility of reconstructing not only surface waves but also body waves from ambient noise. This further illustrates the usefulness of dense seismic array to study the detailed velocity structure at different scales.

Keyword

Tanlu fault zone, Ambient noise interferometry, Body waves, Tomography

Azimuthal anisotropy of the upper crust beneath the Gyeongju Hi-density Broadband Seismic Network rebuilt by the local shear wave splitting

June Baek[1]*, Division of Earth and Environmental Sciences, Pukyong National University (100june6@gmail.com)
Tae-Seob Kang[2], Division of Earth and Environmental Sciences, Pukyong National University
Dabeen Heo[3], Division of Earth and Environmental Sciences, Pukyong National University
Jin-Han Ree[4], Department of Earth and Environmental Sciences, Korea University
Kwang-Hee Kim[5], Department of Geological Sciences, Pusan National University
Junkee Rhie[6], School of Earth and Environmental Sciences, Seoul National University
YoungHee Kim[7], School of Earth and Environmental Sciences, Seoul National University

Abstract

Crust contains deformation by not only faults but the microcracks which are easily aligned to either the structural features or the stress regime, causing the velocity difference on the same raypath. This phenomenon is easily observed by the shear waves, called shear wave splitting. To investigate the shear wave splitting of the southeastern Korean peninsula, we analyzed the data recorded on the Gyeongju Hi-density Broadband Seismic Network using the eigenvalue method. The method measures two parameters, the fast polarization and the delay time, which enhance the linearity of the particle motion of the shear waves. We applied constraints on the observed measurements to restrict undesired measurements, the incidence angle, the error of the parameters, the analytical difference between the fast polarization and the initial polarization, and the grading system. We obtained 4611 reliable parameter pairs, concentrated mainly on the 2016 Gyeongju sequence and the eastern Ulsan Fault (USF). The distribution of the total measurements has the right-skewed distribution of the delay time and the elliptical rose diagram of the fast polarization. The two regions have similar patterns on the delay time, concentrated on the low values. The fast polarizations, however, showed different aspects as the 2016 Gyeongju sequence has NNE-SSW dominant ellipse shaped rose diagram and the eastern USF has ENE-WSW dominant one. The delay time tomography resulted in high anisotropy on the eastern USF and on the 2016 Gyeongju sequence. Also, two linearly aligned high anisotropy are observed on the western Yangsan Fault (YSF). These heightened regions might be related to some geological features, such as the slip tendency on the eastern USF and the 2016 Gyeongju sequence itself. Spatially averaged fast polarization depicted a complex pattern, two to three representative directions, with the dominant NE-SW. Various directions on the small region could indicate the complex influence of miscellaneous factors on the seismic anisotropy of the crust. The NE-SW and E-W trends on the eastern USF seem to be related to the structural features and stress, respectively. The fast polarizations aligned to the Yangsan Fault (YSF) along it indicate the influence of the YSF on the seismic anisotropy, indicating the structural anisotropy is dominant along the YSF. The NE-SW trends with low values on the delay time tomography might be related to the crustal stress on the shallow depth. Additionally, a strong yet unknown mechanical relationship was noted between the slip tendency (slip susceptibility) and the seismic anisotropy. Such discoveries suggest the crust

beneath the network reflects deformation influenced by various crustal features.

Keyword

Azimuthal anisotropy, shear wave splitting, fault system, crustal stress

Investigation on the Influence of Non-uniform Noise Source Distribution on Ambient Noise Imaging Effectiveness

Fei HUANG[1]*, University of Chinese Academy of Sciences(UCAS)
(huangfei22@mails.ucas.ac.cn)
Yuan ze Zhou[2], University of Chinese Academy of Sciences(UCAS)

Abstract

Ambient noise imaging techniques represent significant advances in 21st-century seismology. These methods derive Green's functions of subsurface structures by utilizing cross-correlation functions from arbitrary pairs of seismic stations. Due to independence from both natural and artificial seismic sources, as well as the capability to provide continuous data, ambient noise techniques have initiated a seismic revolution. These innovative methods find extensive applications in studying underground velocity structures, anisotropy, medium attenuation characteristics, and monitoring shallow subsurface velocity changes. However, the theoretical foundation of ambient noise methods typically assumes a uniform distribution of noise sources, which differs from the non-uniform and time-varying nature of real-world noise sources. Such disparities between theoretical assumptions and real-world conditions may lead to inaccuracies in research outcomes, especially in studies involving the monitoring of shallow subsurface velocity changes, where the influence of noise source distribution is notable. Although numerous scholars have acknowledged the significance of noise source distribution in reconstructing Green's functions, previous research has predominantly focused on theoretical aspects, neglecting to assess the impact of noise source distribution in conjunction with specific empirical studies. Additionally, the potential consequences of incomplete noise field scattering on frequency components and its impact on research outcomes have been overlooked. In this contribution, we quantitatively analyze how the spatial distribution of noise sources and non-uniform frequency distributions affect cross-correlation results. Employing practical studies on shallow subsurface velocity changes as examples, we evaluate the impact of noise sources on velocity change results, analyze, discuss, and seek potential improvement methods. Through this study, we aim to establish a reliable evaluation criterion for ambient noise imaging outcomes and promote the application of ambient noise methods in practical seismic studies.

Keyword

Seismic interferometry, Cross-correlation, Noise source distribution

Short and long-term behavioral characteristics of the Eupcheon Fault in the southeastern part of the Korean Peninsula

Sung-il CHO[1]*, Korea Hydro & Nuclear Power Company (chosi4476@khnp.co.kr)
Jeong-seon Park[2], Korea Hydro & Nuclear Power Company
Sae-woon Choi[3], Korea Hydro & Nuclear Power Company
Donghee Park[4], Korea Hydro & Nuclear Power Company
Jae-woong Ryu[5], Korea Hydro & Nuclear Power Company

Abstract

In order to confirm the seismic safety around nuclear power plant sites, the geological characteristics must be investigated before constructing the plant. The Eupcheon Fault, located near the Wolsong Nuclear Power Plant in Korea, has a history of at least two fault movements during the Quaternary period. The Korea Hydro & Nuclear Power Corporation installed the Eupcheon Fault Monitoring System (EFMS) and has been operating it to confirm the behavioral characteristics since 2012. The EFMS includes a borehole strainmeter to observe changes in underground stress, a creepmeter and GPS (Global Positioning System) to monitor fault displacement, as well as a seismometer to detect seismic waves. All measured data were adjusted for external factors such as earth tide, temperature, atmosphere, and artificial noise to ensure reliability. In this study, changes in underground stress and fault displacement were analyzed using observed data from both short- and long-term periods. According to the borehole strainmeter, the current stress direction predominantly aligns with ENE-WSW in the Gyeongsang Basin in Korea. The temporary abnormal stress from the nearby earthquake events was observed, but its long-term accumulation was not confirmed. As analyzed results from the GPS data, there have been no abnormal changes in fault displacement. A micro-displacement of 0.0047 mm was measured by the creepmeter during the 2016 Gyeongju earthquake (Mw 5.8). But it is attributed to the micro-vibration of the earthquake rather than fault behavior. The results of this study show that the Eupcheon fault is relatively stable and not impacted by earthquakes occurring nearby. The study also confirmed the excellent effectiveness of fault monitoring systems in analyzing the fault stability against earthquakes.

Keyword

Eupcheon fault, fault monitoring system, Strain, fault displacement, GPS

Ground Motion Models for South Korea using the Hybrid Empirical Method and NGA-West2 Empirical Ground Motion Models

Seonjeong PARK[1]*, Korea Institute of Nuclear Safety (sjpark@kins.re.kr)

Abstract

Ground motion models (GMMs) play a crucial role in both deterministic and probabilistic seismic hazard assessments. Developing empirical GMMs is impractical in areas like South Korea with scarce strong earthquake records, leading to the use of alternative methods such as stochastic simulations. Thus far, all GMMs developed for South Korea have employed stochastic methods.

In this study, GMMs are developed for South Korea using the hybrid empirical method (HEM) which was suggested by Campbell (2003). Western United States (WUS) is selected as a host region so that five empirical ground motion prediction equations (GMPEs) developed by the Pacific Earthquake Engineering Research Center for the Next Generation Attenuation-West2 (NGA-West2) project are used as GMMs for the host region.

The high-frequency spectral attenuation parameter, kappa, is one of the most important seismological parameters utilized in the simulation. Therefore, kappa is estimated in this study for the accelerometer observatories operating throughout South Korea.

Derived GMMs are for magnitudes from 5.0 to 7.5 and rupture distances from 10 to 500 km. Median GMMs are provided with aleatory standard deviations. Predictive GMMs are compared with observed ground motions from the available earthquake records for moment magnitudes 5.0 and 5.5. The notable advantages of the GMMs developed in this study are as follows: The implementation of HEM complement the limitations inherent in stochastic simulations such as near-source ground motion saturation effects. The seismological parameters utilized in ground motion simulations for the target region are obtained from recent research or practically estimated values using abundant acceleration data. The aleatory standard deviations are defined for use in Probabilistic Seismic Hazard Analysis (PSHA).

Keyword

GMM, GMPE, PSHA

Investigation of Directional Variability of Earthquake Ground Motion of South Korea for Nuclear Seismic Safety Assessment

JEONGGON HA[1]*, Korea Atomic Energy Research Institute (jgha@kaeri.re.kr)
INKIL CHOI[2], Korea Atomic Energy Research Institute
MINKYU KIM[3], Korea Atomic Energy Research Institute

Abstract

This study investigates the directional variability of earthquake ground motion in South Korea, leveraging recorded data from the 2016 Gyeongju and 2017 Pohang earthquakes. Through the analysis of over 1,200 seismic recordings from the Korean seismic observation network and a comparison with the NGA-WEST dataset from the United States, this research assesses the characteristics of variability in horizontal bidirectional responses and the vertical/horizontal (V/H) ratio of earthquake ground motion in South Korea.

The first part of the study explores the variability of horizontal bidirectional responses, which is crucial for determining structural responses to earthquakes in seismic fragility assessment. It reveals differences in the maximum and minimum directions of ground motion response, as well as component-to-component variability in South Korea. Additionally, the study compares the differences in directional variabilities between the South Korean and United States databases by frequency.

Subsequently, the research investigates the V/H ratio in South Korea, which is essential for defining the vertical spectrum shape to determine the seismic behavior of structures. The V/H ratio by frequency was compared between the South Korean and United States databases. Furthermore, using a previously empirically presented formula for the V/H ratio, the study compares it with the V/H ratio measured at a Korean nuclear power plant.

By the comprehensive analysis of both bidirectional variability and V/H ratios using the recorded earthquake motions in South Korea, this study is expected to provide a fundamental understanding for improving the seismic evaluation method of nuclear power plants.

Keyword

Earthquake, Bidirectional Variability, Vertical to Horizontal Ratio, Gyeongju Earthquake, Recorded Motion

Hybrid Empirical Ground Motion Predictions for the southern Korean Peninsula

Sae-Woon CHOI[1]*, Central Research Institute of Korea Hydro & Nuclear Power Co., LTD (choisewoon@khnp.co.kr)
Dong-hee Park[2], Central Research Institute of Korea Hydro & Nuclear Power Co., LTD

Abstract

Due to the lack of observation records of earthquakes of magnitude 5.0 or higher, there are limitations in developing ground motion prediction equations (GMPEs) for the Korean Peninsula using empirical methods. In this study, GMPEs hybrid empirical method(HEM) was used to develop a GMPE for the southern region of the Korean Peninsula. HEM is a method that provides strong ground motions for the region(target region) with insufficient strong ground motion data, using empirical GMPEs developed for a region(host region) with abundant strong ground motion records and adjustment factors based on stochastic simulations. Five NGA-West GMPEs developed for the western United States were selected as the empirical GMPEs for the host region. To calculate the adjustment factors, strong ground motions were generated by stochastic simulation for the western United States and the Korean Peninsula. Seismological parameters studied for the host region and target region were used for input variables applied to the stochastic model. The shear wave velocity of 2,500 m/s and kappa of 0.006s are applied to the site conditions of the target area. Adjustment factors are calculated for frequencies from 0.1 Hz to 50 Hz, moment magnitudes from 3.0 to 8.0, and rupture distances up to 1,000 km. We compared the ground motions generated from the developed GMPE in this study to ground motion data recorded in the Korean Peninsula. The comparison with the previously developed GMPEs for the Korean Peninsula was also conducted.

Keyword

GMPE, HEM, ground motion

Procedure for the determination of Safe Shutdown Earthquake ground motion for nuclear power plants

Sinae HAN[1]*, KEPCO-ENC (ssinaehan@kepco-enc.com)
Jechan PARK[2], KEPCO-ENC
Hyun-Mi RHEE[3], KHNP
Hyun Jae YOO[4], Pukyoung National University
Seong-Bin YIM[5], KEPCO-ENC
Joohyeon YI[6], KEPCO-ENC

Abstract

The procedure for determining Safe Shutdown Earthquake(SSE), the earthquake which produces the maximum vibratory ground motion for which certain structures, systems, and components are designed to remain functional, is performed in accordance with Korean regulatory guidelines and 10 CFR Part 100 Appendix A. In order to determine seismic design of nuclear power plants, SSE decision must be made in advance, which is a very important procedure. The procedure for determination of SSE can be divided in to two part, a deterministic seismic hazard analysis using seismic source and attenuation characteristics and verifying suitability by conducting a stochastic simulations and probabilistic seismic hazard analysis.

The hazards of ground motion and faults associated with seismic events and geological phenomena must be investigated according to regulatory siting criteria for nuclear power plants and provided. The geological and seismological data provided in this way are used to determine SSE. In particular, seismological data collected through historical earthquake data, instrumental earthquake data, and site specific instrumental data should be combined with geological information to form a seismo-tectonic province. The maximum ground motion value that can occur at the site is calculated through a deterministic method using the ground motion prediction equation, which refer to the attenuation characteristics, and the previously obtained seismo-tectonic province. note that earthquake occurring point at each province must be determined. SSE is determined by adding margin to the calculated largest ground motion value at the site. Once SSE is decided, Standard design response spectrum is scaled for the SSE value to determine Design Ground Response Spectrum(DGRS) at the site.

An earthquake safety assessment is performed to verify the suitability of determined SSE and DGRS, if there is a linear earthquake source such as faults that meet the criteria to be considered in design in the vicinity of the site, stochastic finite-fault simulations is performed to confirm whether impacts to those sources exceed DGRS and SSE. Moreover, probabilistic seismic hazard analysis is executed to calculate the mean value of the annual exceedance probability for the SSE from hazard curve. if the mean value of annual exceedance probability exceeds reference values presented in regulations, the SSE is adjusted upward to prevent it.

Keyword

Nuclear power plants, SSE, seismic hazard, DGRS, seismic siting criteria

[Keynote] Physics-based Ground Motion Prediction for Advanced Seismic Hazard Assessment: Potentials and Challenges

Seok Goo SONG[1]*, Korea Institute of Geoscience and Mineral Resources (KIGAM)
(sgsong@kigam.re.kr)
Eunjin PARK[2], Korea Institute of Geoscience and Mineral Resources (KIGAM)

Abstract

Ground motion prediction is a core element in seismic hazard assessment. However, it is still a challenging task to develop accurate and reliable ground motion prediction methods for future destructive earthquakes. Traditionally two approaches have been intensively studied in the community. One is to construct empirical Ground Motion Prediction Equations (GMPEs), the other is to adopt stochastic ground motion simulation schemes. The former often suffers from the deficiency of recorded data, especially in the near-source region for large events. The latter is also limited in many applications because only single component and single phase ground motions are simulated. Recently researchers have paid more attention to physics-based ground motion prediction approaches, by adopting either dynamic or pseudo-dynamic earthquake modeling methods. Since 3-component and full phase ground motions are required for dynamic structural response analysis in the Performance-Based Earthquake Engineering (PBEE), it is important to develop accurate and reliable physics-based ground motion simulation methods to generate 3-component and full phase ground motions. In this presentation, we briefly overview the potentials and challenges of the pseudo-dynamic source modeling method with 1-point and 2-point statistics of earthquake source parameters, which is one of the physics-based ground motion simulation methods recently developed. In the framework of pseudo-dynamic ground motion simulation with 1-point and 2-point statistics, we may be able to deal with both the epistemic and the aleatory uncertainty of physics-based ground motion predictions efficiently. Although there are still many challenges to overcome, we believe that physics-based ground motion prediction should be future directions for advanced seismic hazard assessment.

Keyword

Seismic Hazards, Ground Motion Predictions, Pseudo-dynamic Source Modeling

Preliminary evaluation of fault activity around the southeastern part of the Korean Peninsula using probabilistic approach on seismogenic potential of a fault

Sung-il CHO[1]*, Korea Hydro & Nuclear Power Company (chosi4476@khnp.co.kr)
Sae-woon Choi[2], Korea Hydro & Nuclear Power Company
Donghee Park[3], Korea Hydro & Nuclear Power Company
Sehyeon Gwon[4], Korea Hydro & Nuclear Power Company

Abstract

One of the main issues related to the seismic source for Probabilistic Seismic Hazard Analysis(PSHA) is the fault activity associated with assessing the earthquake-induced possibility from a specific fault. The US NRC (1999) suggested a probabilistic appoach on seismogenic potential of a fault that considers the spatial association between the fault and the earthquake point, the crustal extent of faults, the relationship between fault slip and tectonic stress regime, and reactivation events of the faults. In this study, we preliminarily evaluated the probabilistic seismogenic potential of active faults around the southeastern part of the Korean Peninsula using the modifed US NRC method by ourselves, which incorporates geomorphological characteristics, fault movement history, and fault origin into the assessment framework. The probability of spatial association can be assessed as 0.1 to 0.2, but this requires consideration of a few earthquake frequency and the extensive reverse fault plane. In case of a fault movement history, the probability is 1.0 because the latest fault movement occurred within 100,000 years. However, it is possible to apply various probabilities considering the recurrence inteval from 260 to 22,000 years of faults. The probability of the crustal extent and reactivation events of faults can be evaluated to be close to 1.0, considering the epicenter depth from 8 to 15 km and has multiple events of fault movement. As analysis results of geomorphological characteristics, various probabilities can be applied depending on whether there is Quaternary displacement or not.

These results can be contribute to a reasonable evaluation by incorporating the probabilistic activity as seismic sources when we conduct Probabilistic Seismic Hazard Analysis. However, in order to assess the probability of fault activity, detailed investigations should be conducted in advance to obtain results with a high confidence level.

Keyword

Seismogenic potential, Fault source, Seismic hazard, Geotectonic movement, Fault segment

Using logic-tree approach, reduction of uncertainty in fault source characterization for probabilistic seismic hazard analysis in South Korea

Sehyeon GWON[1]*, Korea Hydro & Nuclear Power Co., LTD. Central Research Institude (sehyeon.gwon81@gmail.com)
Sae-Woon Choi[2], Korea Hydro & Nuclear Power Co., LTD. Central Research Institude
Sung-il Cho[3], Korea Hydro & Nuclear Power Co., LTD. Central Research Institude
Donghee Park[4], Korea Hydro & Nuclear Power Co., LTD. Central Research Institude

Abstract

Probabilistic seismic hazard analysis (PSHA) is a methodology that calculates the probability of various earthquake shaking levels in a given time window. PSHA produces an estimated annual exceedance probability and provides essential information for design-basis development and safety evaluation criteria for major infrastructure projects. The Korean peninsula is located in a stable intraplate region with low seismicity and long return periods of large earthquakes. Although many Quaternary faults are reported in South Korea, fault source models are challenging to establish in PSHA, generally in the Korean peninsula, due to the significant epistemic uncertainty of fault characteristics. This study introduces examples of fault source characterization in the stable intraplate regions, including central and eastern United States (CEUS), Australia, and the Republic of South Africa, mainly focusing on logic-tree approaches. PSHA conducted in seismotectonic analogs of stable intraplate regions suggests the logic trees can be applied to incorporate considerable uncertainties in the fault source characterization associated with potential future earthquakes. In addition, we discuss the approaches to capture epistemic uncertainty considered in a seismic source characterization, including (1) alternative seismic source model and (2) alternative source parameterization. Finally, we propose an example of a fault source model using logic tree approaches that might apply to reducing the uncertainties for PSHA in South Korea.

Keyword

PSHA, logic-tree, fault source characterization, seismic source model, intraplate earthquake

The Study on the Seismic Source Parameters of Major Earthquakes in 2023

Hyun-Me RHEE[1]*, Korea Hydro & Nuclear Power Co., LTD (rheehm17@khnp.co.kr)

Abstract

The earthquake of magnitude 4.0 has occurred at Gyeongju region on the November 30, 2023. It was the largest earthquake that occurred on the Korean Peninsula in 2023. This earthquake occurred about 21 km away from the epicenter of the 9.12 earthquake in 2016. There are common opinions that it was occurred by different mechanism with the 9.12 earthquake in 2016. So we have been interesting in this event, and analyzed the seismic source parameters to understand the seismic characteristic.

The method of Jo and Baag (2001) which was based on the S-wave spectrum analysis by suggested Snoke (1987) and Andrews (1986) is adopted. The moment magnitude, corner frequency, seismic moment, and stress drop are measured from the seismograms. We used a vector sum of spectra of the 3 components. It was set out by Noh et al. (2003), and has been used in the previous study. In the previous study, self-similarity has been breakdown under moment magnitude 4.0 and the stress drop of the earthquakes over magnitude 4.0 has shown the similar stress drop of about 61.0 bar. The stress drop of the 9.12 earthquake shows more larger than other earthquakes, but the earthquake in 2023 has analyzed more smaller then other earthquakes even considering the self-similarity breakdown. The average stress drop measured from the records which are recorded at borehole station of the KMA within 150 km of the epicenter is about 20 bar.

Keyword

seismic source parameter, 2023, stress drop, seismic moment, Gyeongju

Shallow earthquakes in stable continental regions and implications for probabilistic seismic hazard analysis in SE Korea

Sehyeon GWON[1]*, Korea Hydro & Nuclear Power Co., LTD. Central Research Institude (sehyeon.gwon81@gmail.com)
Sae-Woon Choi[2], Korea Hydro & Nuclear Power Co., LTD. Central Research Institude
Donghee Park[3], Korea Hydro & Nuclear Power Co., LTD. Central Research Institude

Abstract

In probabilistic seismic hazard analysis (PSHA), future earthquakes are generally characterized by the location, geometry, and faulting types of the through-going structure in the seismogenic crust and the associated potential maximum earthquake magnitudes over long recurrence intervals. The uncertainty in the spatiotemporal distribution of stable continental region (SCR) earthquakes is a significant issue for the reliability of PSHA, although multidiscipline data, including paleoseismic, geomorphic, and remote sensing investigations, provide essential information for fault source characterization. The observations of surface ruptures and strong ground motions associated with low-magnitude (≒ Mw 5.0) shallow earthquakes in the global analogs of SCRs demonstrate that the importance of considering the potentials of earthquakes at a very shallow depth (7km <), even in ~3 km, is necessary in terms of PSHA. In the present study, we describe several issues related to SCR earthquakes for PSHA and discuss the mode of shallow earthquakes and possible mechanisms of their seismogenesis with examples of damaging earthquakes. Recent studies of SCR earthquakes show that these very shallow earthquakes emerged as a source of exceptional ground acceleration near the causative fault and likely unexpected hazards in SCRs. In addition, the distribution and depth of the rupture area can reflect variable geological conditions, tectonic force or anthropogenic contribution, and preexisting geological structure. These observations suggest that the fault-scaling relations relating surface measurements (length and displacement) to earthquake magnitude estimations, which were routinely used for PSHA, should be carefully used. Paleoseismic investigations have revealed surface rupture earthquakes in SE Korea. It is necessary to identify and characterize the causative geological structures in subsurface and the associated earthquake potentials. In the future, geological and geophysical analyses should characterize the distribution of the geological units, the tectonic history, and the seismogenic potential of the fault source for PSHA in SE Korea.

Keyword

shallow earthquake, stable continental region, fault source characterization, PSHA

Development of Earthquake Ground Motion Database in Korea

Sang-hyun Lee[1]*, Seoul National University (hiuni3@snu.ac.kr)
Junkee Rhie[2], Seoul National University

Abstract

The earthquake ground motion data plays a fundamental role as an important resource in seismic hazard analysis. The significance of seismic hazard assessment in South Korea was highlighted following consecutive earthquakes with magnitudes over 5 in 2016 and 2017. In this study, we developed a standardized database of earthquake ground motion in Korea by expanding the previous seismic motion database with additional data and refined data processing procedures. The database construction followed the methodology of the NGA-East Database from the Pacific Earthquake Engineering Research Center, adapted to South Korea's context. It includes comprehensive lists of earthquakes, observatories, observed accelerations, and seismic motion measurements from 2003 to 2022, focusing on earthquakes above local magnitude 3.0. The list of earthquakes is based on an authoritative public list from the Korea Meteorological Administration. Moment magnitudes were determined from various sources, including the annual report of the Korea Institute of Geoscience and Mineral Resources. The observatory list is derived from the National Earthquake Comprehensive Information System, incorporating site characteristics like VS30. Seismic motion data were meticulously collected and processed to obtain seismic motion measurements and Fourier amplitude spectra. The ground motion measurements of peak ground acceleration and Pseudo-Spectral Acceleration are calculated using the RotD50 method. The earthquake ground motion database is a significant resource for future earthquake research and seismic hazard analysis, expected to greatly contribute to the field.

Keyword

Korea, Ground Motion Database, Peak Ground Acceleration, Pseudo-Spectral Acceleration

The high frequency spectral decay in seismic station near nuclear power plant using S wave autopicking.

Arim HAN[1]*, KHNP (arimh0523@khnp.co.kr)
Sae Woon Choi[2], KHNP
Dong Hee Park[3], KHNP

Abstract

It is important to evaluate the site characteristics of each seismic station because the site effect significant impact on amplitude and frequency components of seismic waves depending on the site characteristics such as the velocity structure and density of the near-surface layer of the site.
Among the research methods to identify site characteristics, there is a method using the high frequency spectral decay parameter (κappa). Kappa was related to shallow velocity structure of the site and is an important input variable for ground motion simulation and seismic hazard analysis.
In this study, the site characteristics of a seismic station install near a nuclear power plant were analyzed through the analysis of the high frequency spectral decay (kappa) of seismic waves. Earthquakes that occurred after 2017 with 2.0 or higher magnitude in a radius of 150 km from the site were selected through signal-to-noise ratio, and S wave was autopicked using the envelope function. We calculated Kr using the extracted S wave, and then kappa was derived through regression analysis. In this study, the κR required to obtain kappa was calculated by two methods. First, κR was derived for each seismic data recorded at each seismic station, and then we calculated one kR by stacking all seismic data recorded at each seismic station. And then we derived kappa using regression analysis. Using this, we classified the seismic station level and compared them with previous research results.

Keyword

kappa, S wave, autopicking, high frequency spectral decay, site characteristic

Application of High-Dimensional Visualization Techniques for the development of Ground Motion Characterization Model for the Korean Peninsula

Sae-Woon CHOI[1]*, Central Research Institute of Korea Hydro & Nuclear Power Co., LTD
(choisewoon@khnp.co.kr)
Dong-hee Park[2], Central Research Institute of Korea Hydro & Nuclear Power Co., LTD

Abstract

One of the important aspects of developing a ground motion characterization (GMC) model for probabilistic seismic hazard analysis (PSHA) is quantifying epistemic uncertainty. A simple method is to select developed ground motion models (GMMs) and assign weights to it. However, since each GMM does not have same uncertainty for all frequencies, distances, and magnitudes, the simple method has limitations in capturing the center, body and range of epistemic uncertainties in GMMs. Therefore, it is necessary to individually evaluate a distribution of ground motion for each magnitude and distance. A useful method in this case is the High-Dimensional Visualization Technique. In this study, we used Sammon map, one of the High-Dimensional Visualization Techniques, to develop a ground motion characterization model for the Korean Peninsula. First, the GMMs developed for the Korean Peninsula was selected as the seed GMMs. Both of GMMs based on stochastic methods and empirical methods were included. After defining the ground motion space for magnitudes from 4.0 to 8.0 and distances from 1km to 1,000km, parameters such as mean and covariance matrix to create a continuous distribution of GMM were calculated. 5,000 GMMs were sampled using these parameters and a Sammon map was created. During this process, physically non-plausible sampled GMMs were rejected. The ground motion space of the Sammon map was divided into a total of 17 cells, and a representative GMM for each cell was derived. To derive the final GMC, the weight for the representative GMM was determined using the number of sampled GMMs included in each cell.

Keyword

Sammon map, Ground motion characterization, Ground Motion Model

Fault investigation through geomorphic analysis

Su-Ho JEONG[1]*, Structural Engineering Department, Korea Hydro & Nuclear Power (jsh.1212@khnp.co.kr)
Sambit Prasanajit NAIK[2], Active Fault and Earthquake Hazard Mitigation Research Institute, Pukyong National University
Young-Seog KIM[3], Department of Earth and Environmental Sciences, Pukyong National University

Abstract

Site investigation is essential to confirm the geological safety of nuclear facilities. Site survey is conducted to examine vatious impacts such as surface faulting, ground motion, sliding, etc. Among them, direct investigation of faults is especially important as it allows obtaining information such as slip-rate and recurrence interval, which is crucial for confirming geological safety. These pieces of information hold significant importance as they can be utilized as fundamental data for deterministic and/or probabilistic seismic hazard analysis.

To conduct a fault investigation, we need to locate the fault. In the case of the Korean Peninsula, the frequency of large magnitude earthquakes and fault slip-rate are low, and the original topography has been significantly altered due to high-density development, posing limitations on fault tracing. To overcome these limitations, we carried out geomorphic anaylsis(lineament extraction, analysis of geomorphic indices and Quaternary landforms classification) using vintage aerial photographs.

As a result of the investigation, a new fault was discovered in the Cheongun-dong area of Gyeongju City, and it was named 'Cheongun Fault' after the name of the area. Stratigraphic evidences recorded in trench sections indicate that the Cheongun Fault has been active at least three times since the Quaternary period. Additionally, based on the 14C and OSL age dating results, the lastest movement period and slip-rate of Cheongun Fault are estimated to be 37±4ka~4.2±0.4ka and around 0.02mm/yr respectively.

Keyword

Quaternary fault, intraplate, geomorphic analysis, surface rupture, earthquake hazard

Geological and Geotechnical Characterizations in the Arabian Gulf Coast

Yongwoo NOH[1]*, KEPCO E&C (major7700@naver.com)
Joohyeon YI[2], KEPCO E&C
Sungbin YIM[3], KEPCO E&C
Kyunghan SEO[4], KEPCO E&C

Abstract

The Arabian Plate is located in the Middle East of Asia and separated from Africa approximately 25 million years ago, resulting in the closure of the subducting Tethys sea in the northeast. The rifting of Africa and Arabia opened the Red Sea as well as the Gulf of Aden, bordering the plate on the southwest and southern sides respectively.

The Arabian Gulf is a foreland basin to the Zagros Fold and Thrust Belt (ZFTB), and is located within the tectonically stable craton of the Arabian Plate. The geology of the Arabian Gulf area has been substantially influenced by the deposition of marine sediments associated with numerous sea level changes during relatively recent geological time.

The geology of the Arabian Gulf coast area is characterized by flat-lying sedimentary rocks of predominantly the Miocene Shuweihat and Dam formations and the Eocene Dammam Formation, capped by clastic alluvial and colluvial sediments from the Arabian Shield known as the Baynunah and Hofuf formations. The Quaternary surficial sands are locally underlain by a thin, stiff clay layer that represents the completely weathered mudstone of the Shuweihat Formation.

All rock layers beneath the overburden soils are primarily carbonate dolomitic mudstone, siltstone, sandstone and gypsum. Gypsum beds are interspersed within the Shuweihat and Dam Formations, but represent a small percentage of rock and are confined within thicker beds of mudstone and sandstone. It is reported that the typical adverse effects of gypsum are subsidence due to dissolution and heave due to expansion. The subsurface is divided into engineering layers with distinct physical properties.

In this study, geological setting, main stratigraphic units, typical geotechnical profile, and engineering properties of the Arabian Gulf coast area are presented through field investigation and literature studies.

Keyword

Arabian Plate, Salt Tectonic, Gypsum, Engineering Properties

On a numeric and interactive database for Algerian historical earthquakes

Radia KHERCHOUCHE[1]*, Centre de Recherche en Astronomie Astrophysique et Géophysique CRAAG (radia.kherchouche@gmail.com)
Khaled Roubeche[2], Centre de Recherche en Astronomie Astrophysique et Géophysique CRAAG
Redouane Chimouni[3], Centre de Recherche en Astronomie Astrophysique et Géophysique CRAAG
El-Mahdi Tikhamarine[4], Université de Ferhat Abbas Sétif 1
Yasmina Rouchiche[5], Centre de Recherche en Astronomie Astrophysique et Géophysique CRAAG
Amal Sebai[6], Centre de Recherche en Astronomie Astrophysique et Géophysique CRAAG

Abstract

The study presents the conception and development of a comprehensive numeric and interactive database dedicated to cataloguing historical earthquakes. Understanding the historical seismic activity of a region is crucial for assessing current and future seismic hazards. The database will be an update of the Earthquake Catalogue for Eastern Algeria (ECEA) (Harbi et al., 2010) by determining the location, intensity magnitude MI, and focal depth of historical earthquakes by using the macroseismic data available in the Algerian Homogenized Macroseismic Database (AMD), compiled and published by (Harbi et al., 2015) (https://users.ictp.it/~naget/PUBLICATIONS/resources/AMD.pdf).

The interactive nature of the database allows users to explore and analyse earthquake data dynamically. Users can access a wealth of information, such as the time, location, magnitude, and depth of each earthquake, providing a detailed historical perspective on seismic events. Additionally, the database incorporates advanced visualization tools, enabling users to generate maps, charts, and graphs to better comprehend the spatial and temporal distribution of earthquakes.

The database's user-friendly interface makes it accessible to a wide range of users, including researchers, policymakers, and the public. By promoting transparency and collaboration, the database serves as a valuable resource for advancing our understanding of historical earthquakes and enhancing earthquake resilience in Algeria

In conclusion, the numeric and interactive database represents a significant step forward in consolidating and presenting historical earthquake data. Its multidimensional approach provides a comprehensive tool for researchers to navigate and interpret seismic information effectively, ultimately contributing to the advancement of earthquake research and for assessing current and future seismic hazards.

References:

Harbi, A., Sebaï, A., Benmedjber, M., Ousadou, F., Rouchiche, Y., Grigahcene, A., ... & Ayadi, A. (2015). The Algerian homogenized macroseismic database (267–1989): a deeper insight into the Algerian historical seismicity. Seismological Research Letters, 86(6), 1705-1716.

Harbi, A., Peresan, A., & Panza, G. F. (2010). Seismicity of Eastern Algeria: a revised and

extended earthquake catalogue. Natural hazards, 54, 725-747.

Keyword

Historical earthquake, earthquake parameters, Algeria, Database, Software

Role of the Main Himalayan Thrust in generating earthquakes in the Himalaya

Devajit Hazarika[1]*, Wadia Institute of Himalayan Geology, Dehradun
(devajithazarika@gmail.com)
Monika Wadhawan[2], National Centre for Seismology, Ministry of Earth Sciences, New Delhi, India
Somak Hajra[3], Department of Physics, University of Alberta, Edmonton, T6G2M8, Canada
Naresh Kumar[4], Wadia Institute of Himalayan Geology, Dehradun

Abstract

The strain energy originated due to the India-Asia collision largely accumulates in the detachment plain or the Main Himalayan Thrust (MHT) that separates the downgoing Indian plate from the overriding Himalayan wedge. The MHT produced several major and great earthquakes in the Himalaya. Several researchers reported the presence of a ramp structure in the MHT in the Himalaya which is responsible for generating earthquakes. Thus, to understand the geometry of the MHT at depth and its relationship with seismicity, we carried out passive seismological studies in different segments across the Himalaya. Here, we present the passive seismological experiment carried out across two segments of the Himalaya i.e. Satluj and Kali River Valley of the NW Himalaya based on receiver function (RF) analysis.

The RF imaging in the Satluj valley suggests a gentle dipping nature of MHT from south to north between the Sub and Higher Himalaya in contrast to the ramp structure in the Garhwal, Kumaon, and Nepal Himalayas, while the ramp structure is identified further north beyond the South Tibetan Detachment. The depth of the MHT varies from ~16 to 27 km across the Sub, Lesser, and Higher Himalaya, and it increases to ~38 km beneath the Tethyan Himalaya forming a ramp. The crustal thickness varies within the range of ~44-62 km. The change in the location of the MHT ramp can be attributed to the effect of underthrusting Delhi-Hardwar Ridge, a transverse structure to the Himalayan arc. Conspicuously, no strong or large earthquake is observed during 1964–2023 in this segment of the Himalayan Seismic Belt suggesting a ramp-seismicity linkage.

On the other hand, the RF image along the Kali River Valley of Kumaon Himalaya shows a ramp (∼20◦) structure on the MHT beneath the Chiplakot Crystalline Belt (CCB) that facilitates the exhumation of the CCB. A cluster of seismicity coincides with the location of the ramp structure. The presence of steep dipping imbricate faults inferred from focal mechanism solutions suggests a Duplex structure in the CCB. The crust is observed to be thinner (~38-42 km) compared to other parts of NW Himalaya. The study reveals a low-velocity zone (LVZ) with a high Poisson's ratio (σ ∼0.28–0.30) at lower crustal depth beneath the CCB suggesting the presence of fluid/partial melt. Both experiments emphasize the effect of the ramp structure of the MHT in the generation of earthquakes in the Himalaya.

Keyword

Crustal Imaging, Main Himalayan Thrust, Seismicity

Imaging the Aegean crustal structure using P and S phase travel times

Pratul RANJAN[1]*, CSIR-National Geophysical Research Institute (NGRI), Hyderabad, India (pratulranjan@ngri.res.in)
Konstantinos I. Konstantinou[2], National Central University, Taiwan
Prakash Kumar[3], CSIR-National Geophysical Research Institute (NGRI)

Abstract

We performed P and S wave velocity tomography of the Aegean crust using travel-times of 2,135,625 P arrivals and 1,095,515 S arrivals from 178,676 earthquakes recorded across 324 stations. Several resolution and robustness tests helped discern areas with good resolution, where results can be considered reliable. These areas include the gulf of Corinth and the Kefalonia Transform Zone, active volcanoes and the regions along the fore-arc. From the tomography results and the final earthquake locations, the structural variations in the Aegean crust, possible fluid induced seismicity, porosity beneath active volcanoes, as well as the structures near the source zones of large earthquakes have been analyzed. The results show that the Aegean crust-mantle boundary exists as a transition zone and the crust is composed of three main lithological units: extremely low velocity sediments, low velocity silicic units, and high velocity metamorphic units. The porosity modeling indicates Santorini may have the highest melt-fraction out of all the volcanoes in the Aegean, which agrees with the high rate of volcanism at this volcano. Source zones of several large earthquakes (Mw > 6) indicate high Vp/Vs, which suggests an important role played by fluids in their nucleation. The 3D model thus obtained will help in the accurate relocation of crustal seismicity as well as detailed study of source zones of future large earthquakes. This study will also help in the assessment of seismic hazard in the region.

Keyword

Tomography, Aegean, Volcanoes, Large Earthquakes, Hellenic Subduction Zone

Automatic earthquake detection using open source software

Nomin-Erdene ERDENETSOGT[1]*, Institute of Astronomy and Geophysics of Mongolian Academy of Sciences (nominerdene@iag.ac.mn)
Gylfi Pall Hersir[2], GRO-GTP

Abstract

Earthquake location is the first step in seismological studies. Many countries have their own seismological monitoring center. They monitor earthquake activity and help with related warnings in their respective countries. One of the important elements in monitoring earthquake activity is locating earthquakes accurately. Operators usually work around the clock to locate earthquakes and create a database of events. It is hard work that requires a lot of manpower and time. Recently, due to the development of technology, it became possible to automatically detect and locate earthquakes. Automatically detecting earthquakes helps to reduce the workload of operators and research can consequently start earlier. Many algorithms have been developed in terms of detecting and locating earthquakes. One such algorithm is QuakeMigrate. QuakeMigrate is a Python package for automatic earthquake detection and location system (Hudson, 2019). This package scans coherent seismic phase arrivals across a network of instruments using a stacking algorithm and waveform migration. Through this paper the QuakeMigrate tested for the first time at Icelandic and Mongolian database by processing a real seismic data acquired at each country. The test was done by reliance a simple processing flow and the application was successful. Pick errors were around 0.08 to 1 s. The depth distribution was between 2 and 15 km which was reasonable compared to the seismicity of the area.

Keyword

Automatic detection, QuakeMigrate, stacking algorithm, waveform migration, earthquake

Ambient noise levels and their effects on the Pohang Community Seismograph Network (PCSN), South Korea

Yujin Sohn[1]*, Department of Geological Science, Pusan National University (yujinsohn@pusan.ac.kr)
Kwang-Hee Kim[2], Department of Geological Science, Pusan National University, Busan, Republic of Korea
Tae-Seob Kang[3], Division of Earth Environmental System Science, Pukyong National University, Busan, Republic of Korea
Byung Seok Ahn[4], Division of Earth Environmental System Science, Pukyong National University, Busan, Republic of Korea
Dabeen Heo[5], Division of Earth Environmental System Science, Pukyong National University, Busan, Republic of Korea
Hyungjin Jeon[6], TerraEG, Seoul, Republic of Korea

Abstract

A seismograph not only captures signals from earthquakes but also records background noises simultaneously. The data quality of a seismograph network, thus, is highly influenced by ambient noise which exhibits variations influenced by factors including, but not limited to, cultural activities, weather conditions, spatiotemporal changes, and installation depths. These fluctuations in ambient noise levels have a direct impact on the earthquake detection capabilities of the seismograph network. This study analyzes ambient noise variations within the Pohang Community Seismograph Network (PCSN), a dedicated seismograph network to monitor continued seismicity since the 2017 MW 5.5 Pohang earthquake. The earthquake was the most damaging in Korea since the initiation of instrumental seismic recording in 1905. At least one person was killed and 134 injured, and ~1,700 people stayed at emergency shelters. Notice that the source area never experienced significant earthquakes in the historical and instrumental seismic observation period. Although the number of earthquakes and their magnitudes are steadily decreasing, ongoing small and shallow seismicity has been a major concern to the local community and government. Utilizing data from twenty broadband seismometers on the surface and two sensors in a downhole array (one at 2.5 m depth and the other at 500 m depth below the surface), we have assessed variations in the power spectral density (PSD) and their implications. We categorized stations in rural, urban, and coastal areas and discussed results across four different period ranges: very short-period (less than 0.02 seconds), short-period (0.02-1 seconds), long-period (1-10 seconds), and very long-period (more than 10 seconds). In the very short-period range, noise from weather conditions, such as precipitation, occasionally elevates background noise levels on surface seismometers. Our results also indicated the rainfall events did not impact the ambient noise level at 500 m depth. From 0.02 to 1 second, cultural noise generated by human activities is predominant, with noise levels ranking higher in coastal areas, followed by urban and rural areas. Notably, in the period range crucial for monitoring microearthquakes (0.07-0.2 seconds), urban areas exhibit significantly higher noise levels (14-48 dB) compared to coastal or rural areas. In the period range of 1-10 seconds, a peak in probability density functions (PDF) is noticeable, which is

known as a secondary microseism or double-frequency peak in global noise observations. Noise levels increased across all seismometers as typhoon Hinnamnor approached in early September 2022, and reached a peak when the typhoon passed the Pohang region. After the typhoon passed the region, the PSD began to decrease and stabilize. Last not the least, in the very long-period range, horizontal components are noisier than the vertical component by 20-40 dB, attributed to the effects of ground tilt. Recently compiled PCSN earthquake catalog also demonstrates the effect of background noise on the earthquake detection capability. During nighttime and daytime, the number of detected earthquakes under the magnitude of completeness (Mc = 0.34) was 53 and 5 events, respectively. These findings underscore the importance of considering background noise levels and strategic deployment locations for effective microearthquake observation in the Pohang region.

Keyword

Ambient noise analysis, Pohang earthquake, Seismograph network, Power spectral density, Earthquake detection capability

IMPLICATIONS ON THE PALEOSEISMICITY IN THE PRECAMBRIAN INTRACRATONIC BASINS: CASE STUDY OF THE BALTIC SEDIMENTARY BASIN

Jurga LAZAUSKIENĖ[1]*, Vilnius University (jurga.lazauskiene@chgf.vu.lt)
Albertas Bitinas[2], Nature Research Centre
Gražina Skridlaite[3], Nature Research Centre

Abstract

The central part of Baltic sedimentary basin is characterized by rather seismic activity, still, several tens (~ 40) of historical earthquakes of small scale with intensities of VI-VII points (MSK-64 scale) are described and instrumentally recorded (magnitudes up to M-5) in the region and adjacent territories since year 1303 (Pačėsa et al., 2005). Historical seismic activity in the central part of Baltic sedimentary basin is significantly lower comparing with seismicity of Fennoscandian shield. High seismic activity of Fennoscandian shield and adjacent Baltic Sea territories during the Late Glacial and Holocene (last 13 000 years) is well documented by numerous paleoseismic investigations and corresponding publications. The earthquakes coused landslides in glacial till, seismically-induced soft sediment deformation structures, “seismites”, are common in trench exposures in the vicinity of the faults in northern Sweden and even with tsunami events reported in the Baltic Sea (Bitinas et al., 2021).

The resent studies of soft-sediment deformation structures central part of Baltic sedimentary basin demonstrated that their formation also could have been caused by liquefaction of sediments possibly triggered by palaeo-earthquakes; thus, they could be identified as seismites.

A distribution of seismic activity in the central part of Baltic sedimentary basin could be attributed to several factors, predominantly related to the lithospheric geodynamic processes and variations of rheological properties of lithosphere within the study area. The seismic activity has an irregular distribution – the northern part of the region is more seismically active than the southern one, but still is higher to compare with more inland cratonic areas. It is difficult to associate single earthquakes with some certain faults unambiguously due to significant errors of location of seismic events and location of faults. Moreover, not all the earthquakes in the central part of Baltic sedimentary basin are related to fault zones. An identification of the seismogenic faults is also rather complicated due to the small scale of tectonic structures in the intracratonic area.

A part of seismites could be attributed to the seismic events triggered by glacio-isostatic adjustment of the lithosphere during the Last (Weishselian) glacial advance. The detailed overview of soft-sediment deformation structures of possibly seismic origin discovered in the several sites of Estonia, Latvia, Lithuania, Belarus and Kaliningrad District of Russia is presented. A number of the geological structures early interpreted as cryoturbations, glaciotectonic features or so-called water-escape structures, clearly shows all the characteristics of the liquefaction-inducted sediment deformations. Such a structures have been distinguished and described in a number of localities in Estonia, Latvia, Lithuania and Belarus (Bitinas et.al, 2021). Majority of

these seismites were formed during the Late Glacial and Holocene times, and several of them are related to Middle Pleistocene, Eemian Interglacial and Early Weichselian strata.

Keyword

paleoseismicity, Baltic sedimentary basin, historical seismicity, glacially trigerred faults, seismites

Vector Autocorrelation and Cross Correlation for Resolution Improvement of Apparent Source Time Function

Ying-Ju Lai[1], Institute of Earth Sciences, Academia Sinica
Wu-Cheng Chi[2]*, Institute of Earth Sciences, Academia Sinica (chigeophysics@gmail.com)

Abstract

To understand spatial distribution of the crustal dislocation (earthquake source), we use seismic waveforms to study a moving source and the associated Doppler shift. Such a Doppler effect at some sites may be affected by site (observatory) effect, instrument filters, radiation patterns, and path effects. Therefore, apparent (relative) source time function which reduces these effects from mainshock seismogram is conducted by deconvolution by an aftershock. In order to study the rupture process of the mainshock, we used the aftershock as an empirical Green's function, which has been done by many excellent previous works. However, the derived apparent source time functions sometime are strongly affected by the picked starting time of the P waves. For our new approach, the mainshock data are automatically picked by the vector autocorrelation function of three-dimensional ground motions. Through the self-similarity (e.g. vector autocorrelation>0.34) and the cross similarity (e.g. vector cross correlation>0.95). We found that the uncertainty of apparent source time is suppressed so we can get better resolution of the rupture dimension. We have tested this new code using an example of Mw5.66 thrust and Mw4.62 aftershock. Even the empirical Green's function is replaced by farther and smaller aftershocks, the results are still very robust. The self-similarity and the cross similarity can be automatically processed and might help empirical Green's function research.

Keyword

seismology, cross correlation, empirical Green's function, apparent source time function, Doppler effect

Estimation of seismic source parameters and high-frequency attenuation characteristic (Kappa) using microearthquake data in the southeastern Korean Peninsula

BYEONG SEOK AHN[1]*, Pukyong National University (11196abs@gmail.com)
TAE-SEOB KANG[2], Pukyong National University
DABEEN HEO[3], Pukyong National University
HYUN JAE YOO[4], Pukyong National University

Abstract

We investigated the relationship between seismic source parameters (seismic moment, corner frequency, and stress drop) using source spectrum analysis of microearthquakes. We utilized S-wave data from approximately 5,300 microearthquakes detected by a seismic network installed in the Pohang region in the southeastern Korean Peninsula. S-wave arrival times manually picked were used to extract the S-wave domain, followed by baseline correction and instrument response removal. Finally, transverse components calculated from the two horizontal components were utilized in the analysis. After obtaining observed spectra through the Fast Fourier Transform, de-noised spectra with pre-event noise amplitudes removed were used for source spectrum calculation. An averaged source spectrum, calculated from source spectra at each station, was employed for source parameter estimation. Stress drop was found to be proportional to seismic moment at low seismic moments (~1014 N-m), contrary to the commonly known fact that stress drop is regionally specific regardless of magnitudes. Additionally, we estimated the high-frequency attenuation characteristics (Kappa) using two methods: source spectrum fitting and measurement of high-frequency slopes of acceleration spectra. Then, we reevaluated the source parameters after correcting for the site attenuation effects of source spectra by using Kappa estimates. By examining changes in the distribution pattern of the source parameters from the corrected observation spectra, we investigated the effects of applying Kappa on source parameter estimation for microearthquakes.

Keyword

Seismic source parameter, Microearthquake, Kappa

Seismic Noise in the Deep Underground Seismic Laboratory (JSTB): Influences from Mining Activity, Typhoons, and Precipitation

Do Woon KIM[1]*, Standards Certification Division, Korea Meteorological Institute (rlaehdns77@gmail.com)
Kwang Hee KIM[2], Department of Geological Science, Pusan National University, Busan 46241, Republic of Korea

Abstract

Yemilab is an underground laboratory situated within the active mining operations of Sinyemi Mining, located in Sindong-up, Jeongseon-gun, Gangwon Province, South Korea. Since July 2021, the Korea Meteorological Administration (KMA) has established and operated the "Jeongseon Special Observation Station (JSTB)" within the Yemilab, dedicated to earthquake observation, research, and comprehensive seismic instrument tests. The station has been integrated into the Korea National Seismograph Network (KNSN) operated by KMA. Operating at a depth exceeding 600 meters below the surface, JSTB stands out as one of the deepest stations within the KNSN. Understanding ambient noise is crucial for assessing frequency-dependent noise levels and ensuring data quality for seismic stations. Given the variable noise sources from nearby mining and blasting activities, it becomes imperative to characterize and comprehend the background noise levels for reliable seismic signal analysis. This study employs the Probability Density Function (PDF) method developed by McNamara and Buland (2004) to analyze the background noise at JSTB. Comparisons with neighboring seismic observation stations shed light on the distinctive characteristics of this deep observation station. Daily and weekly Power Spectral Density (PSD) Probability Density Functions (PDFs) effectively highlight elevated noise levels attributable to mining activities. In contrast, when compared with PSDPDFs from nearby seismic observations, the study reveals comparable effects of typhoons on seismic noise levels among stations. Interestingly, the impact of precipitation on background noise levels at JSTB is found to be minimal.

Keyword

Seismic Noise Level, Underground Laboratory, Mining Activity, Typhoon, Precipitaion

Determining Hypocenter of recent earthquakes in South Korea using the 3D velocity structure model and Antelope DB

Yeongjae CHOI[1]*, Korea Meteorological Administration(KMA) (yeongjaee1@gmail.com)
Kyungmin Min[2], Korea Meteorological Administration(KMA)
Mikyung Choi[3], Korea Meteorological Administration(KMA)
Eunyoung Jo[4], Korea Meteorological Administration(KMA)
Sun-Cheon Park[5], Korea Meteorological Administration(KMA)

Abstract

The Korea Meteorological Administration (KMA) performs real-time earthquake monitoring and earthquake analysis using Antelope software. For estimating a hypocenter and developing the accuracy of earthquake information, it is significant to analysis the complicated seismic waveforms. The seismic propagation is affected by the medium, so the velocity structure model reflected these effect is utilized. When analyzing a hypocenter, the 1D velocity model considers only vertical change, but the 3D velocity model contemplates spatial change, not only vertical change but also horizontal change. The 3D velocity model has more regional and geological properties than the 1D velocity model, so the accuracy of the hypocenter determination is improved. The 3D velocity model is one of the results of the subsurface fault and velocity structure model project and construct to use three different surface velocity model set using ambient noise. This study utilizes NonLinLoc program that can apply the 3D velocity model and constructs a system to determine the hypocenter through Antelope Database. In this study, the earthquakes around the southern Korean Peninsula are selected with the magnitude greater than 2.0 from January, 2022 to November, 2023. The accuracy of hypocenter result using 3D velocity model is investigated through the uncertainty, and the hypocenter result using 3D velocity model is compared with the result using 1D velocity model. The difference in hypocenter is greater in the sea than in the inland. The earthquake occurred in the inland does not show significant change in epicenter, but difference in depth. It provides that the 3D velocity model has more information spatially and is more constraint than 1D velocity model. However, the earthquake occurred in the sea shows differences in both depth and epicenter. Since the uncertainty of various hypocenter determination factor for sea earthquakes exists, such as station gap, additional research is requisite to improve the result.

Keyword

3D velocity model, hypocenter, Southern Korea Peninsula

A Study on Earthquake Detection and Intensity Analysis Using High-Density MEMS Observation Network

EUNA PARK[1]*, Korea Meteorological Administration(KMA) (eunapark@korea.kr)
Hye-Won Lee[2], Korea Meteorological Administration(KMA)
Eui-Hong Hwang[3], Korea Meteorological Administration(KMA)
Sun-Cheon Park[4], Korea Meteorological Administration(KMA)

Abstract

Earthquake early warning(EEW) uses the difference in propagation velocity between P waves and S waves to determine the occurrence of an earthquake with P waves detected at each station. It informs the occurrence of an earthquake before the S wave, which causes damage by large shaking, arrives. The Korea Meteorological Administration(KMA) has been operating the nationwide EEW service since 2015. The best way to shorten the warning time is to increase the density of the seismic observation network. Currently, the national earthquake observation network in Korea is very dense and at an excellent level worldwide, but a denser seismic observation network has been established to give better earthquake information to the people. Since the existing fixed observation network has limitations in that the expansion cost is high and maintenance is difficult, a low-cost MEMS(Micro-Electro Mechanical Systems) sensor with a built-in accelerometer has been newly designed. A high-density seismic observation network using the MEMS sensor has been established and is being operated for research. As of February 2024, the MEMS observation network is about 5200 sensors. The earthquake detection of the MEMS observation network uses only the MEMS observation network alone and is carried out in real time. It normally determines the occurrence of an earthquake (inland earthquakes of magnitude 3.5 or greater and sea earthquakes of 4.0 or greater) that correspond to the earthquake breaking news among the earthquake notification criteria of the KMA, and determines the occurrence of an earthquake several seconds faster than the analysis of the EEW system. It is also possible to calculate detailed intensity information using MEMS sensors. The PGA(peak ground acceleration) is observed to be higher than the seismometer due to the influence of the structure because the MEMS sensor is basically installed on the wall of the building and is installed at a height of more than one floor. The PGA by observed MEMS sensors and seismometers installed at the same location were compared for the appropriate intensity combination of MEMS sensors and seismometers. In addition, we intend to prepare an optimal intensity combination plan by comparing the PGA observed on the seismometer and the PGA observed on the MEMS sensor that applied the transfer function to correct the surface amplification effect of the borehole station.

Keyword

MEMS, high-density observation network, Earthquake detection

Case study on maximum seismic amplitude estimation for high-rise structures

Keun-Joo SEO[1]*, Korea Meteorological Administration (kjseo214@gmail.com)
Eui-Hong Hwang[2], Korea Meteorological Administration
Hye-Won Lee[3], Korea Meteorological Administration
Sun-Cheon Park[4], Korea Meteorological Administration

Abstract

Estimating maximum seismic amplitude is crucial for predicting earthquake damage and preparing appropriate responses. In South Korea, seismic intensity, utilized in earthquake alerts, is calculated based on the maximum ground motion. However, most individuals experience earthquake vibrations within buildings, where the structure's characteristics such as building shape, height, and construction material amplify ground vibrations. To estimate maximum amplitude experienced within structures during earthquakes, a method that utilizes ground motion data is essential. For this purpose, we employed the multi-degree-of-freedom (mDOF) model, which accounts for the nonlinear behavior of structures based on their height. This model is divided into elastic and inelastic components and was utilized to estimate amplitude ratios in upper levels of structures through simulations using various input seismic ground motions. The results of these analyses were compiled into tables presenting averages and standard deviations, thus termed as the detailed method. To validate the results of our model, seismic records were collected from accelerometers installed both at ground level and upper parts of high-rise structures. Collected data from the Ministry of the Interior and Safety (MOIS) in South Korea were gathered for domestic seismic events, primarily consisting of mid-sized earthquakes and focused on government buildings over 9 stories. To enhance the diversity of verification data, seismic information on earthquakes of varying magnitudes and structural heights was collected from international databases such as CESMD and BRI. Validation of the detailed method results revealed a significant alignment with actual amplification ratios across most datasets. However, inconsistencies were observed in cases where small earthquakes resulted in reduced seismic amplitude in the upper parts of buildings, indicating a need for further refinement. Despite these challenges, the detailed method demonstrated suitability for estimating maximum amplitude in high-rise structures during significant earthquakes. Nonetheless, future research endeavors aim to establish criteria for applying the estimation methods, particularly concerning seismic amplitude of ground motions, through comprehensive case studies.

Keyword

high-rise structures, seismic amplitude estimation, seismic intensity

Surface-to-borehole Site Correction: Assessing the suitability of transfer function

JeongYoon OH[1]*, Korea Meteorological Administration (ovita17@korea.kr)
Hye-Won Lee[2], Korea Meteorological Administration
Keun-Joo Seo[3], Korea Meteorological Administration
Eui-Hong Hwang[4], Korea Meteorological Administration
Sun-Cheon Park[5], Korea Meteorological Administration

Abstract

During an earthquake, the ground motion experienced by people on the surface or inside buildings results from a convolution of the earthquake source, path effect, and site effect. Even in areas situated at an equal distance from the earthquake's epicenter, ground motion may vary depending on the characteristics of the area. Therefore, it is necessary to understand the geological characteristics of the station site and to analyze the effect of site-specific conditions on seismic data.

Most of the seismic stations operated by the Korea Meteorological Administration are installed in bedrock, minimizing the impact of background noise and advantageous for earthquake detection. However, because these stations do not consider the site effect from installation depth to the surface, the ground motion of earthquakes recorded by the downhole stations is lower than those recorded by surface stations. Therefore, in order to accurately estimate the intensity of an earthquake as felt by people, prior research on correcting the borehole record based on surface observations is necessary.

The Korea Meteorological Administration applies the amplification coefficient presented in Borcherdt (1994) to correct the observed amplitude in borehole seismometers to the surface level. However, since this amplification coefficient was developed for the western United States, it may not accurately represent the regional characteristics of the Korean Peninsula. Furthermore, as proposed by Lai et al. (2022), a method has been suggested for correcting borehole earthquake data using the amplitude ratio between borehole and surface. Nevertheless, seismic data collection is challenging due to infrequent earthquakes on the Korean Peninsula and the most seismic stations are borehole-type. Accordingly, a correction technique has been developed through a transfer function, which applies background noise recorded simultaneously between borehole and surface installations by temporarily placing a seismometer on the surface (Lim and Ahn, 2023).

In this study, the transfer function method was applied to approximately one hundred borehole seismic stations, and the geological information from these borehole seismic stations was classified based on the soil classification provided by the Ministry of the Interior and Safety. Using the method proposed by Lai et al. (2022), we compared four types of seismic data: raw borehole data, borehole data corrected by applying the transfer function and site amplification model, data from a temporary surface seismometer that operated from November 2023. Additionally, station-specific averages were calculated based on the comparison results of the seismic data. Moreover, site characteristics, including bedrock depth and soil shear wave velocity,

were estimated at each borehole seismic station site.

Keyword

site effect, seismic station, transfer function, Site Correction, borehole seismic station

Research on the identification of micro-seismic events in the Kangping area of Liaoning province based on random forest.

Zihao LI [1]*, Liaoning Earthquake Agency (772004380@qq.com)

Abstract

Efficient and accurate identification of earthquake occurrences is crucial for earthquake prediction and safeguarding lives and property. Presently, earthquake distinction heavily relies on manual interpretation, necessitating the development of more effective technical approaches to enhance identification accuracy. This research selected 634 Kangping mine earthquake incidents and 942 non-mine earthquake incidents in the Kangping region based on the nationwide unified catalog database. The seismic characteristics, including waveforms and spectra, were extracted to develop the Kangping mine earthquake random forest classification model (RFC). Upon training the model with optimal parameters (n_estimators=407, max_features=7), the prediction accuracy achieved 0.761954262 (Precision=0.743243243, Recall=0.949500263, F1_score=0.833805774). Subsequently, the trained RFC model was employed to differentiate and classify seismic waveform data collected by 8 stations in Liaoning Kangping and surrounding regions from 2014 to 2023 over a decade, identifying 783 previously missed microseismic events, six times the count recorded in the seismic network center's catalog. The identified missed earthquakes were precisely located, examined, and validated, exhibiting a correlation of 0.8532 with the mine earthquake incidents cataloged in the nationwide unified catalog database template. The technical approach introduced in this study effectively filters out manually misidentified mine earthquake occurrences, boosts the identification precision of mine seismic events, and offers a solid data foundation for investigating earthquake activity and seismic monitoring.

Keyword

Identification of Mine Seismic Events, Kangping area, Machine Learning

Impact of data fidelity for double-difference relocation: A case study of the Kiskatinaw microseismic monitoring, British Columbia, Canada

Suhee PARK[1]*, Division of Earth Environmental System Science, Pukyong National University (suhee2308@gmail.com)
Dabeen Heo[2], Division of Earth Environmental System Sciences, Pukyong National University
Tae-Seob Kang[3], Division of Earth Environmental System Sciences, Pukyong National University
Junkee Rhie[4], School of Earth and Environmental Sciences, Seoul National University
Seongryong Kim[5], Department of Earth and Environmental Sciences, Korea University
Sang-Jun Lee[6], Department of Earth Science Education, Korea National University of Education
Jan Dettmer[7], Department of Geoscience, University of Calgary

Abstract

Determining the accurate hypocenter of an earthquake is important for identifying and understanding the geological structures that caused seismic events. For this purpose, methods such as hypoDD, which analyzes the correlation between event pairs to determine their relative hypocenters, are widely used. However, determining the relative hypocenters is influenced by various factors, such as the parameters for inversion and differential time data and type of phases. We conducted a parameter tuning experiment for the double-difference relocation method to determine the relative hypocenters using the earthquakes that occurred in the Kiskatinaw area of northeastern British Columbia, Canada. The seismic activity in the Kiskatinaw area has significantly increased due to fluid injection for the development of unconventional resources since the early 2000s. We constructed an initial earthquake catalog of the Kiskatinaw area for 2020 using seismic data from the EON-ROSE and GSC-BCOGC seismic networks. We simplified the 1-D velocity model provided by the BC Energy Regulator based on the geological stratigraphy of the Kiskatinaw area and utilized it to determine the hypocenters. We detected events using an automatic algorithm based on the short-term-average to long-term-average ratio (STA/LTA) and kurtosis method. Then, we refined the phase arrival times through visual inspection and determined absolute hypocenters of the detected events using the Hypoinverse location algorithm. We used the hypoDD algorithm to relocate the relative hypocenters of the initial event catalog. To minutely refine the relative hypocenters, we tried to optimize the parameters for inversion and those for differential time data and type of phases. The parameters of clustering did not significantly influence the location determination, whereas parameters for the inversion affected the number of earthquakes and hypocenters. Using both P and S phases for relocation can better constrain the hypocenter than using either one. Cross-correlation analysis of waveforms is also more effective in determining relative location than using phase-picking results. By considering these factors in the input information, we can expect more concentrated relative location results at the depth where the fluid injection is most active for most events. However, the variation in these input parameters did not significantly affect the relative locations in this study. Instead, modifying the weighting parameters had a greater impact on the results. This occurrence can be explained by the accuracy of the input data utilized in this study rather than being a general characteristic of all

relative location studies. In other words, this study highlights the high accuracy of the phase-picking results obtained through preliminary analysis. This finding suggests that when using phase-picking data with verified sufficient accuracy, optimizing the weighting parameters used in a relative location study is more important than optimizing the parameters related to the input data themselves.

Keyword

microseismic, Kiskatinaw, injection-induced earthquake

Tracking Typhoon Hinnamnor (2022) using microseism recorded at CTBTO seismic array

Yunah KIM[1]*, Chonnam National University (kyuna@jnu.ac.kr)
Dong-Hoon Sheen[2], Chonnam National University

Abstract

Typhoons in the ocean create ocean waves, and the energy of the ocean waves generates microseisms. Secondary microseism (SM) or double frequency microseism is known to be generated by nonlinear interaction between opposite ocean waves with similar wavenumbers (Longuet-Higgins, 1950), and SM generated by typhoons can be categorized into three classes according to their generation mechanism (Ardhuin et al., 2012). The source region of SMs generated by typhoons changes with the movement of the typhoon. Therefore, SMs can be used to track the path of the typhoon. In this study, we tracked the path of Typhoon Hinnamnor which developed in the Pacific Ocean from August 27 to September 06, 2022, using microseisms. SMs generated by Typhoon Hinnamnor were observed at coastal and island seismic stations near the typhoon's track, as well as at the Comprehensive Nuclear-Test-Ban Treaty Organization (CTBTO) seismic arrays in Asia and Australia, which are far from the track. We investigated the variations in the power spectral density of SMs and compared them to significant wave heights from Wave Watch III. The back azimuth of SM was obtained from frequency-wavenumber analysis of CTBTO seismic arrays (PETK, SONM, USRK, KSRS, MJAR, LZDM, CMAR, WRA) in the frequency band of 0.1 - 0.5 Hz, where the spectral energy of the SM was clearly visible, which was used to track the source region of the SM using a triangulation method. Then we compared the estimated source region of the SM with the best track of Typhoon Hinnamnor provided by the Joint Typhoon Warning Center (JTWC).

Keyword

secondary microseism, typhoon, CTBTO seismic array, frequency-wavenumber analysis

Estimating Moment Magnitudes of Certain South Korean Macroseismic Events

SUNGSU KIM[1]*, KEPCO International Nuclear Graduate School (suya917@naver.com)
Yee Eric[2], KEPCO International Nuclear Graduate School

Abstract

The Korean peninsula is one of the few regions in the world that has a written record of macroseismic events since the beginning of the first millennium. These events were compiled by the Korea Meteorological Administration and released as a publication log. Surprisingly, for a somewhat seismically stable region, the records show there have been several large magnitude earthquakes throughout the past two millennia. To better understand, and perhaps, constrain the seismicity in the region, an estimate of earthquake magnitudes from the macroseismic events as published the Korea Meteorological Administration would be needed. These magnitudes are estimated by comparing the macroseismic events to more modern instrument recorded earthquake events. These modern events have been locally recorded by the Korea Meteorological Administration as well as other international seismological agencies such as the Global Centroid Moment Tensor project. Preliminary results suggest that several older macroseismic events in the southern portion of the Korean peninsula displayed intensity measures larger than those exhibited by the more recent M 5.5 events, i.e. the 2016 Gyeongju and 2017 Pohang earthquakes. This would mark these earthquakes as events with magnitudes larger than M 5.5. Additionally, other factors being constant, this suggests the region is capable of producing events larger than M 5.5.

Keyword

Macroseismic Events, Magnitude Estimation, Korean Peninsula

Seismicity in the South Korean Region Across Two Millennia

SEUNGHEE YUN[1]*, Kepco International Nuclear Graduate School (yshjjjj@gmail.com)
YEE ERIC[2], Kepco International Nuclear Graduate School

Abstract

The seismic events in South Korea have sparked concerns about the region's seismicity, prompting a closer examination of historical earthquake data. Continued research and monitoring are essential for improving understanding and preparedness for seismic risks in the area. Due to important infrastructure, such as nuclear power plants and radioactive waste storage facilities, two specific events, the 2016 M5.5 Gyeongju and 2017 M5.5 Pohang earthquakes, have forced many to question the seismicity of the Korean peninsula. This is because prior to these events, few earthquakes with magnitude greater than M5.0 were recorded in South Korea. However, the time period of recorded events can be extended to get a better picture of the seismicity along the Korean peninsula. The Korea Meteorological Administration compiled a list of macroseismic events from 2 A.D. to 1904, and published the results as a log. This underutilized data source is combined with events from 1900 to present as recorded by the Korea Meteorological Administration, International Seismological Center, and Global Centroid Moment Tensor project to extend the earthquake catalog for South Korea. When evaluating this compiled data set via the Gutenberg-Richter law, we observe a difference in seismicity within South Korea. Results imply slightly higher levels of seismicity before 1900 and thus an overall increase in seismicity parameters considering two millennia.

Keyword

Seismic events, Historical earthquake data, Seismicity of the Korean peninsula, Korea Meteorological Administration, Gutenberg-Richter law

Comparing Acceleration and Velocity Horizontal-To-Vertical Spectral Ratios at South Korean Sites

Youngtaek HONG[1]*, KEPCO International Nuclear Graduate School (KINGS)
(hyt730@naver.com)
Yee Eric[2], Kepco International Graduate School

Abstract

The shear wave velocity of the upper 30 m of earth materials is a common parameter in understanding site-specific properties. This parameter is used in a variety of earthquake risk and seismological studies. One approach used to help estimate the shear wave velocity is the Horizontal-To-Vertical Spectral Ratio method. This method compares the ratio of vertical and horizontal response spectra to response spectra frequency. If there is a peak frequency, it is used to estimate a shear wave velocity for the site-specific materials. Typically, acceleration response spectra is used in this method. However, sometimes a peak cannot be identified and there is some curiosity as to whether using velocity response spectra may be a better as it would imply a velocity-to-velocity comparison. Site and ground motion data are obtained from the Korea Institute of Geoscience and Mineral Resources. Results show that there is a lack of local site-specific shear wave velocity data. Nonetheless, of the sites with both shear wave velocity and ground motion data, there did not appear to be a significant difference when acceleration or velocity response spectra were applied for a majority of the sites. An interesting observation was that for sites with similar shear wave velocities, the actual value of the Horizontal-To-Vertical Spectral Ratios were not the same in an absolute sense, but did produce peaks at similar frequencies.

Keyword

Shear Wave Velocity, Horizontal-To-Vertical Spectral Ratio, Response Spectra Frequency, Acceleration Response Spectra, Ground Motion

Comparing South Korean Earthquakes to Next Generation Attenuation West Ground Motion Models

Jungho KIM[1]*, KEPCO International Nuclear Graduate School (wbforever012@naver.com)
Yee Eric[2], KEPCO International Nuclear Graduate School

Abstract

For Seismic and earthquake risk studies, there have been few robust ground motion models dedicated to the South Korean peninsula. However, there have been many ground motion models developed around the world throughout the years. Some of the relatively more robust ground motion models have come from the Next Generation Attenuation West program at the Pacific Earthquake Engineering Research Center in the U.S.A. These ground motion models estimated ground motion shaking by correlating intensity measures to variables such as earthquake magnitude, distance, faulting mechanism, mean shear wave velocity in the upper 30m, as well as several others depending on the model developers. The ground motion models from the first rendition were released in 2008 and have proven to be slightly unique over time. These ground motion models estimated intensity measures using the geometric mean from the rotation of two horizontal axes, which fell out of favor due to specific calculation and directionality issues. The current method relies on rotation of one horizontal axis. An investigation on the performance of the 2008 versions of the ground motion models from the Next Generation Attenuation West program is made by analyzing the residuals from several recent South Koreans of moderate magnitude. Results suggest significant variation at close and far distances, but surprisingly acceptable performance at moderate distances. However, results also showed the differences between modern estimations of intensity measures from the original 2008 suite to be more than expected. These suggest that although the ground motion models from the 2008 version of the Next Generation Attenuation West program can be applicable to South Korea even though the base tectonic regime is different.

Keyword

South Korean Earthquakes, Ground Motion Model, Next Generation Attenuation West program, Intensity measures

Comparing Peak Frequency to Shear Wave Velocity Models in South Korea

Joohwan CHA[1]*, KEPCO International Nuclear Graduate School (cha480@naver.com)
Yee Eric[2], KEPCO International Nuclear Graduate School

Abstract

To better understand subsurface material properties, a variety of physical testing and analysis techniques have been developed over the years. One such technique involves relating the mean shear wave velocity of the earth materials in the upper 30 m to a site-specific peak frequency. If not directly measured, these peak frequencies can be estimated using a horizontal-to-vertical spectral ratio method. The horizontal-to-vertical spectral ratio is typically calculated as the ratio of the vertical response spectra to the horizontal response spectra. Response spectra are derived from ground motions at the site. For this study, horizontal-to-vertical spectral ratios are estimated using several South Korean earthquake ground motions recorded by the Korea Institute of Geoscience and Mineral Resources. Along with the spectral ratio derived peak frequencies, the corresponding field measured shallow shear wave velocities are compiled to form a dataset for comparison. This dataset is compared to several methods developed for global use. Results show that there is a lack of local site-specific shear wave velocity data overall. There are also difficulties in identifying a peak frequency in several sites using these Horizontal-To-Vertical Spectral Ratio models and even when working the results are scattered. Additionally the global model did not perform as well, but a model based on central and eastern North America did well.

Keyword

South Korea, Shear wave, Peak frequency, Response spectra, Spectral ratio

New insights of seismicity and stress pattern from the dense temporary deployment network in Anker, Kunene Region, Namibia

Bufelo Lushetile[1]*, Geological Survey of Namibia (Bufelo.Lushetile@mme.gov.na)
Azangi Mangongolo[2], GEO4D Consultancy

Abstract

The monitoring of seismic activity in the Anker settlement was initiated in May 2018 after the Anker community reported an increase of seismic events in the area. Between the months of March and May 2018, five (5) significant earthquake events were recorded on the National Seismological Network in the Kunene Region with local magnitudes (ML) ranging from 4.0 to 4.6 ML. This write-up provides an update based on the continued processing and analysis of data from the temporary seismic stations deployed around Anker settlement. The temporal seismic stations were deployed for a period of one year from November 2021 to December 2022. The Deep Learning method was used as huge amount of data was acquired. The Deep Learning successfully picked P and S wave arrivals that were used for subsequent processing for location and moment tensors. Picks having probability higher than 0.6 to mimic the model were used. 27603 earthquakes from Ml 0 to 4.6 were located, with depth ranging from 0 to 22 km. The epicentres were aligned in an NNW-SSE direction which is the prolongation like of the eastern part of the Kaoko Belt. Few epicentres were aligned along the NE-SW direction which is believed to be associated with the Northern Damara Belt. The biggest epicentral cluster is located in Anker along a structural line. In the vicinity of Anker, three major structural lines can also be identified: two faults and magnetic lineament. 5047 moment tensors were obtained: 1061 of normal faulting type, 998 of strike slip right lateral type, 903 of strike slip left lateral type, 935 of thrust/reverse type, and the rest was of oblique normal or reverse type. Results of the focal mechanism showed NNW-SSE direction of the principal stresses as well as Thrust and Strike Slip faulting types surrounding Normal faulting type. This means, the area has a complex stress regime characterised by extensions compensated by a small amount of compression in the middle. The NNW-SSE extension regime coincides with the NNW-SSE trending of the Kaoko Belt. The reverse/thrust regime expresses the N-S horizontal contraction.

Keyword

Deep Learning, Kaoko Belt, Focal mechanism, Principal stresses

Stratigraphic Analysis of Regressive Erosion in the Upper Coca River Basin: Insights from Seismic Imaging and Field Data

Isabel Cristina Garcia[1], Universidad Regional Amazónica Ikiam
Christian Wladimir ROMERO CÓNDOR[2]*, INSTITUTO DE INVESTIGACIÓN GEOLÓGICO Y ENERGÉTICO (criscescz@gmail.com)
Jóse Sebastían Araujo[3], Universidad Regional Amazónica Ikiam

Abstract

The phenomenon of regressive erosion in the upper basin of the Coca River was characterized by rapid erosion velocity and a high rate of undercutting. Previous researchers have studied this phenomenon from morphological and hydrological aspects; however, sedimentological and stratigraphic parameters still need to be reported. The main objective of this research is to analyze the geometry of the depocenter of the Coca River Basin from tomographic images and stratigraphic sections (field data). We use seismic data from RENSIG. We used INSIGHT software for the tomography results for the P-wave velocity model in two models of 50° and 0°.
From this perspective, this research applies a combination of seismic and stratigraphic techniques to establish the geometry of the paleo-basin, relative thicknesses, and the geographical position of the depocenter. Seismic images reveal that the basin exhibits a regular elongated concave geometry, elongated in the NE-SW direction. The thickness of the basin fill sequences averages 800 m. Field data indicate that the fill consists of five first-order sequences, including lava flows and pyroclastic deposits linked to the construction history of the El Reventador volcano, as well as fluvial-lacustrine deposits associated with the fluvial dynamics of the Coca River. The thickness of the sequences, observed through morphological field observations and measured in seismic images, suggests that the depocenter of the basin is located northeast of San Luis. The development of sub-vertical slopes on the flanks of the Coca River, attributed to fluvial erosion, is directly related to the lithology and thickness of the depocenter.

Keyword

Regressive Erosion, Coca river, Seismic, stratigraphy

Focal mechanisms of earthquakes in the Korean Peninsula based on P-wave first-motion polarity determination using deep learning

Ah-Hyun BYUN[1]*, Korea Meteorological Administration (ahyun0809@korea.kr)
Mikyung CHOI[2], Korea Meteorological Administration
Kyungmin MIN[3], Korea Meteorological Administration
Eunyoung JO[4], Korea Meteorological Administration
Sun-Cheon PARK[5], Korea Meteorological Administration

Abstract

The focal mechanism of earthquakes is usually obtained by using P wave first-motion polarities. In order to accurately determine the focal mechanism of an earthquake, sufficient numbers of reliable P-wave first-motion polarities are required. Recently, deep learning techniques that can learn inherent features in the data have been widely used in various fields, and various studies based on deep learning techniques are also being proposed in the field of seismology. Deep learning techniques for identifying P-wave first-motion polarity are also being introduced. In this study, we developed a procedure that can automatically determine the focal mechanism of earthquakes using a deep learning model for P-wave first-motion polarity identification trained using global and local seismic data.

Deep neural network models were trained using data from the Southern California region and local earthquake data from South Korea. The Southern California data is the same data used in Ross et al. (2018), which consists of about 2.5 million local earthquake data and P-wave first-motion polarity information. P-wave first-motion polarities of local data was manually identified from seismograms of earthquakes of magnitude 2.0 or greater that occurred in the Korean peninsula between 2017 and 2020, and a total number of local training data was about 30,000. In this study, the VGG16 model structure was tested, and the neural networks were configured to identify P-wave first-motion polarity using 2.56-second-long vertical component earthquake waveform as the input. A base trained model was obtained using the Southern California dataset and improved by fine-tuning with relatively small amount of local dataset.

The performance of the trained neural network model was evaluated using global and local earthquake data that were not used in the training. The performance of the base trained model was measured to have an average precision of about 96 % and that of the fine-tuned model was improved to an average precision of 98 %. For Japanese earthquake data, the fine-tuned model performed with a very high precision of about 99%.

We are currently testing the applicability of the P-wave first-motion polarity identification model developed in this study to earthquakes of occurring on the Korean Peninsula.

Keyword

P-wave first motion polarity, focal mechanism, deep learning, HASH

Detection of the buried rupture of the North Anatolian Fault in Kocaeli, Türkiye using ERT and VLF-R methods

Ümit AVŞAR[1]*, Istanbul Technical University-Department of Geophysical Engineering, İstanbul Türkiye (avsaru@itu.edu.tr)
Gökhan KARCIOĞLU[2], Istanbul University-Cerrahpasa, Geophysical Engineering Department, Istanbul and Institute of Geophysics of Czech Academy of Sciences, Bocni II/1401, 14100, Praha 4 - Sporilov
Annisya B.TEKKELİ[3], Istanbul University-Cerrahpasa, Geophysical Engineering Department, Büyükçekmece, Istanbul
Mehmet Ali ÜGE[4], Istanbul University-Cerrahpasa, Geophysical Engineering Department, Büyükçekmece, Istanbul
Mehmet Safa ARSLAN[5], Istanbul University-Cerrahpasa, Geophysical Engineering Department, Büyükçekmece, Istanbul

Abstract

Rupture zones of active faults in the near-surface are studied widely for engineering purposes, and for paleoseismic studies to reveal parameters of past events and to provide more precise future hazard estimations. Detection of rupture zones presents a challenge when they are buried and become invisible from the surface. Geophysics provides numerous methods to image near-surface structures in detail. Among these, Electrical Resistivity Tomography (ERT) and VLF-R methods are applied to image the subsurface by the means of electrical resistivity. Models representing the subsurface resistivity distribution are recovered by the interpretation of collected data using a mathematical algorithm called "inversion".

Fluid distribution is known to be one of the major factors affecting the electrical resistivity structure in the subsurface causing significant anomalies in ERT and VLF-R measurements. Faults often interact with the fluids by acting as conduits or barriers, revealing themselves as strong conductors for the first case or causing fluid accumulations at one side for the latter. Horizontal and vertical movements caused by the fault slip also shifts geological units with different fluid contents.

We investigated the buried surface rupture of the 17 August 1999 (Mw = 7.4) earthquake on the North Anatolian Fault using ERT and VLF-R methods comparatively and in a complementary way to determine the location of the rupture and to test a new regularization scheme to improve VLF-R inversion results. The recovered resistivity models of the subsurface using both methods reveals the now buried rupture of the NAFZ and suggests that the non-permeable clayey fills in the rupture are causing the fault to act as a barrier accumulating meteorological waters in the north.

Keyword

North Anatolian Fault Zone, Electrical Resistivity, VLF, Inversion

Detection of buried faults: a case study at the north end of the Miryang Fault, southeastern Korean Peninsula

Lanbo Liu[1]*, Pusan National University (lanboliu77@gmail.com)
Fei Peng[2], China Earthquake Administration
Su Young Kang[3], Pusan National University
Young-cheol Lee[4], Pusan National University
Kwanghee Kim[5], Pusan National University

Abstract

We present the results of a seismic investigation aimed to characterize the structure of shallow formation stratigraphy across an area believed to be in the vicinity of the north tip of the Miryang Fault in the Geoncheon Valley, Gyeongju City, Republic of Korea. The Miryang Fault is a major branch of the Yangsan Fault system in the Gyeongsang Basin, southeastern Korean Peninsula. Despite local earthquake records showing scattered micro-seismicity along the surface expression of the fault, other geophysical and geological information are relatively rare. The location of the Geoncheon Valley is tectonically critical: it is on the borderline that separates a major part of the Gyeongsang Basin into two sub basins: the Miryang Basin (formed by late Cretaceous Yucheon Group) to the south and the Euiseong Basin (formed by the early Cretaceous Hayang group) to the north. Consequently, this special tectonic setting poses the following questions: First, is the Miryang Fault terminated in the Geoncheon Valley? Second, if the fault is terminated in the valley, what is the type of tip damage zones of the right- lateral strike-slip Miryang Fault?

The surface expression of the Miryang Fault in this area is difficult to define due to surface morphology of highly cultivated rice lands. Integrated seismic exploration is an effective solution to locate subsurface structures where surface geomorphological evidence is inconclusive to define fault structures. On a 1200-m long linear profile we deployed a dense array using 3-component seismic sensors and acquired both passive and active seismic data. The passive seismic data acquisition lasted about 12 days. At the end of the deployment period directly before withdrawing the array, an active survey using sledgehammer source. The integrated seismic profile displays significant segmentation of the texture of the seismic image, the sediment-bedrock interface is between several meters to a bit greater than 20 meters with a general trend of dipping to the southeast. The preliminary seismic results suggest that it is likely the Miryang fault is terminated inside the Geoncheon Valley, with a high likelihood of horsetail splay type of tip damage zone. We will validate this preliminary recognition with more geophysical data acquisition and analysis including ERT and gravity surveys.

Keyword

Miryang Fault, seismic profiling, strike-slip faults, damage zone

Structural characterization of intracratonic strike-slip faults in the southern Oridos Basin

Yunwen GUAN[1]*, NorthWest University(China) (gynw_6@163.com)

Abstract

In the southern Ordos Basin, China, a series of small-scale strike-slip faults have been observed, with their scale differing by several orders of magnitude from the plate-boundary strike-slip faults. This paper analyzes the geometric and kinematic characteristics of the intracratonic strike-slip faults in the southern Ordos Basin, based on high-accuracy 3D seismic data. The formation and evolution are deeply discussed through geological and structural settings. The results obtained by this study show that the small-scale strike-slip faults in the research area have undergone multiple stages of tectonic evolution, exhibiting complex structural features. Braided, horsetail, feather, flower structures and Riedel within Riedel Structures are observed, with differential activation observed in plan view and cross-section view, respectively. This fully demonstrates that the control exerted by tectonic stress direction and the angle between pre-existing faults on fault movement varies.In addition, the extension and lateral linkage growth pattern of intracratonic strike-slip faults are also evident in this region. The terminations of strike-slip faults typically arc outward, gradually connecting with other fault terminations as they expand, resulting in a gradual decrease in fault spacing. This research enhances understanding of the development characteristics of intracratonic strike-slip faults and enriches the development patterns and mechanisms of strike-slip faults in intraplate structural transition zones of small blocks and multi-cycle basins.

Keyword

Ordos basin, Intracratonic strike-slip faults, Structural characteristics, Fault growth model

GPR detection of buried paleo-channel through unconsolidated layer and characterization of the channel fill

Takao KOBAYASHI[1]*, Korea Institute of Geoscience and Mineral Resources (tak@kigam.re.kr)
Changwan Sun[2], Geological science, KIGAM School, University of Science and Technology
Jin-Hyuch Choi[3], Korea Institute of Geoscience and Mineral Resources

Abstract

Observation of surface terrain around an active fault helps to better understand the nature of the fault. Stream channel is one of surface terrain features that provides valuable information regarding fault.

We conducted Ground Penetrating Radar (GPR) survey over a fault which is a part of Yang-san fault system, South Korea, for a purpose of defining the paleo-surface around the target fault, and detected a paleo-channel buried under an unconsolidated layer.

A 2-D (multiple-line) GPR survey was conducted to obtain 3D information of subsurface structure. The survey area was as wide as 10 m X 20 m. The survey line interval was 0.5 m whereas the measurement point interval was 0.5 m.

GPR measurement was done with 40 MHz antennas. All the measurement data were processed to produce a 3-D instantaneous power grid data set. We studied the data through visual inspection to define paleo-horizon, and found paleo-channel signals.

The paleo-channel appeared to have an oval shape in the GPR instantaneous power vertical cross section image, and showed a band-like shape on a horizontal slice image, implying a flow area, at a depth of ~1 m (assuming relative permittivity of 16). Ground truth trench work found the U-shape of the paleo-channel gouging on the paleo-surface, hence confirmed the GPR survey result.

Furthermore, we conducted a real scale Finite Difference Time Domain (FD-TD) simulation to examine if there is any influence of the filling material of the paleo-channel on the GPR image appearance. This examination led to an interesting result that the relative permittivity difference of the filling material and the paleo-surface material result in difference of instantaneous power signals of the two media materials: If paleo-channel fill has a larger permittivity than that of the paleo-surface material, the paleo-channel signal instantaneous power is smaller than that of the paleo-surface, and vice-versa. The result implies that the paleo-channel fill of this study has smaller permittivity than that of the paleo-surface material. The smaller permittivity is due to typically large porosity of the filling material. This was confirmed by the observation of the trench cross section of the paleo-channel.

Keyword

GPR, paleo-channel, FDTD

Buried Geomorphic Signatures of Paleo-Earthquakes Detected by 3D GPR survey and Trench Analysis: A Case Study of the Yangsan Fault, South Korea

Changwan SUN[1]*, Geological science, KIGAM School, University of Science and Technology (csun@kigam.re.kr)
Jin-Hyuck Choi[2], Geological science, KIGAM School, University of Science and Technology / Active Tectonics Research Center, Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources
Takao Kobayashi [3], Active Tectonics Research Center, Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources
Yire Choi[4], Active Tectonics Research Center, Geologic Hazards Division, Korea Institute of Geoscience and Mineral Resources

Abstract

Near-surface geophysical techniques have been used as important tools in paleo-seismological research. Particularly, in the intraplate regions, they are able to uncover the records of the surface faulting buried by the unconsolidated sedimentary deposit. This study conducts three-dimensional Ground Penetrating Radar (GPR) survey coupled with the multiple-trench surveys to investigate geomorphic features which are related to paleo-earthquakes of the Yangsan Fault, S. Korea, that is located in an intracontinental setting. The research site is the Miho area, of which a previous study had reported geologic records of paleo-seismological event. We conducted GPR surveys in an area of 20 m x 20 m over a fault with using 40 MHz unshielded antennas and acquired 21 GPR profile data of 20 m long parallel to the fault. Additionally, we conducted trench works for a purpose of "ground truthing": 4 trenches intersecting the fault and 6 trenches being parallel to the fault were excavated in an area of 20 m x 30 m that covers the GPR survey area. Three-dimensional GPR results revealed different slopes of unconformities parallel to the fault on its both sides. The findings from a series of trenches represented that the local slope of the unconformity parallel to the fault had sudden variation, and that their stratigraphic and geochronological assessment facilitated how the sag pond and the colluvial wedge behaved during the earthquake event. Such geomorphic indicators are interpreted as results of along-strike variations in the vertical separation on the right-lateral earthquake surface rupture. This case study shows how valuable it is to analyze the geomorphic features related to paleo-earthquakes through three-dimensional geophysical exploration of GPR with multiple trenches.

Keyword

Geomorphic signatures, Trench, Geocrhonology, 3D GPR, Yangsan Fault

Geophysical investigation using ERT and MASW surveys at the Quaternary faults along the Yangsan fault system, SE Korea

Hwanwoo SEO[1]*, Ulsan National Institute of Science and Technology (UNIST)
(hwanwooseo@unist.ac.kr)
Jeong-Ryul CHOI[2], Chungnam Nationa University
Seung-Sep KIM[3], Chungnam Nationa University
Byungmin KIM[4], Ulsan National Institute of Science and Technology

Abstract

This study aims to assess the reliability of the results obtained from the two geophysical surveys (Electrical resistivity tomography (ERT) and multi-channel analysis of surface waves (MASW)) in areas where the Quaternary faults have been observed. Furthermore, we evaluate the applicability of the two surveys for fault detection. We conduct the ERT and MASW surveys at the five sites (Site 1: Bogyeongsa area in Pohang; Site 2: Manseok-ri 64 in Pohang; Site 3: Nangsu-ri 184-2 in Pohang; Site 4: Nangsu-ri 113 in Pohang; Site 5: Bangi-ri 65-2 in Ulsan) along the Yangsan fault system in southeastern Korean Peninsula. Through these non-invasive surveys, we estimate the electrical resistivity and shear wave velocity of the subsurface and identify zones with relatively low resistivity and shear wave velocity at each site. These anomaly zones might be attributed to a fault anomaly or fracture zone. We also compare the thickness of the Quaternary sediments as determined from the boring test and the MASW survey, and they are consistent with each other. Based on the results of the geophysical surveys and trench excavations, we provide comprehensive analyses up to a depth of approximately 25 m. This study demonstrates the usefulness of the ERT and MASW surveys for fault detection by identifying anomaly zones and suggests their applicability for tracing faults in urban areas where trench excavation is challenging.

Keyword

ERT, MASW, fault detection, trench excavation

3D Imaging of Fault Fracture Zones using Electrical Resistivity Survey

Samgyu PARK[1]*, Korea Institute of Geoscience and Mineral Resources (samgyu@kigam.re.kr)
Jin-Hyuck Choi[2], Korea Institute of Geoscience and Mineral Resources
Youngbeom Cheon[3], Korea Institute of Geoscience and Mineral Resources

Abstract

During the active fault investigation process, trench surveys are vital for conducting paleoseismological research. Since most trench survey sites are buried with unconsolidated sediments, geophysical exploration technology is used to select suitable locations. In Korea, 2D electrical resistivity surveys are commonly employed for this purpose. Because the ground resistivity is influenced by various factors such as rock type, porosity, weathering, water saturation, pore water conductivity, and clay contents, fault fracture zones typically show lower resistivity compared to their surroundings. In this study, a 3D electrical resistivity survey was conducted in the field to visualize a fault zone characterized by linear geological structures, and its effectiveness was evaluated. The survey site includes a Quaternary fault located south of the Yangsan Fault and a granite-based fault positioned northeast of the Gongju Fault, both previously confirmed as active faults through trench surveys. To create a 3D image of the fault fracture zone, a rectangular area with horizontal and vertical lengths of 27 m was established. Fourteen survey lines were set at 2 m intervals horizontally, while eight survey lines were positioned at 4 m intervals vertically. The electrode array used a dipole-dipole configuration, with field data collected at an electrode spacing of 1 m and a survey line length of 27 m. The DC_3DPRO inversion program developed by KIGAM was employed to calculate the 3D resistivity model using the field-acquired data. Upon comparing the block diagram of the 3D resistivity distribution and depth-specific slices with the trench logs, it was observed that the ground resistivity accurately represented the geological characteristics of the fault zone. This facilitated a comprehensive understanding of the spatially geological structure, including the fault fracture zone.

Keyword

electrical resistivity survey, active fault, fracture zone, three dimension, resistivity distribution

Utilizing Electrical Resistivity Method to Characterize Buried Faults in Suhari, Hong-Cheon, South

Jeong-Ryul CHOI[1]*, Chungnam National University (ddolbong@cnu.ac.kr)
Seung-Sep Kim[2], Chungnam National University
Youngboem Cheon[3], Korea institute of Geoscience and Mineral Resources

Abstract

Prior to 2017, South Korea lacked a systematic, government-level investigation of Quaternary active faults. However, following the consecutive occurrences of the 2016 Gyeong-ju and 2017 Pohang earthquakes, the urgency for research on the distribution and activity of Quaternary faults on the Korean Peninsula became apparent, triggering proactive research endeavors. Such investigations aim to evaluate seismic disasters and risks, crucial for identifying high-risk areas and ensuring the safety of critical infrastructure. Employing interdisciplinary methods including remote sensing, geophysical exploration, and trench investigation, researchers aim to delineate Quaternary faults. Trench investigation plays a pivotal role in confirming fault cross-sections obscured by unconsolidated sediment layers, crucial for understanding seismic activity timing along fault planes. However, relying solely on this point-based survey method presents limitations in determining the spatial connectivity of buried faults. To overcome uncertainties in tracing the extension of buried faults, near-surface geophysical exploration techniques such as electrical resistivity tomography (ERT) prove invaluable. ERT effectively images geological structures and faulted strata by reflecting fundamental physical properties of the rock matrix. Particularly in regions characterized by fault fracture zones or weathered strata, ERT reveals low electrical resistivity values attributed to increased clay minerals and water content resulting from weathering and fracturing processes. In this study, ERT was employed around a fault identified through trench investigation in the Suhari area of Hongcheon, Gangwon-do, to trace the extension of the buried fault. Post-processing and correction of collected ERT data generated detailed images of underground structures, revealing anomalous patterns associated with faults near the trench site. The trench investigation conclusively verified the fault's presence, discerned through sharp transitions between high and low resistivity values in ERT sections. Furthermore, the alignment of low resistivity anomalies in the southern study area followed a north-northeast direction, whereas those in the northern area exhibited a north-northwest alignment. 3D inversion results corroborated the fault's orientation predominantly aligning with the north-northeast direction, characterized by a distinct lineament of low resistivity. Integrating the trench survey's identified fault direction with ERT results confirmed the efficacy of this method in imaging buried faults and tracing their extensions.

Keyword

Electrical resistivity survey, Buried fault, Fault characterization, ResIPy, Near-surface geophysics

Peering Through Sediments: Ground-Penetrating Radar Mapping of the Yangsan Fault

Hak Min LEE[1]*, Chungnam National University (hakmin2379@cnu.ac.kr)
Seung-Sep Kim[2], Chungnam National University
Jeong-Ryul Choi[3], Chungnam National University

Abstract

Traditional fault characterization methods involve a combination of survey techniques to provide comprehensive insights into fault structures and zones. Typically, the initial phase employs airborne LiDAR surveys to detect fault lineaments. Subsequently, trench surveys or boreholes are deployed to validate assumptions, often supported by isotopic dating of obtained samples near fault zones. Geophysical methods, such as Ground-Penetrating Radar (GPR), are pivotal for subsurface imaging, offering high-resolution data acquisition. In this study, we applied the GPR method to image unconsolidated sediment structures within the Yangsan fault area. Utilizing the PulseEKKO Pro GPR system with a 50 MHz antenna frequency ensured adequate penetration depth. To optimize signal quality, the UltraReceiver augmented recordings to enhance the signal-to-noise ratio. Accurate positioning was achieved through RTK GPS system integration, enhancing data reliability. Notably, GPR data often suffer from attenuation and noise interference. To mitigate these issues, we employed an f-k filter alongside de-wow, band-pass, and background subtraction filters for comprehensive post-processing. Characteristic GPR signals indicative of fault structures, such as discontinuities in radargrams resembling displaced strata, were consistently observed along the Yangsan Fault. Additionally, these discontinuities were noted proximal to river terraces, highlighting landforms affected by fault movement. Low amplitudes and chaotic reflection signals further suggested historical subsurface strata movements. To bolster interpretive confidence, Electrical Resistivity Tomography (ERT) data were concurrently collected along survey lines. Remarkably, anomalous zones delineating fault planes were consistently identified in both datasets, augmenting interpretive robustness. In conclusion, our findings underscore the efficacy of the GPR method in fault movement tracing, facilitated by effective noise suppression through the f-k filtering method. This integrated approach not only enhances understanding of subsurface fault dynamics but also underscores the importance of multi-physics data fusion for comprehensive fault characterization.

Keyword

Ground-Penetrating Radar, Near-surface Geophysics, Buried Fault

Understanding the subsurface structure of Bukpyeong Basin through 2-D electrical resistivity survey

WooHyun Kim[1]*, Pusan National University (1030banana@pusan.ac.kr)
Hanjin CHOE[2], Pusan National University
Kwang-Hee KIM[3], Pusan National University

Abstract

The Bukpyeong Basin, located in southeastern Gangwon Province, South Korea, is a sedimentary basin formed in the late Miocene. A May 2023 earthquake (M4.5) off the east coast of Donghae-si highlighted the potential for natural disasters in this area. To understand the subsurface structure of the basin and its surrounding tectonic environment, we conducted various ground geophysical surveys. We compared 2-D electrical resistivity tomography (ERT) and Horizontal Vertical Spectral Ratio Analysis (HVSR) to investigate the consistency between the two datasets and estimate the thickness variations of the unconsolidated sediments in the basin. The results showed similar depth variations in both datasets. The northern ERT image revealed a thicker sedimentary section at the hanging wall bordering the fault line, indicating a normal fault structure. In contrast, the southern ERT image displayed a shallower sediment layer, suggesting a reverse fault structure. By analyzing the ERT images, we delineated a possible fault line trending NW-SE. The HVSR results corroborated this interpretation, with thicker sediments deposited northeast of the fault line and thinner sediments on the southwest side. This suggests a higher stress environment in the southern part of the hanging wall compared to the north, potentially causing the rotation of the tectonic block. The formation of a reverse fault and basin evolution likely resulted from compressional forces and sedimentation, possibly indicative of a piggyback basin. However, due to limited data, additional geophysical surveys are necessary. This study aimed to improve our understanding of the Bukpyeong Basin's subsurface structure, which can provide valuable insights into the mechanisms of earthquakes and related hazards in the surrounding area.

Keyword

2-D electrical resistivity tomography (ERT), Horizontal Vertical Spectral Ratio Analysis (HVSR), Bukpyeong Basin, fault rotation, compressional force

A top-down control on upper crustal inheritance on the south-eastern Tibetan Plateau

Kun ZHANG[1]*, Chinese Academy of Geological Sciences (zhangkun1010@163.com)

Abstract

Mantle tectonics, such as asthenospheric upwelling, usually controls subsequent fluid formation and migration from deep to shallow levels in the lower lithosphere and promotes rock failure and deformation, especially in southeastern Tibetan Plateau. Some models have proposed that lithospheric shearing and lower-crustal flow have controlled the crustal deformation in the Cenozoic. However, crustal rotation models show less possibility of a channel flow and relate the crustal deformation to the remote effect of India-Asia collision. Based on the concept whereby the fluid migration location defines the structural inheritance, we aim to relate crustal processes to mantle tectonics using fluids revealed by a new dense magnetotelluric (MT) array across the Ailao Shan-Red River belt with high quality, investigating above hypotheses. The 3D resistivity model of the study area reveals notable variations in the electrical property throughout the lithosphere. The lithosphere is interpreted to have been divided into two horizontal systems by a fluid diffusion layer at the bottom of upper crust, indicating a transition zone. In the lower lithosphere, two prominent near-vertical conductive regions are revealed and determined as consistent with the Dian-Qiong (DQ) suture and Song Da (SD) belt. These resistivity lows, which have spread at the bottom of upper crust, are inferred due to partial melting of deep lithosphere and reworking of the paleo sutures (DQ and SD) in the Late Cenozoic, because surface potassic magmatism in our study region was enabled by partial melting in the lower lithosphere. Therefore, fluid migration is considered to generate a transition zone featured by low-viscosity conductivity, which is inferred feeding by aqueous and melt fluids originating from the two channels and diffusing at depths from 15-20 km. Rather than the channel flow, this fluid migration process sensitively reflected in our model relates the mantle tectonics to crustal rotation by providing rheological conditions. We, hence, propose an inherited structure model featured by vertical mantle tectonic and upper-crustal translation-rotation that may occur before the major strike-slip event. The lithospheric transition zone could have provided convenience to induce the entirely upper crustal translation-rotation. The upper crust may move southwards and rotate clockwise, with respect to the lower part of the lithosphere, which is consistent with the surface geological and petrological observations to the north of our study region. Moreover, this transition-rotation process may have occurred within the time interval between potassic magmatism and strike-slip of the RRF (34-31 Ma), constrained by the geochronology results and duration estimation of shear zone by electrical model and energy equation. This translation-rotation process is inherited from the underlying mantle processes and may further be remotely affected by the upper crustal movement of the Tibetan Plateau, conforming with the mechanism interpretation of crustal rotation observed to the north of our study region. Furthermore, the crustal translation-rotation may also control the inherited strike-slip event in our study region.

Keyword

Eastern Tibetan Plateau, 3D electrical model, mantle tectonic, crustal rotation, inherited process

[Keynote] Pacific Array: an observational effort to find a link between the deep mantle process and surface features of the Pacific Basin

Hisashi UTADA[1]*, Earthquake Research Institute, University of Tokyo (utada@eri.u-tokyo.ac.jp)

Abstract

There is an apparent contrast between the eastern and western parts of the Pacific basin. For example, the eastern part exhibits a systematic deepening of seafloor depth depending on the age that can be explained by a simple cooling of the oceanic lithosphere, while the seafloor depth of the western part is almost independent on age. The bathymetric variation is smooth in the eastern part, while a lot of sea mounts and LIPs are distributed in the western part. Although such contrasting features were known since long time ago, the mechanism is still a matter of controversy. A well-known plate cooling model explains the flattening of the old seafloor such as we see in the western Pacific, in which development of small-scale convection below older lithosphere is regarded as one of the most plausible mechanisms. If we accept such a scenario, it means that seafloor flattening has nothing to do with the topographic contrast because volcanism in the western Pacific is an ancient event. Volcanism that created seamounts and Lips was active when the lithosphere was young, and ceased 90~100 Myr ago. The seafloor is flat in the western Pacific owing to extra heating below the currently old lithosphere. Are these two asymmetric features really independent? There is a general consensus that knowledge on deep mantle structure (the lithosphere-asthenosphere system: LAS) is one of the key issues to solve this kind of problem. Global seismic tomography is a powerful tool toward this goal but contains a limitation on the spatial resolution due to relatively sparse separation of existing observatories. Some years ago, we proposed a new concept (Kawakatsu and Utada, 2018) of an array study of seafloor observations (array of arrays) to overcome this limitation, and the first attempt is on-going in the Pacific Ocean called the Pacific Array. This is an international effort to which different groups from Korea, US, Taiwan and Japan are contributing. The entire array is not complete yet but is supposed to consist of a number of independent seafloor arrays of ocean bottom seismic and electromagnetic observations. Each seafloor observation array which is normally deployed for 1-2 years with 10-20 sites can reveal the lateral heterogeneity of sub-array scale, which contributes to understand the mantle dynamics locally. In addition, a properly distributed array of such arrays (10-20 sites/array, 10-20 arrays/entire basin) will provide accurate information on the basin-scale lateral heterogeneity in the oceanic lithosphere asthenosphere that may relates with surface features such as the east-west contrast. This presentation reviews some of recent efforts and major scientific outcomes during the past decade or so.

Keyword

Pacific Array, Pacific Basin, deep mantle process

Lithosphere thermal structure of Greenland and Antarctica: Implications for the ice sheets dynamics –

Irina M. ARTEMIEVA[1]*, SinoProbe Lab, China; GEOMAR, Germany (iartemieva@gmail.com)

Abstract

I present results of geophysical modeling of lithosphere thermal structure, lithosphere thickness and compositional heterogeneity in Greenland, North Atlantic region and Antarctica. For Greenland, the results indicate that mantle thermal anomaly around the Iceland hotspot is too weak to be resolved by seismic methods, while its hotspot track can be seen in the reduced lithosphere thickness across Greenland. The cratonic part of Greenland preserves a typical thick cold cratonic lithosphere, except for the NW-ES trending area, possibly modified by the passage of the Iceland hotspot. Thermal structure and lithosphere thickness variations imply that the Greenland icesheet melts primarily from the above, with the major melting anomaly located outside of the ice sheet.

For Antarctica, the results on the compiled crustal thickness, and newly calculated lithosphere thickness, thermal structure and mantle density anomalies demonstrate that West Antarctica lithosphere does not have continental characteristics, but instead represents a series of back-arc basins, therefore reducing the size of the Antarctica continent by 30%. The cratonic part of East Antarctica shows strong magmatic reworking, with significant lithosphere thinning below several regions. In contrast to Greenland, the Antarctica icesheet melting is associated with a strong mantle melting anomaly (characterized by a thin, hot and very low-density lithosphere) located below the ice sheet, in particular below West Antarctica and parts of the East Antarctica craton, in an overall agreement with GOCE-based models on the icesheet dynamics. The results imply that the Antarctica icesheet melts by lubricated sliding, promoted by basal melting of the icesheet.

DOI: 10.1016/j.earscirev.2018.10.015;
DOI: 10.1016/j.earscirev.2020.103106;
DOI: 10.1016/j.earscirev.2022.103954

Keyword

Greenland, Antarctica, LAB, icesheet, lithosphere

Kinematics of Capricorn plate inferred from the GPS data relative to its surroundings region and possible Geodynamical implications

AKILAN A[1]*, CSIR-National Geophysical Research Institute (akilan@ngri.res.in)
Abdul Azeez K. K[2], CSIR-National Geophysical Research Institute
Sravan K Kotluri[3], National Centre for Earth Science Studies
Satyanarayana H.V.S[4], CSIR-National Geophysical Research Institute
Padhy S[5], Indian Institute of Technology, Roorkee
Pandey O.P[6], CSIR-National Geophysical Research Institute

Abstract

The Capricorn micro-plate is a prominent tectonic block located between the Indian and Australian plates. We evaluate the kinematics of this microplate relative to adjacently located tectonic plates using GPS data to understand the plate tectonic processes and deformation/strain pattern in the Indian Ocean. The lengths of baseline are computed from the DGAR GPS site, placed at the northern fringe of the Capricorn plate and adjacently positioned other GPS sites over the different geotectonic plates. The study suggests a relative convergent tectonics between Capricorn and southern tip of India at a rate of 1 mm/yr. In comparison, a clear convergence at a high rate of 18 mm/yr is seen between the Capricorn and Sunda plates. Such a high convergence rate, if persists, would considerably shrink the wide diffusive boundary that exists today between the Capricorn and Sunda blocks. Similarly, the baseline length change between Capricorn and Australia indicate a shortening at a rate of about 10 mm/yr, which is in good agreement with earlier findings with a diffusive convergent boundary inferred between Capricorn and Australia. A complex rate of change in baseline length is also noticed between Capricorn and two different sites inside the African plate. The DGAR-ZAMB station pair shows divergence between the two plates at a rate of 9 mm/yr, while the DGAR-SUTH (southern margin of Africa) pair shows convergence between the plates at a rate of about 4 mm/yr. The observed divergence between the Capricorn and the Rovuma microplate can be explained by the presence of Comoros hotspot in the Somalian plate which is centered between north Madagascar and Rovuma plate and causing deformation due to magmatic extrusion led internal rifting (or spreading) below the Comores Islands and its surrounding regions. Consequently, a broad deformation zone is being formed east of Rovuma plate due to internal rifting of the Somalian plate that covers the northern part of Madagascar and northernmost part of the Lwandle plate.

Keyword

Plate kinematics, Capricorn plate, Madagascar, Indian Ocean, GPS

Geodynamic implications of small plume-driven weakening of the continental lithosphere

Ritabrata Dasgupta[1]*, Department of Earth System Sciences, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea (rdasgupta@yonsei.ac.kr)
Changyeol Lee[2], Department of Earth System Sciences, Yonsei University, 50 Yonsei-ro, Seodaemun-gu, Seoul 03722, Republic of Korea

Abstract

Mantle plumes are integral geodynamic components of Earth and other terrestrial planets (e.g., Mars and Venus) that transport primordial deep mantle material to shallow depths. Plumes of different sizes mostly originate from the thermal boundary layer at the core–mantle boundary, the base of the mantle transition zone (at 660 km depth), or the hydrated portion of the subducting or stagnant slabs. Plume emplacement within the lithosphere alters the rheology of the crust and lithospheric mantle through mechanical and thermal weakening, influencing the dynamic topography and architecture of the lithosphere–asthenosphere boundary. Previous studies on plume emplacement within the lithosphere have described these outcomes, albeit without considering plume-driven weakening. In this study, we quantitatively evaluated the effects of small plume-driven weakening of the lithospheric mantle and crust on the dynamic topography and LAB depth changes using a series of two-dimensional numerical models. Model calculations showed that small plume-driven weakening developed short-wavelength dynamic topography and LAB depth reduction through both mechanical and thermal erosion of the lithospheric mantle by the plume. A higher degree of weakening decreases the lithospheric strength and reduces the LAB depth, thereby transforming the short-wavelength topography from depression to elevation as the extension is changed to compression. Our model findings are verified by comparisons with the lithospheric strength, topography, and LAB depth of natural small plume emplacement zones.

Keyword

plume emplacement, plume-driven lithospheric weakening, dynamic topography, lithosphere asthenosphere boundary, numerical modeling

Deformation microstructures of experimentally deformed epidote blueschist and implications for seismic low velocity layer and S-wave anisotropy in warm subduction zones

Yong PARK[1]*, School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, Republic of Korea (dark2444@snu.ac.kr)
Haemyeong JUNG[2], School of Earth and Environmental Sciences, Seoul National University, Seoul 08826, Republic of Korea

Abstract

To understand seismic low velocity layers and S-wave anisotropy at the top of a subducting slab in warm subduction zones, seismic velocity and anisotropy for experimentally deformed epidote blueschist were calculated based on their deformation microstructures. Deformation experiments of epidote blueschist were conducted by using a modified Griggs apparatus in simple shear under pressure of 0.9–1.5 GPa, temperature of 400–500 ℃, shear strain (γ) in the range of 0.4–4.5, and shear strain rate of 1.5×10-5–1.8×10-4 s-1. After deformation experiments, lattice preferred orientations (LPOs) of minerals were determined by electron backscattered diffraction (EBSD) analysis. Seismic velocity and anisotropy of constituent minerals and whole rock were calculated using the LPOs and elastic constants of each mineral. The average P- and S-wave velocity (Vpaver and Vsaver) of glaucophane were in the range of 7.65–7.80 km/s and 4.54–4.56 km/s, respectively, and the anisotropy of P-wave (AVp) and maximum anisotropy of S-wave (Max.AVs) were in the range of 6.9–15.2% and 3.73–8.06%, respectively. The Vpaver and Vsaver of epidote were in the range of 7.31–7.37 km/s and 4.21–4.22 km/s, respectively, and the AVp and Max.AVs were in the range of 3.0–5.6% and 5.31–7.23%, respectively. The Vpaver and Vsaver of albite were in the range of 6.35–6.52 km/s and 3.68–3.72 km/s, respectively, and the AVp and Max.AVs were in the range of 8.4–14.5% and 12.54–15.56%, respectively. The Vpaver and Vsaver of whole rock (epidote blueschist) were in the range of 7.19–7.63 km/s and 4.22–4.47 km/s, respectively, and the AVp and Max.AVs were in the range of 4.5–11.0% and 3.91–6.40%, respectively. The Vpaver and Vsaver of experimentally deformed epidote blueschist were reduced about 8–13% and 6–11%, respectively, compared to the seismic velocities of lithospheric mantle surrounding the slab. The delay time of S-wave calculated from subducting oceanic crust composed of epidote blueschist was generally increased with increasing the subducting angle of the slab and volume proportion of glaucophane. Our results suggest that volume proportion of constituent minerals, LPO types of glaucophane and epidote, and the subducting angle of the slab are important factors in controlling the seismic velocity and anisotropy observed in warm subduction zones.

Keyword

Epidote Blueschist, Deformation Experiments, Seismic Low Velocity Layer, Seismic S-wave Anisotropy, Warm Subduction Zone

Formation of the Continent and Surrounding Region from the Perspective of Changes in Subduction Configuration

SANG-MOOK LEE[1]*, SEOUL NATIONAL UNIVERSITY (smlee@snu.ac.kr)

Abstract

The formation of continental crust is a big and contentious issue that requires a deep understanding of the tectonic setting and the region's geologic evolution. The Korean continent consists of several granitoid blocks attached over its geological history and sedimentary basins severely deformed. Several cases do not match the standard development of continental growth. In this presentation, I explore how the changes in subduction configuration (angle and overall shape) could have played a role in forming the landmass and surrounding basins. For instance, if the subduction angle is low, a collision will happen between the island arc material on the subducting plate and the existing continental material on the overriding plate. Low-angle subduction can result from the subduction of a young oceanic slab or lithosphere affected by a plume. Subduction of extinct spreading centers can also lead to shallow subduction. An extreme case would be a flat subduction, which could have been possible when the mantle was hotter, and the subducting slab was more buoyant than the present day. Head-to-head collisions will generate a large resistive force near the surface and eventually cause the subducting plate to dip at a higher angle. A rapid transition of the subducting slab from low angle to high angle may trigger instability, such as trench rollback, which would then cause the creation of back-arc spreading (sedimentary basins). I present preliminary results of our numerical modeling and insights from the simple experiments. Several hypotheses on how the subduction angle could change and how the change in subduction angle would contribute to different tectonic regimes will be discussed in relation to the regional tectonic features of crust and mantle, including the stagnant slab that extends below Northeast Asia.

Keyword

Formation of continental margin, subduction configuration change, subduction angle, numerical modeling

Unraveling the diversity in arc volcanism and seismicity in Southwest Japan subduction zone: insights from numerical models

Goeun HA[1]*, Seoul National University (goeunh@snu.ac.kr)
Changyeol Lee[2], Yonsei University
YoungHee Kim[3], Seoul National University

Abstract

The Southwest Japan arc, formed by the subduction of the Philippine Sea Plate, exhibits an uneven distribution of both arc volcanoes and seismic tremors. The western part of the arc, encompassing the Kyushu region, features a higher density of Quaternary volcanoes compared to the eastern part, but adakite is not observed. On the contrary, the eastern part covering the Shikoku and Kansai regions has fewer volcanoes but exhibits the occurrence of adakitic magma. Moreover, seismic tremors are mostly concentrated in the Shikoku and Kansai regions, excluding the Kyushu region. Many numerical studies have aimed to explain this phenomenon, considering the age and subduction rate of the Philippine Sea Plate sinking south of Kyushu and Shikoku. Nevertheless, these studies neglected to consider the dehydration and hydration processes occurring in the slab and mantle, and therefore, were unable to explain the presence of a low-temperature sub-forearc mantle, commonly referred to as a “cold nose.” In this study, we performed two-dimensional numerical simulations that consider both dehydration/hydration and fluid transport to explain unevenly distributed volcanoes and tremors in the Southwest Japan subduction zone. In the Kyushu region, where an older plate subducts with a higher angle, most dehydration occurs at 80 - 120 km depth. As a result, the majority of free water is expelled towards the sub-arc region, and a reduced volume of water reaches the wedge tip along the weak hydrous layer. This aligns with more frequent volcanic activities and a lack of tremors in the forearc. Conversely, in the Shikoku region, where a younger plate subducts with a lower angle, slab dehydration occurs at depths shallower than 75 km. The majority of the released water then travels through the weak hydrous layer, reaching the wedge tip. This explains the sparse distribution of arc volcanoes and frequent tremors in the forearc. Partial melting of the wet oceanic crust occurs at depths deeper than the depth limit for adakitic magma generation (<~100 km) in the Kyushu region while it is shallower in the Shikoku region. In the Kyushu region, the active dehydration occurring in the sub-arc and the subsequent substantial flux melting in the mantle wedge could lead to the dilution of adakitic magma through magma mixing. This is consistent with the exclusive presence of Quaternary arc adakite in the Shikoku region.

Keyword

subduction zones, weak hydrous layer, numerical modeling

New Parameterization of Lithosphere-Asthenosphere System Beneath the Oldest Pacific Based on In-situ Seafloor Geophysical Observations

Hogyum KIM[1]*, Seoul National University (kamhokam@gmail.com)
Kiyoshi BABA[2], Earthquake Research Institute, The University of Tokyo
Sang-Mook LEE[3], Seoul National University
Hisashi UTADA[4], Earthquake Research Institute, The University of Tokyo

Abstract

Even though the oceanic lithosphere-asthenosphere is widely accepted as a vital component of the Plate Tectonics paradigm, the exact mechanism and its nature as a system remain a topic of active discussion, varying from the classic half-space cooling to the plate cooling model due probably to sub-lithosphere small-scale convection. However, those widely accepted oceanic lithosphere thermal models mainly focused on global surface observations, such as seafloor subsidence, heat flow, and gravity anomalies. Additional knowledge on the deep mantle structure is a key to understand the thermal evolution of the oceanic lithosphere-asthenosphere system in the framework of mantle dynamics. Recent increases in seafloor geophysical instruments and international collaborative efforts, namely the Pacific Array, have shown that the in situ observations occasionally do not support the conventional global models and even contradict them in some cases. In 2018-2019, a year long seafloor seismic and electromagnetic survey was conducted on the oldest Pacific seafloor as a part of the Pacific Array project by the joint Korean-Japanese science team. The result of this experiment provided a typical example of the aforementioned mismatch between the observation and the global models. This presentation will demonstrate a preliminary result of lithosphere-asthenosphre structure modeling beneath the oldest Pacific basins based on the seafloor geophysical observations. Using the new structure, we aim to reconcile the observation and global models or to create a new global model otherwise, which needs to newly consider other possible parameters which are related to Mesozoic volcanic activities in the west Pacific basin, such as the melt-depleted lithospheric structure and possible hydration contrast across the lithosphere-asthenosphere boundary.

Keyword

Lithosphere-asthenosphere system, Seafloor geophysical observation, ocean bottom electromagnetometer, Pacific Array, Lithosphere-asthenosphere boundary

GEOELECTRIC STUDY OF BARAK BASIN USING MAGNETOTELLURIC TECHNIQUE, NORTH-EASTERN INDIAN REGION

Devesh WALIA[1]*, North-Eastern Hill University (deveshwalia.17@gmail.com)
Ilia LOZOVSKII [2], North-Eastern Hill University Shillong
Mrinal Kanti PATHAK[3], North-Eastern Hill university Shillong

Abstract

The study area is situated within the Barak Basin of Lower Assam, specifically in the Cachar region of Northeastern India. The Cachar region is situated in the far northeastern part of the Bengal basin and is bordered by the Shillong plateau to the north and the Indo-Burmese wedge to the east. The Cachar-Tripura thrust-fold belt is a part of the central compressive frontal region of the Assam-Arakan fold belt (AAFB), which constitutes the frontal fold belt of both the Assam and Assam-Arakan Basin. The AAFB comprises an array of elongated, sub-parallel, en-echelon, linear, and closely aligned north-south trending plunging anticlines, set apart by expansive synclinal troughs.

A field MT survey was carried out in the Cachar region of Assam, India. The MT data were acquired from 27 sites using the KMS 820 and LEMI 120 magnetic coils. 2D inversion models were constructed along the profiles to illustrate the variations in subsurface resistivity across the survey area down to a depth of 25 km, along with the boundaries of geological structures and fault zones. The relatively resistive layers in the 2D sections are interpreted as arenaceous sediments predominantly composed of sandstones whereas the relatively conductive layers are interpreted as argillaceous sediments, predominating with shales, claystones, and siltstones based upon the field exposures. The depth of the resistive crystalline basement is estimated to be between 16 and 17 km.

Keyword

Magnetotellurics, Deeper Geoelectric Structure, Barak Basin, Assam- Arakan Fold Belt, Bhuban Sediments

Deformation fabrics of talc and chloritoid and implications for seismic anisotropy in subduction zones

Jungjin LEE[1]*, Seoul National University, Seoul, Republic of Korea (ljj2718@snu.ac.kr)
Haemyeong Jung[2], Seoul National University, Seoul, Republic of Korea

Abstract

Talc and chloritoid are common metamorphic minerals observed in mafic-ultramafic rocks and/or high-pressure metapelitic rocks comprising subducting slabs. Crystallographic preferred orientations (CPOs) of elastically anisotropic minerals have been known to be important for interpreting seismic anisotropy observed in subduction zones. However, studies on the CPOs of talc and chloritoid have been very limited. In this study, CPOs of talc and chloritoid in garnet-chloritoid-talc schist samples from ultrahigh-pressure Makbal Complex (Tianshan, Kazakhstan-Kyrgyzstan) which has been regarded as a part of subducting slab were measured using SEM/EBSD technique. CPO-induced seismic properties of both talc and chloritoid were analyzed and compared. The results showed that both talc and chloritoid displayed strong CPOs characterized by the [001] axes aligned subnormal to the foliation (see also Lee et al., 2021). CPO-induced seismic properties of polycrystalline talc and chloritoid were calculated and they showed that both P-wave anisotropy (AVp = 5 – 72 %) and high S-wave anisotropy (AVs = 10 – 24 %) of talc and chloritoid were much higher than those of garnet (AVp = 0.4 %, AVs = 0.9 – 1.0 %). In addition, the AVp of polycrystalline talc was much higher than that of polycrystalline chloritoid. Analysis of S-wave delay time and fast-polarization direction based on the modelling study of subduction zone geometry showed that the CPOs of talc and chloritoid induced a long delay time of 0.3 – 0.5 s and trench-parallel polarization direction for high dip-angle subduction, which is consistent with the observation of strong trench-parallel seismic anisotropy in subduction zones. Our results suggest that the strong CPOs of talc and chloritoid would influence trench-parallel seismic anisotropy induced by subducting slab in subduction zones.

Keyword

talc, chloritoid, CPO, seismic anisotropy, subduction zone

Constraining Upper Mantle Seismic Anisotropy beneath the Oldest Pacific Seafloor from Shear-wave Splitting

Seung-Heon CHOI[1]*, Seoul National University (spica6375@snu.ac.kr)
YoungHee Kim[2], Seoul National University
Hyunsun Kang[3], University of Florida
Hwaju Lee[4], Seoul National University
Takehi Isse[5], Earthquake Research Institute, The University of Tokyo
Hitoshi Kawakatsu[6], Earthquake Research Institute, The University of Tokyo
Sung-Joon Chang[7], Kangwon National University
Sang-Mook Lee[8], Seoul National University
Hajime Shiobara[9], Earthquake Research Institute, The University of Tokyo
Hisashi Utada[10], Earthquake Research Institute, The University of Tokyo
Nozomu Takeuchi[11], Earthquake Research Institute, The University of Tokyo
Hiroko Sugioka[12], Kobe University

Abstract

In this study, we report shear-wave splitting measurements in terms of its strength and orientation to resolve upper-mantle seismic anisotropy, which allow for inferences on the style of deformation and flow of mantle below the oldest part of the Pacific Plate (160–180 Ma) known as the Pacific Triangle. Total 195 teleseismic S phases (XKS, ScS, and direct S) recorded by 11 broadband ocean-bottom seismometers are used to estimate fast polarization directions (FPDs) and delay times (DTs).

Although splitting measurements displayed complicated features with some deviations even at the same station, several main characteristics were found throughout the study region. Our findings reveal a distinct frequency dependence in the splitting parameters at two frequency bands (0.05–0.125 Hz and 0.125–0.5 Hz), suggesting the presence of vertical heterogeneity in seismic anisotropic structures. With regard to the FPDs, the dominant orientation in the low-frequency band is a WNW-ESE or NW-SE orientation, aligning with the N73°W absolute plate motion (APM). Conversely, in the high-frequency band, FPDs show a NE-SW orientation, perpendicular to the N40°W paleo-spreading direction.

In addition to FPD results, a higher number of null (non-split) measurements in the low-frequency band were found particularly from four stations on the Magellan Seamount Trail (MST) and northeast of MST, where pronounced slow-velocity anomaly exist at approximately 100–300 km depths (Kang et al., 2023), implying potential mantle upwelling. Alternatively, the high ratio of null measurements may indicate destructive interference as waves traverse multiple anisotropic layers. In summary, the weak correlation between FPDs and APM suggests that a drag-induced asthenospheric flow alone cannot explain most of our observation; the variation in the FPDs might likely result from the complexity of the upper mantle.

Keyword

mantle processes, seismic anisotropy, Pacific Plate, Body waves, shear-wave splitting

Geodynamic Investigation of Subduction Angle and Possible Flat Subduction Beneath East Asia During Mesozoic

Kien Ngoc PHAM[1]*, Seoul National University (phamngockien@snu.ac.kr)
Sang-Mook Lee[2], Seoul National University

Abstract

Mesozoic volcanism in the Korean Peninsula appears to have an interesting characteristic, with the younger volcanic arc located further inland compared to the older ones. This landward migration of the volcanic arcs is explained by the flat subduction of the ancient Izanagi Plate beneath East Asia, which affects the surface tectonics and facilitates the movement of the partial melting above the slab. However, the mechanism of flat subduction is still highly debatable. On one hand, numerical simulation in the case of early Earth hypothesizes that a higher mantle potential temperature, thicker crust, depleted mantle layers, and the effect of dolomitization can keep the subducting plate afloat. On the other hand, the present-day shallow flat subduction model focuses on the effect of the young age of the plate, existence of an oceanic plateau, trenchward movement of the overriding plate, and slab suction force in the mantle wedge. The former scenario may explain the movement of the ancient oceanic plate during the Mesozoic era when the mantle might be hotter than the present day. Many factors that affect the angle and the buoyancy of the subducted slab remain to be carefully examined. In this paper, several numerical models and their assumptions will be investigated to figure out at which temperature elevation and oceanic crust thickness the buoyancy of the subduction plate can keep it afloat right beneath the continental plate. We also compare our results with important geological features in Korea and China.

Keyword

Flat subduction, subduction angle, Geodynamic Simulation

Anomalous Inclination of Rock Samples from the South Atlantic Transect (SAT) and Their Implications for Variability in Magmatism of Slow-Spreading Ridges

Gilbert HONG[1]*, School of Earth and Environmental Sciences, Seoul National University (hongfellow@snu.ac.kr)
Sang-Mook Lee[2], School of Earth and Environmental Sciences, Seoul National University

Abstract

Analyzing the remanent magnetic signatures inside igneous rocks is crucial for understanding the evolution of oceanic plates. An important part of this process is to examine the fine-scale structure of polarity reversal, which can be used to constrain the nature of crustal formation at the spreading axis. The magnetic direction can change as a result of hydrothermal alteration of magnetic minerals and subsequent magmatism. However, no systematic analysis has been conducted in recent years using updated techniques. In this study, rock magnetic and chemical properties of basalts along the slow-spreading southern Atlantic ridge flank were investigated to identify the anomalous signatures and key factors that have caused them. Cores drilled from a total of 6 sites of different crustal ages (U1556, U1557, U1558, U1559, U1560, U1583) during IODP expeditions 390 and 393 – which are also referred to as the South Atlantic Transect (SAT) were investigated. Our results show that the distribution of inclination values at a given hole is wider at older sites, which reflects that the rocks have experienced more secondary remagnetization as they aged. We suggest that this is a result of persistent hydrothermal alteration during seafloor spreading and an empirical formula is derived. In addition, one of the sites (U1560) display an unexpected distribution where both normal and reverse polarities coexist in one hole. This pattern implies that magmatism and subsequent crustal accretion occurred in different time periods. It is important to check whether other properties besides inclination have changed.

*The South Atlantic Transect IODP Expedition 390 & 393 Scientists have also contributed to this work.

Keyword

Remanent magnetism, Seafloor spreading, Hydrothermal alteration

Bole beds and earthquake swarms in Deccan Volcanic Province, India

Rajender Kumar CHADHA[1]*, CSIR-NGRI (rajen0555@gmail.com)
Kusumita Arora[2], CSIR-NGRI

Abstract

Several isolated earthquake swarms of M<3.5 clustering in space and time are observed in the Deccan Volcanic Province (DVP) of India. These swarms are very localized activity confined to shallow depths of <3.0 km. No systematic pattern in terms of foreshocks, mainshock and aftershocks is observed and do not have a dominant mainshock. The number of events in each of these swarms vary from hundreds to thousands and are often associated with loud explosive sounds indicating shallow source. Swarm durations range from a few weeks to months and sometimes reoccur in the same place after a time interval. The Indian Peninsular Shield seismicity shows a diffused pattern typical of Stable Continental Regions. The seismicity is dominated by infrequent moderate tectonic earthquakes of M ≤ 6.5 mostly along known rift valleys with large recurrence periods. The most prominent cases of Reservoir Triggered Seismicity (RTS), including the largest known M6.3 Koyna earthquake on 10 December 1967 also occur in the DVP region of the Indian Shield.

The role of pore fluid pressure in triggering RTS cases is well known but the occurrence of several seismic swarms in the Deccan Traps terrain points to the geological and hydrological controls in triggering such events. The DVP is a continental flood basalt province in India with a maximum thickness of about 1 km extending over hundreds of kilometres in western and central India. Several red clay-rich horizons of few meters between two basalt flows are commonly seen in the outcrops. These are highly weathered erosional surfaces known as the bole beds facilitating lateral groundwater flow in Deccan basalts. Core samples from several deep boreholes of ≥1 km in the Koyna region have confirmed presence of several such horizons. Most of the reported seismic swarms have followed heavy rainfall episodes during monsoon time leading to the suggestion that these are rainfall triggered. The role of bole beds in triggering seismic swarms in the Deccan basalts is explained in terms of consolidation that is linked to changes in effective stress due to changes in pore water pressure. During heavy rainfall episodes, water percolates to bole beds horizons through fractures, and vertical and horizontal vesicular cylinders observed in Deccan basalts, increasing pore water pressure. Since, the bole beds are rich in clay, it has very low permeability and the dissipation of excess pore water pressure lead to volumetric strain deformation that can get transmitted to the deeper faults or fractured medium leading to failure. The number and thickness of bole beds encountered in different boreholes vary indicating their variable lateral extent. It is inferred that seismic swarms occur in the regions that are underlain by bole bed horizons in the DVP and absence of similar swarms elsewhere in the Indian Shield in different geological terrains support this hypothesis.

Keyword

Earthquakes, Swarms, pore pressure, Red bole, Deccan Traps

Remnant mantle pathways of the Deccan volcanic eruption in the Indian subcontinent revealed by 3D magnetotelluric imaging

ABDUL AZEEZ KIZHAKKEKARA KUNJAVARAN[1]*, CSIR-National Geophysical Research Institute, Hyderabad, India (azeez@ngri.res.in)
Prasanta K Patro[2], CSIR-National Geophysical Research Institute
Arvind K. Gupta[3], CSIR-National Geophysical Research Institute

Abstract

The massive Deccan volcanism induced by the Reunion mantle plume upwelling under the Indian subcontinent (Greater India), which produced one of the largest igneous provinces on the earth during the Cretaceous-Paleogene boundary, has been a crucial phase in the geodynamics and evolution of the modern Indian lithosphere. Significant alterations produced in the geological and geophysical characteristics of the pristine Precambrian Indian lithosphere by this youngest (~65 Ma) thermal event operated inside the Indian subcontinent are relatively well reported, however, there is no explicit revelation on the mantle pathways of the Deccan magma ascent through the Indian lithosphere. A 3D magnetotelluric (MT) imaging study was carried out in central-western India that mostly exposes the iconic Deccan flood basalt cover and Proterozoic to Quaternary sedimentary formations to produce a holistic lithosphere resistivity structure of the region. The 3D resistivity model showed high to moderately conductive crustal zones and weak to moderate lithospheric mantle resistivity in most parts of the study region, indicating an intensely modified Precambrian lithosphere due to multiphase tectono-magmatic episodes that affected the region from the Neoproterozoic to Cretaceous-Paleogene boundary. Interestingly, the MT study mapped two prominent high conductive (<30 Ωm) pipes commencing from a common deep mantle conductive zone imaged below the northernmost lobe of the Deccan volcanic province (Malwa plateau) and its proximity. These are inferred to be the remnant of hitherto unknown primary magma ascent channels that originated from a melt-rich deeper mantle zone related to the Reunion mantle plume upwelling. This study gives first compelling geophysical evidence of key eruptive centers of the massive Deccan volcanism in central-western India at a locale not anticipated earlier. The results support the plume origin and negate the inkling impact hypothesis for the Deccan volcanism.

Keyword

Deccan volcanism, Indian subcontinent, resistivity structure, magnetotellurics, Reunion plume

Characterization of 3D shallow subsurface structure of Deccan Volcanic Province, India using high frequency noise tomography

Sion Kumari KUMARI Pasagadgu[1]*, 1. CSIR-National Geophysical Research Institute, Hyderabad-500007, India. 2. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India (sion.ngri19a@acsir.res.in)
Sandeep Gupta[2], 1. CSIR-National Geophysical Research Institute, Hyderabad-500007, India. 2. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India
Sanjay KUMAR[3], 1. CSIR-National Geophysical Research Institute, Hyderabad, India

Abstract

Deccan volcanic province (DVP) in west-central India is a large igneous province formed due to the massive outpouring of a magmatic igneous volume at ~65 Ma and is surrounded by Dharwar craton, Bastar craton and Aravalli-Bundelkhand craton in south, east and north respectively. Since the region is totally covered by Deccan basalt, sub-basalt information is difficult due to the poor transmission of seismic energy through basalt. In the present study, we investigate the variation in basaltic thickness and delineate the sub-basaltic structure in the western and central regions of DVP by improving the resolution of the subsurface structure, to be used for further study of seismotectonic and geodynamics of DVP. We conduct high frequency ambient noise tomography using the vertical component of waveform obtained from the dense network of 100 and 23 seismic stations that were deployed in both western and central regions respectively. The deployed network of seismic station provides a good ray path coverage for the study area with the interstation distances varying between 3 - 120 km in the western region and 3 - 23 km in the central part of the region. The 3-D shear velocity model (0-10 km) beneath these regions reveals distinct variation in the basaltic thickness and sub-basalt crustal shear velocity structure.

Keyword

Deccan Volcanic Province, Basaltic thickness, Ambient noise tomography, Seismotectonics

[Keynote] The Deccan Volcanic Province (DVP) of India hosts three different types of earthquake sequences

Harsh K K GUPTA[1]*, CSIR-National Geophysical Research Institute (harshg123@gmail.com)

Abstract

Mogi (1963a, b) classified the earthquake sequences into three categories. Type 1 earthquake sequence occurs when the material is homogeneous, and the stress is uniformly applied. In this type, a mainshock occurs, with no foreshocks, and the aftershocks follow. Type 2 earthquake sequence is observed when the material has a rather heterogeneous structure and/or the applied stress is not uniform. In this case, the main shock is preceded by foreshocks and the number of aftershocks as well as the duration of the occurrence of aftershocks increases. Type 3 of the earthquake sequence is observed when the material is extremely heterogeneous and/or the applied stress has different concentrations, then there is no main shock, and a swarm kind of activity occurs where the number and magnitude of shocks increase with time and then decrease after some time. In the Deccan Volcanic Province (DVP) of India, all three types of earthquake sequences have been witnessed. Type 1 (Latur earthquake of M 6.2 on 29 September 1993), Type 2 (Koyna earthquake of M 6.3 on 10 December 1967), and Type 3 (Palghar earthquake swarm 2018-2020). It has been proposed that the change in the mechanical properties in the shallow crust due to the loading of the water reservoir has caused the change from Type 1 to Type 2 earthquake sequence for Koyna. Similarly, intense rain is considered to cause the change to Type 3. However, how these changes occur is not well understood.

There is a need to understand the cause leading to three different characteristics of earthquake foreshock-mainshock-aftershock sequence for a single geological domain, which is the DVP. It is hoped that the detailed near-field studies of earthquakes being undertaken at Koyna through a 3 km deep pilot borehole near the Donachiwada Fault hosting the reservoir-triggered seismicity (RTS) will provide an explanation.

Keyword

Mogi's model, Deccan Volcanic Province, Foreshock- aftershock sequences, b-values, triggered earthquakes

Tomographic imaging of sub-trappean Mesozoic sediments and basement configuration using long-offset seismic data in the Deccan Volcanic Province (DVP) of India

LAXMIDHAR BEHERA[1]*, CSIR-NATIONAL GEOPHYSICAL RESEARCH INSTITUTE (CSIR-NGRI) (laxmidhar@ngri.res.in)

Abstract

Abstract

The shallow sub-surface 2-D tomographic P-wave velocity (Vp) image of the Deccan Volcanic Province (DVP) of India is derived using long-offset seismic data along the 90-km long N-S trending Sinor-Valod seismic profile in the Deccan Syneclise region. The tomographic image depicts smooth velocity variations of Quaternary and Tertiary (2.0-3.0 km/s) sediments, basalts/traps (5.0-5.5 km/s), sub-trappean Mesozoic sediments (4.3-4.5 km/s) as well as the basement (5.9-6.1 km/s) geometry down to a maximum depth of 5.0 km. Due to Late Cretaceous volcanism and outpouring of basaltic lava flows, this region is affected by numerous dyke intrusions and thick basaltic trap (2-3 km) exposed on the surface and surrounded by graben structures due to deep-basinal faults forming a large-igneous-province (LIP). Although sub-basalt imaging is a major challenge for the oil industry, with the help of tomographic imaging technique of long-offset seismic refraction data, it is possible to image sub-trappean Mesozoic sediments (< 0.75 km) deposited below the two sequences of thick basaltic flows above the basement. The imaged Mesozoic sediments are expected to contain hydrocarbon because of their wide extension in this sedimentary basin with suitable trapping mechanism due to basalts. The robustness of velocity image is assessed through numerous tests like velocity perturbations, chi-square estimates, RMS residuals of traveltime fit, uncertainty estimates through computation of ray-density (or Hits) and series of checkerboard resolution tests with velocity anomalies having different cell size. The thickness of basalt and sub-trappean Mesozoic sediments along with basement configuration obtained from tomography are constrained through ray-trace modelling and pre-stack depth migration (PSDM) of long-offset seismic reflection data for different shot gathers along the profile.

Keyword

Tomography, Sedimentary basin, DVP, Mesozoic sediments, Basement

Crustal geoelectrical structure of Koyna region, India: Role of fluids as inferred from magnetotelluric study

Bantu Prasanta Kumar PATRO[1]*, CSIR-NGRI (patrobpk@ngri.res.in)
Ujjal Kumar Borah[2], Gauhati University

Abstract

The Koyna region in India is known for reservoir triggered seismicity since 1962. This region is covered with Deccan Basalt of 67.4 Ma of age. Under a deep drilling project, broad band MT survey was carried in and around Koyna-Warna seismic zone. Modelling (2D and 3D) studies carried out in Koyna Seismogenic Zone, India brought out moderately conductive (~700-1,000 Ωm) near vertical features within a high resistive (>20,000 Ωm) granite/granite-gneiss basement. The orientation of earthquake hypocenters along the resistive-conductive boundary indicates them as basement faults. Occurrences of these anomalous moderate conductors are corroborated with sensitivity analysis. The conversion of resistivity values to the ratio of seismic P- to S-wave velocity (vp/vs) proposes that the resistivity of the fault zone seems due to the presence of fluid in the fault zone. Geophysical evidences reveal ~2.5-3.6 vol% fluid in the fault zone with ~1.8-2.6% interconnected porosity, which migrates along the structural boundary. It occupies the mechanically strong basement to nucleate the brittle failure within it. The present study proposes two mechanisms for the seismicity in the Koyna region such as: the meteoric water circulation due to the loading-unloading of nearby Koyna reservoir and due to the dehydration of amphibole bearing rocks (as observed conductive feature at 20 km depth). The fluid generated from dehydration might act as a probable source to the triggered seismicity, since the conductive feature has a linkage to the upper crust.

Keyword

DVP, Koyna Siesmic Zone, Magnetotellurics, fluids

Constraining focal mechanisms of reservoir triggered seismicity in the Deccan Volcanic Province

D SHASHIDHAR[1]*, CSIR-National Geophysical Research Institute (shashi.geo@gmail.com)
K Mallika[2], CSIR-National Geophysical Research Institute

Abstract

Estimation of focal mechanisms of reservoir triggered earthquakes provides understanding on the fault/fracture pattern and features of triggered seismicity. However, focal mechanisms of micro earthquakes (around Mw 2.0) are often not well determined with first motion data alone due to station coverage and feeble signals. In the present study fault planes have been precisely determined using independent methods from the readings of polarities, inversion of amplitudes, amplitude ratios and waveform inversion techniques of the local earthquakes. The Koyna region located near the west coast of India in the Deccan Volcanic Province is a global significant site of reservoir triggered seismicity. CSIR-NGRI is monitoring a network comprising of borehole and surface seismic stations at Koyna-Warna. High-quality borehole data have provided better constraints on the estimation of fault planes. For most of the grid search solutions, more than 50 possible solutions resulted with a 2 degree increment search window. Interestingly, all the solutions aligned in almost similar trend. Further, only a few possible solutions using a 5 degree increment search and ended up with a single best fit solution while used a 10 degree increment search. In this way, the polarities and the station distributions allowed in achieving a best fit for the estimation of focal mechanism solutions of the selected earthquakes, where the solution is well constrained by polarities only, and then amplitude ratios have been used in the inversion which provided confirmation of a solution and helped to select one of several equally good solutions. The seismicity and fault plane data have enabled precise delineation of trends of major causative faults and lineaments in the region. We also discuss the variation of P-axis plunge and tectonic stress with time.

Keyword

Koyna, focal mechanism, Deccan, fault, earthquake

Mid-crustal basement below Deccan Volcanic Province: Evidence from multiparametric borehole study

Om Prakash PANDEY[1]*, CSIR-National Geophysical Research Institue
(om_pandey@rediffmail.com)
Priyanka Tripathi[2], Geological Survey of India, Western Region, Jaipur

Abstract

Mid-crustal basement below Deccan Volcanic Province: Evidence from multiparametric borehole study
O. P. Pandey1 and Priyanka Tripathi2
1CSIR-National Geophysical Research Institute, Hyderabad-500007 (India)
2Geological Survey of India, Western Region, Jaipur-302004 (India)

Indian peninsular shield has been experiencing moderate intraplate seismic activity since historical times, which includes many recent disastrous earthquakes, like 1967 Koyna (Mw 6.3), 1993 Killari (Mw 6.3) and 2001 Bhuj (Mw 7.7). Interestingly, epicenter of many such earthquakes are located over 65 Ma old Deccan Volcanic Province, which constitutes one of the largest flood basaltic eruptions on the surface of the Earth. In spite of several geological, geophysical and seismotectonic studies, carried out by national and international agencies since last four decades, seismotectonics of the earthquake prone areas of this region still remains poorly understood. We even do not know what kind of geologic terrain is concealed below the thick volcanic pile. In view of this, a deep scientific drilling programme was carried out in two such regions, Killari and Koyna. Out of the two, the first core drilling attempt was made in the epicentral region of 1993 Killari earthquake, which killed almost 10,000 people. 617m deep KLR-1 borehole, was the deepest and drilled by CSIR-NGRI and AMD (Hyderabad). It penetrated 338 m thick column of Deccan basalts, 8 m of infratrappean sediments and a further 270 m of the late Archean crystalline basement. We made a unique attempt and carried out detailed multiparametric geological, geochemical, mineralogical, isotopic, elastic and petrophysical studies on 43 basement cores. These iron-rich rocks (avg. FeOT: 9.0 wt%) are found to be made-up of high velocity-high density (2.82 g/cm3) amphibolite to granulite facies mid-crustal rocks, with intercalations of TTG. Basement samples are highly deformed, retrogressed and metasomatized by mantle fluids and contain 2 wt % of CO2. They have been subjected to temperatures between 540 and 860 °C and pressure 5–7 kb, equating to 15–21 km emplacement depth. The granitic-gneissic layer, which is typical of the upper crust, appears absent. It further appears that the earthquake nucleation in the intraplate stable regions, may have a close link with mantle metasomatism.

Keyword

Amphibolite-granulite facies basement, Killari Earthquake region, Mantle metasomatism, Retrogression, Deccan Volcanic Province

A RELOOK AT THE THICKNESS OF DECCAN TRAPS: IMPLICATIONS ON PALEOTOPOGRAPHY

MADHU RAJPUT[1], Fergusson College, Pune
DEVDUTT UPASANI[2], Fergusson College, Pune
GAURI DOLE[3], Savitribai Phule Pune University, Pune
SHILPA PATIL PILLAI[4], IISER, Pune
VIVEK S. KALE[5]*, ACWADAM (dr.vivekale@gmail.com)

Abstract

The rapid and voluminous eruptions of the flood basalts in the Deccan Volcanic Province (DVP) straddling the Cretaceous – Paleogene Boundary (K-PgB) are recognised as a primary causative factor for the environmental stress leading to a dramatic global faunal turnover across this boundary. This makes the computations of the volume of basaltic eruptions important.

The thickness and volume of the Deccan Trap flood basalts have been previously computed using (a) geophysical (gravity, seismic reflection profile, deep resistivity sounding and magnetotelluric) methods and (b) stratigraphic compilations and correlative extrapolations. Whereas the latter use the former only for partial justifications of the estimates. A review of literature shows wide discrepancies between the final tally in both cases. Both these methods assume a smooth basement profile, notwithstanding mapped undulations in the Trap – basement contact, which could seriously modify the real versus estimated thickness values.

In an effort to arrive at a more realistic estimate, we have used mapping data published by the Geological Survey of India, integrated with the emerging revisions in the stratigraphic classifications, projected basement profiles in different sectors elucidated by geophysical methods and drilling with our own observations. The input material used by us has a far superior granularity in terms of data points, and consistency in computations across the entire province. Based on this data we demonstrate that

(a) All previous estimates of the total volume of basaltic lavas were overestimated by a factor of 3 on the conservative side. The total volume of preserved lavas is not more than 0.2 million km3. Assuming more than half is eroded away, still leaves a total eruptive volume of only half a million km3.

(b) Several basement structures have controlled the geometry & spread of lava during the eruptive episodes of Deccan volcanism in different subprovinces. The possibility of their synvolcanic reactivation and movements along them need to be taken into considerations when correlating lava flows and computing their volumes. This also reaffirms that the lava stratigraphy of each subprovince was different.

(c) The Late Maastrichtian volumes of extrusion (and by implication the net magmatism) were far greater in proportion than the Danian volumes, unlike all previous estimates. The case for Deccan magmatism as a causative mechanism is further reinforced. This does not dilute the relevance of

the post-K-PgB volumes of lava in delaying the post-Cretaceous recovery of biotic systems.

The revised thickness computations and volume estimates of the Deccan Traps based on mapping and integration of the pre-Trappean topography opens new vistas for exploring the sub-Trappean data for resources. This study also recognises ancient zones of weakness that have evidence of Cenozoic & Quaternary reactivation.

Keyword

Deccan Volcanic Province, India, Volume estimation, Sub-trappean topography

Crustal Architecture beneath southern Deccan Volcanic Province: Implications from Integrated Studies

Vasanthi ANTHWAR[1]*, CSIR-National Geophysical Research Institute
(vasanthi99ngri@gmail.com)
N Durga Prasad Korimilli[2], CSIR-National Geophysical Research Institute
Nageswara Rao Bodapati[3], CSIR-National Geophysical Research Institute
Hema Sundar Tandule[4], CSIR-National Geophysical Research Institute
Abhey Ram Bansal[5], CSIR-National Geophysical Research Institute

Abstract

The Deccan Volcanic Province exhibits an intricate geodynamic architecture due to the massive magmatic eruption around 65 Ma. The massive eruption ensued in the Late Cretaceous period and started flowing from west to east along the pre-existing zones of weakness in the Indian shield. High-resolution terrestrial gravity data along with magnetic, heat flow, and seismic data have been analysed in the southern part of the Deccan Volcanic Province (south of Central Indian Tectonic Zone) to determine the density discontinuities beneath the region. The primary structural framework in the region has been scrutinized at various depth levels, which delineated prominent W-E to WNW-ESE gravity anomaly trends parallel to the Narmada-Tapti rift zone. An important observation is that the extensions of the Godavari rift basin are observed underneath the Deccan Volcanic Province. The 2.5D gravity modelling along a NW-SE profile suggested that the Moho depth varies between 38 and 42 km. The density model further delineated the presence of low-density zones, which corroborate with the low-velocity layers as inferred in the previous studies. In addition, this study unveils distinct characteristics influenced by the evolution of the Narmada-Tapti rift during the Cenozoic era, effectively distinguishing the northern and southern segments of the Deccan Volcanic Province.

Keyword

Gravity, Gradients, Isostasy, Crustal thickness, modelling

Seismic imaging of southern part of Kachchh region (western India)

CHANDRAKALA KOTESWARA[1]*, CSIR-NATIONAL GEOPHYSICAL RESERCH INSTITUTE (chndrbhat@gmail.com)

Abstract

Seismic imaging of southern part of Kachchh region (western India)
K. Chandrakala
CSIR-National Geophysical Research Institute, Hyderabad- 500 007, India

Kachchh region, situated in the northern part of the western continental margin of India, is a contiguous part of South Indus Basin that extends from onland to the adjoining offshore areas of Arabian Sea. It is the westernmost extension of the Deccan volcanic province, which is considered one of the largest basaltic eruption on the surface of the earth. This region is underlain by thick Mesozoic sequences and on its eastern side, it is surrounded by hydrocarbon-rich thick Tertiary sediments. This region remains one of the most prominent earthquake sites in India since historical times, where deep crustal earthquakes keep on occurring. It has witnessed several large events like, 1819 Kachchh (Mw 7.7), 1956 Anjar (Mw 6.0), and 2001 Bhuj (Mw 7.7) earthquakes. In view of the active seismicity associated with this region, CSIR-National Geophysical Research Institute (Hyderabad) acquired seismic refraction data. In the present study, we have reprocessed the seismic data acquired along Jakhau-Mandvi profile, which traversed through the southern part of the Kachchh region. Our initial study revealed a five layered structure above the basement in which Vp (km/s) varies from 2.10-2.20 (upper Tertiary sediments), 4.40-4.60 (Deccan volcanics), 3.20-3.50 (upper Mesozoic sedimentary layer), 5.30-5.40 (Mesozoic volcanics) and 3.30-3.70 (lower Mesozoic sedimentary layer). Basement characterized by velocity of 5.90 to 6.0 km/s is underlain by mid crustal (Vp:6.30-6.40) and lower crustal (Vp: 6.8-06.90 km/s) layers, which is further underplated by thick magmatic layer (Vp: 7.10 -7.20 km/s) above the Moho. Moho detected at an extremely shallow depth of 29 to 32 km is characterized by velocity 8.10- 8.20 km/s.

Keyword

Seismic velocity structure, Jakhau-Mandvi DSS profile, seismicity, Deccan volcanic province, Magmatic underplating

Development of rift systems in the Kutch-Saurashtra region-A tale of multiple breakup events: Constraints from geophysical and geochronological data

Munukutla RADHAKRISHNA[1]*, Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai, India (mradhakrishna@iitb.ac.in)
Pattabhiram Kondepudi[2], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai, India
Bhavya K. B.[3], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai, India
Kanchan Pande[4], Department of Earth Sciences, Indian Institute of Technology Bombay, Mumbai, India

Abstract

The rift systems in the Kutch-Saurashtra region developed in three major stages related to the continental breakup of India from East Africa (~160Ma), Madagascar (~88Ma), and Seychelles (~63Ma). The north-western Indian shield and adjoining offshore region is blanketed by the Late Cretaceous Deccan Volcanism, up to ~3km thick, inhibiting the understanding of pre-Deccan rift configuration. An integrated approach combines drilled well information, Ar-Ar geochronology, and geophysical data to decipher the complex tectonic history and volcanism (episodic?). The present study reports the Ar-Ar ages of 5 igneous rock samples from the Kutch offshore wells comprising two basalts(b), two dolerites(d), and a rhyolite(r). The Ar-Ar plateau ages of the samples are 80.5 ± 0.5(b), 81.4 ± 0.5 (r), 100.3 ± 0.6 (b), 72.6± 0.4 (d), and 67.1 ± 0.6 (d) (errors quoted at 2σ level). These results were correlated with previous geochronological data from this region. Different rifting events and their directions were identified using multi-channel seismic data. Magmatic bodies, which are strong reflectors, were mapped in the seismic sections at various stratigraphic levels from the Jurassic to Late Cretaceous age and are substantiated by the drilled core data. The seismic data shows that the major fracture systems in this region acted as conduits for the magma to reach the surface. The constrained gravity interpretation of the region provided new insights into the basin architecture and onshore-offshore tectonic linkage. The Present study demonstrates the development of the Kutch-Saurashtra rift systems during different continental breakups and associated magmatism from a geodynamic perspective. The striking similarity of the tectono-magmatic history of the Kutch-Saurashtra region with the Seychelles and Madagascar is fascinating.

Keyword

Deccan Volcanism, Kutch Saurashtra, fragmentation of Gondwana, Rift systems, Ar-Ar geochronology

Possible sub-surface extension of Deccan Magma in the north Arabian Sea

Vasanthi ANTHWAR[1]*, CSIR-National Geophysical Research Institute
(vasanthi99ngri@gmail.com)

Abstract

Gondwanaland break-up during the late Cretaceous and subsequent geodynamic activities in the Arabian Sea, resulted into the formation of several prominent geotectonic features like, Laxmi, Chagos-Laccadive, Panikkar and Palitana ridges and Laxmi and Gop basins. Out of these features the Laxmi Ridge, associated with conspicuous negative gravity field, is considered extremely unusual. The crustal structure beneath this ridge has been a subject of intense debate since many decades. We have analysed high-resolution satellite gravity field over the Laxmi Ridge and its adjoining areas to address this incongruity. We provide detailed sub-surface crustal and lithospheric density model across this region using residual gravity anomalies, computed by the Finite Element Method. This ridge associated with a residual gravity low of the order of -30 to -80 mGal contrasts with the adjacently located Laxmi Basin, Panikkar and Palitana ridges that are characterised by distinctly positive gravity field. Such a negative character of the gravity anomaly over a ridge structure, is highly unusual in a typical oceanic crustal environment. In the absence of active rifting, it can only possibly be explained with the occurrence of a low-density underplated material below the Moho. The 2½D residual gravity model indicates that the underplated magmatic layer (2.9 g/cm3) below the Moho is about 10 km thick, which can be ascribed to a fractionated and highly differentiated magma related to Deccan Volcanic episode and Seychelles break-up, that occurred at the K-T mass extinction boundary (~ 66 Ma) and covered a large part of west-central India and adjacent offshore region in the Arabian Sea.

Keyword

Deccan Volcanic Province, Gravity field, Laxmi Ridge, Magmatic Underplating, Finite Element Method

Tectonomagmatic evolution of the crust and lithosphere beneath the Western Deccan Volcanic Province, India – A magnetotelluric study

Pavankumar GAYATRI[1]*, CSIR-NATIONAL GEOPHYSICAL RESEARCH INSTITUE (gayatripavan@ngri.res.in)
Chakravarthi Narasimha Nalluru[2], CSIR-NATIONAL GEOPHYSICAL RESEARCH INSTITUE
Ajay Manglik[3], CSIR-NATIONAL GEOPHYSICAL RESEARCH INSTITUE

Abstract

The western continental margin of India is constituted of significant geomorphological features namely the Konkan coastal plains, coast parallel Western Ghat escarpment and the elevated Deccan plateau; one of the largest igneous provinces of the world. The margin witnessed at least two rifting episodes that affected not only the surface morphology but the concealed pre-eruptive tectonic features in the region. Neotectonic activity has been reported from the region. Here, we present the results from a magnetotelluric study carried out along a 200 km long E-W profile traversing major tectonics features between the Konkan plains and the Deccan plateau. Deep geoelectric structure constructed from two-dimensional modelling of the impedance tensors at 39 sites reveals the presence of highly resistive fragmented cratonic blocks of the Greater Dharwar Craton with variable thickness dissected by the faults/fracture zones of pre-eruptive time. We attribute the recent past and ongoing seismic activity in the western Deccan Volcanic Province to reactivation of these tectonic features. The cratonic blocks are overlain on moderate-to-high conductivity zones representing the relics of the interaction process of the Indian lithosphere with the Réunion plume and indicate the zone of partial melts due to the effect of the residual thermal anomaly. We infer that the magmatic underplating and subsequent uplift might be a plausible cause for persistent and dynamic topography of the western Ghats and gradual eastward thickening of the cratonic blocks.

Keyword

Deccan Volcanic Province, Western Ghats, Magnetotellurics, Cratonic blocks, Low Resistivity Zone

Delineation of lithospheric structure across the Deccan Volcanic Province and Eastern Dharwar Craton, south Indian shield using joint inversion of receiver function and surface wave dispersion data

Sudesh KUMAR[1]*, CSIR-National Geophysical Research Institute (kumarsudesh77@gmail.com)
Sandeep Gupta[2], CSIR-Nastional Geophysical Research Institute
K. Sivaram[3], CSIR-National Geophysical Research Institute

Abstract

The Deccan Volcanic Province (DVP) is one of the largest flood basalt region in the world, together with Dharwar craton constitutes a large portion of the south Indian shield (SIS). The SIS is influenced by several tectono-thermal events during its evolutionary history. The Deccan volcanism is the last tectono-thermal event (~ 65 ma) which influenced the significant part of SIS. To understand the evolution of the DVP, we determine the lithospheric structure across the Deccan Volcanic Province–Eastern Dharwar Craton (EDC), using seismological waveforms recorded at 18 seismological stations. We infer the nature of lithospheric structure using joint inversion of teleseismic receiver functions and surface wave dispersion data, teleseismic relative residuals, and upper mantle seismic anisotropy measurements.

The results of inversion show the distinct nature of lithosphere beneath the DVP-EDC transacts. The crustal thickness is systematically varying from EDC (32-34 km) to DVP (34-39 km). We found sharp and felsic crust (Vp/Vs ~1.74) beneath the EDC while DVP has gradational and mafic crust (Vp/Vs ~1.78). The calculated lithospheric thickness shows a significant difference in the DVP (~125 km) and EDC (~175 km); it is 50-60 km thinner in the DVP in comparison of the EDC.

From the analysis of teleseismic travel time residuals, the DVP depicts delay of 0.2 -0.4 s with respect to the EDC. The measurement of splitting parameters (i.e. fast polarization orientation, Φ, and delay time, δt) also show distinct splitting patterns highlighting deeper geological structures. In the DVP, Φ is nearly NE-SW for most stations, along with an average (at each station) δt varying between 0.5 s and 1.2 s. In the EDC, our results show Φ predominantly in the NW-SE orientations with δt varying between 1.0 and 1.4 s.

Based on the results obtained, we infer that different evaluation processes are responsible for the DVP and EDC. The DVP is significantly affected by Deccan plume while EDC has remained unaffected since long geological time.

Keyword

Deccan Volcanic Province, Lithosphere thickness, Receiver function, surface wave dispersion, seismic anisotropy

Configuration of Deccan Traps and its effect on triggered seismicity in Koyna-Warna Seismic Zone, India

Ujjal Kumar BORAH[1]*, Gauhati University, Guwahati 781014, India (ujjal.borah6@gmail.com)
Prasanta Kumar Patro[2], CSIR-NGRI, Hyderabad 500007, India

Abstract

Koyna-Warna Seismic Zone (KWSZ), western India is well known for reservoir triggered seismicity (RTS). The entire area is covered by Deccan basalt which is seated on the granitic basement. Configuration of the Deccan Traps in and around KWSZ plays a critical role on RTS in the region; since the increase in trap thickness will lead to the increase of pressure on the basement. This increment in pressure, due to the increased trap thickness, affects the accumulated stress regime inside the basement faults. When fluid percolate into these stressed basement faults under pressure, strain will be released. Therefore, to understand the trap configuration, a magnetotelluric (MT) investigation is carried out in and around KWSZ. The dimensionality analysis of the acquired MT data signifies a one-dimensional (1D) structure for the upper part of KWSZ (0.001 s – 1 s). Therefore, 1D inversion is carried out to configure the trap. The efficacy and the reliability of the 1D inversion output is also tested. The 1D inversion brings out that significant variation in the trap thickness follows mainly E-W trend (average ~800 m thickness) with thicker central part. This central part of the trap in KWSZ exerts an average pressure of 25.6 MPa upon the basement, which is bounded by lower average pressure of 17.6 MPa on both sides. This comparatively high pressurized central part of KWSZ coincides with the observed RTS in the area. This association points towards a probable role of pressure, as catalyst, on stress release for the triggered seismicity in KWSZ.

Keyword

Koyna, Magnetotelluric, 1D inversion, Deccan Trap thickness, Trap pressure

Deep Seismic Reflection Profiling across the Seismically active Mesozoic Kachchh rift basin, NW India: implications for crustal evolution

BISWAJIT MANDAL[1]*, CSIR-NATIONAL GEOPHYSICAL RESERACH INSTITUTE, UPPAL ROAD, HYDERABAD, INDIA (bisuman@gmail.com)
V. VIJAYA RAO[2], CSIR-NATIONAL GEOPHYSICAL RESERACH INSTITUTE, UPPAL ROAD, HYDERABAD, INDIA
P. KARUPPANNAN[3], CSIR-NATIONAL GEOPHYSICAL RESERACH INSTITUTE, UPPAL ROAD, HYDERABAD, INDIA
K. LAXMINARAYANA[4], Academy of Scientific and Innovative Research (AcSIR), Ghaziabad-201002, India
SUMER CHOPRA[5], Institute of Seismological Research, Gandhinagar-382009, India.
M. RAVI KUMAR[6], CSIR-NATIONAL GEOPHYSICAL RESERACH INSTITUTE, UPPAL ROAD, HYDERABAD, INDIA
PRAKASH KUMAR[7], CSIR-NATIONAL GEOPHYSICAL RESERACH INSTITUTE, UPPAL ROAD, HYDERABAD, INDIA

Abstract

The Kachchh Rift basin, located in the western region of India, is considered to be one of the most seismically active zones after the Himalayas. In order to understand the tectonics and architecture of the rift basin, a deep seismic reflection profiling study was conducted. The data was processed using the common reflection surface stack approach, which provided high-resolution seismic images of the crust. These images revealed a sub-horizontal lower crustal reflection fabric that was approximately 15 km thick, as well as a dome-type structure that extended from the surface to the Moho. The earlier structure was interpreted as magmatic underplating, while the latter was interpreted as the Kachchh Mainland uplift. There were significant variations in the thickness of sediments, ranging from 150 m to 6.5 km, and crustal thickness, ranging from 45 km to 35 km from north to south. The Moho was found to be upwarped by 4 km beneath the Kachchh Mainland fault. Interestingly, the Kachchh rift basin exhibited an unusually thick crust of 45 km, which is contrary to many other rift basins. The study suggested that the syn-rifting and Reunion mantle plume activity, as manifested by the Deccan volcanics, were responsible for magmatic underplating and crustal thickening. The uplift in the region was found to be multi-genetic in origin. The study also revealed new faults and provided insight into the nature of various other faults. Moderate to large earthquakes in the region were attributed to the regional and local stresses resulting from the plate boundary and heterogeneous crustal structure. Based on the mafic lower crust and distribution of aftershocks through the entire crust, the study interpreted that the lower crust is brittle, which is contrary to most models of continental rheology.

Keyword

Crustal Structure, Deep Seismic Reflection Study, Mantle plume, Uplift, Seismicity,

Paleomagnetism of KBH-7 core from Koyna, Western Ghats, India

Venkateshwarlu Mamilla[1], CSIR-National Geophysical Research Institute
Venkateshwarlu MAMILLA[2]*, CSIR-National Geophysical Research Institute
(mamillavenkateshwarlu@gmail.com)

Abstract

Deccan Trap surface samples are subjected to Paleomagnetism studies since last three decades but to study the erupted lava at depths is very rare. Basalt flows are considered to be accurate recorders of geomagnetic field direction. Paleomagnetic studies were carried out on 1250 m thick continuous drill core (KBH-7) from Koyna, Western Ghats, India. Basalt sequence along the core is demarcated into 37 flows. Individual flows demarcated by red boles are massive at the bottom and vesicular and/or amygdaloidal at the top. Palaeomagnetic results from 113 slices of the drill core is retrieved. Rock magnetism study indicate that the core samples carry Titanomagnetite and Magnetite as the remanence carrier. Present study core sample inclinations (~30-60°) are determined systematically in a vertical orientation along the axis of the core. The results clearly display a single geomagnetic polarity transition in palaeomagnetic data for KBH-7. The flow samples from surface down to ~640-650 m MSL show normal polarity with upward inclination (I = −50 ± 10°) and the flow samples down to the basement show a reverse polarity with downward inclinations (I = +44 ± 14°). These results establish unequivocally a single geomagnetic polarity transition during the eruption of the entire section of the basalt.

Keyword

Paleomagnetism, Deccan Traps, KBH-7, Koyna, India

Secondary mineralization and fluid channelization through fractures within the basement rocks of seismically active Koyna-Warna area, Maharashtra, India

Manas GOSWAMI[1]*, Gauhati University (manasgoswami160@gmail.com)
Surajit Misra[2], Gauhati University

Abstract

The Koyna-Warna area is located in the Deccan Volcanic Province (DVP), Maharashtra, western peninsular India, and is well known for persistent seismic activity since 1967. The seismic activities were followed by the impoundment of the Shivajisagar lake, an artificial reservoir of the Koyna dam in 1962. The largest earthquake occurred in 1967, with M~6.3, which was followed by approximately 22 earthquakes of M≥5, 200 earthquakes of M≥4, and thousands of smaller magnitude earthquakes have occurred in the area. Most of these earthquakes are restricted within an area of ~ 20×30 square km. The DVP is underlain by cratonic granitoid basement rocks. Most of the earthquake hypocenters are located within a depth range of 7-10 km, whereas maximum DVP thickness in the study area is 1251 m. Therefore, basement rocks are important to study on deformation signatures related to the ongoing brittle failures below the study area.

Recent scientific deep drilling activities by Govt. of India in the study area facilitate us to direct investigation on the basement rocks. This study helps us to explore multiple brittle deformation events, which are evident from the basement rocks in the Koyna-Warna region. Evidence of these deformations are mainly present in the form of slickensides, slickenlines, and several fault rocks, which include cataclasites, fault breccia, and fault gouge. Further brittle deformation events are recorded in the form of fractures which range from mm to cm scale in width, creating an anastomosing fracture network from surface towards depth. Secondary mineralization has occurred within these fractures which can be broadly classified as siliceous, ferruginous, carbonate, and clay materials. Siliceous and ferruginous materials are the most abundant and present within a wide range of fracture width. Association of both crystallized as well as amorphous ferruginous materials following the same fracture indicate variable conditions of mineralization. Presence of calcite crystals as veins without any deformation attributed their recent formation. Further, occurrences of amorphous carbonates are very few compared to the siliceous and ferruginous materials. Besides, presence of clay materials within the basement fault zone rocks indicates a periodic distribution. Summarily, these fractures are facilitating pathways for fluid channelization at depths. The channelized fluid is carrying materials through fractures for secondary mineralization. The association of different secondary materials within the same fracture indicates multiple episodes of fluid influx with different chemical compositions at seismogenic depth.

Keyword

Koyna-Warna, active seismicity, secondary mineralization, fault rock, sealing

Blank strip filling method for electrical logging images based on the combination of convolution neural network and Transformer

XU PANG[1]*, +8618668047099 (404099199@qq.com)
PING GUO ZUO[2], +8613456851348
LIU YANG[3], +8613777828020
FENG CHAO WANG[4], +8618857115926
WEN SI WANG[5], +8618782288813
GANG YONG ZHANG[6], +8613989474348

Abstract

Electrical imaging logging has been an indispensable means of obtaining subsurface information images in geophysics and an effective technical means for reservoir logging evaluation, but with the rapid expansion of deep-water exploration and development activities, oil-based mud electrical imaging logging has been widely used. However, because the spacing and size of the polar plate cannot be matched exactly with the well diameter, the coverage can be as low as 32%, and the data imaging will show regular blank strips, which seriously affects the image visualization and logging interpretation process. In order to ensure the accuracy of image interpretation and quantitative parameter pickup, it is necessary to carry out blank strips recovery to obtain resistivity information of the whole well wall. In this paper, on the basis of exploring the existing methods for blank strip filling in electrical imaging images, a method based on the combination of CNN and Transformer is proposed, which, combined with the strategy of multiple iterations of the results, achieves the best complementary effect among all the current methods. Compared with the commonly used interpolation method, the image complemented by this method has richer and more reasonable texture and semantic information as a whole, while no artifacts are introduced. The method also outperforms other complementation methods in terms of evaluation metrics such as MAE, SSIM, and PSNR. The method proposed in this paper can meet the practical application requirements of blank strip filling in scale for electro-imaging, and can also provide a reference means for the information processing of measurement missing strips between the measurement polar plates.

Keyword

Electrical imaging logging, Blank strip filling, convolution neural network, Transformer

Application of supervised neural network algorithm in logging predicting shale lithofacies - A case study from the first member of Qingshankou Formation in Gulong Sag, Songliao Basin

danting LUO[1]*, Northwest University (danting2012@qq.com)
jinglan LUO[2], Northwest University
zihui FENG[3], Exploration and Development esearch Institute of Daqing Oilfield Co Ltd
min YAN[4], Northwest University
hongmei SHAO[5], Exploration and Development esearch Institute of Daqing Oilfield Co Ltd
chao DENG[6], Northwest University
ze TAN[7], Northwest University

Abstract

Identification of shale lithofacies is a key in understanding the spatial distribution of shale oil and predicting exploration targets. However, it may result in redundant logging information in characterizing complex lithofacies, due to the strong heterogeneity of the shale reservoir, rapid changes in lithofacies, and the highly similar characteristics of logging curves. Furthermore, the highly nonlinear characteristics of logging curves may lead to ambiguity and uncertainty in the mapping relationship between logging curves and lithofacies, which further affects the recognition and prediction results of shale logging lithofacies. A new intelligent lithofacies recognition model is proposed in this study. It can effectively address the above problems by integrating linear discriminant analysis (LDA) and a self-organizing mapping neural network (SOM) model. The four key well logging curves of gamma ray (GR), density (DEN), spontaneous potential (SP), and resistivity (RD), which can adequately provide the physical properties of shale through the application of linear discriminant analysis (LDA), are selected as the discriminant input curves. The geological lithofacies of the shale within the first member of the Qingshankou Formation in the Gulong Sag are systematically categorized, utilizing a shale classification scheme that takes into account organic matter, sedimentary structure, and mineral composition. Furthermore, three neural network algorithms, namely quantitative classification, minimal distance, and majority voting method, are introduced as data label indices for supervised learning modeling. The nine lithofacies recognition models are established for the shale, based on the three neural network algorithms. A shale lithofacies recognition model with the highest universality for the study area is selected from the nine lithofacies recognition models, by verifying the geological lithofacies division. This model can quickly and accurately identify shale lithofacies in a single well and predict their spatial distribution. Consequently, it serves as a solid foundation for providing data support to the subsequent prediction of favorable areas for shale oil exploration.

Keyword

Linear discriminant analysis, Neural network models, Machine learning, Shale lithofacies identification, Songliao Basin

A review of the utilization of novel artificial intelligence tools for advanced reservoir characterization

SHIB SANKAR GANGULI[1]*, CSIR – National Geophysical Research Institute (NGRI)
(ganguli.ism@gmail.com)
PRAKASH KUMAR[2], CSIR-National Geophysical Research Institute

Abstract

Accurate estimation of reservoir properties is crucial for characterizing hydrocarbon-bearing reservoirs, and conventional methods often face challenges in delivering such precise estimates from geophysical data. Recent technological advancements have significantly improved the accuracy of predictive models, pushing the boundaries of what machines can achieve. This study aims to offer an in-depth examination of both conventional methods and novel artificial intelligence (AI) algorithms for the qualitative and quantitative evaluation of reservoir source rock quality and mapping heterogeneities/facies. For this, a novel approach based on the particle-swarm-optimization (PSO) method and neural network is proposed to develop an accurate predictive model for total organic carbon content estimation in unconventional shales. Moreover, a deep learning-based seismic attribute is utilized to locate the lateral changes in heterogeneities/ facies. The proposed approaches have been tested with a selection of synthetic and field data examples, which will be discussed in this work. The effectiveness of the predictive models was evaluated using established statistical metrics, including the coefficient of determination, correlation coefficient, root mean square error, mean absolute error, and mean percentage error. Once trained, these tools have been found to be robust in predicting reservoir parameters of interest and delineating heterogeneities and facies distribution within the reservoir zones. This study demonstrates the potential of AI algorithms and their role in selecting data features, thereby enhancing prediction accuracy in models for effective reservoir characterization.

Keyword

reservoir characterization, artificial intelligence, predictive models, geophysical data

Appraisal of gas hydrate saturation in KG basin using synergistic implementation of geophysical log analysis and machine learning approaches

SUMAN KONAR[1]*, Controlled Source Seismics and Gas Hydrates, CSIR - National Geophysical Research Institute, Hyderabad-500007, India (konarsuman2@gmail.com)
BAPPA MUKHERJEE[2], Seismic Interpretation Laboratory, Wadia Institute of Himalayan Geology, Dehradun-248001, India
KALACHAND SAIN[3], Seismic Interpretation Laboratory, Wadia Institute of Himalayan Geology, Dehradun-248001, India

Abstract

Gas hydrate saturation estimation is vital for assessing gas hydrate reservoirs. Resistivity and acoustic logs are traditionally used to estimate gas hydrate saturation, but they often overlook limitations like calibration of exponent terms, unknown hydrate morphology, mineralogy, and bulk modulus terms. Hence, we address these challenges by employing machine learning (ML) algorithms. This study conducts gas hydrate saturation (Sh) prediction using three supervised machine learning techniques namely Decision Tree (DT), Extreme Gradient Boosting (XGBoost) and Gaussian Process Regression (GPR). The practicability of the proposed method has been demonstrated with well log data from the Krishna-Godavari (KG) offshore basin, India. Initial saturation estimates were made using modified Archie's equation and Indonesian equation from log data of two clay-dominated wells. This data was then used to train the ML models, which further predicted Sh in two neighbouring wells. The accuracy of the ML models was validated through root mean square error (RMSE) and correlation coefficient calculation between original and predicted saturation, showing ML algorithms outperform traditional methods. DT showed the lowest RMSE and highest correlation, while XGBoost and GPR also exhibited reliable prediction performance. Predicted saturation levels at the analysed locations vary from 0% to around 43%, providing precise saturation estimates essential for accurate resource evaluation and strategic production planning.

Keyword

Gas Hydrate, Machine Learning, KG basin

Fine Structure Description and Hydrocarbon Prediction of Fault-karst Reservoir

Hong ZHANG[1]*, Research Institute of Petroleum Exploration and Development (2384224423@qq.com)
Zhipeng GUI[2], China University of Petroleum (East China)
Junhua ZHANG[3], China University of Petroleum (East China)
Dong CHEN[4], Research Institute of Petroleum Exploration and Development
Pengbo YIN[5], China University of Petroleum (East China)

Abstract

Fault-karst Reservoir is an important carbonate hydrocarbon reservoir. Due to the coupling of strike-slip fault and karst cave seismic response, the fine description and prediction are very difficult. For a case study of YJ Oilfield, some practical methods are ultilized including fine structure description and hydrocarbon prediction.

In order to predict the strike-slip fault, we introduce residual blocks to replace all convolutional layers of the 3D UNet to build a new 3D Res-UNet network and select appropriate parameters through experiments to train a large amount of synthesized seismic data. After the training is completed; we introduce the mechanism of knowledge distillation and train the 3D Res-UNet as teacher network, so as to learn more fault information, improve the performance of the network, and optimize the fault recognition effectFor karst cave, the U-Net++ network is selected as the deep learning model. It adopts a hierarchical and gradually refined feature extraction method, which can effectively process multi-scale and multi-resolution images, and can better capture the details in the image. Two data volumes can be fused together according to a certain probability. It can further integrate with the original data volume to carry out targeted interpretation. Using two primary colors display technique, it can also obtain wonderful horizontal slice.

The hydrocarbon direct description effect is poor, for the reservoir in the study area are interspersed in the reflection events with strong energy. Considering that matching pursuit and compressed sensing are only suitable for the removal of a single seismic event, but there are multiple strong reflection layers, a Karhunen-Loeve transform removing the stratigraphic background is developed through treating the stratigraphic structure as noise. In order to improve the accuracy of denoising, the stratal slicing and interpolation technique are used to obtain an equal-length interpolation cube before the transform is used. After processing, it is embedded into the original data volume. For processed volume, finally, the improved S transform is used to perform high-precision spectral analysis. The study found1The frequency spectrum of high-yield oil wells has absorption attenuation phenomenon;2 The frequency of dry well increases without attenuation;3) The frequency of the water well is not attenuated, and the buried depth is relatively deep.

The studies obtain good results. The methods and techniques have certain guiding significance for the exploration and development of fault-karst reservoir at home and abroad.

Keyword

strike-slip fault, deep learning, U-Net++ network, carbonate hydrocarbon reservoir

Quantification of uncertainty in the reconstruction of resistivity tomography image with machine learning

Xixi LAN[1]*, China University of Geosciences (Beijing) (lxx_cugb@163.com)
Changchun ZOU[2], China University of Geosciences (Beijing)

Abstract

The Electrical Resistivity Tomography (ERT) method plays an essential role in researching electrical properties at the core scale, and the resistivity image inversion reconstruction technique is the key to constraining measurement accuracy. In recent years, with the improvement of computer operation capabilities and the acquisition of a large amount of geophysical data, the inversion algorithms represented by machine learning (ML) have made it possible to reconstruct ERT images automatically. However, the solution of ERT image inversion has large uncertainty due to high nonlinearity. Meanwhile, traditional ML methods are not initially developed for evaluating the uncertainty of such reconstruction results. In this paper, we propose a novel MC-Net ML scheme to quantitatively estimate the uncertainty of the ERT image reconstruction by introducing the Monte-Carlo Dropout strategy with one multiple stochastic method to approximate Bayesian inference. As one important evaluation index, the correlation coefficient (CC) between target image and reconstructed image is used to compare the effects of six types of simulated data carried by different ML schemes. The inversion results show that MC-Net increases lower limit of CC on the premise of ensuring average CC. Moreover, the accuracy of regression and classification results defined in this paper also obtained the highest value by MC-Net. With the proposed scheme, we can further provide a quantification of the uncertainty to determine whether reconstructed images are reliable after reconstructing the ERT images, which is of great significance for actual intelligent inversion tasks.

Keyword

ERT image reconstruction, quantification of the uncertainty, machine learning, Monte-Carlo Dropout strategy

Identification Method Of Micro Residual Oil Types And Quantitative Characterization Based On Deep Learning

Xianda SUN[1]*, Northeast Petroleum University (sunxianda@nepu.edu.cn)
Xudong QIN[2], Northeast Petroleum University
Yangdong CAO[3], Northeast Petroleum University
Tao LIU[4], Northeast Petroleum University
Ling ZHAO[5], Northeast Petroleum University

Abstract

This study focuses on porous media, combining the distribution frequency of pore throat size measured by mercury intrusion porosimetry and the coordination number obtained from CT scans. Taking into account the shape and wettability of the throat, an adaptive porosity method is employed to construct a digital pore network model based on the fitted measured permeability. Utilizing this model, the paper applies theoretical methods from fluid mechanics, seepage theory, calculus, and numerical calculations to simulate the fluid flow process. Mathematical models for processes of oil saturation, waterflooding, and polymer flooding are established and solved. Furthermore, the state of the model after the oil displacement process is visualized using 3DMAX software. The study identifies that the residual oil shapes after polymer flooding can be classified into various forms such as cluster, throat, blind-end, columnar, and droplet shapes. Moreover, the paper employs MobileNet V1, MobileNet V2, and an improved SENet convolutional neural network model to classify residual oil images, demonstrating that the model can accurately identify residual oil forms. The improved SENet surpasses the original MobileNet models in both precision and recall, with an accuracy improvement of 0.6 percentage points. This achievement not only proves the superiority of the improved SENet in the task of residual oil image recognition but also provides a robust reference for subsequent research work.

Keyword

Digital Pore Network Model, Fluid Mechanics, Residual Oil Characterization, Convolutional Neural Networks, Polymer Flooding

Particle Swarm Optimization - Gravitational Search Algorithm Tuned Deep Neural Network to estimate the subsurface interlayer boundary

Sunam Kumar SHARMA[1]*, Geotech Solutions International (sunamsharma@gmail.com)
Anil Kumar Khambampati[2], Jeju National University
Manita Timilsina[3], Geotech Solutions International
Kyung Youn Kim[4], Jeju National University

Abstract

Electrical impedance tomography (EIT) is a non-invasive image reconstruction method. It reconstructs the cross-sectional conductivity distribution of the domain. However, it suffers from poor spatial resolution due to the ill-posed and non-linear nature of the problem. Boundary or shape estimation is the alternative approach to solve this poor resolution problem. In this approach, the number of unknowns to be estimated is reduced which improves the spatial resolution. The conductivity of the closed disjoint region of the domain is assumed to be known as prior for the boundary estimation. The subsurface region can be approximated as piece-wise separate regions with constant conductivity in each region; therefore, the conductivity estimation problem is transformed to estimate the shape and location of the layer boundary interface. Each layer interface boundary is treated as an open boundary that is described using front points. A Deep Neural Network (DNN) model is used to estimate the front points describing the multi-layer interface boundaries. This DNN model is tuned for hidden layer nodes using Particle Swarm Optimization - Gravitational Search Algorithm (PSOGSA). The PSOGSA tuned DNN model is trained for interlayer boundary reconstruction using training data that consists of pairs of voltage measurements of the subsurface domain. The tuned DNN model estimation result is compared with the 7-layer DNN model. The study on all three cases shows the proposed method has a better estimation result than the manually tuned DNN model.

Keyword

Deep Neural Network, Electrical Impedance Tomography, PSOGSA, Parameter estimation, Subsurface layer

A novel method of seismic data reconstruction in reverse time migration

Yue ZHENG[1]*, CNPC (zhengy2022@petrochina.com.cn)
Wencheng Yang[2], SINOPEC
Tao Xu[3], IGGCAS
Youshan Liu[4], IGGCAS
Ren Jiang[5], CNPC

Abstract

With the development of computer cluster, the application of reverse time migration is widely used in the oil and gas production because of its high imaging resolution and precision. However, the seismic data will be sparsely sampled or irregular sampled due to the constraints of production cost, terrain (such as cities, rivers, etc.) in field exploration and acquisition hardware failure which will have a severe impact on the image quality of reverse time migration. The traditional seismic reconstruction method including the Fourier transform, the wavefield reconstruction based on checkpoint technique, the directional 2D interpolation based on partial differential equation, the point spread function interpolation based on density perturbation, the structural-oriented method and etc. These methods above involve massive amount of computation, domain transform, solving the wave equation and the iteration of inverse problem.

In this paper, we proposed a fast method to reconstruct the missing traces which as a result of irregular sampling by applying the opening- and closing- operation. This process only involves addition and subtraction operation which has higher computational efficiency and faster computation speed. An important character of seismic data is that the event is continuous and the amplitude is similar along the event. In terms of that, several seismic traces are regarded as point sets, and the seismic data reconstruction method can be treated as: under the traverse of the structural element through out several adjacent seismic traces, the value to be interpolated can be predicted using different structural element. The value of the predicted results are used as the amplitude of the points to be interpolated which is a true amplitude processing. This method takes advantage of the "sifter" property of the mathematical morphology to detect the size of structure. Only when the structural element format is larger than the missing points can it be successfully interpolated.

In this paper, we adopted the mathematical morphology method, effectively combined with elastic wave inverse time migration imaging to verify the reconstruction quality through the application of simple and complex model. The results show that the seismic data reconstruction method based on mathematical morphology can effectively recover the frequency, amplitude and waveform characteristics of seismic data in complex subsurface. The noise caused by the inverse transformation of space and frequency domain to time domain is avoided, the diffraction wave converges to the original location, and the migration imaging resolution is much higher, and the missing traces with Gaussian noises in seismic data can be reconstructed.

Keyword

Mathematical morphology, Seismic data reconstruction, Reverse time migration, Irregular sampling

Characterizing electrical properties of hydrate-bearing sediments during dissociation via 3D multifield-coupled numerical simulation

Xixi LAN[1]*, China University of Geosciences (Beijing) (lxx_cugb@163.com)
Changchun ZOU[2], China University of Geosciences (Beijing)

Abstract

Since natural gas hydrate is stable only under low-temperature and high-pressure conditions, it will dissociate and transform from solid to gas state once conditions vary in the course of exploitation. It is fundamental but challenging to characterize the electrical properties of hydrate during dissociation. However, few studies have been conducted on its dynamic electrical mechanism. Based on the finite element approach, this paper studies the electrical properties of marine hydrate-bearing sediments by constructing the 3D model in the pore scale. Two physical fields of electric and thermal are coupled innovatively to achieve the purpose of dynamic characterization. Moreover, the effects of various hydrate distribution morphologies and saturations have been considered at different times during the dissociation process. The results show that resistivity decreases gradually with temperature change and hydrate phase transition. According to temperature change caused by heat conduction, the hydrate dissociation process can be divided into three stages. Moreover, the variation in saturation during the hydrate phase transition affects the speed of resistivity variation but does not change the trend of that. It is also found that the trend of hydrate dissociation with time is similar for different distribution morphologies. Additionally, the relationship between exponent n and temperature during hydrate dissociation is discussed. This study provides insight into the electrical properties of hydrate-bearing sediments with phase transition and shows potential application value in the exploitation of natural gas hydrate.

Keyword

Natural gas hydrate, Electrical properties, Phase transitions, Microstructure, Numerical modelling

Structure of the Denizli Graben-Horst System & Acıgo¨l Graben in the Western Anatolian Extensional Province from magnetotelluric resistivity models.

Ümit AVŞAR[1]*, Istanbul Technical University-Department of Geophysical Engineering, İstanbul Türkiye (avsaru@itu.edu.tr)
Erşan Türkoğlu[2], Saudi Aramco, EXPEC Advanced Research Center, 31311, Dhahran, Saudi Arabia

Abstract

The ongoing convergence between Arabia and Eurasia, which performed by active Aegean and Cyprus arcs in the south, makes Anatolia one of the most tectonically active regions on Earth. Related to this tectonic setting, three regions with different tectonic features have formed in Anatolia. The westernmost of these regions is called Western Anatolian Extentional Province where crust extension takes place related to high angle slab subduction and a slab tearing associated with asthenospheric rising. The reflection of this subsurface structure on the surface is seen as E-W Horst-Graben systems. Survey area is controlled by the WNW-ESE trending, approximately 7-28 km wide and 62 km long Denizli graben-horst system and western part of Acıgöl graben developed upon metamorphic rocks of both Menderes Massif and Lycian nappes. Actively growing grabens are bounded by seismically active oblique-slip normal faults from North and South. The sedimentary basin overlies the Palaeozoic-Mesozoic metamorphic bedrock and comprises Early Miocene–Pliocene sediments consist of conglomerate, sandstone, claystone, limestone, marl and siltstone alternations, Quaternary sediments and travertine occurrences.

The magnetotelluric method (MT) is very sensitive to the variations of conductivity changes in the subsurface and MT method is widely used to reveal tectonic structures in active tectonic zones. The main reason for high conductivity in these regions is the presence aqueous fluids, partial melting or both. Magnetotelluric data were acquired at 300 stations over a frequency range of 10,000 Hz to 0.001 Hz. 2D and 3D inversion were performed to reveal subsurface conductivity structures. In the recovered models, low resistivity values are associated to Çürüksu, Honaz and Acıgöl grabens. Strike directions and Phase Tensor (PT) ellipses reflects the dominant effect of the major faults and conductive basin fills and high frequency PT ellipses have 1D characteristic in compliance with the undeformed, nearly horizontal bedding of the neotectonic graben fills. The depth of the basin fills and conductive features of faults are identifiable in sections.

Keyword

Magnetotelluric, Western Anatolia, Graben Systems

2-D Integrated Geophysical Modelling Over an Anomalous Magnetic Body in North-Western Bangladesh

Mohammad Tawhidur Rahman Tushar[1]*, Department of Geology, University of Dhaka (mtrt@du.ac.bd)
Asif Ashraf[2], University of Oregon
Anwar Hossain Bhuiyan[3], Department of Geology, University of Dhaka
Md. Shahjahan[4], Geological Survey of Bangladesh

Abstract

As of the present, Bangladesh faces a void in operational iron or metal mines. However, our investigation in the Pirganj region of Rangpur district uncovers a distinctive feature—an intriguing magnetic anomaly coinciding with heightened gravity values. This anomaly reignites the possibility of establishing a metal mine in this region, offering new avenues for exploration. Our study specifically focuses on constructing a 2D model targeting the causative magnetic body in Pirganj, Rangpur. To ensure the model's reliability, we conducted meticulous cross-verification, integrating diverse datasets encompassing gravity measurements, magnetic readings, and drilling data. Notably, the basement in our study area exhibits a tilt, aligning with the Mohorovičić discontinuity (Moho) in the southwest-northeast direction. The inclusion of drilling data becomes crucial, particularly to account for the presence of gabbro—a mafic igneous rock—within the continental crust. Emphasizing the essential incorporation of a conically shaped highly magnetic body, ranging from 220m to 280m, potentially housing magnetite, our model establishes a foundational framework for further exploration and development in Pirganj. This research underscores Pirganj's potential significance for the establishment of a metal mine in Bangladesh, with its unique magnetic anomaly and associated features presenting a compelling opportunity for future mining endeavors and contributing valuable insights to regional geological processes.

Keyword

Pirganj, Bangladesh, magnetic anomaly, 2D geophysical modeling, gravity and magnetic integration, metal mine potential

Oscillatory constituents of the secular variation of the geomagnetic field

Crișan - DEMETRESCU[1]*, Institute of Geodynamics, Romanian Academy (crisan@geodin.ro)
Venera Dobrica[2], Institute of Geodynamics, Romanian Academy
Cristiana Stefan[3], Institute of Geodynamics, Romanian Academy

Abstract

The study is based on values of the geomagnetic field returned by the model gufm1 (Jackson et al. 2000) of the main geomagnetic field in a grid of 2.5x2.5 degrees of latitude/longitude, covering the European continent, for the time interval of the model validity – 1850-1990). Each time series returned by this model was first subjected to a Hodrick and Prescott analysis (1997), to separate a decadal variation from a so-called trend, and then the trend to a Butterworth (1930) filtering, to retrieve inter-decadal and sub-centennial variations (timescales of 20-30 years, respectively 60-90 years). We show first that external origin residual variations in the annual means provided by geomagnetic observatories or in historical values appear in the decadal, inter-decadal, and sub-centennial time scales values returned by gufm1. Characteristics of the sub-centennial variation in case of the horizontal component is compared to the magnetosphere ring current effects at the Earth's surface, with the important conclusion that variations seen in the geomagnetic field are at least long-term effects of the induction in the Earth of the magnetosphere ring current variations. We are aiming to a new concept of the secular variation of the geomagnetic field, with externally-driven long-term variations superimposed on an internal component secular variation.

Keyword

geomagnetic field, secular variation, inter-decadal and sub-centennial constituents

Investigation of fluid gas migration with an insight of mineralization using Amplitude vs Offset analysis for offshore Multichannel Seismic reflection Data

DEBAJYOTI SAHA[1]*, Geological Survey of India, Central Headquarter, Kolkata
(debajyoti.saha@gsi.gov.in)
Suman Mandal[2], Geological Survey of India, M&CSD Kolkata
Alekhya Gurajada[3], Geological Survey of India, M&CSD, Visakhapatnam
Raja Mukhpadhay[4], Geological Survey of India,Nagpur
Nitin Kumar[5], Geological Survey of India,RSAS Bengaluru

Abstract

The amplitude versus offset (AVO) phenomena on multichannel reflection seismic data can provide substantial exploration and development information to detect the possibility of fluid gas migration with the estimation of amplitude information for seabed along with fault layer. The phenomenon also known as Amplitude versus angle (AVA) and is based on the relationship between the reflection coefficient (RC) and the angle of incidence (θ). Seismic AVO can be classified into four different classes (I, II, III, IV) based on the zero offset reflection coefficient (Intercept, Gradient) which are function of offset or incidence angle. Geological survey of India (GSI) has acquired multichannel seismic data onboard R.V. Samudra Ratnakar within the EEZ of Andaman and Nicobar, Bay of Bengal to study the tectonic setup of Andaman-Nicobar Suture zone and also to identify the stratigraphy and structural pattern in the vicinity of Trench and Accretionary Prism. The present analysis involves the AVO analysis on offshore seismic reflection data (interpreted) showing the presence of fault plane reflection to detect fluid gas zone in the vicinity of trench through the presence of nearly vertical fault bearing negative polarity with reference to Seafloor. Based on the intercept and gradient values using AVO Cross plot, two distinct classes of seismic AVO responses are observed; One is class III AVO with increasing negative amplitudes with increasing offsets and the other is class IV AVO with decreasing negative amplitudes with increasing offsets. The presence of class III AVO anomaly can provide evidence of existence of free gas which may be migrating along the fault system exposed up to the surface. Fluid/gas migration in the shallow subsurface from class III anomaly may indicate the zones of hydrothermal mineralization. Further detailed analysis may provide major insight on offshore reflection data regarding gas migration through fault system.

Keyword

Seismic Amplitude versus offset (AVO), Fluid gas migration, Fault Plane reflection, AVO Cross plot,, Polarity, Intercept, Gradient

The density structure of the around Gyeongju based on gravity analysis

Young-Cheol Lee[1]*, Pusan National University (geoyoung@pusan.ac.kr)
Tae-Seob Kang[2], Pukyong National University
Kwang-Hee Kim[3], Pusan National University
Su Young Kang[4], Pusan National University
Yu Jin Sohn[5], Pusan National University

Abstract

The Gyeongsang Basin is located in the southeastern part of the Korean Peninsula and is a sedimentary basin formed during the Cretaceous and Cenozoic periods, corresponding to the eastern margin of the Eurasian continent. The Gyeongsang Basin is underlain by the Proterozoic metamorphic rocks of the Yeongnam Massif, thickly deposited by non-carboniferous sedimentary layers(K3, K2) and various volcaniclastic deposits of the Late Cretaceous, and intruded by Bulgugsa granite composed with neutral to acidic plutonic granites of the Tertiary Cenozoic after the deposition of sedimentary rocks and volcaniclastic rocks was completed.

It can be observed that the Bouguer anomaly in the Gyeongsang Basin increases toward the southeast (south of Pohang and east of Gyeongju), and the areas with relatively low Bouguer anomalies within the Gyeongsang Basin coincide with the areas where igneous rocks are distributed. This can be attributed to the lower density of igneous rocks on the Korean Peninsula compared to sedimentary and metamorphic rocks, and the relatively deep distribution of igneous rocks in the Korean Peninsula, which results in lower Bouguer anomalies. This study analyzed the density structure of the Gyeongsang Basin through gravity modeling.

A temporary seismic array was in operation between October 2010 and March 2013 in the Gyeongju area of Korea. Teleseismic records of the seismic array appropriate for receiver function analysis were collected, and selected seismograms were split into five groups based on epicenters the Banda-Molucca, Sumatra, Iran, Aleutian, and Vanuatu groups. 1D velocity structures beneath each seismic station were estimated by inverting the stacked receiver functions for possible groups. The 3D velocity structure was modeled through interpolation of 1D composite velocity structures.

The 3D velocity structure was converted to a density structure. The relationship between seismic wave velocity and density was converted to a density distribution using the equation $\rho=0.714VS+0.287$, which was formulated by Christensen and Stanley (2003) as an empirical relationship between S-wave velocity and density for sedimentary, igneous, and metamorphic rocks from about 2000 core data sets. The average densities of the mantle, lower and upper crust are 3.25 g/cc , 2.90 g/cc and 2.65 g/cc, respectively. The average density of the low-velocity layer in the Gyeongju region is 2.60 g/cc, which is about 20% lower than the average density of the upper crust. Gravity modeling was performed using the converted density structure as the initial density structure.

Gravity modeling indicates that the Mesozoic sediments are overlain by K3 to a depth of about 2,

with K2 below to a depth of about 9 km. South of Gyeongju, the Bulgugsa granite (2.60 g/cc) is expected to be at a depth of about 4 km, and north of Gyeongju, the Bulgugsa granite is found to be at a depth of about 8 km. Southwest of Gyeongju, Bulgugsa granite is encountered at a depth of about 8 km and is associated with a low Bouguer anomalies.

Keyword

density structure, gravity anomaly, Gyeongsang Basin

Neotectonic deformation in the southwestern part of the Anatolian Block in consideration of palaeomagnetic results in Bodrum peninsula.

Ümit AVŞAR[1]*, Istanbul Technical University-Department of Geophysical Engineering, İstanbul Türkiye (avsaru@itu.edu.tr)
Turgay İşseven[2], Istanbul Technical University, Department of Geophysical Engineering,İstanbul Türkiye

Abstract

Anatolia can currently be described as the amalgamating of various continental platforms with the closure of Neotethyan ocean.. During this period which is from the Late Cretaceous to the Late Miocene, N-S compression and associated calcalkaline type magmatic activity developed in Aegean and Western Anatolia. After the Miocene, N-S compressional regime was replaced by about N-S extension regime and caused the nature of the magmatism to change from calcalkaline to alkaline type in the region. Bodrum Peninsula takes place in the southwest part of Aegean Region and is the southeast section of the Western Anatolian magmatism that gives outcrop.

On the Bodrum Peninsula, magmatism has started from taking place of the Middle Miocene aged calcalkaline monzonitic pluton, and on the surface it has been followed by the Middle-Late Miocene aged felsic intermediate volcanism. Between these two magma rock groups, similar aged hypabisal rocks take place. They are all together, form a common “magmatic complex” in time, in location and in source. Taking into account the relationships between each other of the rocks forming this association that is called as Bodrum magmatic complex.

Palaeomagnetic samples were collected from 53 Miocene volcanic lavas, autochthonus and relatively undeformed, from different area of the Bodrum Peninsula. Natural remanent magnetisations (NRMs) were measured using a spinner magnetometer, after implementing thermal and alternating field demagnetisation methods on samples. 36 normal and 13 reverse polarities have been determined in the statistically reliable sites. Anti-clockwise rotations are predominant in the study area, clockwise rotation has been determined only 4 sites of the Bodrum Peninsula. The site mean direction is obtained as D=341°, I=50° (k=29.6 and alpha95=3.8°) with perfect consistency which indicates that the Bodrum Peninsula has rotated as a single block with a 23.7° anti-clockwise direction since ~10 Ma.

Keyword

Palaeomagnetism, Western Anatolia, Miocene

Seismic Fine Description of Facies Change Reservoir in Subei Basin

Zhipeng Gui[1]*, China University of Petroleum (East China) (gzp_upc@163.com)
Junhua ZHANG[2], China University of Petroleum (East China)
Qiqi SHAO[3], China University of Petroleum (East China)
Xiangyu ZHU[4], Jiangsu Oilfield Company, SINOPEC
Lianjun XIA[5], Geophysical Research Institute of Jiangsu Oilfield Company, SINOPEC
Zhen LUO[6], Geophysical Research Institute of Jiangsu Oilfield Company, SINOPEC
Chunli ZOU[7], China University of Petroleum (East China)

Abstract

Subei Basin is the main oil area of Jiangsu Oilfield. There are many types of reservoirs such as beach-bar sand, underwater distributary channel and so on. Due to different strata, buried depth, lithology and gray content, the sedimentary facies and seismic facies are complex, which brings great difficulty to the seismic fine description.

Starting from logging facies analysis, combined with drilling data, seismic calibration and facies analysis are carried out to clarify the geological and geophysical mechanism. In the shoreside, the bioclasts are developed, and their velocities are high, they result in the superposition or even composite of the seismic reflection to a single event. In the transition zone, a set of thin calcareous mudstone develops above the target layer, and its existence makes a strong reflection layer appearing above the reservoir, shielding the reflection of the underlying reservoir, and it is necessary to carry out strong shielding suppression. Multiple sets of strong reflection will appear in the seismic data when multiple sets of gray layers are developed in the reservoir. At this time, the suppression of one seismic event can no longer meet the requirements, and the strong energy of the whole reflection background should be removed. In the deep water zone, although there is no gray development, its sand body generally has the characteristics of high velocity, resulting in the phenomenon of reservoir overarching. Underwater distributary channel, the thickness of sand body is thicker, when the reservoir contains oil, there will be strong amplitude of bright spots, and its spectrum also has attenuation characteristics.

In view of the characteristics of thin reservoir, multiple layers and facies change in the study area, some object processing methods are studied, including: 1) matching pursuit to remove strong reflection; 2) compression sensing to raise frequency; 3) (Karhunen–Loeve) KL transform to remove similar background; 4) 90° phase shift technology to improve sand body characteristics. Three fine reservoir descriptions are put to use. First is using the seismic attribute of zero crossing number to characterize nearshore bioclastic belt. Second is developing a high precision spectrum analysis method of (Mask Filter Wigner-Ville Distribution) MFWVD to predict oil. Third is using a cascade technology of compressed sensing and 90° phase shift to identify thin sand body.

Accounting three facies zones exist in the study area, and conventional thickness prediction method without facies separation cannot meet the actual production requirements, a kind of improved thickness prediction methods are developed. These methods include single-attribute direct fitting, multi-attribute multi-linear regression and (Support Vector Machine) SVM. They all

reached good results.
The research method and technique in this paper make up the theoretical gap of reservoir description and prediction for facies change reservoir to a certain extent, and can also be used as a reference for the fine description of complex reservoirs in other oil fields.

Keyword

De-strong shielding, Matching pursuit, Compressed sensing, Facies change, Thickness prediction

Improved C3 coherence algorithm considering structure dip without interpolation

ZiCheng Wang[1]*, China University of Petroleum (East China) (B23010001@s.upc.edu.cn)
JianGuo Song[2], China University of Petroleum (East China)
Zhe Li[3], China University of Petroleum (East China)

Abstract

Reservoir fractures play an important role in oil and gas transport, and reservoir accumulation. it remains a challenging and hot research topic worldwide in recent decades. The coherence attribute, was first proposed by Bahorich and Farmer (1995), which is the one of most important fracture prediction methonds. Then Gersztenkorn and Marfurt (1999) proposed C3 coherence algorithm based on the eigenstructure of covariance matrices of windowed seismic traces. This algorithm has high robustness and resolution, but does not consider the dip information.

Take dip information into account the coherence calculation is necessary, especially in a region with a large structural dip, the steep dips, such as anticline and syncline, usually cause faintness and low-valued artifacts. Then, interpolation is often necessary in the calculation of time window due to the discrete nature of seismic data. However, interpolation is usually time-consuming when calculating the covariance matrix while considering the structure dip. On this basis we propose a C3 coherence algorithm that considers dip information but avoids computationally expensive interpolation operations by using one-time FFT, iFFT, and matrix product operations. And we used the method proposed by Yang et al. (2017) by using original seismic traces and Hilbert-transformed seismic traces to construct the covariance matrix, which improves stability at the zero-phase point and has higher resolution and better noise immunity ability.

In order to add the dip information to the covariance matrix, we first estimate the dip by the GST(Gradient Structure Tensor) method proposed by Bakker et al. 2002. and obtain the apparent dip p,q in the X and Y directions.

Consideration for dip is achieved by tilting the window. The tilt of the window is determined by multiplying the calculated dip value with the 3D seismic signal in the frequency domain. For the time-domain 3D seismic signal u(t,x,y), according to the time shift property of Fourier transform, if there is F[f(t)]=F(ω), then F[f(t-t_0)]=e^(-jωt_0) F(ω), So for the covariance matrix D and its Hilbert-transform H, we can get the feature matrixes: C_F (p,q)=F^(-1) {e^(-jωt_0)·F[(D^T D)×(H^T H)]}, the dip information is included in t_0, t_0=px_j+qy_j, where x_j,y_j denote the distance of the jth data relative to the center point in the x,y direction of the local analysis window. The final C_F (p,q) is a symmetric semi-positive definite matrix with J eigenvalues, and the C3 coherence value is: C_3=λ_max/Tr(C_new) , where λ_max is the largest eigenvalue of matrix C_F (p,q), Tr(C_F)is trace of matrix C_F (p,q), C_3 has a value between 0 and 1, and small values indicate discontinuity.

This process involves once Fourier forward and inverse transform, as well as a matrix product operation. Its computational cost is significantly lower than that of interpolation calculations. And

the method we proposed will not affect the acceleration of the eigenvalue calculation process,therefore, it can be further optimised on the basis of the method proposed in this paper, thus continuing to improve the computational efficiency.

Keyword

Seismic attributes, Coherency, Algorithm

MODERN GEOELECTRIC MODEL OF GROUNDWATER FILTRATION FLOWS AND ITS SEARCH VALUE

Rakhimjan TURSUNMETOV[1]*, State Establishment "Institute of hydrogeology and engineering geology" (tursunmetov45@mail.ru)
Azam Kadirkhodjaev[2], MINISTRY OF MINING INDUSTRY AND GEOLOGY OF THE REPUBLIC OF UZBEKISTAN
Bakhtiyar Ismailov[3], State Establishment "Institute of hydrogeology and engineering geology"
Timur Gafurov[4], State Establishment "Institute of hydrogeology and engineering geology"
Valentine TYO[5], State Establishment "Institute of hydrogeology and engineering geology"
Khasan Khasanbaev[6], State Establishment "Institute of hydrogeology and engineering geology"

Abstract

Providing access to clean drinking water for populations residing in mountainous and remote areas poses significant challenges. One of the main difficulties lies in reliably identifying sources of freshwater, as the formation of groundwater deposits is not always clearly understood, and their distribution areas are often uncertain. To address this issue, the utilization of mobile electromagnetic methods offers a promising solution, particularly in regions where limited prior information is available.

Circular vertical electrical sensing is employed to study groundwater filtration flows, allowing for the determination of flow presence and directions based on maximum apparent resistance values. This method investigates the mechanism behind the formation of maximum apparent resistance in the direction of flow. Electroosmosis and groundwater movement in filtration streams lead to surface conductivity on capillary surfaces, resulting in anisotropic properties and the manifestation of electrical anisotropy paradoxes. Electrical resistivity decreases in the direction of flow due to the development of surface conductivity in capillary-porous media.

Filtration flow is not only reflected in electrical properties but also in generated electric field structures, necessitating a comprehensive investigation of development mechanisms. The medium is considered electrically anisotropic, characterizing groundwater movement, with lower resistance in the flow direction. Surface conductivity plays a crucial role, oriented strictly along groundwater flow. Anisotropic property occurrence depends heavily on applied electric field structures.

A model has been developed to study groundwater's anisotropic properties, utilizing symmetrical installations. Dipole sensing installations rotate pie charts by 90°, aligning the major semi-axis perpendicular to flow and the minor semi-axis with flow direction, corresponding to current line and groundwater movement structures. Circular soundings are influenced by filtration flow intensity and geological heterogeneities within the sounding point spacing.

The specific electrical conductivity of the medium, characterizing surface conductivity, correlates closely with aquifer water conductivity. A method for detecting groundwater filtration flow presence in the field has been developed based on these features, focusing on electrical resistivity and anisotropy coefficient parameters, which strongly correlate with water conductivity indicators.

Through the application of this technique, deposits of fresh groundwater have been identified in mountainous and foothill zones, enabling the identification of well sites with higher productivity.

Keyword

surface conductivity, electrical resistivity, anisotropy coefficient, electrical sensing, filtration flow

Generalized linear inversion of prestack data based on exact Zoeppritz equation

Guobin HU[1]*, China University of Petroleum (East China) (z22010037@s.upc.edu.cn)
Jianguo Song[2], China University of Petroleum (East China)

Abstract

Geophysical inversion is the study of geophysical inverse problems. The methods of obtaining the elastic parameters of the subsurface medium from seismic data can be categorized into post-stack inversion and pre-stack inversion. Unlike post-stack inversion, which can only obtain impedance, pre-stack inversion can obtain independent elastic parameters more precisely. Pre-stack seismic data inversion is to use the pre-stack seismic data to invert the elastic parameters of the subsurface medium, using these parameters can identify the subsurface fluids, they are also an important basis for evaluating the characteristics of hydrocarbons in the subsurface reservoir. The generalized linear inversion method is a very important part of seismic data inversion. The inversion of pre-stack seismic data is composed of two kinds: full waveform inversion based on fluctuation equation and AVA/AVO inversion based on Zoeppritz equation and its approximation. However, due to the limitation of its approximation, this will make the pre-stack seismic data cannot be effectively utilized. To address this problem, in this paper, the reflection coefficient and transmission coefficient equations for the longitudinal and transverse velocities and densities are derived directly from the Zoeppritz equation based on the elasticity theory, and the longitudinal and transverse velocities and densities are directly inverted based on the generalized linear inversion. The use of the exact Zoeppritz equation effectively avoids the approximation assumptions and angular limitations brought by the use of various approximations, and provides a reliable theoretical basis for the theoretical study of AVO in front of the superposition with higher accuracy. The direct inversion can effectively avoid the cumulative errors brought by repeated calculations, thus improving the inversion accuracy. Through the model test and the actual seismic data data test, it is proved that the above methods can reliably obtain the information of underground medium, which lays the foundation for the subsequent lithology identification and hydrocarbon evaluation.

Keyword

Inversion of pre-stack data, generalized linear inversion, direct inversion, Zoeppritz equation

Optimized spectral decomposition method based on Restart and Adaptive Rapid Iterative Shrinkage Threshold

Jifei Qi[1]*, China University of Petroleum (East China) (qjf1093094085@gmail.com)
Jianguo Song[2], China University of Petroleum (East China)

Abstract

With the development of thin-layer analysis detection methods based on the frequency variation of seismic data, there is an increasingly urgent need for high-precision time-frequency analysis algorithms. Conventional Constrained Least Squares Spectral Analysis (CLSSA) offers high time-frequency resolution, but its matrix inversion process primarily uses Gaussian elimination for solving, which is inefficient and struggles to meet the demands of practical production when facing large matrices. In order to better apply this method in practical seismic data, this paper improves its efficiency in spectral decomposition in practical applications by introducing the efficient optimization inversion algorithm of restarting and adaptive fast iterative shrinkage thresholding (Rada-FISTA).Firstly, by using trigonometric functions as kernel functions, the forward equation between seismic signals and trigonometric functions is established. Diagonal matrix-form model weights and data weights are introduced to constrain and reduce the uncertainty of the inversion solution. At this point, the forward spectral analysis is transformed into the process of solving the inverse problem. To improve the efficiency of the subsequent matrix calculations, a sliding time window is applied to the data to transform it from one-dimensional data to a two-dimensional matrix. Based on the principle of L1 regularization-constrained least squares, the seismic signal's spectrum can be obtained through the introduced Rada-FISTA iterative solution.Comparative analysis with Short-Time Fourier Transform (STFT), Continuous Wavelet Transform (CWT), and CLSSA in theoretical models, as well as practical application results, shows that this method can not only obtain high-precision time-frequency spectra but also has high computational efficiency, with broad application prospects.

Keyword

FISTA, Time frequency analysis, CLSSA, Thin-layer analysis

Analytical study of geomagnetic observations using automated absolute measurements collected in 2023 at the Cheongyang Geomagnetic Observatory in South Korea.

Sohyeon Park[1]*, Kangwon National University (077psh@kangwon.ac.kr)
Seokhoon Oh[2], Kangwon National University

Abstract

Geomagnetic observations with longer time series and greater absolute accuracy are used in geophysical applications such as producing International Geomagnetic Reference Field(IGRF) and monitoring of secular variations. In particular, the IGRF is used as an important reference model in studies of the dynamics of the Earth`s core field space weather, and localized magnetic anomalies in the Earth's crust(Thébault 2015). The IGRF model is generated based on various data obtained from satellites, ground observatories, and magnetic survey, which are measured in real time, standardized, and shared through the International Real-Time Magnetic Observatory Network(INTERMAGNET) organized by the International Association of Geomagnetic and Aeronomy(IAGA). In South Korea, the Korea Meteorological Administration(KMA) provides geomagnetic field data observed at the Cheongyang Geomagnetic Observatory(CYG Observatory) to INTERMAGNET.

The CYG Observatory utilizes proton magnetometers and fluxgate magnetometers to continuously monitor the total magnetic field and its component variations. And, absolute measurements are performed through weekly visits by observers who measure the declination and inclination. The resulting definitive data are shared internationally via INTERMAGNET and consist of component and total field values for HDZ coordinates. These definitive data require precise values measured in a stable environment and require the skill of the observer to minimize machine errors, especially during manual absolute measurements. At the 2008 IAGA-workshop, an automatic absolute instrument was introduced that automatically performs this manual absolute measurement process without the need for an observer. In 2022, the Korea Meteorological Administration introduced AutoDIF mk2.2, an automatic absolute measuring instrument developed by the Royal Meteorological Institute(RMI) of Belgium, to improve the data quality and maintenance efficiency of the CYG Observatory.

In this study, we analyze the observed declination and inclination measured by the AutoDIF mk2.2 automatic absolute measuring instrument, collected from 2022 to 2023. The automatic absolute measuring instruments at the CYG Observatory measured declination and inclination at hourly intervals and showed a diurnal variation. These variations were confirmed by manual absolute measurements taken at 1-hour intervals during the daytime hours of the summer solstice in 2023. In addition, when the K-index was higher than 4 for declination and inclination, the value fluctuated abruptly. Due to these characteristics of the automatic absolute measurement data, we found that the quality of the data decreases if the definitive data is produced using both the declination and inclination data measured during the day. Therefore, in order to produce stable

definitive data using automatic absolute measurement data, it is necessary to extract time periods that are less affected by diurnal variations and time periods where magnetic storms do not occur. To this end, we proposed a method to analyze the automatic absolute measurement data to consider the variation and compare it with the K-index data. The definitive data produced using the automated absolute measurements data extracted by this method was of stable quality.

Keyword

Geomagnetic Observatory, Absolute Measurements, Automatic DI-flux system, Declination, Inclination

Deterministic Approaches and Machine Learning Approaches for fluid detection: a comparison and integration

Mohammed FARFOUR[1]*, Sultan Qaboos University (mfarfour@squ.edu.om)

Abstract

Detecting fluid expression manifested in seismic data is of great importance in reservoir characterization studies. Over time, numerous deterministic techniques have became available for interpreters and explorationists. Attributes extracted from Reflectivity-based AVO (e.g., Gradient, Fluid Factors, Scaled Poisson, etc.) and from Impedance-based AVO (Poisson Ratio, Bulk Modulus, Lambda-Rho, etc.) are good examples of the fluid deterministic approaches. Recently, Machine Learning (both shallow and deep) approaches have increasingly emerged in reservoir characterization and fluid detection workflows and tasks, including Multilayer Perceptron (MLP) Neural Networks, and Convolutional Neural Networks (CNN).

In this study, all the above approaches are examined on synthetic and real seismic data from a gas-saturated field. The approaches are compared in terms of their complexity, accuracy, and resolution. Different modern data analysis tools are implemented to help accomplish the comparison task.

The deterministic approaches are capable of achieving fluid detection with good accuracy but suffer from their lengthy workflows that are prone to error accumulation. Moreover, the latter approaches require special attention and expertise all the way along to mitigate uncertainty. Machine Learning approaches, on the other hand, offer faster implementation with less effort; however, they require special care in the data preparation and during training. In terms of accuracy, both approaches reach a similar level of precision and uncertainty. In conclusion, the choice of approach ultimately rests with the interpreter, taking into into consideration factors such as workflow preferences, expertise, and project requirements.

Keyword

Seismic, Fluid, Machine Learning, Deep Learning, AVO

Use of geochemical and ground magnetic data in the definition of copper-cobalt targets in the blind area. A case study: Kanseba prospect.

Anani Tebagwe J. M.[1], Lubumbashi University
Tshimanga Tshilombo Patrick[2], Lubumbashi University
Naveen BHADU[3]*, Jai Narain Vyas University (nvnch@tuta.io)
Guylain Katombe[4], Lubumbashi University
Kusunga Kabambi Charles[5], Lubumbashi University

Abstract

The type of geophysical method used in mineral exploration depends on the characteristics of the type of ore body to be targeted. It has become common nowadays for using different geophysical methods in advanced stages of geophysical mapping after surface geological mapping and geochemistry. This case study highlights the potential of the ground magnetic survey coupled with geochemistry in copper-cobalt exploration in the central African copper belt where there outcrops are less and therefore clear delineation of different lithologies remains challenging. The objective of this study is to highlight how-to low-cost methods can be used i.e. soil geochemical survey and ground magnetics for defining future targets for copper and cobalt exploration. Perhaps, the same method could also be used in other types of copper deposits. In this study, ground magnetic data was used in the preparation of reduced to pole magnetic maps. Further regional-residual anomalies were separated to filter the regional anomalies from depth to keep only the residual anomalies for which causes are geological and located in shallow depth. These residual anomaly maps along with geochemical anomaly and geological maps by superimposition were used in interpreting ore mineralisation. It is inferred that both positive and negative anomalies marks different types of mineralisation mainly disseminated sulphides and oxides. This method of using ground magnetic data in conjunction with geochemical data offers tremendous potential in the exploration of copper-cobalt mineralisation in blind areas with fewer outcrops.

Keyword

Copper-cobalt exploration, Geochemistry, Soil survey, Ground magnetic anomalies, Blind areas

A seismic geomorphology study of the fluvial and shallow-delta facies of the Oligocene Huagang Formations in the East China Sea Shelf Basin, China

Huafeng LIU[1]*, China University of Petroleum (East China) (liuhuafeng1989@163.com)
Chengyan LIN[2], China University of Petroleum (East China)
Xianguo ZHANG[3], China University of Petroleum (East China)

Abstract

The Xihu Depression in the East China Sea Shelf Basin is a significant natural gas-producing region in China, with the primary gas-bearing layers situated in the upper section of the Oligocene Huagang Formation. During this period, the depression was in the post-rift stage, characterized by the development of a fluvial and shallow-delta sedimentary system. The presence of widespread thin sand bodies within the fluvial and shallow-delta sedimentary system poses challenges for the exploration and development of lithologic oil and gas reservoirs in sparse well areas due to rapid lateral and vertical changes in sedimentary facies.

In this study, we primarily utilized high-resolution 3D seismic data and employed a comprehensive set of techniques, including seismic attributes, stratigraphic slicing, wavelet transforms, RGB fusion, and multi-attributes fusion driven by AI. These techniques were applied for seismic geomorphological analysis of the fluvial-shallow water deltaic sedimentary system. Concurrently, modern sedimentology (including braided rivers, meandering rivers, and shallow-delta) were incorporated to better guide the quantitative seismic geomorphological interpretation of different channel types within the fluvial and shallow-delta sedimentary system. Based on quantitative interpretations of typical seismic geomorphology within high-frequency sequence stratigraphy (fifth-order) in the study area, multiple types of in-channel deposites with obvious characteristics are developed in the target layer, including braided channel, lager high-curvature meandering channel, micro meandering channel and underwater distributary channel. The evolution of channel patterns is mainly driven by paleoclimate change, paleogeography and base-level change (medium-term cycles). Within the fourth-order sequence, the base level rose, the paleoclimate became drier, and the paleo-slope gradient decreased, leading to a transformation of channel types from braided channels to meandering channels and underwater distributary channels.

This study integrates model-driven and data-driven seismic geomorphology interpretation methods, establishing a new quantitative seismic geomorphology interpretation workflow. It accurately characterizes various channel systems within the upper section of the Huagang Formation in the southern part of the Xihu depression, yielding reliable sandbody distribution results and providing guidance for the exploration of lithologic traps in the area.

Keyword

seismic geomorphology, 3D seismic, seismic attributes, AI, fluvial and shallow-delta facies

Research On The Frontier Technology Of Continuous Coring For Directional Drilling

Jie Ren[1], Jilin University
Yinlong MA[2]*, Jilin University (ylma@jlu.edu.cn)
Xiaoyang Li[3], The Institute of Exploration Techniques, CAGS
Qingquan Zhou[4], Jilin University

Abstract

How to obtain rock or ore core samples quickly and continuously to provide accurate parameters for the evaluation of mineral resources reserves is a key technical challenge in the stage of domestic mineral exploration. Aiming at the exploration technical problems of "low ore content and low core monitor rate" of strategic rare-earth metal minerals and scarce strategic iron ore resources in the coal system, the company intends to independently research and develop high-precision, low-cost, high-efficiency precision directional drilling and continuous core-taking technology, overcome the incompatible bottleneck between directional drilling and core-taking, and realize the precise regulation and improvement of drilling trajectory, and help build a transparent mine system. Meanwhile, in the process of strategic mineral resources exploration and sampling, the traditional vertical holes are faced with the problems of high investment in a single hole and limited access to geological information, which can't meet the needs of efficient reserve exploration. In this respect, based on wireline coring and directional drilling technology, a continuous coring technology for directional drilling is proposed, which is intended to realize efficient and accurate acquisition of geological cores in underground three-dimensional space. This study formulated the continuous coring drilling process for directional drilling, determined the specification size of drilling tools and borehole caliber, and carried out the structural design of directional coring drilling tools and the trial production of drilling tools. Innovative design of small-diameter, high-flexibility directional drilling continuous coring new technology, the formation of a push against and hollow single-bend short section synergistic drilling tool attitude precision control technology, the development of salvageable small-diameter high-torque screw motors and storage-type drilling probe tube and other core key components, and strive to provide rapid and efficient drilling tools and process methods for the exploration of mineral resources to increase reserves.

Keyword

directional drilling, continuous coring, wireline coring

Research on Anti-Adhesion and Drag Reduction Performance of Bionic Sampling Tube for Shallow Submarine Sediments

Pengyu ZHANG[1]*, Jilin University (pengyu1213@jlu.edu.cn)
Yuan Wang[2], Jilin University
Rui Jia[3], Jilin University
Xiaochu Wang[4], Jilin University
Wei Guo[5], Jilin University

Abstract

The ocean floor harbors abundant mineral resources, and the coring and acquisition of high-quality core samples from deep-sea sediments are prerequisites and foundations for exploring the occurrence of deep-sea mineral resources. Due to the high water content, high clay content, and high plasticity of submarine sediments, they are easily disturbed and damaged during sampling, resulting in low sample recovery rates and sample plastic deformation, which affect the determination of engineering geological properties of submarine sediments and the evaluation of marine resources, posing technical challenges in marine exploration engineering.

Evolved over billions of years, active soil organisms in soil have self-cleaning properties on their body surfaces, attributed to their non-smooth surface and material composition. Based on the self-cleaning and low adhesion characteristics of dung beetles in soil, a material-non-smooth structure-coupled bionic sampling tube for marine sediment sampling was developed. Submarine sediment samples were prepared according to the material composition and particle size distribution characteristics of submarine sediments. The coring effect of the sampling tube was analyzed using a drilling and sampling test platform. The results show that the non-smooth corrugated structure can effectively reduce the penetration resistance of the sampling tube, and the low interfacial energy of the polytetrafluoroethylene coating can effectively weaken the clay adhesion. Under the combined action of low interfacial energy materials and non-smooth structures, the sample recovery rate can be effectively improved, and the sample quality can be enhanced.

Complete high-fidelity samples are an important basis for evaluating marine resources. This study introduces the theory of biomimetic engineering and develops material-structure-coupled sampling tubes for submarine sediments, providing technical support for the accurate evaluation of submarine mineral resources.

Keyword

submarine sediments, truth-preserving sampling, low-disturbing, sample recovery rate

Microscopic structure and wear properties of micro-nano sized (TiCp-SiCp)/ 7075Al composites

Yueqi LI[1]*, liyueqi5291@163.com (liyueqi5291@163.com)
Yinlong Ma[2], +8613843085948
Jie Ren[3], +8615568869207
Shiyu Zhang[4], +8613322109530
Jiacheng Li[5], +8615043081021

Abstract

Due to the advantages of high specific strength, low density, low bending stress, stable mechanical properties, and corrosion resistance, aluminum alloy drill pipes can better meet the needs of deep drilling compared to traditional drill pipes. As a high-strength forging alloy,7075aluminum alloy is the most commonly used material for aluminum alloy drill pipes. It is easy to process and can be heat treated to enhance mechanical properties such as strength and hardness. In this study, the new 7075Al composites reinforced by 3.0 wt.% micro-TiC particles and nano-SiC particles (n-SiCp) with different mass fractions (0, 0.2, 0.5 and 1.0 wt.%) were successfully prepared by powder metallurgy method. The precipitated phases became more homogeneous with increasing amounts of added n-SiCp. Furthermore, there were no apparent reaction products at the interface between the n-SiCp and the 7075Al matrix. As the content of n-SiCp increased, the compactness of the new 7075Al composites first improved and then declined. The maximum compactness of 7075Al composite material was 97.88% when the n-SiCp content exceeded 0.2 wt.%. The wear resistance of the composite materials had been improved after adding n-SiCp. The wear resistance of the 0 wt.% n-SiCp/7075Al composite material was the worst, and the composite that filled in 0.2 wt.% n-SiCp got the most excellent wear resistance. Furthermore, with the increase of n-SiCp addition, the friction coefficient and wear quality of the composite material gradually increased. Under the load of 15N, the friction coefficient and wear mass of the 0 wt.% n-SiCp/7075Al composite material reached maximum, with the friction coefficient of 0.3290 and the friction mass loss of 8.6 mg. The friction coefficient of the 0.2 wt.% n-SiCp/7075Al composite material reached minimum, with a decrease of 16.6%, at 0.2745. The friction mass loss of 0.2 wt.% n-SiCp/7075Al composite material was 3.9mg, which as 54.7% better than the 7075Al matrix. It was the relatively uniform distribution of n-SiCp and the well-bonded interfaces between the n-SiCp and the 7075Al matrix that led to improvements in the wear properties. The results are preliminary but can be used to significantly promote the development of n-SiCp reinforced aluminum metal matrix composite materials.

Keyword

micro and nano hybrid particle, 7075 aluminum matrix composites, wear behavior, mechanical properties

[Keynote] Identification of prospective regions for selected critical minerals through integrated geophysical, geochemical and geologic data

Carol A FINN[1]*, US Geological Survey (cfinn@usgs.gov)
Cliff D Taylor[2], US Geological Survey

Abstract

Exploration for critical elements requires integration of a variety of geophysical, geochemical and geological data as most deposits are not exposed. Mineral resource assessments and prospectivity mapping exercises identify the potential for undiscovered minerals deposits and help project future resource development. Here we present a few examples of approaches to prospectivity mapping of several critical minerals. Platinum-group element (PGE) exploration in layered mafic intrusions such as the Stillwater, Duluth and Bushveld Complexes relies heavily on understanding the geophysical signature of the entire magmatic system. Mapping the 3D geometries of layered intrusions and their staging chambers are important for exploration because large igneous systems are more likely to have PGE-enriched deposits than small ones. The presence of cyclical layering indicates possible PGE targets and knowing the stratigraphic order of the layering may help trace economic horizonsbelow cover. Gravity models constrained by geologic mapping, rock properties, upper and lower crustal thickness and/or densities typically derived from seismic velocities, and magnetotelluric (MT) data constrain the areal distribution of the Stillwater, Bushveld and Duluth Complexes. Although the thickness of the intrusions are poorly constrained due to uncertainties in crustal and mantle densities, reasonable ranges of 1-10 km can be obtained. The Stillwater and Bushveld Complexes extend significantly beyond their extents mapped at the surface.

Mauritania is the 15th largest iron producer in the world but recent depletion of high-grade hematitic ores requires prospecting for lower grade iron in highly magnetic banded iron formations. High amplitude aeromagnetic highs identify target areas where magnetite BIF that contains low magnetization hematitic ore is likely to be thickened by faulting or foldingDepth to basement calculations from the aeromagnetic data indicate prospective regions for iron deposits buried beneath sand and less than 1000 m depth.

Assessment of tungsten mineralization in central Uzbekistan is based on regional geological, remote sensing, geochemical and geophysical data that allows identification of potential tungsten-bearing skarn in carbonates adjacent to plutons. Geologic mapping and remote sensing, extended beneath cover based on borehole data, identifies the carbonates. Aeromagnetic data image magnetite-poor plutons, and the soil geochemistry identified anomalous tungsten values. Estimates of undiscovered tungsten skarn deposits in permissive tracts are combined with grade and tonnage distributions of known deposits to generate probabilistic estimates of undiscovered resources.

Rare Earth element prospectivity in southeastern Botswana is related primarily to alkaline

complexes and carbonatites. Aeromagnetic highs identify carbonatites and geologic mapping and gravity data identify structural corridors in which the deposits may have formed. Radiometric data identify granitic plutons enriched in potassium, uranium and thorium, which could be sources of REE's. Because many of the carbonatites are buried beneath sand, the REE prospectivity map relies on mapping magnetic anomalies with similar shapes and amplitudes as those associated with known carbonatites that are on or near major structural corridors.

Keyword

Geophysics, Mineral Resources, Critical Minerals, Geochemistry

Identification of River Sand Body Based on Deep Residual Shrinkage Network

yufei SU[1]*, China University of Petroleum (East China) (b22010044@s.upc.edu.cn)
Jianguo Song[2], China University of Petroleum (East China)
Zhe Li[3], China University of Petroleum (East China)

Abstract

The study of channel sand bodies has always been a key and difficult point in the exploration of oil and gas resources in terrestrial sedimentary basins. At present, the methods of using seismic data for oil and gas detection can be summarized into three categories: pre-stack AVO technology, multi-wave and multi-component oil and gas detection methods, and post-stack seismic attribute analysis technology. The prediction methods based on amplitude, impedance, and other factors have not fully explored the inherent information contained in seismic data, resulting in a strong multiplicity of solutions.

Based on known cases of river sand research, utilizing various information such as seismic data, logging curves, and drilling cores, and introducing artificial intelligence theory, a deep residual shrinkage network is constructed. The deep residual shrinkage network is mainly based on three parts: deep residual network, soft threshold function, and attention mechanism. The deep residual network adopts a cross-layer, identity path approach to alleviate the training difficulty of deep networks. Utilize attention mechanism to achieve soft thresholding of features and learn features for highly redundant data. Before training, preprocess multiple seismic attributes. By integrating multiple seismic attributes and using logging curves as label constraints, an intelligent network can be trained to achieve intelligent prediction of river sand bodies. This network can integrate multiple seismic attributes, eliminate redundancy between attribute data, and obtain a new attribute. The fused output attributes can effectively indicate the distribution of river sand bodies. Combined with logging data verification, it has very high accuracy.

Keyword

Deep Learning, Sand body identification, Channel sand body

New progress in research of lightweight wear-resistant drilling pipe materials

Shaoming MA[1]*, CCTEG Xi'an Research InstituteGroupCo., Ltd. (mbright@163.com)
Chuanliu WANG[2], CCTEG Xi'an Research InstituteGroupCo., Ltd.
Geng LI[3], CCTEG Xi'an Research InstituteGroupCo., Ltd.

Abstract

With the integrated development of drilling and geophysical exploration technology, the proportion of drilling projects with precised controlled trajectories such as horizontal wells and directional wells is increasing. The traditional steel drill pipe is hard to satisfy the safety and efficiency due to its large weight, poor corrosion resistance, and serious drag pressure. Aluminum alloy is the most mature and widely used non-steel lightweight structural material, but the engineering practice has proved that the surface wear resistance of aluminum alloy drilling tools is insufficient, which is easy cause wear failure. Therefore, lightweight wear-resistant composite pipe has become a potential replacement material for drill pipe used in current drilling construction. The steel and aluminum alloy are combined by advanced preparation and connection technology, making full use of the advantages of light and high strength of aluminum alloy and good wear resistance of steel. The thin layer of alloy steel is coated in the outer wall of the thick wall aluminum alloy tube to prepare light wear-resistant bimetal composite pipe. The inner layer of the drill tool is light aluminum alloy, which plays the role of bearing pressure. The outer layer is thin wall steel pipe, which plays the role of wear resistance and protection. The bimetal composite pipe can effectively reduce the weight of drilling tools per unit length without reducing the wear resistance of drilling tools, providing solutions for the lightweight and life extension of drilling tools required for coal field geological exploration, underground gas extraction, water damage prevention and comprehensive utilization of coal seam gas mining. At the same time, it provides new materials and new technical support for lightweight wear-resistant drilling tools for ultra-deep drilling such as oil, gas and scientific drilling.

Keyword

drill pipe, lightweight, wear-resistant, bimetal composite

Enhancing Reservoir Performance Prediction Through Advanced Data Analytics and Machine Learning: A Study on Reservoir Evaluation Management for Improved Oil and Gas Recovery in the Orange Basin, Namibia.

Freddie Nampa KAFULA[1]*, YES Network Namibia, Geological Survey of Namibia (kafulafredricka@gmail.com)

Abstract

The oil and gas industry's pursuit of innovative strategies for optimizing reservoir performance and augmenting recovery methodologies has led to the integration of advanced data analytics and machine learning techniques. With the current oil discoveries in Namibia, this research focuses on leveraging these technologies to enhance reservoir performance prediction, specifically emphasizing reservoir evaluation management in the unique geological context of the offshore Orange Basin, Namibia. The primary objective is to advance the understanding of reservoir dynamics and improve the accuracy of recovery forecasts, thereby facilitating more informed decision-making in the field of oil and gas production. The research methodology involves the comprehensive integration of historical reservoir data, encompassing geological, petrophysical, and production parameters, into a unified dataset. Advanced application of geological modelling software such as Petrel and seismic interpretation software, and machine learning algorithms will all be utilised to unveil intricate relationships and patterns within the dataset. The study also explores the incorporation of real-time data streams from sensors and monitoring devices to enhance the temporal aspect of reservoir performance prediction. This real-time data integration allows for dynamic model adjustments, enabling adaptive management strategies to respond promptly to changing reservoir conditions. Therefore, this culminates in the development of predictive models capable of deciphering intricate patterns, optimizing exploration and development, and mitigating unique risks associated with the basin's complex geological setting. Additionally, accurate predictions will contribute to maximizing recovery rates and minimize uncertainty in geological interpretations and the overall environmental footprint. In conclusion, this study contributes to the broader reservoir management knowledge by showcasing the efficacy of advanced data analytics and machine learning in comprehending reservoir dynamics within the unique context of the Orange Basin, Namibia. The results offer valuable insights for industry professionals and decision-makers seeking to maximize oil and gas recovery while navigating the challenges of this specific geographic and operational environment.

Keyword

Data Analytics, Machine Learning, Reservoir Data, Production Optimization

The application of comprehensive electromagnetic methods in the search for copper-nickel polymetallic ores in shallow-covered areas-A case study of the Jing'erquan area in the East Tianshan Mountains of Xinjiang

ShiHao JIA[1]*, Institute of Geophysical and Geochemical ExplorationCAGS (jsh180121@126.com)
Yong LI[2], Institute of Geophysical and Geochemical ExplorationCAGS
Tseedulam Khuut[3], Department of Geology and Hydrogeology,School of Geology and Mining,Mongolian University of Science and Technology
KeQiang ZHAO[4], Institute of Geophysical and Geochemical ExplorationCAGS
ShengPing GONG[5], Institute of Geophysical and Geochemical ExplorationCAGS
HongYu GUO[6], Guilin University of Technology

Abstract

Due to the rapid development of China's economy and significant improvement in national living standards, the demand for copper, nickel, and other mineral resources in key industries such as energy, automobiles, and construction is continuing to grow. However, meeting the rapidly expanding demand for nickel resource reserves and production in China is a challenge. Therefore, exploring copper-nickel and other polymetallic resources is particularly crucial. Long-term resource development gradually depletes surface and shallow, easy-to-mineralize deposits. Therefore, there is a urgent need to explore new areas to alleviate the shortage of resources. Currently, global exploration efforts are focused on exploring deeper continents and overburden directions. The conventional approach of relying on geological outcrops for the discovery of ore bodies and mineralization information is also shifting towards geological theoretical predictions and integrated physico-chemical exploration techniques.In recent years, comprehensive geophysical exploration methods have played an important role in the field of metal ore detection. Breakthroughs have been made in the detection of hidden ore bodies in the covered area. The Jing'erquan area in the East Tianshan Mountains of Xinjiang presents challenges to surface geological exploration for ore bodies due to its shallow coverage. This study overcame these challenges through a combination of geophysical methods. The exploration process began with magnetic anomaly mapping to identify areas of interest. Next, the TDIP method was used to estimate mineralization extents and structural distributions within the mining area. Finally, the Controlled Source Electromagnetic (CSEM) method was employed to generate resistivity section maps, revealing underground structural characteristics and ore body occurrences.

Comprehensive data processing and interpretation identified two magnetic anomalies and two IP anomalies. The results of these applications provide

foundational support for future drilling projects in the mining area and offer valuable insights for similar regions seeking copper-nickel polymetallic deposits. In summary, integrated electromagnetic methods can achieve economical and effective metal ore detection in the study area. The obtained physical parameters are consistent with each other and minimize the influence of polydisintegration, resulting in better outcomes. These results not only provide a scientific basis for subsequent drilling work in the Jing'erquan area but also offer a valuable methodological and empirical reference for exploring Cu-Ni polymetallic deposits in other areas with similar geological features.

Keyword

covered area, electromagnetic method exploration, copper-nickel metal ore, Xinjiang East Tien Shan

An efficient 3D inversion algorithm for the inversion of large-scale magnetic dataset when remanence exists

Xiaohong Meng[1], China University of Geosciences, Beijing
Jun WANG[2]*, China University of Geosciences, Beijing (wangj@cugb.edu.cn)
Yuan Fang[3], China University of Geosciences, Beijing

Abstract

In mineral exploration, the ores with magnetic susceptibility contrasts with the surrounding rocks can be well studied by using the physical property inversion of the magnetic data. However, in real applications, the inversion of magnetic data is often affected by the existence of remanence. In addition, computational efficiency is another challenge faced by the inversion of large-scale dataset. In order to address the above two issues, this study introduces an efficient magnetic inversion method in the presence of strong remanence. In this algorithm, the objective function for the converted magnetic component is established based on the weighted data misfit term and regularization terms. Then, the complex nonlinear relationship between the transformed magnetic data and magnetic susceptibility is linearized using the Taylor series approximation. To achieve efficient computation, the objective function is further derived to a general Tikhonov form using matrix equivalence transformation. Afterwards, a fast randomized algorithm is adopted to solve the standard Tikhonov problem efficiently. Notably, the regularization parameter can be determined simultaneously utilizing the intermediate parameters of the randomized algorithm based on the generalized cross-validation (GCV) criterion. The effectiveness and efficiency of presented method is tested on synthetic examples, and is successfully applied to two real magnetic datasets in China.

Keyword

Magentic data inversion, remanence effects, computational efficiency

Accurate first arrivals picking method combining dynamic threshold control and bisection in complex geological environment.

Hongyan Yan[1]*, China University of Petroleum (East China) (1362568562@qq.com)
Zhenchun Li[2], China University of Petroleum (East China)
Haotian YANG[3], China University of Petroleum (East China)

Abstract

In today's world, the pursuit of oil and gas exploration is reaching deeper and more complex territories. However, the significant variations in the near-surface low-velocity zone present greater challenges in accurately positioning and characterizing exploration targets, thus increasing the difficulty and complexity of tasks in this domain. The precise identification of first arrivals is essential in seismic exploration, as it lays the groundwork for further calculations related to surface velocity, layer thickness, and plays a pivotal role in static corrections. Given the challenge of achieving precise first arrivals picking under complex surface conditions, greatly affected by the signal-to-noise ratio, we propose a novel and comprehensive methodology. This technique integrates dynamic thresholding with the dichotomy method for the efficient picking of first arrivals. Unlike the traditional fixed thresholding method in the time domain, our approach employs a sliding window technique to concentrate on local features, thereby capturing signal variations over time. By adjusting weights based on various parameters such as signal-to-noise ratio, local energy, and local gradient, we establish local thresholds. These thresholds are then used to plot threshold curves, which in turn delineate the estimated range of the first arrivals. This method is more adept at accommodating the temporal variations of seismic signals and is versatile enough to handle different types and changing amplitudes of seismic signals, optimizing the initial picking outcomes. To pinpoint the exact onset of the first arrivals wave more accurately, a bisection method is employed for focused searching within the preliminary picking range. Through iterative refinement of the time window, the precision of first arrivals picking is significantly improved. Upon evaluation, this comprehensive strategy demonstrated superior performance, especially in complex geological settings and noisy environments. Overall, this method meticulously accounts for the time-domain characteristics of seismic signals and achieves accurate picking of first arrivals by harmonizing dynamic thresholding with the bisection method.

Keyword

first arrivals, dynamic threshold, bisection, complex geological environment

S-wave propagation and analysis under the modified couple stress theory

Wenlei BAI[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (wl_bai@163.com)
Hong LIU[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Lifeng WANG[3], Hainan Branch of CNOOC (China) Limited
Chaopu CHEN[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Zhiyang WANG[5], College of Information Science and Technology, Beijing University of Chemical Technology
Youming LI[6], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

It is a trend in the development of geophysics to seek wave theory closer to the physical reality and derive corresponding wave equations to achieve the highly accurate forward modeling, imaging, and inversion of complex structures. There always exist complicated internal microstructures, common for both the natural rock and soil medium and man-made materials. Recently, researchers have introduced the framework of generalized continuum mechanics (GCM) theory to seismic wave propagation, taking into account the influence of heterogeneity caused by complex microstructure characteristics of the medium, and derived the corresponding asymmetric wave equations (Wang et al., 2021; Wu and Ma, 2022). The GCM theory enriches the context of the classical continuum mechanics theory by introducing the additional higher than the first-order displacement gradients and the first-order rotation gradients, and the additional characteristic length scale parameters characterizing the microstructure characteristics of the medium (Yang et al., 2002; Kong et al., 2009; Karparvarfard et al., 2015; De Domenico et al., 2019). The couple stress theory, as a branch of the GCM theory, is relatively successful and widely used (Wang et al., 2020; Bai et al., 2023). In the frequency band of seismic waves, Wang et al. (2020) derived elastic wave equations based on the modified couple stress theory and simulated the seismic waves excited by high-speed trains under the viaduct system.

In this abstract, based on the asymmetric wave equations in the framework of the modified couple stress theory, we derive the decoupled asymmetric wave equations according to the Helmholtz decomposition theorem. The expression of the phase velocity of P- and S-wave in the modified couple stress theory is given. Then, according to the theoretical analysis and numerical modeling, we focus on the influence of heterogeneity caused by the microstructure characteristics of the medium on S-wave propagation. The results of theoretical analysis and numerical modeling indicate that the heterogeneity caused by the microstructure characteristics of the medium leads to the dispersion of the S-wave. The perturbation of the S-wavefield caused by microstructure interactions of the medium increases with the increase of the characteristic length scale parameter.

Keyword

Asymmetric wave equations, Numerical modeling, Dispersion, Decoupled wave equations

Improving Seismic Profile Resolution through Inversion of Reflection Coefficients based on Short-Time Fourier Transform and Restarted Fast ADMM

Wei SONG[1]*, China University of Petroleum (East China) (2969623819@qq.com)
ZhenChun Li[2], China University of Petroleum (East China)
Min Zhang[3], China University of Petroleum (East China)
Min Hu[4], China University of Petroleum (East China)
XiangDa Feng[5], China University of Petroleum (East China)

Abstract

As exploration efforts intensify, thin beds and interbeds underground have emerged as primary targets. However, their thickness being below the conventional tuning threshold results in waveform interference between layers, compromising layer resolution. Enhancing seismic profile resolution is crucial in seismic exploration. Traditional methods for resolution improvement, such as compression-aware sparse inversion, face two significant challenges. First, the Fourier transform's limitation in correlating specific frequencies with time can lead to an overemphasis on local high-frequency components during frequency expansion. Second, the vast volume of seismic data, combined with conventional iterative algorithms like the alternating direction method of multipliers (ADMM), greedy algorithm, and iterative shrinkage thresholding algorithm, results in high computational costs and diminished accuracy. To address these challenges, we propose two innovative solutions. Firstly, we employ the short-time Fourier transform (STFT) over the traditional Fourier transform (FT) for frequency band expansion across various time intervals. This approach ensures that the frequency magnitudes throughout the time domain are consistent with the seismic wave propagation law. Secondly, we introduce the restart fast ADMM (READMM) algorithm to the sparse inversion challenge. Unlike ADMM, READMM incorporates the acceleration principle found in Nesterov's gradient descent method, allowing for variable updates based on the outcomes of the two preceding iterations. This method also integrates a "restart" mechanism that mitigates oscillations during iterations, enhancing both computational efficiency and accuracy. Empirical evidence from both synthetic and real-data experiments validates that our method not only reduces computational expenses but also significantly enhances the resolution of seismic profiles.

Keyword

compressed sensing, short-time Fourier transform, alternating direction methods of multipliers, reflection coefficient inversion, resolution improvement

Wave propagation and analysis under the single-parameter second-order strain gradient theory

Chaopu CHEN[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (bh_ccp@163.com)
Hong LIU[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Lifeng WANG[3], Hainan Branch of CNOOC (China) Ltd
Wenlei BAI[4], Institute of Geology and Geophysics, Chinese Academy of Sciences
Zhiyang WANG[5], Beijing University of Chemical Technology
Youming LI[6], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

To reflect the finer subsurface structures and construct the relation between the microstructures of the medium and seismic response, it is needed to seek the wave theory and corresponding wave equations closer to the physical reality. There always exist complicated internal microstructures in both man-made materials and natural rock and soil media. Recently, researchers have introduced the framework of generalized continuum mechanics (GCM) theory to seismic wave propagation, taking into account the heterogeneous response caused by complex microstructure characteristics of the medium, and derived the corresponding generalized wave equations (Wang et al., 2021; Bai et al., 2023).

In the second-order strain gradient theory, a relatively successful and widely used branch of the GCM theory (Mindlin, 1964; Aifantis, 2011; Wang et al., 2021), the smaller-scale microstructural interactions can be described by introducing the higher derivative and the additional characteristic scale parameters of the medium. According to the Cosserat theory (Cosserat, 1909), Mindlin (1965) introduced the second-order strain gradient into the strain energy density function and proposed the second order strain gradient theory. Askes and Metrikine (2005) applied the continuum method to convert the discrete heterogeneous medium at a small scale into a continuous homogeneous medium at a large scale, and derived the equivalent constitutive equation including the second-order strain gradient and the characteristic scale of the medium. Aifantis (2011) proposed the nonlocal-gradient linear elasticity theory by combining the nonlocal theory, that is, the stress at one point is related not only to the strain at the point, but also to the strain at all points in a certain neighborhood of the point. According to the nonlocal theory, Wang et al. (2021) investigated the constitutive equations of the single-parameter second-order strain gradient theory, and derive the mathematical expression of the generalized elastic wave equations by incorporating the geometric equations and the differential equations of motion, and also analyzed the influence of scale effects caused by microstructure interactions of the medium on seismograms.

In this abstract, based on the generalized elastic wave equations in the framework of the second-order strain gradient theory, we derive the decoupled generalized wave equations according to the

Helmholtz decomposition theorem. And the expression of the phase velocity of P-wave and S-wave considering the microstructure characteristics of the medium is given. Then, according to the theoretical analysis and numerical modeling, we focus on the influence of heterogeneity caused by the microstructure characteristics of the medium on wave propagation.

Keyword

Generalized wave equations, numerical modeling, Dispersion analysis, Helmholtz decomposition, nonlocal theory

A holistic approach towards geophysical characterization of the Quick Clays in Norway; A case study from Gjerdrum

Saman Tavakoli[1]*, NGI (saman.tavakoli@ngi.no)
Christos Boufidis[2], TEM Company
Thue Bording[3], TEM Company
Søren Bjørn[4], TEM Company
Le Hue Thi Minh [5], Norwegian Geotechnical Institute (NGI)

Abstract

About 5,000 km2 of Norway is covered by marine deposits, with 20% of this area consisting of highly sensitive clay, or quick clay. In the early hours of 30.12.2020 at Ask village in Gjerdrum, Norway, a quick-clay landslide costs the lives of several 10 residents and led to destruction of several houses. To better understand the ground conditions, a combined geophysical-geotechnical investigation took place at and around the landslide area in Gjerdrum.

Geophysical investigations were conducted to, together with geotechnical results, improve the existing ground model. These geophysical investigations include Electrical Resistivity Tomography (ERT), Towed Transient Electromagnetic (tTEM), ground magnetic and refraction seismic data which were conducted in three zones in and around the landslide area. In this paper, we present results from tTEM and ERT data. Data processing, filtering and inversion was applied on all geophysical data prior to the interpretations. Resistivity contrast was observed between the values for leached clay (potentially quick), unleached clay, and bedrock, which made it possible to identify potential high-risk areas. Results from interpretations of the multidisciplinary data indicate three major stratigraphic units. A thin layer of dry crust with generally higher resistivity (ca. 200 – 400 Ωm) compared to the underlying (predominantly) clay layer.

Our holistic approach proved efficient for indirect characterization of the quick clay areas based on e.g., estimating depth to the top of bedrock and identifying slope steepness. This information, when combined with direct characterizations based on geotechnical investigations, can provide significant information about ground conditions, and thereby reduce the risks associated with quick clay landslides.

Keyword

Quick clay landslides, geophysical mapping, electromagnetic, geotechnical investigations

Interpretation of aero-magnetic ring features in Sausar fold belt, Bastar Craton, Central India

SHEIKH MOHAMMAD SHAKIL HASHMI[1]*, GEOLOGICAL SURVEY OF INDIA
(sheikhmohammad.hashmi@gsi.gov.in)

Abstract

The central India exposes rock formations ranging from the Archaen to Quaternary period which are represented by cratonic segments of Bundelkhand and Bastar along with Proterozoic fold belts like Sakoli, Sausar, Mahakoshal and Betul. Owing to its unique geological set up, the central India is known to host plenty of mineral deposits of gold, base metals and industrial minerals.

The study area is located in Seoni and Balaghat districts of Madhya Pradesh and Bhandara and Gondiya districts of Maharashtra, Central India. The area is known for manganese deposits and geologically comprises Tirodi gneiss overlain by rocks of Sausar fold belt which include quartz muscovite schist, biotite schist, quartzite, marble and calc gneiss.

Multi-Sensor Aero-Geophysical Survey was carried out under the ambit of the National Aero-geophysical mapping program (NAGMP) over block IV in parts of Chhattisgarh, Madhya Pradesh and Maharashtra covering an area of 48000 sq. Km. The survey was carried out at an altitude of 80m with a line spacing of 300m which helped in generation of high resolution geophysical maps and delineation of concealed mineral potential areas.

Three aero-magnetic ring like features were identified in the area using the aero-magnetic reduced to pole map and other derivative maps like ANS and 1st vertical derivative which were correlated with the occurrence of manganese deposits found in the area to identify new/concealed locales of manganese mineralization.

On ground its was observed that the known occurrences of Tirodi, Jam, Arjuni, Jarahmohgaon, Hatoda and Garra Chowki manganese mines lie along the margins of the identified magnetic ring features. It was also observed that these manganese mines are associated with magnetite and hematite within muscovite schist having sheared contact with granite. In the areo magnetic tilt derivative map, two major shear zones trending NNE-SSW have been identified in the area along the peripheries of ring structures which are related to mineralization as evident from the sheared contact between granite and muscovite schist. The presence of magnetite is responsible for high magnetic intensity at the mineralized locations thereby creating a ring like pattern in the aero-magnetic map and its derivatives. At a few places along the ring, lateritic zones were also observed. A linear magnetic feature trending NE-SW intersects one of the ring features at two locations near Tirodi and Jaramohgaon villages and both these locations host huge manganese deposits suggesting a possible control of this feature in deposition of manganese.

Based on these observations, it may be concluded that manganese mineralization in the area is structurally controlled and majority of known mines/old workings lie along the margins of the ring features thereby opening possibilities of exploration of new/concealed deposits of manganese along the margins of the ring features in gap areas like west of Jam, south of Jarahmohgaon and

Garragusai. The present study therefore throws light on utility of aero-magnetic data for direct mineral targeting at mineralized zones associated with magnetite and other ferrimagnetic minerals.

Keyword

Aeromagnetic, Ring features, Sausar, Bastar Craton, Central India

Slope Failure Back Analysis from Ground-Based Radar Data to Estimate the Safe Re-entry Time After Failure

Dio Yudha PRATAMA[1]*, GroundProbe (dio.pratama@groundprobe.com)
Muhammad Ikhsan Nasrullah[2], GroundProbe
Ignatius Ega Putra[3], GroundProbe

Abstract

The main objective of modern mining operations is to extract resources safely and efficiently, economically maximizing production. On the other hand, slope failure hazard is one of the factors that could affect the conformity between the mine production plan and the actual mining activity. As a result, slope failure hazard management is essential to ensure that the site personnel is always working in a safe environment and that mine production is in accordance with the actual plan. In that case, real-time slope monitoring to evaluate and control risks associated with unstable natural and engineered slopes is crucial.

Slope monitoring tools that are widely utilized to control slope failure risk is interferometric ground-based (GB) radar which offers capabilities for real-time measurement, sub-millimetre precision, and broad area slope coverage. Following a slope failure, intensive and close monitoring can be conducted using the GB radar to facilitate effective risk management.

GB radar data used for this paper such as deformation and coherence graphs is provided from GroundProbe's Slope Stability Radar (SSR). Deformation and coherence data of the failure event could be determining factors in deciding when mine personnel can safely resume mining activities around failure area. At the time of failure, the maximum rate of slope movement will certainly exceed the limitation of any GB radar using the interferometry method. Any deformation exceeding the maximum measurement threshold may result in ambiguity or the loss of accurate tracking of deformation magnitude. In addition, the coherence data could also depict the slope surface condition during and after the failure event.

Furthermore, by integrating the analysis of SSR deformation and coherence data, a total of 14 slope failures from undisclosed gold and coal mines will be analyzed to understand the behaviour of the slope during and after each failure, particularly concerning the time required to ensure the area is safe for resuming mining activities. 7 failures originated from a gold mine which has a brittle rock material while the other 7 failures occurred in a coal mine with a ductile rock behaviour.

All in all, comparing both sets of results reveals that the approach of analyzing deformation and coherence data in the course of a failure event could be utilized to comprehensively estimate the required waiting time. This allows for the optimization of mining processes while efficiently

managing the risk associated with re-entering affected areas.

Keyword

Slope Failure, Hazard Management, Ground-Based Radar, Re-entry Time

Multi-thematic geoscience study in Hamirgarh Bhiyana segment, eastern Aravalli Craton Rajasthan, Western India: Evidences of existence of dual mineral systems

Rana BANDYOPADHYAY[1]*, GEOLOGICAL SURVEY OF INDIA
(rana.bandyopadhyay@gsi.gov.in)
Reenika Ms[2], Geological Survey of India

Abstract

South central Rajasthan is a metal-endowed zone in NW Indian shield where Zn-Pb-Cu are accumulated over time in different metallogenic environments. The current study utilised newly acquired high resolution multisensor airborne geophysical data and evaluated the mineralisation potential of the eastern Aravalli Craton through magnetic data interpretation and integration in Hamirgarh-Bhiyana sector. The domain host a combination of rocks displaying a spectrum of ages and genetic makeup, including rocks of Mangalwar Complex, Berach granite, Hindoli group and Rajpura-Dariba group, hosting major Pb-Zn deposits. The southern part is characterised by migmatite and gneisses of Mangalwar Complex with enclaves of felsic and mafic volcanics. The domain is characterised with sheared lithological contacts between Hindoli Group and Berach Granite in the north, Rajpura Dariba Group and Hindoli Group in the south west and a tectonised contact between Hindoli Group and platformal sediments of Vindhyan in the east. In addition to the sheared contacts between various litho domains, the area is also affected by a series of deformational events mainly D2 and D3 which affected entire NW Indian Shield.

Integrated geophysical study has been executed in this domain through interpretation of high resolution airborne magnetic data, airborne gamma ray spectrometric data, airborne electromagnetic data (AEM) and ground gravity data for delineation of zones of metal concentration. Study of the geophysical derivative maps viz. Reduced to Pole (RTP) and Tilt Derivative (TDR) of RTP, Horizontal Gradient Bouguer Gravity map identified areas with sharp susceptibility and density contrast and facilitated in understanding lateral and vertical continuity of existing faults, shear zones and litho contacts in areas of thick soil cover and limited outcrops. Structural fabric identified through magnetic and gravity lineaments analysis decipher areas with high lineaments density and rock permeability with possible hydrothermal fluid migration pathways. Anomalous radioelement enrichment of potash (K%), K composite maps (K, eTh/k and eU/K), eTh/K lows are some of the characteristics of the hydrothermal zones over the basement granitoids.

Ground appraisal of such zones of high lineament density and their intersection, identified a segment where quartz reefs impregnate the fracture system created by later deformational events in the northern part of Hamirgarh-Bhiyana sector. Such fracture systems are manifested as linear magnetic highs owing to creation of secondary magnetite during the hydrothermal activities Sulphide/ Copper mineralisation is also manifested in the sheared and altered portions of Berach granite and hydrothermally affected quartzites in the northern part. The southern sector of the area

exhibits as layer parallel occurrence of copper mineralisation within amphibolite, meta-rhyolite and quartz-sericite schist in close spatial proximity of a major NW-SE trending magnetic anomaly which is in turn the sheared contact between Mwangar al Complex and Rajpura Dariba Group of rocks .A linkage between copper mineralisation and strong physical property contrasts viz. magnetic susceptibility, density and conductivity is a striking character of the VMS type deposit owing to its peculiar mineral assemblage in the form of pyrite, pyrrhotite, magnetite, sphalerite, galena, barite etc. As an outcome of this multi-thematic geoscience data analysis, a dual mode of base metal

Keyword

East Aravalli Craton, Integration, Mineral System, Hydrothermal, VMS

Nuclear magnetic resonance constrained triple-water resistivity model to estimate the fluid saturation in Zao 34 block, Bohai bay basin

XueJuan ZHU[1]*, China University of Petroleum (East China) (04012126@163.com)
ShaoGui Deng[2], China University of Petroleum (East China)
YiRen Fan[3], China University of Petroleum (East China)
XinMin Ge[4], China University of Petroleum (East China)
Jin Li[5], Tianjin Branch, China National Logging Corporation

Abstract

The reservoir of Zao 34 block in Cangdong Sag is characterized by a typical low resistivity and low permeability, with high shale content, fine particle size, complex pore structure. The resistivity of the oil layer is close to that of the water layer, making it challenging to calculate oil saturation through well logging.

The triple-water resistivity model comprehensively characterizes several different conductivity mechanisms of rocks, taking into account the unique conductivity characteristics of clay water and the significant impact of micropore water on rock resistivity. It is an important bridge to establish the relationship between resistivity and saturation in low-resistivity reservoirs. However, there are limitations in the application of the calculation process, which requires knowledge of the contents of free water, microporous water and clay water, as well as their corresponding petroelectric parameters. To address this issue, a method is proposed to calculate the parameters of the triple-water resistivity model using nuclear magnetic logging constraints on conventional logging, ultimately calculating the oil saturation of the reservoir. Firstly, the quantitative relationship between resistivity and fluids of different components is derived based on the parallel conduction mechanism, namely the triple-water resistivity model for pure water layers. Secondly, the volumes of free water, micropore water, and clay water are determined based on the NMR logging response characteristics of pure water layers and substituted into the triple-water resistivity model. The optimization method is applied for iteration to obtain the cementation index of different component waters. Meanwhile, the conventional logging curves are constrained by nuclear magnetic logging to establish a method for calculating the volumes of clay water, micropore water, and free water using conventional logging data. Finally, a triple-water resistivity model for oil-bearing reservoirs is established, and the free water saturation index is calculated using optimization methods with core saturation data. This method effectively avoids the limitations of having to rely on experimental data such as mercury injection, petroelectrical experiments, clay analysis, and cation exchange capacity measurements to determine the parameters of the triple-water resistivity model. It can still obtain relatively accurate model parameters in the absence of experimental data. The saturation calculation of the low- resistivity oil and gas reservoirs in the study area was carried out using the triple-water resistivity model, and the final calculation results show good agreement with core saturation measurement data and oil testing results, proving the feasibility of this method.

Keyword

Low resistivity reservoir, Triple-water resistivity model, Nuclear magnetic resonance logging, Optimization algorithm

Proximity Excavation in Down Town area Using High Tension Net

BYUNG DON RO[1]*, Architecture Safety Center, Gangseo-Gu, Seoul, Korea (engeo@naver.com)

Abstract

Recently, along with the construction of group housing facilities, redevelopment or reconstruction of existing sites is being carried out more actively than ever before. Most of these are often carried out in existing dense urban centers, and as a result, not only group complaints, but also various environmental issues and technical reviews are emerging. We will face numerous practical problems such as noise, dust, and hazardous materials such as asbestos generated during the demolition of existing buildings, various problems related to excavation and blasting, technical restrictions due to tight construction conditions. In particular, blasting stones, noise, and dust will be unavoidable challenges during proximity excavation along public roads or in adjacent buildings. Therefore, in this study, it is an example of applying an excavation method using a high-strength tension net after reinforced an existing slope based on various field survey results in conditions where it is impossible installation of protection barrier during excavation near a roadside or adjacent structure during public use. In order to apply this method, an overall geological survey of the site was carried out, a slope stability assessment on the exposed outcropping surface was carried out, and necessary stabilization measures were carried out. After that, careful investigation and evaluation of the architectural characteristics, usage characteristics, and maintenance conditions of nearby structures were carried out, and the high-tention net was adopted in consideration of the construction limitations, costs, and complaints. In particular, in situations where various methods for rock excavation, such as blasting methods, installation of blasting barriers, and rockfall prevention measures, etc., are restricted, considerations were taken to minimize inconvenience to users of adjacent building due to secondary damage such as rockfall, noise, and dust.

Keyword

high-tention net, blasting barrier, proximity excavation, BYUNGDON RO

Correlation between consolidation of soft ground and time-lapse gravity

YeongJae LEE[1]*, Geo-information Research Group Co. Ltd (dudwovjscl@naver.com)
SungWook Kim[2], Geo-information Research Group Co. Ltd
Sungchan Choi[3], Geo-information Research Group Co. Ltd
DaeHong Go[4], Geo-information Research Group Co. Ltd
EunKyeong Choi[5], Geo-information Research Group Co. Ltd
TaeHyung Kim[6], National Korea Maritime & Ocean Univ.

Abstract

The study area is a soft ground that is being improved by applying a free-loading method, and changes in the gravity field were observed at intervals to confirm changes in the ground during the construction process. The gravity field was measured by crossing the soft ground in the north-south direction. The spacing between measuring points was 10 m, and field data for a length of 360 m were obtained. Additionally, to observe the gravity effect over time, measurements were repeated 5 times at the same location with a time difference of about 2 months. The soft clay, which is consolidated by load, lies on top of the bedrock, and because the bedrock does not deform due to ground improvement, the change in gravity observed in repeated measurements can be interpreted as consolidation of the soft clay. An increase or decrease in time-lapse gravity indicates changes in the density of the clay layer. As a result of the gravity field interpretation, the degree of consolidation of the clay layer varies depending on the location, and the consolidated portion and the unconsolidated portion in the profile of the continuous Bouguer anomaly could be distinguished. This is considered to be suitable as a method of diagnosing the condition of the layer in the soft ground improvement stage because it can determine the discontinuity of consolidation.

Keyword

time-lapse, gravity, Bouguer anomaly, soft ground, consolidation

Gravity and Gravity Gradient Joint Fast Inversion Method

Zhengyuan JIA[1]*, China University of Geosciences Beijing (jzy@cugb.edu.cn)
Luofan Xiong[2], China University of Geosciences Beijing

Abstract

High-precision airborne and marine gravity gradient measurements are quick, efficient, and cost-effective, playing a crucial role in studying crustal structure, as well as the distribution of minerals, oil, and gas resources. As exploration depths increase, the joint inversion of gravity and gravity gradient data becomes essential for a more comprehensive and unique revelation of underground density structures. However, this brings challenges of large computations, slow convergence, and high memory requirements. To enhance both the computational speed and precision of joint inversion for three-dimensional gravity and gravity gradient multi-components, addressing key challenges related to the large computational memory and slow processing speed requirements of inverting extensive airborne and marine gravity gradient measurements datasets, this study introduces a novel fast forward modeling algorithm for gravity and gravity gradient fields. The algorithm is based on exploiting the inherent Block Toeplitz-Toeplitz Block (BTTB) matrix structure of the forward problem, allowing for highly efficient matrix-vector multiplication during the inversion process. It is integrated into a hybrid optimization workflow employing an outer loop based on the Gauss-Newton method to linearize the inverse problem. Within this, an inner loop utilizes the conjugate gradient method to solve the normal equations rapidly. By taking advantage of the BTTB structure, computation of gravity and gradient responses for the dense model meshes required for 3D inversion is accelerated by over an order of magnitude compared to conventional approaches. At the same time, solution precision is also improved. The accuracy and effectiveness of the proposed joint inversion algorithm, combining the new fast forward solver within its optimization framework, was systematically validated through a series of synthetic modeling experiments. Results demonstrated convergence to high-quality models could be achieved in significantly reduced processing times compared to previous techniques while still satisfying misfit targets. This makes joint 3D inversion of extensive multi-component datasets now feasible where it was not previously possible. Finally, the method proposed in this paper is applied to jointly invert airborne full-tensor gravity gradient data and ground gravity data in the Winton Salient region. The inverted density structure aligns with geological data for the region, demonstrating the method's promising application prospects in handling real-world data with short inversion times.

Keyword

Gravity Gradient, Fast Inversion, Block Toeplitz-Toeplitz Block

Distribution of plume-shaped low-gravity zone in the southeastern part of the Korean Peninsula estimated through 3D gravity modeling

sung-wook KIM[1]*, Geo-information Research Group Co. Ltd. (suwokim@chol.com)
Sungchan Choi[2], Geo-information Research Group Co. Ltd.
Eun-Kyeong Choi[3], Geo-information Research Group Co. Ltd.
Jeoung-Seok Yoon[4], DynaFrax UG

Abstract

To provide 3D density distribution around the Yangsan fault (YSF) situated in the Gyeongsang sedimentary basin (GB), the southeastern part of the Korean Peninsula, 3D gravity forward modelling was performed using the IGMAS+ software package. A total of 3,000 gravity stations were compiled and used to calculate the Bouguer gravity field. From the Bouguer anomaly field, the residual gravity field was calculated by subtracting the gravity effect of the Crust-Mantle boundary (Choi et al., 2023). The residual gravity field along the YSF shows that the mean value of the southern segment (approx. 34 mGal) is very similar to that of the northern segment (approx. 35.5 mGal), meanwhile, the mean gravity value of the central segmentation (C-YSF) is about 27 mGal, significantly lower than those of the other segmentations. This implies that the crustal structure and petrophysical properties (e.g., density) of the C-YSF are significantly different than those of the other segmentations. Several polyhedral and density constraints (e.g., gravity field interpretation, Vs-tomography, measured rock density, faults and rock type) obtained from geologic and geophysical interpretation, were considered for the 3D gravity forward modelling. The results of the modelling indicate that the prominent low gravity zone shown in the C-YSF is explained by combined density effects from the modelled Bulguksa-Granite (2.60 g/.) and Low-Velocity Zone (LVZ) with a mean density of about 2.65 g/. Comparing the low gravity zone with the geological map, receiver function analysis and spatial distribution of the Heat Flow Unit (HFU), we conclude that the low gravity zone is caused by the Plume-Like-Structure (PLS) which should be uplifted from the Mantle. The maximum depth of the PLS exists in the central part of the C-YSF and is assumed to be about 20 km from the lower crust to the basement of the GB. The bottom depth of the PLS in the southern part of the C-YSF is about 15 km, where the Gyeongju earthquake (2016M5.8_GY) occurred. Meanwhile, the bottom depth of the PLS is about 7 km in the area where the Pohang earthquake (2017M5.4_PO) registered. All points of our gravity field interpretation and modelling results indicate that the Gyeongju- and Pohang earthquakes that occurred in the vicinity of the PLS are closely related to the tectonic movement of the PLS. In other words, it is assumed that the Pohang earthquake was caused as the largest aftershock of the Gyeongju earthquake by transmitting of seismic wave through the PLS.

Keyword

Yangsan fault, Gravity field interpretation, 3D density modelling, Gyeongju earthquake, density

Investigation on the magnetotelluric (MT) survey from the Yeonil Tectonic Line and Ulsan fault zones in the Gyeongsang Basin of Korea

Kyeongho Ryu[1]*, Kangwon National University (rudgh2942@kangwon.ac.kr)
Hyoung-Seok Kwon[2], Kangwon National University
Seokhoon Oh[3], Kangwon National University

Abstract

In 2016 and 2017, earthquakes with magnitudes of ML 5.8 and ML 5.4 occurred in the Gyeongju and Pohang regions of southeastern South Korea, and lots of micro-earthquakes were observed not only near the epicenter but also below the Yeonil Tectonic Line and Ulsan faults.

A magnetotelluric (MT) survey has been proposed as a geophysical method to identify the deep geology of micro seismic zones. Prior to the MT survey, numerical modeling was performed to account for the influence of the topography and ocean on the MT data.
The study area is mostly mountainous and is bordered by the sea to the east. The ocean is a very strong conductor that has a strong influence on the MT data and can be misinterpreted as a distribution of false low resistivity anomalies if ocean effects are not considered.

In the model considering the ocean, the MT response curves are similar to those in homogeneous model at high frequencies. However, at low frequencies, the difference between the XY and YX mode resistivity curves becomes larger due to the electrical conductivity of the ocean. At the closest point to the ocean (0.2 km), the XY and YX mode curves differ in the 100 Hz frequency band, and the frequency at which the two modes differ decreases with distance from the ocean.

The MT survey was carried out in the study area in July and August 2023, and a total of 28 data points were acquired along a 70 km long survey line with a spacing of 2-3 km between survey points. To obtain reliable MT data, a minimum of 88 hours, a maximum of 208 hours, and an average of 144 hours of data were collected per survey point. Two-dimensional inversion was applied to the MT data to generate a 35 km deep electrical resistivity cross-section, which was used to understand the deep geologic structure and distribution of geologic soft zones beneath the Yeonil Tectonic Line.

In the electrical resistivity cross-section, steep dip low-resistivity anomalies are clearly distributed in the lower part of the Yeonil Tectonic Line and Ulsan faults, and east of the Yeonil Tectonic Line, the low-resistivity layer of the Yeonil Basin, composed of sediments of seafloor origin, is imaged to a depth of 8 km.

In the future, audio magnetotelluric (AMT) surveys, which acquire high-frequency data with higher resolution than MT surveys, are expected to provide more reliable information on the

geological characteristics of the Yeonil Tectonic Line and the Ulsan fault at depths of several kilometers.

“This work was supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and Korea Foundation of Nuclear Safety(KOFONS) grant funded by the Korea government(Nuclear Safety and Security Commission, NSSC)(RS-2021-KN066110)”
"This work was also supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT, MSIT) (No. 2022R1A2C1092301)"

Keyword

Magnetotelluric, Yeonil Tectonic Line, Ulsan faults, Micro-earthquake, Electrical resistivity cross-section

PROFESSIONAL INITIATION RESIDENCE PROGRAM LATO-SENSU IN EARTH SCIENCES AT THE GEOLOGICAL SURVEY OF BRAZIL – CPRM

Patricia DURINGER Jacques[1]*, cprm (patricia.jacques@sgb.gov.br)
Alexis Rosa Nummer[2], UFRRJ
Geraldo Advíncula[3], CPRM
Andrea Sander[4], CPRM

Abstract

The Professional Initiation Residency Program in Earth Sciences (Residência SGB) aims to qualify recent graduates (up to two years after graduation) through immersion in a professional environment (in the Geologycal Survey of Brazil – CPRM), enabling them to efficiently practice their profession. Consequently, it facilitates their entry into the job market, contributing to the development of geosciences in Brazil in line with the socio-economic demands of the country. The inspiration for this program is drawn from the medical field, where a doctor, after completing their degree, undergoes medical residency in a hospital, engaging in daily practical activities and specializing in a specific area of medicine after two or three years. The program was developed through several stages, starting with the mapping of hole process, establishing technical cooperation agreements with a higher education institution (in this case, the Federal Rural University of Rio de Janeiro - UFRRJ), and formulating a risk matrix, culminating in the publication of the residency policy by the Geological Survey of Brazil - CPRM (https://www.sgb.gov.br/publique/media/sobre/governanca/politica_residencia.pdf). The inaugural class started in August 2023 and will run for two years until July 2025. The class comprises eighteen professionals with backgrounds in geology across various fields of knowledge, including geological mapping in the Amazon region, hydrogeology and hydrology, environmental geology, geoscience mediation, paleontology, data science, tectonics and fluids, geomorphology, prospective geochemistry, economic geology, and mineral production systems. Each student has a mentor from the geological service and a professor from the UFRRJ. The lato sensu program offered by UFRRJ operates within the geological service's facilities and is funded by CPRM, covering project expenses and residents' scholarship amounts, which are comparable to a master's degree scholarship (stricto sensu). Residents are encouraged to participate in internal and external scientific and technical events, presenting their work and engaging with the scientific community, alongside full immersion in geological service projects. Upon completion of the residency, residents are required to disseminate the final product through CPRM's institutional systems, such as publishing geological or geomorphological maps available on RIGEO (https://rigeo.sgb.gov.br/) and GeoSGB (https://geosgb.sgb.gov.br/), developing products mediated by geoscientists available on SGBeduca (https://sgbeduca.sgb.gov.br/), or alert products for floods available on SACE (https://www.sgb.gov.br/sace/). The residency program aims to enhance knowledge, skills, and essential professional conduct while fostering ethical

responsibility. It provides an opportunity for practical experience in a corporate environment, involvement in company projects and actions, and participation in supervised and guided theoretical and practical training. Additionally, the program contributes to the development of public policies for the professional development of young and adult individuals in Brazil, solidifying the Geological Survey of Brazil - CPRM as an institution for extension and training in Earth Sciences and related areas.

Keyword

Residence Program, Practical experience, earth sciences

ERASMUS+: a strategic tool to build partnerships among continents to enhance Geoscience through Higher Education.

Lola PEREIRA[1]*, University of Salamanca (mdp@usal.es)
Helio Vasco Nganhane[2], Universidade Pùngué
Giovanna Dino[3], University of Torino
Daud Jamal[4], Universidade Eduardo Mondlane
Pedro Dinis[5], Universidade de Coimbra
Nelson Rodrigues[6], Universidade de Coimbra

Abstract

Sustainable and responsible management of geo-resources requires a rethinking and redesign of our production and consumption patterns. Awareness of the natural environment as a common good to be preserved, and knowledge of the close link between the natural environment and the socio-economic system are prerequisites for a profound change in human attitudes at both individual and societal levels. In this context, training and education of all actors involved in the management of geo-resources is an indispensable starting point for the acquisition of critical, ethical, and conscious thinking and the technical skills necessary to solve local problems and initiate sustainable development.

The present research focuses on two consequential ERASMUS+ projects: SUGERE and GEODES. Both had the common goal of the international standardization of Higher Education training and teaching in Earth Sciences and Mining Engineering.

SUGERE (Sustainable Sustainability and Wise Use of Geological Resources) was successfully completed in September 2023, involved 3 European universities (from Portugal, Spain, and Italy) and 6 non-European universities (from Mozambique, Cape Verde, and Angola). The objective was to enhance capacity building for the responsible and sustainable use of geological resources by supporting the didactic organization and standardization of 5 degree courses at Bachelor, Master and Doctorate levels in Earth Sciences and Mining Engineering. Both online and face-to-face training sessions were organized in European and African universities.

Deepening technical skills in geomining from a sustainable perspective is crucial for developing critical thinking and acquiring ethical values necessary for solving local problems. SUGERE and GEODES contribute to this outcome with a solid network of research, training, sharing and exchange of expertise and research activities between European and non-European universities interested in mining issues. A careful analysis of the local economic development of the countries involved in the projects is required to achieve the most effective methods for the exploration and sustainable exploitation of underground georesources.

GEODES, started in June 2023, represents the continuation of the SUGERE project and involves a total of 9 partners. The same 3 European universities and 6 African institutions, formally attributing teaching and training roles to 2 universities that participated in SUGERE, already achieved a good standard in terms of infrastructures and have long teaching experience in the field of geosciences, and receiving 4 young institutions from less favored regions of Angola and

Mozambique.

SUGERE and GEODES aim to strengthen the role of geosciences in the development of up-to-date strategies for the sustainable management of natural resources and to implement new collaborations thanks to an international network focused on local economic and social development and respect for the natural environment in the geological-mining context. The culture of sustainability and the deepening of skills in the field of geological mining form the basis for the development of the critical thinking necessary for local problem solving, the acquisition of ethical values and the technical skills that underpin sustainable development.

Deepening technical skills in geomining from a sustainable perspective is the basis for developing critical thinking and acquiring ethical values necessary for solving local problems.

ERASMUS-EDU-2022-CBHE-STRAND-1 Project 101082202

Keyword

ERASMUS+, Geoscience, Africa, Geoethics

Towards a common understanding of raw materials education worldwide – An international Qualification Framework for Raw Materials

Vitor Correia[1]*, INTRAW (vcorreia@intraw.eu)
Philipp Hartlieb[2], Montanuniversitaet Leoben
Manuel Regueiro [3], Geological Survey of Spain
Christopher Keane[4], American Geosciences Institute

Abstract

Different training and education requirements prevent the free flow of workers from one region or industry to another, hampering local and regional development. This is driving countries to develop National Qualification Frameworks (NQFs) and attempt to relate those NQFs to international systems.

This presentation advances an international sectoral qualifications framework for the raw materials sector (SQF-RM), hence improving relevance, transparency and coherence between qualifications along the minerals value chain and the corresponding international recognition. The proposed SQF-RM is based on extensive literature study, linking regulatory constraints and currently taught engineering discipline and their skills and learning outcomes.

The SQF-RM is focused on the areas, subareas, professional roles and sets of key competences of the raw materials sector. Because the spectrum of approaches across the world of professional qualifications in the minerals sector is vast, the SQF-RM is based on the existing European Qualification Framework (EQF). The EQF is a common reference framework that allows qualifications from different countries to be easily compared, using learning outcomes associated with each qualification. This establishes a basis for improving the quality, accessibility, linkages and employers' recognition of qualifications in the raw materials sector, within a country and internationally.

An internationally acknowledged qualification framework for raw materials is strongly needed to enhance interchange of geoscience expertise and people. Two important factors, namely governance and quality assurance are key assets for successful implementation and need to be well-designed.

Keyword

Professional qualifications, Reference framework, Learning outcomes, Skills

Vision and Change – Transforming Geoscience Education in the United States

Christopher KEANE[1]*, American Geosciences Institute (keane@americangeosciences.org)

Abstract

The geosciences in the United States boast a rich history of educating students who have pursued careers in the resource, environmental, and engineering consulting industries. Traditionally, these students embarked on a geology curriculum comprising approximately 60 hours of geology coursework, which included traditional field camp and classroom-based courses. However, over the last 15 years, both the nature of the geosciences as a discipline and its related employment landscapes have undergone significant changes. This evolution prompted the National Science Foundation to sponsor the Vision and Change project, which convened over 1,000 geoscientists from academia, government, and industry. Their mission was to reevaluate both undergraduate and graduate-level geoscience education to ensure it meets the needs of the country as well as those of the students. This collaborative effort has produced several critical recommendations, many of which are being implemented by geoscience programs to varying extents. Key among these recommendations is the shift towards structuring curricula around learning outcomes rather than specific courses. This approach empowers students by allowing them to map their educational pathways, highlighting achieved outcomes, and developing work portfolios for employment purposes. Additionally, the importance of enhancing quantitative skills and recognizing the value of business and communication skills were emphasized. Various strategies have been adopted in response to these insights, notably the redevelopment of curricula focused on learning outcomes. This has led to the creation of geology degree programs designed to enable graduates to meet professional licensing requirements. A recurring observation concerning graduate education in the United States is that while geoscience graduates excel as researchers capable of conducting sophisticated studies, employers often note a gap in practical skills for non-academic settings. Graduates frequently struggle to identify and effectively tackle real-world problems. Addressing these challenges is crucial for preparing geoscientists who are not only adept at research but also equipped with the necessary skills to excel in professional environments.

Keyword

education, higher education, skills, professionalism, undergraduate

Geoscientists for Ireland's future – What are we doing to encourage their creation?

Siobhán Eilís Power[1]*, Geological Survey Ireland (Siobhan.Power@gsi.ie)

Abstract

Ireland has a relatively good education system and a population that shows an interest in the natural world, but geoscience-related subjects are not a strong component of the national curriculum nor the mainstream media, nor national conversations. Ireland is good at publicly supporting science education at secondary school level (13 – 18-year-olds), funds teaching and research at third level education, and benefits from local and international industry investment in science-related companies, but there are still gaps in the work towards a national understanding of climate and environment issues, and deficiencies in how we encourage geoscientists for Ireland's future.

Governmental, professional, cultural, and educational organisations have worked independently and together over the last few years to address some of these issues, but progress is slow, and it is difficult to quantify success. Some of the activities include a temporary exhibition at the national museum, a primetime television series, professional scientists input to national curriculum development, sponsoring of national young scientist prize, and co-creation of teaching resources. A review of some of the activities lead by Geological Survey Ireland, a division of a national government department, is presented here, as well as an overview of other related activities carried out by professional and educational organisations to bring geoscience to national attention, connect it to climate and environmental questions, and show it as a possible and worthy profession.

By reviewing current work in Ireland, looking to best practice in other countries, and giving careful and focused consideration to future plans for education, outreach, and the geoscience aspects of the busy field of science communications and messaging, it is hoped that we can improve our methods of creating new and essential geoscientists for Ireland, and by extension, for the stable human habitation on our planet in the future.

Keyword

Geoscience, Outreach, Education, Exhibitions, TV Show

The role of the NATIONAL FORUM OF GEOLOGY COURSES IN BRAZIL in the training of geologists and geological engineers

Alexis Rosa NUMMER[1]*, UFRRJ (rosanummer@gmail.com)
Celso DalRé Carneiro[2], casado

Abstract

In Brazil, the training of geologists and geological engineers in undergraduate courses is offered by 27 federal public universities, 04 state public universities, and 04 private higher education institutions. The Ministry of Education and Culture (MEC) establishes standards, controls the organization and supervises the performance of the courses. The minimum duration of the courses must be equal to or greater than 3,600 hours, including field activities, whose minimum duration is 720 hours. Control of professional activity is exercised by the Federal Council of Engineering and Agronomy, which manages the so-called CONFEA-CREA System. Each state is under the jurisdiction of a Regional Engineering and Agronomy Council (CREA), which supervises the performance of professionals in the different activities carried out in accordance with social demands on the environment and natural resources. In 2001, the National Forum of Geology and Geological Engineering Courses was created, composed of researchers, university professors and representatives of the National Entity of Geology and Geological Engineering, to organize and evaluate the direction of teaching in Geology in Brazil more effectively. In this aspect, the most relevant issues that are discussed in these meetings include evaluations and construction of regulations regarding the Curricular Guidelines for Undergraduate courses in Geology, dropout rates, workload of undergraduate courses, degrees in geosciences, field activities and the market for work. Curricular Guidelines allow defining the different profiles of graduates in Federal and private Higher Education Institutions and adapting them to the rapid changes of the modern world.

Keyword

Brazilian Geology Courses Forum, Geology Curriculum, Curriculum Guidelines for Higher Education in Brazil

Enhancing Geoscience Education Through Critical Thinking: Insights on Teacher Development and Student Engagement

Lixian Tian[1], Hebei Normal University
Liang Qiu[2]*, China University of Geosciences, Beijing (qiul@cugb.edu.cn)
Man Zhu[3], China University of Geosciences, Beijing

Abstract

Engaging in argumentation serves as a vital component of geoscience education, facilitating both the professional growth of teachers and the cultivation of critical thinking skills in students. By fostering critical thinking, educators promote in-depth processing of information and enhance students' conceptual understanding of scientific concepts. This research focuses on the role of argumentation in geoscience education, examining how teachers structure lessons to incorporate argumentation and how students actively participate in critical discourse. The study involved teachers and undergraduate students enrolled in a foundational geoscience course at a northern university in China, specializing in geoscience education. Various argumentation tools such as argument schemes, critical questions using argumentation vee diagrams, model-evidence links, and both oral and written discourse were employed. Employing a mixed-method approach, the study collected quantitative data through self-efficacy and critical thinking surveys administered to both teachers and students, along with qualitative data including interviews, student work samples, and collaborative discussions. The findings revealed that teachers in the experimental group demonstrated increased confidence in utilizing argumentative pedagogy, particularly in employing critical questions, over the course of a semester. Similarly, students in the experimental group exhibited greater engagement in critiquing arguments and delving deeper into geoscience scenarios, notably by presenting more counterarguments. This research underscores the significance of integrating argumentation, particularly critical questioning, into the design of geoscience curricula, offering a pathway to enhance teachers' professional development and nurture students' critical thinking abilities.

Keyword

argumentation, critical thinking, geoscience education

Promoting Geoscience Education in a South African Science Centre

Tanja REINHARDT[1]*, University of KwaZulu-Natal (reinhardtt2@ukzn.ac.za)

Abstract

Informal educational settings such as science centres play an important role in science education around the world. Science centres are known to have a positive influence on promoting visitors' curiosity, interests, and knowledge of science because visitors can interact with real objects and engage with exhibits in a relaxed informal environment. They can also watch science shows, or consult websites. In addition to the informal education that takes place in science centres, learning can also be non-formal through organized, systematic, educational activities such as workshops.

The Science and Technology Education Centre at the University of KwaZulu-Natal (STEC@UKZN) in Durban, South Africa which includes the Geology Education Museum, is one of these science centres. It is a place of hands-on science learning with an emphasis on Geoscience education. Our aim is to develop programs, workshops and undertake outreach programs, which focusses on creating awareness, promoting and teaching science and technology particularly in disadvantaged communities, e.g. rural areas and townships.

Geoscience forms an integral part of South Africa, with its rich geological heritage. They feature in the curriculum at primary and secondary school level (Earth and Beyond and geography) and are an important factor of the South African economy and society (e.g. mining of diamonds, gold, platinum or evolutionary aspects). Over the years, STEC@UKZN was involved in the development of numerous low-cost geoscience-related activities, exhibits and educational material using an informal and non-formal education approach. While we usually operate face to face, the Covid-19 crisis had us also explore online avenues.

In the presentation we want to highlight how we introduced geoscience education as a basic science in a science centre, be it non-formal or informal, face to face or online and the situation on promoting geoscience education in other science centres.

Keyword

geoscience education, science centre, informal education, non-formal education

Teaching with toilet roll and learning with LegoTM to address the geosciences knowledge and skills gaps in the UK and beyond. -Teaching in the shadow of a king

Phillip MURPHY[1]*, University of Leeds, UK (p.j.murphy@leeds.ac.uk)

Abstract

The place of geoscience education in the English state schools system historically was mostly under the banner of geography as a subject. This has been a contributing factor to the problematic nature of recruitment to university level geoscience courses as few schools offered a geoscience qualification. Geoscience does form part of the national curriculum science in England but has often been ignored or poorly taught. The Earth Science Education Unit (ESESU) was formed in 1999 under the leadership of Professor King in order to address these issues through in service training for teachers. Since the demise of the ESEU in 2015 recruitment to university geoscience courses has become even more challenging partly due to its association with the hydrocarbons industry in the eyes of young people and a further decline in the number of schools offering the subject.

The reality is the need for geoscience graduates has never been higher as the move towards a zero carbon economy and the requirements for geological input into modern infrastructure developments has driven a jobs boom in the sector. Geologist, engineering geologist, hydrogeologist, geochemist, geoscientist and geophysicist are listed in the government skilled workers visa list showing vacancies are having to be filled from outside the UK.

Examples of how ideas and practices developed by the ESEU have been further developed to engage a new generation of young people in the UK with geoscience as well as ensuring much of the work of the ESEU and associated educational communities has been disseminated beyond national borders. Central to the ethos of the ESEU was ensuring there was no or at least very little cost incurred during teaching delivery which has proved a vital part of ensuring the ESEU legacy has grown beyond any of our expectations.

Keyword

england, geology, school, university

Geoscience outreach for visually impaired learners: A journey to “see” Earth and space differently

Tanja REINHARDT[1]*, University of KwaZulu-Natal (reinhardtt2@ukzn.ac.za)

Abstract

The Science and Technology Education Centre at the University of KwaZulu-Natal (STEC@UKZN) which includes the Geology Education Museum is a place of hands-on informal science learning with the emphasis on Geoscience Education. Numerous geoscience related workshops and educational material have been developed by us.

Over the last few years the South African Department of Science and Innovation aim is to provide inclusive science education, and to provide equitable learning opportunities for learners with diverse abilities. This provides to be difficult for learners with visual impairment, as the majority of science experiments are heavily relying on visual instruction techniques.

In collaboration with astronomy researchers, we as a Science Centre wanted to provide the same informal teaching and hands-on geoscience activities to learners with visual impairment. In this inclusive education approach, we decided to adapt some of our geoscience material for learners with seeing difficulties. We used different innovative strategies to improve their learning experience by employing a multisensory approach. Usually traditional teaching methods rely heavily on visual cues, creating barriers for learners who can’t see. To address this challenge, our method incorporated tactile, and experiential elements, such as two- and three-dimensional models, as well as audio and sensory stimulations.

Especially models are beneficial to learners when learning about science. This is particularly true for learners with visual impairments, as they have to rely on senses like touch to be able to “see”. With our astronomy and volcano models learners are provided with a tactile experience in which they can explore and examine different planets and a volcano. They are for example able to distinguish between rocky and gaseous planets, identify planets by their size and to recognize the different features of a volcano.

In our presentation we will showcase our astronomy and geology models, and share our experience with hands-on astronomy and geology workshops for learners with visual impairments.

Keyword

geoscience education, hands-on learning, visual impaired

The Transformative Power of International Geoscience Experiences for Students

Tara Schielein[1]*, Department of Environmental Sciences Southern Illinois University Edwardsville (tschiel@siue.edu)
Sharon LOCKE[2], Southern Illinois University Edwardsville
Mariam Sani[3], Southern Illinois University Edwardsville
Adriana Martinez[4], Southern Illinois University Edwardsville

Abstract

The decline in university geoscience enrollments in the U.S., U.K., Australia, and other countries creates an urgent need to develop strategies and activities that will increase student interest in earth and environmental sciences. In the United States, inconsistent earth science education in primary and secondary education means that many students enter university unaware of the career opportunities in critical fields such as natural hazards, climate change, and energy. To raise geoscience career awareness, our team provided an active learning program for first- and second-year university students that included an international field excursion to a geological setting that is very different from the geology in the region where they live. The field excursion included visits to a volcano, river, coast, plantation, and archaeological sites, along with cultural activities and an opportunity to teach science to secondary students. We administered surveys and conducted interviews to examine student learning outcomes resulting from the international experience and the other program activities. Interviews showed that the students found the international experience to be the most significant and beneficial part of the program. Students described the field excursion as “life-changing,” and they noted that the experience affected them in “unexpected” ways. Students also thought that observing and being part of an international collaboration helped them to better understand the work of a scientist. The findings indicate that geoscience educators and funding agencies should prioritize learning experiences with an international component, with the goal of broadening students’ understanding of the modern geoscientific enterprise, where teams of scientists work together to solve problems of global scope.

Keyword

field learning, geoscience careers, university geosciences, learning outcomes

Sharing outreach and educational materials through YouTube: a case study from the Shear Zone Channel.

Rob BUTLER[1]*, University of Aberdeen (rob.butler@abdn.ac.uk)

Abstract

This presentation shares experiences of delivering educational and outreach content via YouTube. It examines the reach of videos, their longevity and the utility of the platform for sharing materials – based on a personal case-study of a relatively popular and content-rich YouTube channel.

In common with many university teachers, during the Covid pandemic I developed online educational resources, including a suite of videos. These not only covered content previously delivered through in-person lectures but also enacted worked demonstrations of practical exercises. The content supported teaching in the interpretation of geological maps, field techniques, structural geology/tectonics and the geological interpretation of seismic reflection profiles. Initially these videos were hosted through the university's Panopto account but in April 2021 I decided to collate these and publish through YouTube. Even though teaching has returned to pre-pandemic norms, I still use the videos, largely to permit flipped learning activities and for providing debriefs on practical classes. I continue to populate the channel (a new video every c 2 weeks) – chiefly making short documentaries "on location" to share geo-sites, geological techniques and concepts (including the history and primary publications behind them), and practical exercise demonstrations. While students and professional geoscientists seeking educational materials remain key audiences, the videos also target "engaged amateurs" – especially those interested in discovering field locations. Moderated discussion and clarifications are delivered through the "comments" facility on YouTube. There is a parallel website (hosted on WordPress) that holds many of the practical exercises, creating an open-access resource for geological training.

But how effective is the channel at sharing geology with diverse audiences?

YouTube provides statistics on viewer demographics and view-times. As of February 2024, the Shear Zone Channel hosts 231 videos, with c 415 k views and has attracted 6.36 k subscribers. Unsurprisingly most users are based in the UK, with few based elsewhere in Europe. Significant user-communities live in North America, India, Indonesia and the Philippines. Through weeks there is a drop-off of views on Fridays. Annual viewing peaks occur in early-mid December, with a rapid drop-off through the festive season that follows, as might be expected for a student-dominated viewing population. Life-time views of individual videos are remarkably variable: some show steady accumulation, others plateau after a few days of publication, a few grow exponentially. These differences reflect video content, and presumably therefore, the type of viewer. The algorithms used by YouTube to expose content to site users, and the ways users search for content, preferentially display recent video along with popular content (watched, liked, commented upon) along with that from channels to which the user has subscribed. Interrogation of activity statistics shows few users explore hosting channels or their playlists. Many find channel

content through YouTube (algorithm-based) recommendations.
Content exposure on YouTube, in common with many digital resources, is prone not only to recency bias but also herding, whereby viewing populations repeatedly access the same content. Content creators can modulate this by pairing with other social media platforms or soliciting peer-recommendations.
The channel is available at: https://www.youtube.com/channel/UCIUYjr1yPCZQWYl9cJCO1mA

Keyword

tectonics, video, geological mapping, seismic interpretation, fieldwork

Participatory Photography Methods in Geoscience Education

Sharon LOCKE[1]*, Southern Illinois University Edwardsville (slocke@siue.edu)
Jennifer Zuercher[2], Southern Illinois University Edwardsville
Charlie Blake[3], Southern Illinois University Edwardsville
Andreia Dexheimer Figueiredo[4], Southern Illinois University Edwardsville
Candice Johnson[5], Southern Illinois University Edwardsville
Carol Colannino-Meeks[6], Emory University
Ben Greenfield[7], University of Southern Maine
Georgia Bracey[8], Southern Illinois University Edwardsville

Abstract

Participatory photography is a research method for engaging the community in understanding environmental and social problems and developing systems solutions. In an education program for students in grades 6-8, our team applied photography as a tool to support student learning about their environment using the Environmental Photovoice method. Photovoice is a structured process in which participants observe their surroundings over one or more sessions, taking photographs of places and features that interest them or surprise them. After this, the participants respond to a series of questions that prompt them to examine what is represented in the photographs and the potential impacts on the community. As a final product, students develop a written narrative about the photographs that includes ideas for taking action to solve a problem. Using Photovoice as a foundation, we have developed an out-of-school curriculum that facilitates student exploration of sources of pollution and environmental hazards, such as lead in soils and particulate matter in air. Through active learning about environmental exposure, students are empowered to understand how the environment can affect their health, while they also learn how to use scientific tools such as environmental sensors to practice science. This participatory photography process could be adapted to other natural hazards topics, such as volcanic hazards, flooding, landslides, and water scarcity. Survey and interview data collected from the students in our program indicated that students began to gain awareness of the personal and/or community relevance of geosciences topics. This is a first step towards increasing awareness of geosciences among students, their parents, and community members, which is needed to increase interest in geoscience careers.

Keyword

middle school, out-of-school, community engagement, geoscience curriculum

UK Perspectives on Educating for "No Natural Disasters"

ILAN KELMAN[1]*, University College London / University of Agder (ilan_kelman@hotmail.com)

Abstract

This presentation offers UK perspectives for "natural disaster" education. Around the UK, education for secondary schools and universities covers many disaster subjects. One approach of particular prominence is challenging the idea of a "natural disaster". Disasters do not happen because of nature, but because people and society cannot or choose not to deal with typical phenomena from nature, such as earthquakes, meteorites, microbes, and storms. These phenomena are more correctly called "hazards".

We put ourselves and others in the way of hazards without using existing knowledge and techniques to avert casualties, damage, and disruption. Consequently, we fail to take measures which we know would stop hazards from becoming disasters. Evidence comes from numerous examples of "disasters avoided", in which pre-hazard action was taken and so a disaster did not occur, even though a hazard did.

Fundamentally, disasters are rarely "natural". UK educational material on this point includes a website nonaturaldisasters.com, hashtags #NoNaturalDisasters and #DisastersAreNotNatural, and my book "Disaster by Choice" used across secondary schools in England detailing the choices we make to permit disasters and the choices we could make to avoid disasters. Rather than being "natural", disasters arise from the political processes dictating where and what we build as well as from social circumstances which create and perpetuate poverty and discrimination.

The real cause of disasters is humanity's decisions, as societies and as individuals. The real solution to disasters needs to be emphasised in all education: making better decisions that will stop disasters, irrespective of hazards.

Keyword

decision-making, England, UK

Incorporating Natural Blessings and Disasters to Develop an Integrated School Curriculum

Hisashi OTSUJI[1]*, Toyo University (otsuji@toyo.jp)

Abstract

The Japanese junior high school National Curriculum (Course of Study) includes the term “Natural benefits and disasters”; thus, school science textbooks present both the positive and negative aspects of nature. When students in grade 7 learn about volcanoes and earthquakes and those in grade 8 learn meteorology, they study the mechanisms of not only natural phenomena but also natural disasters. Moreover, there are many cases in which natural disasters, not just blessings, are historically and culturally related to human activities. Examples include the development of the bicycle, various famous paintings or stories, the rise of historical figures, gardening soil, and eating habits. To organize and develop an effective integrated school curriculum, it is important to include the perspective of the relationship between nature and humans in all subjects. Based on this idea, I examined the present Japanese school curriculum and found that it could be enriched by adding and emphasizing the perspective of natural blessings and disasters. Thinkers have pointed out that human life is disconnected from nature. In order to develop global citizens in the 21st century, we need to look beyond individual subjects and consider the school curriculum as a whole; students should be taught about human relationship with nature from an early age. Among various subjects, geology (geo-sciences) not only deals with the foundations of our lives but also serves as the key to our educational curriculum for future generations.

Keyword

Integrated school curriculum, Geoscience, Disaster education

Natural Disaster and Education in South Korea

Young Shin Park[1]*, Chosun University (parkys@chosun.ac.kr)

Abstract

We face more and more natural hazards due to climate change now. This is worse in Asia regions which locate on the boundary of Plate Technics, ring of fire. When we talk about natural hazards, most cases of earthquakes, Tsunami, landslide, and more are from Asia regions. When we assume that those natural hazards can be severer than before, we need to stop ruining the Earth where we live and we need to hand over the better environment for future generations. Therefore, it is our responsibilities to make students and citizens informed of what those natural hazards are, why those happen, how we can restore them, and how we prevent them in advance to reduce the loss of people and economics. We are not free zone any more from earthquakes (we had over 5 magnitude in Gyeongju and Pohang in 2016) and we are starting to be very concerned about Tsunami since Korean peninsula is surrounded by the ocean. Students learn about natural hazards from K to 12 and the content of natural hazards cover the followings; climatological disaster like typhoon, flood, heavy rain, drought, and heavy snow, and geophysical disaster like earthquake and volcanic activity. Students learn why, when, where those disasters happen, and what kinds of advantages we can get from those natural hazards. However, those contents are covered in social studies or science subjects and those contents deal with common knowledge which doesn't make students feel belongings to the community nor responsibilities to solve those disasters to reduce the loss of people and economics.

At the level of secondary schools, for equipping students with competencies of facing the natural disaster issues, recognizing the problem, and solving the problem, I need to develop the integrated science programs through which students learn scientific concepts related to natural disasters. More than anything else, students learn how to prevent those natural disasters with the use of engineering and technology (which has been called STEAM program). More than beyond learning natural disasters by concepts, we need to provide chances for students to apply those concepts in finding out the solution through engineering-based experiments on the basis of scientific concepts. During this process students feel belongings to the community and responsibilities to preserve the earth from natural and human-made disasters. I could say that we need to provide students with chances where students build concepts through science experiments to understand natural hazards and build device through engineering-based experiments to solve the problem.

From the examples of natural disaster education in secondary education carried out by my research team, I can conclude the following for natural hazard education. Engineering-based experiment is pivotal for students to be equipped with competencies of applying the concepts to find the solution. Students experience scientific thinking during scientific experiment to understand its principles and they also experience computational thinking during engineering-based experiment to find out the solution.

Keyword

natural disaster, education, secondary, science curriculum, engineering-based

[Keynote] Systematization of Education for Disaster Risk Reduction from the Viewpoint of SDGs

Tatsuya FUJIOKA[1]*, Shiga University (fujioka@edu.shiga-u.ac.jp)

Abstract

In the Japanese archipelago, where natural disasters occur frequently, disaster prevention, mitigation, and reconstruction have been addressed from the individual level to the national level since recorded history. However, today, due to the effects of climate change, responding to natural disasters has become an international issue. Although it cannot be said that Japan has many opportunities to take leadership in the international community, it can be said that Japan has made a certain contribution to the world regarding disaster prevention, as the United Nations World Conference on Disaster Risk Reduction has been held three times in Japan.

The Cabinet Office's Central Disaster Prevention Council is the highest organization responsible for dealing with natural disasters in Japan. Under this system, Japan's disaster prevention system will be established to respond to major natural disasters and to deal with anticipated natural disasters. For meteorological disasters and associated landslides, which are among the most predictable natural disasters, alert levels and other information are first announced through scientific forecasts by the Japan Meteorological Agency. Based on this, the government will issue instructions to residents, such as issuing evacuation orders in each area. However, no matter how advanced science, technology, and social systems are, the extent of damage will ultimately depend on the actions residents take to prepare for natural disasters. Herein lies the importance of disaster prevention education in schools and awareness of local residents.

On the other hand, Japan's educational system has a national curriculum called the Curriculum Guidelines. However, because the content is uniform across the country, it cannot be said to be sufficient as disaster prevention education for natural disasters that is tailored to local characteristics. For this reason, various disaster prevention education initiatives are being carried out in each region, and the national government supports them.

Under these circumstances, there is a need to develop human resources who can think on a global scale and act in accordance with their local area, using the same stance as environmental education. Today, people's awareness of building a sustainable society is increasing. Education also requires an attitude of not leaving anyone behind even in the face of natural disasters. The SDGs consist of 17 goals and 169 targets. There is a lot of content about reducing natural disasters related to climate change. The importance of education is related not only to the achievement of Goal 4, but also to the realization of all goals.

Today, in Japanese education, there is a need to develop a "zest for living" in preparation for the uncertain future of the VUCA era. In addition, cross-curricular curriculum management and STEAM education that integrates the arts and sciences are expected. Education on natural disasters based on the SDGs can be expected to serve as a concrete example of this. In this report, I would like to discuss the current state of disaster prevention/mitigation and reconstruction

education in Japan, as well as the challenges of Japan's geoscience education, which is the foundation of this.

Keyword

Disaster Risk Reduction, Geoscience Education, SDGs, STEAM Education

Current Status and Issues of Earthquake Disaster Prevention Education in a Major City that Experienced The 1995 Southern Hyogo Prefecture Earthquake: A Case Study of Kobe City

Toshio ARIMICHI[1]*, Graduate School of Regional Resource Management, University of Hyogo (ta54angel@yahoo.co.jp)
Norihito Kawamura[2], Graduate School of Regional Resource Management, University of Hyogo

Abstract

According to USGS data, 17.9% of all earthquakes of magnitude 6.0 or greater that occurred between 2011 and 2020 in the world occurred around Japan. Japan is located at the boundary of four plates. Therefore, not only earthquakes near plate boundaries, but also inland earthquakes occur when active faults shift within the continental plates.

The 1995 Southern Hyogo Prefecture Earthquake that occurred in Kobe, a major city in southwestern Japan, was an inland earthquake with a magnitude of 7.3 and depth of epicenter 16 km. Three faults are estimated to have moved during the earthquake. The city of Kobe suffered unprecedented damage from this earthquake. On January 17, 2025, it will have been 30 years since the earthquake occurred. In order to ensure that citizens do not forget the earthquake and pass it on to future generations, the Kobe City government has designated January 17 as "Citizens' Disaster Prevention Day" and is holding events to help each citizen prepare for increasingly severe natural disasters. All elementary and junior high schools in Kobe City hold "Earthquake Disaster Memorial" events on this day, which include memorial services and earthquake disaster prevention education. However, 30 years have passed since the 1995 Southern Hyogo Prefecture Earthquake, and most of the teachers who taught at the schools at that time have retired. As a result, there are few teachers who can talk about those days. In addition, more than 50% of citizens have not experienced the earthquake. Furthermore, a trench-type earthquake along the Pacific coast has been proposed as a new earthquake risk. The speakers believe that earthquake disaster prevention education needs to be reviewed.

In this study, the speakers will present the results of the 30 years of earthquake disaster prevention education in Kobe City, including the use of the supplementary reader for disaster prevention education, " Shiawase- hakobo " prepared by Kobe City for elementary and junior high school students, and the efforts of earthquake disaster prevention education in the classroom. In addition, the speakers will discuss issues in disaster education in preparation for the coming massive earthquakes, and aim to promote earthquake disaster prevention education.

Keyword

earthquake, tsunami, disaster prevention education, the 1995 Southern Hyogo Prefecture Earthquake, Kobe City

Educating Local Communities in the Southeastern USA through a Natural Hazards Course

Athena Owen NAGEL[1]*, Mississippi State University (amo58@msstate.edu)

Abstract

At Mississippi State University, a research institution in the southeastern United States, a Natural Hazards course is primarily offered as part of the Broadcast Meteorology Program. The course is specifically housed in this program because Broadcast meteorologists are community scientists and the public looks to them for information about all types of natural hazards, especially weather-related ones, and how to prepare for them. By providing a thorough and detailed education for Broadcast meteorologists, a greater number of people in the community can be reached over time.
Our Natural Hazards course is offered as a split-level for both undergraduate upper classmen and graduate students, and it is taught as both a face-to-face class and as an asynchronous online course. The curriculum focuses upon hazards in the USA as well as globally, with the first half of the course addressing meteorological hazards, and the second half of the course considering common geologic hazards . Each of the 12 units focuses upon a different hazard, with each unit addressing how or what causes the hazard to occur, how people should prepare for the hazard, historic occurrences of these events, and more current events. The curriculum incorporates active learning strategies where students address their own preparedness for the different hazards they might face in their location. Class discussion topics also include the effects of climate change on hazard severity and frequency, as well as notable events that occur during the time the class is offered . By engaging future Broadcast meteorologists in natural hazards and having them apply this content to their own geographic areas, the natural hazards curriculum has impact beyond the students for a well-informed community.

Keyword

natural hazards, prepardness, broadcast meteorologist, active learning, United States

Development of Volcano Disaster Prevention Education Program from the Perspective of STEAM Education

Shintaro SATO[1]*, KYOTO NOTRE DAME UNIVERSITY (ssato@notredame.ac.jp)

Abstract

To develop the ability of residents and climbers to take action to reduce damage from volcanic eruptions, it is necessary to link scientific knowledge related to volcanoes with disaster prevention, such as understanding the meaning of eruption warning levels.

One effective way to develop this is through STEAM education related to volcanic eruptions, where volcanic observation methods are covered in Technology and Engineering, and the knowledge learned in Mathematics is used to understand the observed data.

In addition, when dealing with volcanic activities broadly from the perspective of ARTs, it is possible to relate efforts to ESD perspectives and SDG Goal 14 and SDG Goal 15. Geoparks and volcano museums are places where education from such a comprehensive perspective can be conducted.

Against this background, this study will reconstruct the educational content related to volcanoes from the viewpoint of STEAM education, ESD, and SDGs. The objective of the study was then to develop a volcano disaster prevention education program for school education in collaboration with Geoparks, volcano museums, and the Japan Meteorological Agency. The research subjects were sixth-grade elementary school students in Izu Oshima, a volcano that is feared to erupt in Japan.

The following is a description of the content of the volcano disaster prevention education program developed. First, students acquire knowledge of the phenomenological aspects of volcanic eruptions by visiting a volcano museum.

Next, the students will visit the volcano observation equipment on Izu Oshima. We will observe seismographs, tiltmeters, airborne seismographs, GNSS, and a long-range camera on Izu Oshima. In addition, JMA staff will explain how to read data on volcanic earthquakes and what can be learned from the data measured by optical wave rangefinding observation. Afterward, iPads with MESH (manufactured by Sony Marketing Inc) blocks and the MESH application downloaded will be distributed, along with volcanic eruption models, and the class will create a program to reduce damage from volcanic eruptions. Specifically, students will place MESH blocks that look like volcanic observation equipment on a volcanic eruption model, which will resemble volcanic bombs and cinder cones.

Next, the participants will visit one of the Geo-sites on Izu Oshima Island, where they can understand the symbiosis with volcanoes and the benefits of volcanoes, and listen to a talk by a Geopark expert committee member from Izu Oshima. In addition, a model experiment of a "Training dike" will be conducted, in which the bottom of a conduit channel that serves as a pathway for lava flows is dug out and the soil is filled in on the village side to build a dike. Then, we will consider how to protect the community from the lava flow. Afterward, the participants

will visit the Izu Oshima Geopark site "Omiyasawa Training Dike".
In this study, we reported on the development of a volcano disaster prevention education program from the viewpoint of STEAM education. In the future, we will conduct a detailed analysis of the effectiveness of the volcanic disaster prevention education program through classroom practice and add further studies.

Keyword

Volcano Disaster Prevention Education, STEAM Education, Science Education

Examples of SDGs that raise awareness of disaster prevention and mitigation in schools and local communities.

Ichiro MATSUMOTO[1]*, Shimane University (chromim@edu.shimane-u.ac.jp)

Abstract

Japan is a region where natural disasters occur frequently, and in order to maintain a sustainable region, there is an urgent need to raise awareness of disaster prevention and mitigation. For this reason, voluntary disaster prevention organizations and schools such as elementary and junior high schools, which are members of local communities, are important as places for disaster prevention and mitigation education. In order to promote education in the San'in region, where awareness of disaster prevention and mitigation is said to be relatively low, this study conducted a questionnaire survey on the disaster prevention awareness of students mainly at elementary schools in the area. We will also report on examples of study sessions held in collaboration with voluntary disaster prevention organizations.

In light of this situation, we will also consider educational methods to prepare for various natural disasters. Additionally, as activities related to SDGs (Sustainable Development Goals) become more active in schools and local communities, it has been reported that various education and disaster prevention/mitigation initiatives that are integrated with SDGs are extremely effective. and discuss.

It should be noted that the SDGs have passed the halfway point in their implementation period, and the overall results are beginning to be seen. In the past few years, as wars and conflicts have occurred frequently in various places, the goals of the SDGs have been affected, but there are concerns that measures to protect the natural environment, including climate change, will be delayed. Everything in human life comes from the Earth's land, and now is the time to demonstrate the power of earth science education and promote environmental protection, especially among the younger generation. Matsumoto (in press) proposes a global pyramid, which is a fusion of the ecological pyramid and the human pyramid, as a theoretical study of this consciousness reform and earth science education. SDGs initiatives connect and support these two pyramids, and it is important to thoroughly learn about the blessings and disasters of nature, with a focus on disaster prevention and mitigation.

Keyword

SDGs, disaster prevention and mitigation, schools and local communities, Whole Earth Pyramid

Exploring Learning in Virtual Geological Field Trip: A Theoretical Approach Based on the Revised Novelty Space Concept

YOONSUNG CHOI[1]*, Seoul National University (Center for Educational Research)
(clever123123@gmail.com)

Abstract

Following the pandemic, there has been an explosive surge in demand for and research on Virtual Learning Environments (VLE). Various terms such as remote learning environments, VR, AR, AI-based learning, and online learning are used interchangeably with VLE in educational settings. This study interprets the concept of VLE as a paradigm beyond traditional classroom, laboratory, and outdoor learning environments. Focusing on the Geoscience education, particular attention is given to learning in geological field trip as an area where both traditional and virtual learning environments can be applied. Building upon empirical cases of virtual field trip (VFT), this research conducts a theoretical analysis of in-person field trip and its virtual counterpart. The study introduces the concept of the "Revised Novelty Space," which extends the previously proposed notion of Novelty Space associated with traditional learning environments. The Revised Novelty Space incorporates technical and social aspects in addition to the cognitive, geographical, and psychological dimensions defined in the context of learning in geological field trip. In essence, it redefines and expands these dimensions within the context of VFT while introducing technical and social elements. The Revised Novelty Space is composed of five elements, offering a theoretical framework and methods to facilitate smooth implementation of VFT. This contribution adds scholarly significance by proposing theoretical approaches and methods for the successful advancement of learning in virtual geological field trip.

Keyword

Virtual Learning Environment(VLE), Virtual Field Trip(VFT), Learning in Virtual Geological Field Trip, Revised Novelty Space

Anthropomorphic characters: “Lucky charms - Geo-Mascots – Geo-Cartoons – Geo-Emoji Mascots” in Geoscience communication and popularisation

Maria-Luise Luise FREY[1]*, Global Geoparks Network (frey@terra-outreach.de)
Cristian CIOBANU[2], University of Bucharest, Hațeg Country UNESCO Global Geopark (Romania)
Joana Rodrigues[3], Institute of Earth Sciences, Pole of the University of Minho; Naturtejo UNESCO Global Geopark (Portugal)
Cristina Toma[4], Doctoral School of Geography "Simion Mehedinți"- Nature and Sustainable Development, University of Bucharest, Hațeg Country UNESCO Global Geopark (Romania)

Abstract

People from different cultures have been familiar with lucky charms since the beginning of human civilization and express their hope for happiness in life. In modern society, they have been an integral part of moving picture stories on archaeological and historical themes since the middle of the 20th century. They are increasingly being used in product advertising as an incentive to increase the attractiveness of their sale. Their use nowadays seems to vary from culture to culture, but with globalization they seem to be attracting increased attention in other parts of the world, starting in Asia. They have been used to advertise tourist destinations and education in geosciences, as well as to improve the situation in disaster-stricken destinations. Scientists from various disciplines are working on the successful use of anthropomorphic characters in the broadest sense. Such characters, which are often simply referred to as "mascots", have been appearing in natural science topics, particularly geosciences, since the mid-1990s with the development of geopaths and geoparks. With the aim of communicating scientific information, processes, findings and working methods to a broad public, the number of "geo-mascots, geo-cartoons - geo-emojies" has increased significantly in recent years. However, this development is often countered by acceptance from the scientific side with the question of the "seriousness of scientific content" in discussions. With the successful creation of the Global Geoparks Network, there is a demand from the general public to convey complicated facts in a valuable and appealing form. Despite existing infrastructures for geo-paths and geo-routes, museums and interpretations centres, numerous offers of lectures, activities and guided tours for conveying geoscientific information, it is recognisable that in the context of IT development, its application and use: “gamification” - by people of all ages, training and education, as well as in the course of generational change and the existing UNESCO Global Geoparks, the question is being asked whether the communication of geoscientific topics via anthropomorphic characters is a new perspective for communicating to a broad public. Numerous characters have been developed in the UNESCO Global Geoparks to address this question in a serious manner. This presentation addresses and explains the development and its perspective in the mediation and communication of a geopark as a marketing tool for educational and geotourism activities in the broadest sense.

Keyword

Anthropomorphism, Geoscience popularization, Geo-education, Geotourism, Gamification

Understanding time scales: which teaching materials do students find easier to understand? - Cosmic (Geologic) Ticker Tape, Cosmic (Geologic) Calendar, and Cosmic (Geologic) historical film in case of undergraduate students –

Hiroo NEMOTO[1]*, Ritsumeikan University (nemo@fc.ritsumei.ac.jp)

Abstract

In subjects dealing with earth science content, such as Chigaku-kiso (Basic Earth Science) in upper secondary schools in Japan, Cosmic (Geologic) Ticker Tape (e.g. 100 million years in 10 cm), Cosmic (Geologic) Calendar (e.g. 13.8 billion years in 1 year, or 4.6 billion years in 1 year) and Cosmic Historical Film (e.g. 1 million years in 1 second) are well known as teaching materials to give students a real sense of geological time scales (e.g. Morikawa, 2016; Geoscience Research Committee of Saitama Pref., 2017). It is usually difficult to find time to use all or several of these in the classroom. Thereby, teachers are likely to select one of these materials for use. In such cases, which teaching materials are most likely to give students a real sense of the geological time scales (13.8 billion years, 4.6 billion years)?

In this study, I aimed to provide a guideline on how to choose from these materials. In order to do that, a questionnaire survey was conducted among university students who would like to become science teachers at secondary schools to find out which teaching materials would give them the best sense of the geological time scales. The results showed that the proportion of students (n = 21) who found the time scale easy to understand was around 4.8 % for the Cosmic (Geologic) Ticker Tape, around 76.2 % for the Cosmic (Geologic) Calendar, and around 19.0 % for the Cosmic (Geologic) Historical Film when the completed teaching materials were used in class. Although it was expected that the percentage would be low, as the Cosmic (Geologic) Historical Film was almost exclusively thought experiments, it was surprising that a large difference opened up between the Cosmic (Geologic) Ticker Tape and the Cosmic (Geologic) Calendar. However, when the students were asked to make their own Cosmic (Geologic) Ticker Tape and to consider them on a single tape (13.8 m), more than 80% of them said that the geological time scales were easy to understand. This may be due in part to the fact that the calculations required for the creation of the Cosmic (Geologic) Ticker Tape are easier than those for the Cosmic (Geologic) Calendar.

The results suggest that the use of the Cosmic (Geologic) Calendar is appropriate when teaching with pre-made teaching materials, and the use of the creation of the Cosmic (Geologic) Ticker Tapes is appropriate when making them as a practical exercise. Therefore, teachers are expected to be competent in handling both the Cosmic (Geologic) Ticker Tape and the Cosmic (Geologic) Calendar as teaching materials. However, given the small number of survey subjects and they were undergraduate students, future work is needed to increase the number of survey subjects so that the results are statistically significant and to clarify whether the same results would be obtained if upper secondary school students were the subjects.

Keyword

Teaching Materials, Time Scale, Cosmic (Geologic) Ticker Tape, Cosmic (Geologic) Calendar, Cosmic (Geologic) Historical Film

Geodyssey: Forging a new path for app-based geoscientific teaching and learning

Cameron Roy PENN-CLARKE[1]*, Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg (Cameron.Penn-Clarke@wits.ac.za)
Robyn Symons[2], School of Geosciences, University of the Witwatersrand, Johannesburg

Abstract

Geoscience is a complex scientific discipline that has been key to the development of societies and their welfare for millennia. An understanding of geosciences and the world around us has allowed us to access and exploit geological resources that have been used for technological advances that have been utilised to access food, water, and shelter among others. Geosciences has given humanity the opportunity to learn from the past to prepare for the future and explore our present environment in a way no other species has yet been able to achieve. Such insight is, regrettably, wasted on geoscientists alone. If made accessible this, wealth of contextual geological knowledge drawing from both physical and natural sciences in both observational and experimental settings can greatly enrich both our philosophical and practical appreciation of our planet. What wonders this discipline could permit our species had they the same grasp of geosciences as we do…

Geoscience is only comprehendible by few owing to a number of factors, including (but not limited to) comprehension of linked processes and systems, poor understanding of physical sciences, overly complex jargon, access to information and, quite simply, poor marketing. In a society as unequal as South Africa this is complicated further by socioeconomic, basic educational and language barriers (among others). Geoscience education needs to transcend these issues and embrace new technologies to become more accessible if it is to help uplift others. One of these ways is using mobile applications. Geodyssey is an integrated ESRI-driven mobile app for iOS and Android that has been developed by the GSSA WC in partnership with Forge New Frontiers and with the generous financial support of the 35th IGC Legacy Fund, DSI-NRF GENUS, CIMERA and the University of the Witwatersrand.

Since simplicity is key to the communication of geoscientific information in the Geodyssey app, the data displayed in app, has been modified to suit the needs of the user. From interactions with users and focus groups, Geodyssey uses only two layers to display geoscientific information. These are constrained in two feature classes, namely a) an interactive geological basemap and b) geosite point layer. The interactive geological map of South Africa is resolvable at various scales. The interactive geological map uses shapefiles from 1:1 million and 1:250,000 scale maps of the Council for Geoscience, South Africa, with detailed larger scale maps at specific sites. Individual geological units appearing on these maps have been linked to an in-house developed geodatabase which captures most known information pertaining to these units, from various sources. The data which appears in the app is simplified to display only a few fields of interest for the public. The geosite point layer includes known geoheritage sites identified from various sources, as well as sites of geological interest (i.e. stratotypes, historically important sites, sites that appear in

publications of the GSSA and Witwatersrand University, etc.). This allows the user to explore and learn from their environment, unhindered by guides books and maps, while having the wealth of expert knowledge at their fingertips.

Keyword

App-based education, Geoscience education, Geological maps, Database, South Africa

Elementary Students' Understanding of Fossil Formation and Geological Change

Younkyeong Nam[1]*, Pusan National University (ynam@pusan.ac.kr)
DongYoung Lee[2], Pusan National University

Abstract

Fossils captivate elementary students with their mystery and tangibility, making them an excellent tool for teaching about geological changes and paleontology. Teachers often use indirect methods to represent fossil formation processes, as direct experiences with these processes and excavation are nearly impossible. Yet, these methods have their shortcomings and can lead to misconceptions. A prevalent misunderstanding among students is the concept of time regarding fossil and sedimentary rock formation, often perceived as rapid processes. This study surveyed 100 elementary students, already familiar with strata and fossils, about their perceptions of the time it takes for fossils to form. Through qualitative analysis, we aimed to identify students harboring misconceptions about the temporal aspects of fossil formation and categorize their understanding of geological time. Analyzing their responses, we found commonalities and differences in time concepts, shedding light on why misconceptions arise. The study outlines the origins and mechanisms behind common misconceptions about fossils -from everyday experiential conflicts, media influences, scientific understanding, to educational shortcomings-and categorizes these causes. By elucidating these aspects, the study provides significant insights and practical implications for educators in elementary earth science. The ultimate goal is to enhance the pedagogical approaches employed in teaching complex geological concepts, thereby fostering a more accurate and comprehensive understanding among young learners.

Keyword

geological time scale, fossil formation, alternative conception

Promoting Use of the UN Sustainable Development Goals in Pre-college Geoscience Education

Lindsay Mossa[1], American Geosciences Institute
Lauren Brase[2], American Geosciences Institute
Sequoyah McGee[3], American Geosciences Institute
Ed C. Robeck[4]*, American Geosciences Institute (ecrobeck@americangeosciences.org)

Abstract

The American Geosciences Institute (AGI), like many organizations worldwide, recognizes that successfully addressing the most pressing issues of the day—such as access to clean water, climate change, and enhancing community resilience—calls for meaningful action across societies, including (and especially) by young people. AGI has been exploring ways to make young people more aware of the United Nations Sustainable Development Goals (SDGs), especially in terms of their intersection with geoscience knowledge. As a result, we have developed and applied several approaches to our work in pre-college education, including labeling educational materials with associated SDGs and providing SDG information in educator professional development workshops, as well as designing interactive lessons to help students learn about and contribute to the global sustainability goals. The enthusiastic reception of such approaches by educators, as well as the outcomes from actual classrooms, such as student applications of content they're learning to potential solutions, have been encouraging. While most of AGI's activities have taken place in the United States, we has begun to extend this work through its broadening international network.

This presentation will provide examples of these techniques and related materials (including those being made freely available online) to support the ongoing dialogue about effective ways to bring the SDGs into education, thereby empowering students to take transformative action in their communities, and beyond.

The activities that AGI has undertaken in education are now part of a much broader enterprise titled Geoscience for Sustainability (GfS), which AGI began in 2023 to marshal geoscience expertise and understanding to drive the transformative action needed to achieve the SDGs. GfS is a multi-year initiative designed to increase understanding of the vital link between the geosciences and global sustainability. Additional facets of GfS will be outlined in the presentation, as well as ways for interested individuals and organizations to connect with AGI in this initiative to support, create, share, and/or implement techniques and resources will be provided.

Keyword

Pre-college Education, Sustainability, Geoscience Education, Teaching Strategies

Earth of all, Geology for all

Michele LUSTRINO[1]*, Sapienza University of Rome (michele.lustrino@uniroma1.it)
Fabrizio Berra[2], Università Statale di Milano
Gaia Crippa[3], Università Statale di Milano
Patrizia Fumagalli[4], Università Statale di Milano
Andrea Garavaglia[5], Università Statale di Milano
Sara Ronca[6], Sapienza University of Rome
Giuseppe Saracino[7], Sapienza University of Rome
Gianluca Sottili[8], Sapienza University of Rome

Abstract

Different lines of evidence document the effects of anthropogenic actions on present-day climate change. The concept of change is
intrinsic in the nature of the Earth, but the awareness to live on a restless planet is strong in geologists only, who continuously face
major and often dramatic changes recorded in the recent and remote past. Being used to deal with time at every scale, geologists
can have an important role to share the concept of Earth dynamics with citizenry, explaining the differences between anthropogenic
and natural changes. The absence of the awareness that humans live on a changing planet limits the understanding of the
implications of possible activities that we are planning to act on climate changes, i.e., transition to a different way of producing
energy to reduce emission of greenhouse gases. A common approach is to think that we can neutralise our impact on the planet simply by switching energy tapping from fossil fuels to something apparently less impacting, associated with renewable energies.
Unfortunately, things are much more complex and there is no button to press to easily improve our future life quality. Indeed, the
shift to a carbon-free economy is strongly based on the availability of a bunch of “rare minerals” (or, better, elements contained in
them). These rare minerals are defined as critical materials, because their shortage can lead to a collapse of the so-called "green
deal" or "green transition". The need of several minerals essential to support green technologies (i.e., those based essentially on
direct or indirect solar energy) can have an impact in terms of sustainability stronger than fossil fuels, due to the necessity to
increase exploitation in mines with a decreasingly grade of ore minerals.
The geological community in Italy poorly promotes the dissemination of Earth Sciences. Geology instead needs to play a major role
in understanding and explaining the effects of the lifestyles of the rich countries on the entire

planet. Geologists should promote a
correct and sustainable use of natural resources, emphasizing that the transition from fossil fuels to renewable energy sources
necessarily will lead to a strong dependence on elements contained in critical minerals, such as REE, Co, Li, and many others. To
achieve these results, it is necessary to merge the geological sensibility with the competence in social and educational sciences, by
a correct and efficient scientific dissemination, in order to promote a "public understanding of science". The main goal of the project
is therefore to promote sensibility toward a more sustainable management of the Earth resources and increase the awareness to the
complexity of the natural processes that rule our planet. The public we refer to are: 1) school groups (both students of various orders
and their teachers); 2) adults (mostly as member of groups, such as associations, teams and administrative staff) and 3) people with
vision and audio impairment.

Keyword

Outreach, Scientific divulgation, Hands-on activities, Geology

Communicating like Hutton and Muir: Connecting geology and ecology (Geocology) to improve public support for critical raw material extraction

Maureen Gallagher[1]*, European Federation of Geologists (maureen.gallagher@eurogeologists.eu)

Abstract

First came the geology then came the ecology. Life grew from the Earth. The two are inextricably linked and must be considered together in developing solutions for the Green Transition. Significant critical raw material extraction is necessary to build the clean technology of the future. Extraction is often controversial and unwanted by local citizens concerned with environmental destruction. Understanding the linkage between local geology and the ecosystems it supports will allow better global, regional, and site scale planning. Connecting geology with ecology (geocology) in communicating with non-scientists builds greater understanding and trust when scoping local projects.

Siccar Point, the birthplace of modern geology and Dunbar, Scotland, the birthplace of notable naturalist and conservationist John Muir, provide a backdrop of storytelling that illustrates the connection between geology, ecology, and human connection to the land. By investigating the relationship between bedrock geology, biodiversity, and human impacts along the 10 miles of coastal Scotland that separate the two, the author will identify and demonstrate communication techniques for geologists to build trust with the public.

Listening to understand, storytelling, and reframing are critical techniques in communicating with local citizens. Understanding their connection to the land and demonstrating your knowledge of their needs and the ecological impacts of an extraction project, will build trust.

Keyword

Critical Raw Materials, Communication, Green Transition, Biodiversity, Public Trust

Geology and Disaster Risk Reduction Training for Non-Specialist Science Teachers: Implications for Professional Development of Teachers

Magnolia Vida Ante CANO[1]*, Bicol University (mvacano@bicol-u.edu.ph)
Miguel Cerna Cano[2], St. Stephen's High School

Abstract

The Philippines is located in the Pacific Ring of Fire. This fact has created natural wonders but, at the same time, brought disasters. Bicol region, in particular, is home to volcanoes, crater lakes, faults, and other geologic features that make people vulnerable to disasters. The basic education curriculum has included Earth Science and Disaster Risk Reduction in its program, yet many science teachers are not ready to teach it. Teaching Earth Science is particularly difficult for non-specialist teachers. To address this concern, two training programs were conducted in 2018 by RCSMED, a teacher training center based at Bicol University, through a partnership with government agencies and experts to provide lecture sessions, hands-on activities, and field visits.

Eighty (80) secondary science teachers from senior high public schools in two provinces of Bicol participated. The training immersed teachers in lectures and varied ways of teaching geology and DRR concepts. It allowed them to visit geologic sites in their localities to contextualize the concepts learned in the lecture sessions. During the training, data were gathered through written tests and daily logs. Five years after the training, interviews were conducted to determine if the training was helpful and applied in teaching high school students.

The training evaluation results revealed increased teachers' conceptual understanding of geology, endogenous and exogenous hazards, and disaster risk reduction principles. It clarified misconceptions, made the concepts more real through their interaction with practitioners and experts and exposure to sites in their locality, and introduced them to the systems approach in teaching. Furthermore, the training increased their confidence and motivation to teach earth science. Five years after the training, the follow-ups revealed that the concepts, information, and strategies learned during the training were helpful in teaching. Their knowledge of the geologic features of their area was also integrated into their teaching. Narratives of students' responses in their lessons revealed increased engagement in learning science.

Enhancing the professional development of non-specialist teachers in geology and disaster risk reduction needs significant attention. This paper explores a multifaceted approach, suggesting that teachers be equipped with relevant content through hands-on experiences and interactive lectures of experts and practitioners. By engaging them in diverse teaching methodologies and showcasing real examples of geologic features in their local environment, educators can foster a deeper understanding and enthusiasm for earth sciences. This heightened awareness and interest will likely positively influence their students' learning experiences.

Keyword

non-specialist teachers, professional development, Earth Science education, Disaster Risk Reduction education

The Geological History of Colombia Told by Its Rocks

Vanessa Rey León[1]*, Servicio Geológico Colombiano (vannerey0722@hotmail.com)
Jorge Gómez Tapias[2], Servicio Geológico Colombiano
Ana María Saldarriaga Nieto[3], Servicio Geológico Colombiano
Daniela Mateus Zabala[4], Servicio Geológico Colombiano
Marie Joelle Giraud López[5], Servicio Geológico Colombiano

Abstract

The Geological History of Colombia Told by Its Rocks is a science outreach book performed by an interdisciplinary team from the Colombian Geological Survey. This text is primarily intended for students in their final years of high school, students at introductory levels of geology in fields such as biology, topography, and engineering, and people who have no knowledge of geosciences, but are interested in learning how Colombia was made. The base of this book is The Geology of Colombia multivolume book published in 2020.

As a basis for creating the outreach texts, a group of geologists reviewed over 500 scientific articles and developed technical texts. But how do they explain terms like subduction, orogeny, volcanism, and sedimentation to those who are not familiar with geology?

In order to know how the book should be written, nine workshops were conducted with teachers and students from many schools and universities in the country. The aim was to understand the concerns of the intended audience and thus design the format, language, and structure of the book. Also, many fieldworks were carried out in the most impressive places in Colombia to obtain pictures and audiovisual material.

The book's content is presented in nine chapters organized chronologically from the Proterozoic to the Quaternary with an introductory geological chapter. Throughout them, you will find information about the oldest rocks, evidence of the meteorite impact that ended the lives of the dinosaurs, the major volcanoes and their history of formation, when and how the mountain ranges uplifted, and the largest ocean that existed in Colombia, among other topics.

Each chapter includes a scientific illustration that recreates the organisms and paleoenvironments that existed millions of years ago. Additionally, the chapters contain photographs of the most iconic locations, rocks, and minerals in the country.

During 2024 and 2025, the book will be promoted and disseminated in schools and universities, particularly in rural areas of Colombia. The idea is for these events to include educational materials and activities to explain, for example, the formation of a volcano inside the Earth, rock samples to help students become familiar with the textures and structures characteristic of each type, and a map so that, based on what they learned in the book, students can build their own

geological history of Colombia.

Keyword

scientific, outreach, book

Advancing geography education through 3D geospatial information

yuichi S. hayakawa[1]*, Hokkaido Univ. (hayakawa@eis.hokudai.ac.jp)
Yasuhiko Tamura[2], Univ. Tokyo
Sahoko Aki[3], Univ. Tokyo
Ryusuke Ito[4], Hokkaido University of Education

Abstract

Recent advances in capturing three-dimensional (3D) information of geography through technical developments have opened new avenues for enhancing geography education. The potential inherent in these 3D data allows for immersive and interactive learning experiences, providing students with a deeper understanding of geographical features and landscapes. These technological breakthroughs enable educators to incorporate dynamic and visually rich content into their teaching, fostering a more engaging and effective educational environment. In the study site of Taya Cave located in Yokohama, Japan, we present an approach to understanding local geographical and historical backgrounds, including Satoyama (hilly forest and surroundings) and underground built heritage (caves and historical carvings therein) through advanced geospatial technologies. The study employs terrestrial Lidar (laser scanning) for point cloud data acquisition in caves and SfM-MVS photogrammetry, along with Lidar, for aerial measurements in Satoyama. The resulting 3D data facilitate comprehensive environmental assessments, which are then harnessed for educational purposes. The applications of the 3D data are performed as elementary school classes aimed at enhancing students' understanding of regional environments and cultural heritage. Workshops are also conducted for local residents, utilizing 3D print models and paper-clay crafts to actively engage the community. Additionally, the study explores the potential of exhibitions featuring 3D print models to enhance geographic imagination with an artistic touch, fostering a deeper connection to the cultural and environmental significance of the studied sites.

Keyword

3D geospatial technologies, Geography education, Terrestrial Lidar, Satoyama, Underground Built Heritage

Sandsnap: Engaging the Public in Coastal Geoscience Through Social Media and Education Outreach

Brooke Marlo WALKER[1]*, US Army Corps of Engineers, Coastal and Hydraulics Laboratory (brooke.m.walker@usace.army.mil)
Brian C McFall[2], US Army Corps of Engineers, Coastal and Hydraulics Laboratory
David L Young[3], US Army Corps of Engineers, Coastal and Hydraulics Laboratory
Daniel Buscombe[4], MARDA Science
Shelley Whitmeyer[5], James Madison University
Jacob Stasiewicz[6], ORISE Fellow, US Army Corps of Engineers, Coastal and Hydraulics Laboratory

Abstract

Sediment size is often the largest uncertainty for coastal sediment transport modeling input parameters. Collecting this data using conventional methods is unfeasible for large spatial or temporal extents. The SandSnap project builds a comprehensive beach grain size database with the help of smartphone-equipped citizen scientists. Taking a SandSnap requires taking a photo of sand at the beach with a coin in the frame for scaling, uploading the picture to the user-friendly SandSnap web application (www.sandsnaperdcchl.hub.arcgis.com) and filling out a brief questionnaire about the type of coin in the image and beach where the image was taken. The web application passes the photo to a cloud environment, where it is run through two open-source neural networks – one to detect the coin in the frame and one to estimate the grain size. The results are returned to the web application and logged in the freely-accessible beach grain-size database.

The scale of the grain-size database produced by SandSnap hinges upon public outreach and engagement. The SandSnap team employs a multi-faceted approach to build public awareness and interest in this effort, including science kits hosted by public libraries, Science, Technology, Engineering, and Mathematics (STEM) outreach events with youth organizations and universities, the development of lesson plans for use within classrooms of all age ranges, and a continually-growing social media campaign. Through this multi-faceted approach, Sandsnap presents a unique model for maximizing citizen science initiatives in coastal studies and bridging the gap between professional geoscientists and the public.

While initially developed for the North American shoreline, international interest has been growing, and Sandsnap has now reached six continents. Harnessing the power of citizen scientists worldwide with SandSnap is the next step to building a global beach grain-size database, while also encouraging the public to be informed on and engaged with our ever-evolving coastlines.

Keyword

citizen science, STEM Outreach, beach sand, crowd-sourced data collection

Role-Playing: A New Method for Museum Exhibitions(A Case Study from the Liu Guanghua Museum of Natural Heritage)

ZHUQING DENIS DING[1]*, Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology (dzqdzq1988@163.com)
GAO Pan Pan[2], Guanghua Institute of Gemology and Mineral ResourcesGIGM
RONG NAN NAN[3], Guanghua Institute of Gemology and Mineral ResourcesGIGM
MING Shu Jun[4], Guanghua Institute of Gemology and Mineral ResourcesGIGM
ZHU Chen[5], Guanghua Institute of Gemology and Mineral ResourcesGIGM
HUANG YAN[6], Guanghua Institute of Gemology and Mineral ResourcesGIGM

Abstract

Role-playing activities, as an emerging new method for science popularization, have introduced unprecedented levels of interactivity, engagement, and experiential learning to natural history museum exhibitions. The Liu Guanghua Museum of Natural Heritage, located in Nanchang, China, fully utilizes its extensive collection of minerals, meteorites, and fossils for interactive explanations and displays. The museum has designed and implemented role-playing activities and narratives centered around themes such as the formation of the universe, the development of the Earth, and the origin and evolution of life. For example, in our museum's activities, visitors or guides often take on roles such as miners or fossil excavators, geologists or paleontologists, engaging in the collection or excavation of minerals and fossils. This is followed by sorting and identification processes, through which participants gain scientific knowledge and methodologies in geology, mineralogy, and paleontology, while also experiencing enjoyment and engagement. Moreover, through various role-playing activities, our museum has enhanced the interest of youths and the broader community in the natural heritage museum and earth sciences, thereby increasing the museum's popularity and visitor traffic.

These activities, leveraging earth science knowledge through innovative interactive gaming experiences, not only convey scientific knowledge and encourage scientific thinking among participants but also transform museum visitors into active experiencers. This approach offers new methods and insights.

Keyword

Science Education, Educational Interaction, Event Design, Liu Guanghua Natural Heritage Museum, Activity Musuem

Geolchat Fossil Edition: Using Paleontology as an science outreach strategy in social media

María Daniela MUÑOZ-GRANADOS[1]*, Universidade de Coimbra (mdaniela.munozg@gmail.com)
Lina Perez-Angel[2], Institute at Brown for Environment and Society (IBES) and Department of Earth, Environmental and Planetary Sciences, Brown University, Providence, RI, USA.
Carolina Ortiz-Guerrero[3], Geolchat

Abstract

GeoLchat is a bilingual (English and Spanish) science communication project based on social media, aimed at connecting and promoting the work of Earth, Atmospheric, and Planetary scientists worldwide, with a strong commitment to diversity and inclusion. Founded by three Colombian female geoscientists with a passion for geoscience education and communication, the project addresses the challenge of limited Earth Sciences literacy. This issue is critical, given the urgent need to understand and communicate about climate change, the use of fossil fuels, increasing fires, hurricanes, El Niño and La Niña climate phenomena, earthquakes, and other natural hazards. The challenge is especially acute in the Global South, where educational resources in Earth Sciences are scarce.

Social media has emerged as a transformative tool to share science content with a variety of audiences around the globe. These digital platforms offer an open and accessible resource for education beyond the traditional formal educational institutions. To increase Earth Science awareness and engagement, we designed a social media-based science communication strategy: “Geolchat Fossil Edition: A bilingual science communication project in paleontology using social media”. The implementation of this six-month project was the result of being awarded the PaleoSociety Outreach and Education Grant in July 2023, enabling us to reach a broader non-scientific audience.

Leveraging the popular appeal of Paleontology andGeolchat's established follower base, we formulated a communication strategy based on freely available audiovisual content on paleontology topics, shared through GeoLchat’s social-media platforms (Instagram, Twitter, YouTube,TikTok, and Facebook) in both English and Spanish. Additionally, we collaborated with Latin American Paleontology communicators and researchers. A key part of GeoLchat’s mission is to increase the representation of historically underrepresented scientists in Earth Sciences, and we consistently aim to highlight the research of such groups in our social media content. This approach not only bridges society with Earth Sciences through paleontology but also fosters connections between the Global North and Latin America.

The "Geolchat Fossil Edition" significantly expanded our reach and follower base from March 2023 to March 2024, evidencing the effectiveness of our communication strategy. Our Instagram

followers increased by 47.4% (from approximately 3,340 to 4,922), YouTube by 39.4% (from 216 to 301), and X (Twitter) by 19.3% (from 800 to 991). This initiative has demonstrated the power of leveraging paleontology's allure to engage and educate a wide audience. Moving forward, we plan to continue producing audio-visual resources not only on paleontology but also on topics crucial to society, including climate change and the broader impact of geosciences on our daily lives.

Keyword

Scicomm, Outreach, Earth Science outreach, Social media, Science communication

School Rock Maps: Geological information translated for society by the Geological Survey of Brazil

Andrea SANDER[1]*, Geological Survey of Brazil (andrea.sander@sgb.gov.br)
Patricia Duringuer JACQUES[2], Geological Survey of Brazil
Gabriel Guimarães FACURI[3], Geological Survey of Brazil
Francisco Ferreira de CAMPOS[4], Geological Survey of Brazil
Marina das Graças PERIN[5], Geological Survey of Brazil
Cimara Francisca MONTEIRO[6], Geological Survey of Brazil

Abstract

The geological map represents the synthesis of geological knowledge of a location, often being recognized as one of the main products produced by a geologist. It is a complete and dense product of information that can be interpreted and used by geoscientists in their daily work, but it is practically incomprehensible to those who are not in the field, especially society in general. In Brazil, the national common curricular base that guides the pedagogical subjects that must be applied in schools, includes cartography as a form of develop representation and space thinking. It starts from the grade six onwards, and children must develop skills to interpret and prepare thematic maps identifying spatial patterns, regionalization and spatial analogies. It is an axis that permeates geography with the aim of mediating knowledge for a better understanding of the world and the places in which they live. In this way, seeking an inclusive and citizen science, SGBeduca, the Geosciences Popularization Program of the Geological Survey of Brazil, developed the Rock School Map, which is a reinterpretation of the geological map, but simplified to be used in teaching geosciences in schools and accessible to the public. Using the Geological Map of Brazil (1:1,000,000) as a data source, state sections were made and the lithotypes were reclassified into the main types of rocks: volcanic igneous, plutonic igneous, metamorphic, sedimentary, and unconsolidated sediments. The caption presents a brief description in mediated language of what each type of rock is and how to recognize it. All cities in the state represented on the rock school map are identified, as well as the main roads and rivers, under a shaded relief background. Additionally, points of geotouristic interest are marked, with four highlighted photos, takenmainly from state geodiversity books prepared by the Geological Survey of Brazil and the register of geological sites (Geossit). The objective is to create a relationship between already known points with the type of rock that appears in the location, as well as encouraging visits to new places. This type of information awakens a connection and a sense of belonging to the place in children and young people, valuing local knowledge. The last insert presents photos of examples of rocks and outcrops that occur in the state itself, taken mainly from geological mapping reports from the Geological Survey of Brazil. It is noteworthy that, despite being simplified, the information contained in school maps of state rocks maintains the scientific rigor of the original databases and its use in the school environment allows us to understand the relationship between rocks and the environment in which we live, as well as their reflections on the relief, soils and occupation of space. School rock maps are an efficient tool for studying geosciences in schools.

Keyword

simplified geology, teaching geosciences, scientific divulgation

Popularizing Brazilian paleontology through fossil replica workshops at the Geological Survey of Brazil

Andrea SANDER[1]*, Geological Survey of Brazil (andrea.sander@sgb.gov.br)
Patricia Duringuer JACQUES[2], Geological Survey of Brazil
Flasleandro Vieira OLIVEIRA[3], Geological Survey of Brazil
Samanta Bittencourt SUPRANI[4], Geological Survey of Brazil
Irinea Barbosa da SILVA[5], Geological Survey of Brazil
Juliana Stewart FERRAZ[6], Geological Survey of Brazil
Eliane Godoy MOREIRA[7], Geological Survey of Brazil
Cimara Francisca MONTEIRO[8], Geological Survey of Brazil

Abstract

Paleontology makes it possible to tackle a wide range of topics, from the evolution of life to discussions about climate change and its impact on the planet and its inhabitants. Fossils are the gateway to the world of science for children. Despite this, in Brazil the pedagogical potential of paleontology is not fully exploited, and this science is not present in classrooms. This is partly due to the difficulty in finding teaching material in accessible language, suitable for the age of the students. This material, when available, is expensive. Another difficulty is access to fossils, as Brazilian legislation is extremely restrictive on the possession of fossil material. Brazil's laws state that fossils are the country's property, prohibiting the possession of fossils outside research institutions and their sale. However, fossils, particularly dinosaurs, permeate the imagination of children and young people and are an attractive subject for them. As an alternative to this reality and to enable students to come into contact with fossils, the Geological Survey of Brazil, through the SGBeduca Program, has developed plaster replicas of various fossils. Plaster is a cheap, nontoxic material that can be painted in different ways. Pieces that appeal to children's imaginations were chosen from iconic invertebrates such as Trilobite and Ammonite shells; the media dinosaurs and other prehistoric animals, with Tyrannosaurus and Megalodon teeth, Velociraptor and Deynonychus claws, and megafauna mammals from the "Ice Age" franchise, such as Lestodon claws; Glyptodon scute; Smilodon and Notiomastodon teeth. These replicas are used in workshops in schools. In 2023, 38 workshops were held, serving around 1,800 children. Schools located on the outskirts of cities and in rural areas, which are generally the poorest in terms of financial and teaching resources, are given priority. The children listen to a short talk about paleontology, the fossilization process and each of the animals, covering the period in which they lived, their habitat and eating habits, and see artistic reconstructions of these animals and their fossils. Afterwards, they make an artistic painting of the pieces. At the end of the activity, they receive a label identifying each piece with basic information and take home a small collection of fossil replicas. The aim of the workshops is to bring elementary school students closer to paleontology through practical activities related to scientific knowledge, stimulating artistic skills and creativity through the painting of fossil replicas in plaster. The activities presented and aimed at children and young people are of fundamental importance in the relationship between the tripod

of science, education and sustainability, because the greater the knowledge of children and young people about our Planet Earth, the greater the awareness that we have only one planet and that we need to broaden conversations about sustainability and environmental preservation.

Keyword

scientific dissemination, mediation, teaching, didactic material

Dissemination of Geosciences: SGBeduca's teaching collection of minerals and rocks donated to teachers

Andrea SANDER[1]*, Geological Survey of Brazil (andrea.sander@sgb.gov.br)
Patricia Duringuer JACQUES[2], Geological Survey of Brazil
Maiza Moreira RIBEIRO[3], Geological Survey of Brazil
Juliana Maceira MORAES[4], Geological Survey of Brazil
Cimara Francisca MONTEIRO[5], Geological Survey of Brazil

Abstract

The Brazilian Geological Service, aiming to fulfill its institutional mission of "generating and disseminating geoscientific knowledge with excellence, contributing to the improvement of the quality of life and sustainable development in Brazil", encouraging inclusive and citizen science, created SGBeduca, a program to popularize geosciences. SGBeduca serves primary, secondary, and higher education teachers by donating educational collections of mineral and rock samples. This material, when available on the market, is usually restricted to those with gemological value, generally expensive. Even if teachers and students obtain the samples, there are difficulties in classifying them, as stores often use trade names or even incorrect denominations for minerals and rocks. The teaching collections donated by SGBeduca are packaged in a resistant cardboard box that can be sent by mail. Each box contains 26 samples of approximately 5 cm, distributed as follows: 4 samples of igneous rocks (identified by red labels with the rocks granite, rhyolite, basalt and gabbro), 4 samples of sedimentary rocks (identified by yellow labels, with the rocks sandstone, siltstone, varvite and coal), 4 metamorphic rocks (identified by blue labels, containing schist, gneiss, slate and marble) and 14 minerals (identified by green labels: quartz, agate, hematite, pyrite, chrysocolla, gypsum, fluorite , apatite, lepidolite, calcite, kyanite, alkali feldspar, tourmaline and emerald). The identification labels contain the name of the sample, its origin, the chemical formula (if it is a mineral), and on all samples its usefulness in everyday life is described. It is noteworthy that the lack of awareness of the role that geosciences and, in particular, mineral assets, have in everyday life, leads society to consider that activities related to geology are harmful to society. When the subject arises among the lay public, the debate focuses on the socio-environmental impacts resulting from mining, ignoring the role of mineral goods, omnipresent in everyday life. For this reason, handling the collection of minerals and rocks is essential, as in addition to its didactic value, the collection materializes the theory of disciplines such as science, biology, and geography, and awakens understanding of humanity's dependence on mineral goods. Between the years 2021 and 2023, 642 collections were distributed, mainly serving geography teachers (98.2%), distributed across all 26 Brazilian states and the Federal District, mainly from the public education network (82.5%), of primary education (38.6%). The teachers attended, to refer to the impact of the collection on their students, used words such as: stimulus, practice, dynamism, curiosity, and materiality. And when referring to the impact of collections in their classes, they used the following words: interdisciplinarity, practice, understanding, depth and scope.

Keyword

geological survey, socio-environmental responsibility, education, scientific mediation

GEOLOGISTS.COM—the global digital platform fostering communication and collaboration among geologists and other professionals across Earth science disciplines

Pavlo ZAGORODNYUK[1], Ukrainian Association of Geologists
Olena IVANOVA[2]*, Ukrainian Association of Geologists (olena.ivanova@geologists.org.ua)

Abstract

In the 21st century, the global geological community remains fragmented, despite active offline efforts by professional associations and the rise of online data exchange tools. Aiming to bridge this gap, connect specialists across the geological field, and foster their continuous communication and collaboration, in 2024, a group of geological companies and professional societies, including the Ukrainian Association of Geologists, launched a Global digital platform GEOLOGISTS.COM. The platform unveils the crucial role of geology in serving global society and the potential of Earth science disciplines to meet the dynamic needs of humanity in the 21st century, considering Environmental, Social, and Governance (ESG) aspects of development. It informs society about the opportunities brought forth by New Geology, which is presently tasked to shape new global trends in natural resource management and provide comprehensive high-tech support for green transition and transformation processes. This includes reconstructing historical climate changes, adapting to climate change, forecasting changes in natural systems to ensure their stability, preventing and minimizing natural hazard risks, exploring the potential of natural resources, ensuring their sustainable management, developing efficient environmental protection strategies, and preserving the planet's natural wealth.

GEOLOGISTS.COM focuses on such areas as Earth’s material composition; endogenous and exogenous geological processes; historical geology; regional geology; exploration and extraction of energy, mineral, and water resources; E&P and P&A technologies; financial landscape of the geological industry and economic geology. A separate essential platform’s section is dedicated to the development of New Geology in the context of dual digital and green transitions, the synergy of scientific disciplines, and the development of integrated solutions to support sustainable global progress.

By bringing together stakeholders—experts, scientists, companies, professional societies—in a unified digital space, the Platform mobilizes geologists and professionals across Earth science disciplines to promote and elevate the status of geological sciences, enhance the professional level of stakeholders’ employees, address global issues, and accelerate the achievement of Sustainable Development Goals (SDGs) through the application of geological knowledge, participation in green transformation and green transition processes, conducting collaborative scientific research, offering scientific guidance in governmental decision-making processes, disseminating scientific knowledge to facilitate transformative processes, fostering comprehensive collaboration among geologists, and promoting innovative interdisciplinary and intersectoral partnerships.

The GEOLOGISTS.COM platform facilitates the establishment of constructive dialogue among

all stakeholders, enhancing professional connections and disseminating information about activities of international public geological organizations, industry alliances, findings from global scientific research, and sectoral professional events. The mission of the Global digital platform GEOLOGISTS.COM is to facilitate the integration of geological knowledge with other understandings of Earth's natural conditions and resources, aiming to develop the planet's resource potential, ensure effective, balanced, and sustainable use of natural resources, while also protect the surrounding natural environment, preserve ecosystems and shape the green future we want.

Keyword

digital platform, fragmented geological community, connecting professionals, geology awareness, serving global society

REGIONAL DRILL CORE REPOSITORY, GSI, NAGPUR: A CENTRE FOR GEOSCIENCE INFORMATION DISSEMINATION

praveer PANKAJ[1]*, Geological Survey of India (prpankaj@gmail.com)
GAURI VAIBHAO MOTGHARE[2], Geological Survey of India
VANDANA JAYANT UMREDKAR[3], Geological Survey of India

Abstract

Geological Survey of India, Central Region, Nagpur has one of the largest drill core repository of India. Drill core samples provide the glimpse of subsurface geology, caters to the need of students, academicians, mining and multinational companies, mineral related government offices and helps in studying lithology, mineralogy, ore minerals, alterations, structures and many allied details of rocks. The drill core samples attract earth science fraternity to develop new ideas about host rock and their mineral resources and to assist exploration activity. Drill core samples limits the need for additional drilling and the cost of acquiring new samples is also very expensive. These are used in planning of different new projects based on their characteristics, also saves money in terms of lessening the transport cost and time by providing different cores at same place. Drill core is an important tool for industry stakeholders to develop geological models and exploration programs. The repository houses drill cores of 158 projects belonging to cratons, mobile belt,CITZ, Proterozoic sedimentary basins and different tectonic settings such as Bundelkhand, Bastar Bhandara, Betul, Mahakaushal, Sausar, Sakoli, Chhattisgarh basin, Singhora basin, Indravati basin, Deccan trap, Kotri rift belt, Gondwana coal field Malanjkhand area, Western Ghat Maharashtra from Central India. The drill cores have a range of mineral commodities, style of mineralization and tectonic setting, excellent examples of stratigraphy with significant structural features. Cores of precious mineral bearing rocks such as kimberlite, gold, basemetal, copper, tungsten, REE, RM, PGE, chromite, manganese, bauxite, iron, limestone, coal, geothermal, kyanite, sillimanite, phosphorite, molybdenum, nickel, graphite, glauconite, barite, fertilizer, Regional Mineral Targeting, stratigraphy from different parts of Central India. Kimberlite cores belonging to Mainpur kimberlite field, Tokapal kimberlite field, panna lamproite field are significant alongwith Tungston deposits of Kuhi-Khobna –Agargaon. The core repository has cores of 158 projects 13582 core boxes, 264 stratigraphic boreholes, 877 skeletonised boreholes and the total length of core is around 49,600m. The database of all the cores preserved have been prepared in digital mode and available online in Geological Survey of India under CLIS module of OCBIS portal. Regular visit is done by students of many colleges, trainee officers from GSI and Engineering colleges and universities across and acts as a good centre for dissemination of Geoscientific information to the earth science community. Students from RTM Nagpur University, Fergusson college Pune University of Madras Chennai, Shri Shivaji science college, Nagpur, from Akola, Centre Point School, katol road, BVM school Ashti, National college, Trichy, J.D. College of Engg. & NGT Nagpur, MECL, Nagpur, Somalwar Nikals school, Nagpur, Civil Engg. KDK college Nagpur, Civil Branch, Trainees from MECL., S. S Jain Institute of

Tech., Yashwantrao Chawhan college lakhandur, Bhandara, Kamptee polytechnic college, govt. polytechnic College, Nagpur, geologist from Vedanta group, Data code with expert from Australia, G.H. Raisoni College department of Mining Engineering, MP. Section officers from Ministry of Mines, New Delhi and G.H.Raisoni College Department of Mining Engineering , Saikheda , MP have visited in recent past.

Keyword

Core Repository, Geoscience, Information

The importance of informal educators in improving geoscience education in Namibia

Josephine UUSHONA[1]*, Geological Survey of Namibia (Josephine.Uushona@mme.gov.na)
Martin Hipangwa[2], Geological Survey of Namibia

Abstract

Geoscientific research and its practical applications are critical in a variety of fields, including resource management, environmental conservation, natural hazards assessment and mitigation, climate change research, and improving our understanding of the Earth and its evolution. As a result, geoscience significantly influences numerous aspects of our lives and society. As a result, it is critical to launch activities aimed at educating and creating awareness about the value of geoscience in society. These initiatives could take the form of geoscience education programs that not only provide individuals with the knowledge they need to understand geological processes, but also empower them to engage with and address current societal issues such as environmental protection and climate change. Furthermore, such education fosters the development of environmental awareness, promotes sustainable development practices, and enhances overall scientific literacy among the public.

Notwithstanding the obvious necessity of geoscience and geoscience education in Namibia, the discipline is not widely understood in society, let alone in the school system. Namibia, like many other countries worldwide, does not feature a standalone geoscience subject within its school curriculum or as part of teachers' training. On the contrary, geoscience aspects are rather incorporated in traditional disciplines such as chemistry, geography, physical science, and life science. However, avenues exist to bring geoscience closer to students, teachers, and communities, through informal education, including science outreach programs and public engagement initiatives. Geoscientists can play a crucial role in this endeavor, by serving as informal educators who inform, educate, and raise awareness about the relevance of geoscience and its practical applications in schools and communities.

The Geological Survey of Namibia has been actively involved in science communication initiatives aimed at increasing awareness of the significance of geoscience among schools and communities. These efforts include hands-on activities, posters, videos, and presentations designed to engage participants interactively. By utilizing such participatory methods, the survey hopes to improve the accessibility and sustainability of geoscience education. Furthermore, the Geological Survey of Namibia has initiated a geoscience teacher training program, inviting teachers from across the country to learn about earth science and how to incorporate it into existing curricula. This program equips teachers with innovative approaches to enhance students' understanding of earth science, such as implementing hands-on activities in the classroom. These efforts aim to enable the integration of geoscience ideas into classroom education by encouraging collaboration between educators and geoscientists, ultimately leading to a more aware and environmentally responsible society.

Keyword

Geoscience education, informal educators, geoscience awareness

The Importance of Science Communication About Hydrogeology in Culturally Sensitive Arid Areas

Barbara REYES[1]*, Scientists in Parks (breyes0021@gmail.com)

Abstract

The importance of science communication in regards to water protection in the southwest region of the United States is crucial to the survival of water resources in the area. Managing water resources in the Arizona Strip, an arid region in northwest Arizona, United States, has been a struggle for decades. The National Park Service (NPS) is looking for ways to effectively communicate water conservation practices to various communities with different priorities and opinions about the uses of water. Part of this includes highlighting agricultural practices that require low culinary water and prioritizing low water consumption technology at the park.

This poster focuses on water conservation efforts explored at Pipe Spring National Monument. The decline of the spring flow at the monument that holds historical and cultural significance has been a concern since the initial hydrogeological study conducted in the 1970s. Countless reports since then, have drawn a connection between our local water use and the decline in spring flow. One step Pipe Spring has taken to educate the public about water conservation, is to first effectively educate them about the geological processes that occurred during the Sevier Orogeny and Laramide Orogeny that allowed the area to become a welcome oasis in an arid region. The topic of water conservation becomes a delicate subject matter as tribal sovereignty, public lands, and religious freedom debate about the best uses of the springs that are fed from the confined aquifer of the region. The importance of science communication and cultural understanding allows for various communities in the area to understand how the geology of the area has allowed this unique source of water to come about and and why we must protect it.

Keyword

science communication, water conservation, outreach, cultural understanding, hydrogeology

Interpreting Dragons and Dinosaurs: Gaining Insights Through Museum Initiatives (Exhibition Practices at the Liu Guanghua Museum of Natural Heritage)

ZHUQING DENIS DING[1]*, Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology (dzqdzq1988@163.com)
HUANG YAN[2], Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China
ZHU Chen[3], Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China
MING Shu Jun[4], Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China
FENG Li TING[5], Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China
RONG NAN NAN[6], Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China
GAO Pan Pan[7], Guanghua Institute of Gemology and Mineral ResourcesGIGM, Jiangxi University of Applied Science and Technology, Nanchang 330100, China

Abstract

Dinosaurs, which are ancient biological fossils emerging from the geological history, are often translated into "dragon" in Chinese — a motif recurrent in traditional culture. The dragon in China embodies auspiciousness and epitomizes power, a deity that has evolved from millennia-old myths and religious narratives, with the Chinese regarded as the progeny of dragons. In line with the Chinese traditional lunar calendar, 2024 is earmarked as the Year of the Dragon, making the dragon the emblem of the year. The Liu Guanghua Museum of Natural Heritage has adeptly leveraged dinosaurs and akin prehistoric fossils identified with "dragons" to launch an array of educational and science outreach activities. These initiatives have been notably successful in simultaneously elevating Chinese traditional culture and advancing the knowledge of paleontology.

This document employs the educational endeavors of the Liu Guanghua Museum of Natural Heritage as a focal example. It capitalizes on the emblematic significance of dragons within Chinese traditional culture as a seamless conduit for the propagation of paleontological science, elucidating the splendid epochs and pivotal contributions of "dragon-shaped" prehistoric entities in geological history. It augments the visitors' comprehension of ancient life forms, revealing their varied distributions and evolutionary morphologies across marine, terrestrial, and aerial realms. Furthermore, juxtaposing the mythical dragons of Chinese lore with their scientific counterparts unravels fascinating parallels, such as the sovereignty of dragons in the marine domain and their morphological versatility. Through its exhibitions and programming, the museum amplifies its indispensable role in promoting earth science, fostering cultural heritage, rectifying

misconceptions, and enhancing natural science education.

Keyword

Educational Expeditions, Legends of the Chinese Dragon, Science Popularization, Paleobiology, Liu Guanghua Museum of Natural Heritage

ALTERNATIVE E-ASSESSMENT WITH INTEGRATED ACADEMIC STUDENT SUPPORT: CASE STUDY- ENVIRONMENTAL SCIENCES

Helena (prefer ELNA) Johanna VAN NIEKERK[1]*, UNISA (vniekhj@unisa.ac.za)

Abstract

Although the University of South Africa (UNISA), a Comprehensive Open Distance e-Learning (CODeL) institution, has a history of more than 150 years offering quality Distance Education (DE), student support has always been a challenge. Initially, meticulously developed study material was provided to all registered students via the post. Formative assignments had to be completed for a year mark which provided access to summative venue-based examinations. However, the transactional distance between lecturer and student and amongst registered students often caused individual students to feel isolated and alienated, which lead to a series of complaints raised against DE.

In the digital age where the internet increased the speed and amount of information available and provide numerous different technologies to communicate fast and effectively, online modules can be designed and activities can be developed to enable students to collaborate, engage in dialogue and reflect on their learning according to the constructivist learning theory. Students can also be joined together in a digital, online learning community where they can share, discuss and deliberate, and make connections between fields, ideas and concepts according to the connectivist learning theory.

Several High Impact Practices (HIP) related to student support was researched and reported by Higher Education Institutions across the globe. The question arose whether the HIPs identified for face-to-face institutions could be applied to an online module at Unisa. This paper will focus on the application of the academic student support HIPs and show how it could be integrated into one online, writing intensive honours (4th year) module in Environmental Sciences, offered in the College of Agriculture and Environmental Sciences (CAES) at UNISA. The HIPs were integrated through a series of alternative assessments such as discussions, blogs, games, research reports, peer review reports and a debate. The high impact academic student support practices include the following: orientation; goal setting and planning (time management); first time experiences; supplemental instruction; student success courses; class attendance and engagement; learning communities and collaboration; tutoring (regular feedback); research (real-world applications); alert and intervention; writing, presentation, and reflection.

Keyword

Connectivist learning theory, Constructivist learning theory, Distance Education (DE), Comprehensive Open Distance e-Learning (CODeL), Alternative assessment

Conceptions of risk in the face of crises and the memory of events in tropical island territories. Ways of establishing a risk culture in the French West Indies.

Yves MAZABRAUD[1]*, Université des Antilles (yves.mazabraud@univ-antilles.fr)
Alexandra RENOUARD[2], Imperial College London
Adam ABDOU-ALOU[3], Université des Antilles
Michelet CLERVEAU[4], Université d'Etat de Haïti
Béatrice JEANNOT-FOURCAUD[5], Université des Antilles
Thomas Forissier[6], Université des Antilles

Abstract

The Lesser Antilles arc is made up of different island territories that are subject to natural hazards that shape their geography and influence their societies. The various disasters that have marked the archipelago's recent history are memorial markers that leave a more or less deep and lasting mark on people's relationship with their environment. Throughout the world, certain societies have developed historically by forging a link with the natural hazards to which they are subject. This link can be expressed simply by a strong awareness of the issues at stake, visible in the institutional and educational preparation for risks to mitigate their effects and improve resilience. Indonesia and Japan are emblematic examples of this (for example, the god Kashima, associated with earthquakes), and myths linked to volcanoes and earthquakes can be found in many ancient societies.

Our study focuses on two aspects: the first is the persistence of the memory of disasters within society and families. Using questionnaires, we are assessing the duration of memories of crises in Guadeloupe (the Pointe à Pitre earthquake of 1843, the volcanic crisis of 1976, cyclones Hugo, 1989, and Maria, 2017) within generations, depending on the intensity of the impacts. The aim is to provide descriptive information on the establishment and persistence of a culture of risk. The second part of the study consists of establishing individual profiles modelling the interactions of subjects with each other and with their environment. These profiles are intended to be used operationally to help target the awareness-raising or educational initiatives that are best suited to a given social group in its context. Our aim is to define the psycho-social and geographical parameters that enable us to identify groups of individual profiles that are consistent in terms of preparedness for natural hazards, so that we can strengthen the population's preparedness and resilience in the face of crises, in a targeted manner.

This study is resolutely multidisciplinary (geography, geosciences, science education, linguistics) and is supported by the French Red Cross Foundation.

Keyword

Natural risks, Resilience, Scientific conceptions, Intergenerational memory persistence, Risk culture

Deciphering the Scientific Conceptions of Students and Teachers: from Interaction-Based Modelling to Machine Learning Perspectives.

Alexandra RENOUARD[1]*, Imperial College London (a.renouard@imperial.ac.uk)
Yves MAZABRAUD[2], Université des Antilles

Abstract

The description of students' and science teachers' conceptions of fundamental scientific topics is a key factor in improving the effectiveness of science teaching, as it enables the detection of alternative conceptions that hinder the acquisition of officially accepted scientific conceptions. For this reason, it has long been the subject of numerous studies and models. Individual conceptions are now well described in many scientific fields, such as earth sciences. However, despite all these studies and the efforts made by the community (e.g. scientists, academics, secondary and primary school teachers, educators) to develop good teaching practices, some pre-existing alternative conceptions still persist among students. Here, to take things a step further, we present a conceptual model aimed at studying the origins of individual conceptions and the ways in which they are acquired and disseminated. Symbolically based on the crystalline structure of silicates, this model describes the educational context of each student in order to design targeted actions to encourage the acquisition of scientific conceptions by intervening upstream of their acquisition (Renouard and Mazabraud, 2018).

We then propose some perspectives offered by the use of unsupervised machine learning (ML) tools applied to this model. Artificial intelligence and ML are still underused in the field of science education, despite their growing presence in many scientific fields. Our aim is to transfer the ML know-how developed in geophysics to geocognition studies in order to open new doors, while avoiding an over-simplified or black-box use of these newly available tools.

Keyword

Geoscience Education, Context modeling, Machine learning

Languages and natural risk prevention in diglossic territories: a study in Guadeloupe

Béatrice JEANNOT-FOURCAUD[1]*, Université des Antilles (beatrice.jeannot@univ-antilles.fr)
Yves MAZABRAUD[2], Université des Antilles
Adam ABDOU-ALOU[3], Université des Antilles
Alexandra RENOUARD[4], Imperial College London
Chloé ROUSSEAU[5], Unversité des Antilles

Abstract

Our experience of many natural disasters, regardless of their nature or location in the world, shows the importance of people's awareness and knowledge of the risks they may face. We know that these elements can be crucial in determining the human toll of natural disasters. In this respect, prevention efforts must always be considered, especially in cases where the risk culture appears to be less developed. In this study, we focus on prevention, not in its material aspects (adapted infrastructures, etc.), but in terms of preparing the population, particularly in terms of appropriate gestures and behaviour. This being the case, whether we are talking about institutional communication or risk education, a key question that arises in bilingual contexts is which language is the most effective for conveying preventive messages. It is on this point that we focus our reflections, through the study of data collected in Guadeloupe, a bilingual territory characterised as diglossic due to the unequal status and representation of the two languages that coexist there, Creole and French. Using questionnaires collected from primary school children, we aim to investigate the relevance of using Creole, the regional language, or French, the national language, in risk prevention campaigns in Guadeloupe, with a view to improving them. To this end, we are interested in the students' ideas, practices and linguistic skills, as well as the pragmatic effects of using one or the other language (in particular, the effect of the message on the recipient).

This study is supported by the Foundation of the French Red Cross.

Keyword

Natural risks, Languages and Risk prevention, Risk education, Bilingualism, Diglossia

Strategies and challenges for risk education in the city of São Paulo, Brazil

Natalia Leite de MORAIS[1]*, Sao Paulo City Hall Civil Defence Coordination
(nlmorais@prefeitura.sp.gov.br)
Malena D'Elia OTERO[2], Sao Paulo City Hall Civil Defence Coordination
Thaís Feitosa TREVISANI[3], Sao Paulo City Hall Civil Defence Coordination

Abstract

The city of São Paulo (Brazil) has more than 11 million inhabitants and, despite being the richest city in Brazil, the Municipal Defence Coordination (COMDEC) has mapped more than 700 areas of geological and hydrological risk with 200,000 estimated vulnerable homes exposed to those risks.

Regarding risk management and prevention, COMDEC also promotes actions for education and social mobilization focused on risk perception and risk reduction. Despite carrying out several outreach actions, the limited technical staff working in COMDEC are not enough to meet the needs of all risk areas and their inhabitants.

Given this limitation, COMDEC adopted a strategy based on articulating and developing training courses for municipal public servers from other municipal departments. Target groups for these courses are chosen considering servers' capillarity and access to populations who live in risk areas.

In this work, we present two educational and social mobilization actions developed by the COMDEC team: (i) one with teachers from the public educational system and (ii) another one with public health servers. Both courses were organized in classroom and on-site classes, regarding risk types, prevention actions and risk management.

(i) Course for teachers (2019-2020): developed in partnership with the Departments of Education, Health and Environmental Affairs and Forestry, for 592 teachers from early childhood education, elementary school and upper secondary education.
The main objective of the course was to provide teachers with information on risk management and encourage them to develop teaching activities with their students that focus on risk perception and reduction.
During 2019, on-site classes were held in risk areas. In 2020, because of COVID-19 pandemy, the on-site classes were canceled and teachers were asked to develop a practical activity for the students that gathered the theoretical knowledge that they acquired during the course.

(ii) Course for health servers (2024): between February and July of 2024, a training course will be held for Environmental Promotion Agents of the “Green and Healthy Environments Program”, of the Department of Health. The target group is estimated at 330 agents.

The objective is to provide tools for these agents so they can identify the evidence of risk and the conditions that worsen the risk situation.

Recognizing the institutional limitations that pose challenges in the development of public policies is the first step towards creating strategies that adapt to these scenarios. The partnerships formed with teachers from the public educational system and with Environmental Promotion Agents proved to be effective because they work in close contact with risk areas inhabitants. Hence, by training them, they become multipliers of the perception and reduction of risks. As a result, it promotes the creation and improvement of a culture of risk prevention.

Keyword

educational strategies, risk perception, risk area, São Paulo

CREDO-L: An Innovative Landslide Mitigation Strategy for Highschool Students (Study Case: Depok, Indonesia)

TWIN HOSEA WIDODO KRISTYANTO[1]*, Geology Study Program, Universitas Indonesia (twin.hosea@sci.ui.ac.id)
Marlina Tjendra[2], Universitas Indonesia
Abigail Priskila Anna Pratiwi[3], Universitas Indonesia
Fajar Multi Ksatria[4], Universitas Indonesia
Muhammad Badhar Gibran[5], Universitas Indonesia

Abstract

Landslides are Indonesia's most common natural disasters, including in the Depok City area. Through 2022, about 200 landslides were recorded in the Depok City area. This condition is at odds with the ability of Depok people to face the landslide hazard. Therefore, this study aims to build an innovative landslide disaster curriculum for high school students to increase the awareness of Depok citizens, especially the younger generation, and enhance their ability to accommodate their lives to landslide disasters. It used a qualitative method called action research, initiated by constructing a written concept in a learning plan. The study plan includes key topics on landslide disasters, learning methods, and innovative properties in the classroom. The curriculum was tested in Depok High School for several sessions, and each session was assessed to understand the impact of the teaching on students' awareness of the landslide disaster. The disaster teaching curriculum is called CREDO-L (Creative Hazard Education – Landslide Series). CREDO-L also incorporated local wisdom regarding the landslides that occur in Depok. CREDO-L was taught and tested for 91 Depok Senior High School students majoring in science and humanity. The success rate of the curriculum was evaluated using pre- and post-tests. The results show that CREDO-L improved students' understanding of landslide disasters. The learning process also offers benefits in encouraging the students to share their experiences learning the hazard through CREDO-L with their buddies and family members. It is concluded that CREDO-L has successfully enhanced the understanding and awareness of landslide disasters among senior high school students in Depok City, Indonesia. It has also been proven that CREDO-L can encourage students to share their experiences and knowledge with others.

Keyword

Mitigation, Education, Landslide, Hazard, Creative

Over 20 years of serving secondary and tertiary education worldwide – The activities of the Education Committee of EGU

Friedrich BARNIKEL[1]*, Education Committee of EGU (friedrich.barnikel@awg.musin.de)
Jean-Luc Berenguer[2], Education Committee of EGU
Anna Anglisano Roca[3], Education Committee of EGU
Annegret Schwarz[4], Education Committee of EGU
Carlo Laj[5], Education Committee of EGU
Francesca Cifelli[6], Education Committee of EGU
Francesca Funiciello[7], Education Committee of EGU
Gina Pereira Correia[8], Education Committee of EGU
Giuliana Panieri[9], Education Committee of EGU
Hélder Pereira[10], Education Committee of EGU
Konstantinos Kourtidis[11], Education Committee of EGU
Phil Smith[12], Education Committee of EGU
Stavros Stathopoulos[13], Education Committee of EGU
Stephen Macko[14], Education Committee of EGU
Teresita Gravina[15], Education Committee of EGU

Abstract

The mission of the European Geosciences Union (EGU) is, through advances in Earth, planetary and space sciences, to realise a sustainable and just future for humanity and the planet. To achieve this goal, EGU organises topical meetings, and education and outreach activities in addition to publishing more than twenty diverse scientific journals. The Education Committee (EC) of EGU was founded in 2002 with the aim of bringing state-of-the-art science into tomorrow's classrooms via high-school teachers.

The current strategy of the Committee envisages four main objectives. The longest running and most important objective is the organisation of Geosciences Information for Teachers (GIFT) workshops. These are two-and-a-half-day teacher enhancement workshops held in conjunction with EGU's annual General Assembly in Vienna, Austria. There, selected top-level scientists working in the Earth sciences offer the invited teachers talks centred on a different theme every year. Teachers are, in addition to free access to the Assembly and travel grants, also provided with teaching strategies and hands-on activities related to the theme.

With very many teachers keen to get more access to research experience, the European GIFT concept also became international, with the EC helping to organise workshops at different locations worldwide, like in Merida (Mexico, two times), Penang (Malaysia), Cusco (Peru), Port Elizabeth (South Africa), Istanbul (Turkey), Addis Ababa (Ethiopia) and Cape Town (South Africa, four times) with notable success (amongst the latter a GIFT workshop in cooperation with the 35th IGC in 2016).

Until today more than 2500 teachers from over 50 countries had the opportunity to take part in these workshops. For the past 15 years some of the lectures were filmed during the workshop. Along with all the other workshop material (programmes, brochures, abstracts and files of the

presentations) these recordings were made available as web streams and are accessible free of charge via the EGU website.
In addition, the EC has recently started the enormously popular Geoscience Education Field Officers (GEFO) programme as a second objective, which allows for momentarily eleven GEFO to organise local and international teacher training sessions. With almost 3000 participants of roughly 160 workshops in 11 European countries so far, this concept has proven to be an overwhelming success.
Our third objective centers on Tertiary Education. We provide grants for higher education geoscience teaching material to be made freely available to everyone who teaches university-level geoscience and we support one Early Career Scientist (ECS) with experience in teaching Earth, planetary, and space sciences at the university level every year.
Last but not least we financially support geosciences events worldwide like currently Lab and Field Schools in the Mediterranean, a seismology workshop in Nepal or the participation at the International Earth Science Olympiad.
The EC consists of 15 colleagues, professors at universities (active and retired), researchers and high-school teachers. We hope to be able to serve the public even more in the near future.

Keyword

Geosciences, Teachers, Workshop, Education, Classroom

Measuring and Communicating the Impact of Earth Science Research on Society and the United Nations Sustainable Development Goals

Phoebe MCMELLON[1]*, GeoScienceWorld (mcmellon@geoscienceworld.org)

Abstract

The earth sciences cover a range of sub-disciplines that aim to deepen our understanding of the natural world and to apply that knowledge to enable global communities to mitigate disasters, discover and manage natural resources, and be better stewards of the earth. Quantifying and communicating the impact of earth science research on sustainability is critical for attracting new scientists to the field, for advancing and improving quality of life, for mitigating risks, and for addressing the challenges that threaten our future. The impact of research on society is reflected in scholarly research. (1, 2) This paper presents the results of a study undertaken by GeoScienceWorld (GSW) to quantify the impact and contribution of the earth sciences on society and on advancing the United Nations' 17 Sustainable Development Goals (UN SDGs) by leveraging a variety of metrics associated with scientific research output.

The UN SDGs are a call for action to eradicate global poverty, end unsustainable consumption patterns, facilitate sustained and inclusive economic growth, social development, and environmental protection. Leveraging data from Digital Science's Dimensions database (https://www.dimensions.ai), GSW aggregated and analyzed global research output between 2015-2023 across four scientific disciplines(3): earth sciences, biological sciences, chemical sciences, and physical sciences to quantify the impact and contribution towards advancing the UN SDGs and influencing policy. The preliminary results show that the earth sciences have the greatest contribution in terms of total research output (19%) followed by the biological sciences (11%), chemical sciences (7%), and physical sciences (5%). In addition, the grant awards for SDG-related research were highest in the earth sciences (20%), followed by chemical sciences (12%), biological sciences (9%), and physical sciences (7%). All science disciplines contributed to all 17 SDGs; however, research output in the geosciences significantly impacted more SDG categories than the other scientific disciplines.

This study highlights the value of quantifying the impact of scientific research and communicating the impact of the earth sciences on sustainability, and can be used to attract new students, to influence future funding priorities, and to accelerate innovation, new discoveries, and understanding our planet and beyond.

References

(1) Capello, Maria A., Shaughnessy, A. and Caslin, E., (2021). "The Geophysical Sustainability Atlas: Mapping geophysics to the UN Sustainable Development Goals." The Leading Edge 40: 10–24, https://doi.org/10.1190/tle40010010.1.

(2) McMellon, P., 2022, Changing the Narrative by Connecting Earth Science to the United Nations Sustainable Development Goals Abstracts with Programs, v. 54, no. 5, https://doi.org/10.1130/abs/2022AM-383142.
(3) Australian and New Zealand Standard Research Classification (ANZSRC) - a standard classification system of research areas and Fields of Research (FoR), which includes major fields and related sub-fields of research, and emerging areas of study.

Keyword

earth sciences, geosciences, sustainable development goals, research impact, communications

Between Fieldwork and Classroom Training: the School of Geology and the Early Geological Survey in China (1913-1916)

Lijuan YANG[1]*, School of History, Zhejiang University (yang-lijuan@zju.edu.cn)

Abstract

In 1913, the School of Geology affiliated with the Geological Survey of China was established. The aim of the school was to train specialists in carrying out geological surveys. During the years 1913-1916, the School of Geology had cultivated talented people with different educational backgrounds. At the beginning of 1916, the old Geological Section of the Bureau of Mines was reorganized into an independent geological survey, and became the National Geology Survey. Dr. Johan Gunnar Andersson (1874-1960), then Director of the Swedish Geological Survey, was appointed Mining Adviser to the Chinese Government, and his two assistants F. R. Tegengren and E. T. Nyström, all became members of the Geological Survey in 1916. In the summer of the same year, the students who graduated from the School of Geology also became members. Several geological surveys were organized during 1913-1916. This paper combines an investigation of some newly discovered materials with an exploration of the past, to trace the routes by which geology developed in modern China. The author will focus on geological surveys conducted by Chinese geologists between 1913 and 1916. Since then Chinese geologists conducted careful investigations in Northern and Eastern China, and could be considered some of the earliest geological surveys organized by Chinese authorities. This was a period when China trained geological specialists at the School of Geology, and established the National Geological Survey of China. China became able to conduct its own independent geological surveys after the students from the School of Geology graduated and became qualified professionals.

Keyword

The National Geological Survey of China, The School of Geology, Early geological Survey in China

Fostering geoheritage education through Virtual Reality technologies

Paola Coratza[1], Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Campi 103, 41125 Modena, Italy
Mauro Soldati[2], Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Campi 103, 41125 Modena, Italy
Vittoria VANDELLI[3]*, Department of Chemical and Geological Sciences, University of Modena and Reggio Emilia, Via Campi 103, 41125 Modena, Italy (vittoria.vandelli@unimore.it)

Abstract

Education on geoheritage can play a pivotal role in fostering sustainability and sustainable development. Geoheritage is an essential part of the global natural and cultural heritage including key sites and elements (e.g., rocks, minerals, fossils, and landscapes) for the understanding of Earth's history. Geoheritage has been shown to provide essential ecosystem services benefiting all humans. Given its non-renewable nature, the conservation and promotion of geoheritage are deemed crucial. In the last few years, dedicated courses or contents regarding geoheritage have been introduced in universities. However, there is still the need to improve awareness on these topics especially at higher education level.

This paper presents the outputs of a research carried out in the frame of a project centered on "Training new generations in geomorphology, geohazards, and geoheritage using Virtual Reality Technologies", run under the Erasmus+ Programme's Key Action 2: Partnerships for Cooperation under the European Commission. The project aims to propose uniform and integrated teaching guidelines that promote distance education, by utilizing the most recent trend in technologies. VR-based experiences, in the form of Virtual Field Trips (VFTs), were implemented to create immersive lessons on geoheritage with the broader aim to promote its deeper understanding and appreciation. Definitions and values of geoheritage were exposed through virtual itineraries in specific locations chosen for their high educational potential. The selected locations include a Natural Reserve in the Emilia Apennines (Northern Italy), distinguished by spectacular mud volcanoes and badlands. Additionally, a coastal area in the northwestern sector of the Island of Malta (Central Mediterranean Sea) was selected, due to the variety of its landforms. The VFTs were developed through a sequence of stops corresponding to points of interest that exemplify the scientific, aesthetic, ecological, socioeconomic, and historical values of geoheritage. While the VFTs cannot entirely substitute traditional on-site field trips, their integration into geoheritage education has proven highly beneficial. This utilization has enabled: i) Overcoming the challenges posed by site inaccessibility and unpredictable weather conditions; ii) Prevent students/users from being threatened by potential geological hazards; iii) Safeguarding the integrity of the sites. Additionally, in a single lesson, VFTs allow students to explore and compare a wide range of geoheritage features, whether concentrated in a single site or scattered on a global scale.

The implemented virtual itineraries were successfully used as teaching material in bachelor and master degrees including courses on: Geomorphology, Georesources and Physical Geography.

Keyword

geoheritage education, virtual itineraries, Northern Apennines, Italy, Malta

Evolution and Achievements of the IUGS Commission on Geoscience Education (COGE)

Ian Francis CLARK[1]*, University of South Australia (ian.clark@unisa.edu.au)
Sandra Villacorta-Chambi[2], Charles Darwin University/CSIRO Australia
Susanna Occhipinti[3], Camerino University/Education Department of the Italian Geological Society

Abstract

Originally established as the Commission on Geoscience Education, Training, and Technology Transfer in 1990, COGE's evolution is explored against the backdrop of expanding global needs in geoscience education. The Commission's strategic reorientation from purely facilitating scientific conferences to addressing diverse educational demands across developed and developing countries is examined.

COGE has focussed on improving geoscience education globally, and COGE's significant collaborative ventures, notably with the International Geoscience Education Organisation (IGEO) and the European Geosciences Union (EGU) are used to highlight key achievements such as the formulation of an international geoscience curriculum and impactful educational publications. These collaborative efforts underscore COGE's instrumental role in shaping geoscience education on a global scale.

Key independent achievements include the establishment of the Geoscience Education Field Officers (GEFO) Program, the creation of the Chris King Medal for excellence in international geoscience education, ongoing partnerships with other global geoscience education organisations, and the recent reinvigoration of a social media presence to increase awareness of its initiatives giving more visibility to the commission at the same level as other major IUGS commissions; as well as its reorganisation to improve the commission’s effectiveness, including the creation of sub-commissions and subcommittees. Despite these achievements, COGE faces new and persistent challenges, such as resource constraints and adapting to diverse educational systems. The Commission's innovative responses to these challenges, particularly during the COVID-19 pandemic, showcase its resilience and commitment to advancing geoscience education amidst evolving circumstances.

The presentation addresses these challenges to advance geoscience education globally and emphasises the importance of collaboration and innovation. In addition, COGE's future directions are outlined, emphasising its commitment to global collaboration, teaching innovation, inclusivity, and adherence to geoethical principles. This forward-looking perspective reaffirms COGE's role in enhancing and diversifying global geoscience education.

Keyword

Geoscience, Geoscience Education, Professional Networks, IUGS

Philippine Participation in the International Earth Science Olympiad (IESO): A Longitudinal Study

Miguel CANO[1]*, St. Stephen's High School (mcano@ssh.edu.ph)
Marietta De Leon[2], University of the Philippines
Magnolia Vida Ante Cano[3], Bicol University

Abstract

The Philippines has been involved in the International Earth Science Olympiad (IESO) since 2005, participating in the planning stages before its official commencement in 2007. Aside from active participation, the country then hosted the 2nd IESO in Manila and Bicol, Philippines in 2008.

Since 2007 until the country's most recent participation in 2019, the Philippines garnered 1 gold, eight silvers, 18 bronzes, 1 honorable mention during the 3rd IESO in Taiwan, aside from the awards earned in the International Team Field Investigation (ITFI) and Earth Science Project (ESP). A number of former IESO Team members ended up taking Earth Science courses (BS Geology, in particular) even to a PhD level abroad (e.g. most recently at MIT)

The longitudinal study sought not only to account "success stories" of students who later pursued pathways in the Earth Sciences but even those who took different paths and yet elicited narratives of significant appreciation of Earth Science/Systems while in different fields of endeavor. The narratives are categorized into two groups: those arising from their involvement in the written test, camp, and training, and those stemming from their experience during the IESO participation in the host country. The reflections of the former IESO Team members and their experiences in the IESO contribute to the evolution of how gifted students in the Earth Sciences in the Philippines are selected, sifted, and trained for IESO against the backdrop of economic and political milieu in the Philippines. As such, this study has implications on the method of selecting the Team members through the Philippine Earth Science Olympiad (PESO).

Science Olympiads play an important role in the development of scientific talents and giftedness and contribute in building up the science capital of the Philippines. The selection process must therefore be responsive to the experiences of the Olympians and should address the issues of equity, diversity, and winnability.

Keyword

IESO, giftedness, equity, diversity, winnability

Practice of Geoscience Education for Guilin Karst World Natural Heritage Site -- Taking "A Drip of Water Travel" as an Example

Lina SHEN[1]*, Institute of Karst Geology, Chinese Academy of Geological Sciences
(24830298@qq.com)
jinfu QIN[2], 13768721786
zhimin HUANG[3], 8618577396464
jinyun TUO[4], 13557032336

Abstract

The Guilin Karst World Natural Heritage Site has the most typical peak cluster and peak forest landforms in the world, with both above ground and underground karst development, making it a natural museum of karst geoscience education. In order to better carry out karst geological education for primary and secondary school students, experts have developed the "One Drop of Water Travel" geological course targeting the Guanyan Underground River Basin in the core area of Guilin Karst World Natural Heritage. The course covers four age groups: primary school, junior high school, high school, and university. Through PBL teaching methods, students are encouraged to explore the origin and development of water in typical karst environments, shape the above and underground landscapes of karst, understand the relationship between humans and karst environments, enhance the public's concept of sustainable development, and protect and inherit Guilin Karst World Natural Heritage.

In combination with China's research travel policy, the construction of the Guanyan Underground River Karst Research and Learning Base has been carried out to systematically carry out karst geological education for primary and secondary school students. This has improved the level of science popularization and education for Guilin's Karst World Natural Heritage, provided practical experience for world natural heritage geological education, and provided new cases for global karst geological education.

Keyword

The Guilin Karst World Natural Heritage, geoscience education, "One Drop of Water Travel, PBL

[Keynote] Engaged Geosciences: Connecting Students, Teachers, and Community to Solve Local and Global Problems

Sharon LOCKE[1]*, Southern Illinois University Edwardsville (slocke@siue.edu)

Abstract

Global challenges, including climate change, ensuring energy for all, sustaining air and water quality and access, and managing natural resources sustainably, require solutions informed by the geosciences. Engaged science, which is science conducted in mutual partnership with affected communities, is rapidly growing in popularity and in the geoscience scholarly literature. Engaged geoscience ensures that local and community knowledge is integrated with other scientific knowledge to inform solutions. Furthermore, by engaging the community in the scientific process from the beginning, enacted solutions are more likely to account for human dimensions of the problem, leading to better solutions. Our team conducted a geohealth project that engaged grade 6 and 7 students, teachers, scientists, and the broader community to examine sources of pollution in soil and air that contributed to increased exposure to environmental hazards. Using community participation and place-based learning as the theoretical framework, students learned how to design a research study, measure environmental exposures, and communicate scientific fundings to a non-technical audience. The project has the benefit of identifying public areas where soils had elevated lead levels and thus were candidate sites for remediation. The project also revealed opportunities to strengthen communication networks within the affected communities to improve capacity for action. For example, although understanding geohealth is critical to ensuring the health and well-being of residents, this subject area is not taught in area schools. Additional means of creative communication of the results of engaged geoscience projects is recommended, such as public showcases of participatory photography and graphic comics.

Keyword

community science, geohealth, school partnerships, engaged research, middle school students

Arts and Geoscience: An Interdisciplinary Approach to Enhancing Geoscience Education

Sandra Paula VIILLACORTA CHAMBI[1]*, CSIRO (sandra.villacortachambi@csiro.au)
Heather Handley[2], University of Twente
Susanna Occhipinti [3], Camerino university

Abstract

Integrating arts into geoscience education presents a unique and dynamic interplay, offering an innovative approach to understanding and teaching complex geological concepts. Historically, artistic depictions of geological phenomena have demonstrated the relationship between art and science, blending aesthetic appeal with scientific precision. In modern education, this amalgamation is increasingly acknowledged for making scientific research and ideas more accessible and engaging to a broader audience.

Art, in its various forms, can evoke emotions, connect individuals to the natural world, and inspire action, making scientific ideas more relatable and impactful. This is particularly significant in geoscience education, where artistic representations can demystify intricate concepts, enhancing comprehension and relatability. From hand-drawn illustrations to sculptures and installations, artistic interpretations provide unique perspectives on scientific data, bridging the gap between scientific understanding and public perception. Science museums and research institutions capitalise on this symbiosis by incorporating art galleries to stimulate curiosity and improve scientific literacy, thereby enriching the educational experience.

Notable examples of the successful fusion of art and science include art galleries in scientific venues and interdisciplinary conferences focusing on the union between these fields. Such collaborative efforts allow artists and scientists to transcend traditional disciplinary boundaries, creating transformative knowledge and innovative solutions to complex issues like climate change.

Teaching geoscience through art fosters a holistic learning approach, appealing to a diverse audience and deepening students' understanding of Earth's processes. Educators can discover new avenues for exploring and understanding geoscience when they combine artistic creativity and scientific rigour considering the interactive nature of Art.

This poster presentation highlights the benefits of incorporating arts into geoscience education. This approach expands students' perspectives and makes learning more engaging and inclusive. By using artistic communication, complex geoscience concepts can be conveyed in a rich and inspiring way. Visual examples and case studies show how artistic methods improve student understanding, encourage engagement, and promote a comprehensive and inclusive approach to

learning.

Keyword

Geoscience, Arts, Geoscience Education, Interdisciplinary Approach

Mobilizing Geoscience Education: The Mobile Laboratory (Laboratorio Móvil - LAM) Experience in Rural Uruguay

Elena Peel[1]*, Faculty of Science - UDELAR (elena@fcien.edu.uy)
Santiago Fort[2], Faculty of Science - UDELAR
Paula Pellegrino[3], Faculty of Science - UDELAR

Abstract

In the face of pressing global challenges such as climate change and sustainable management of earth resources, the imperative role of Geoscience Education (ESE) cannot be overstated. This abstract presents the Mobile Laboratory (Laboratorio Móvil - LAM) initiative, a pioneering project by the Faculties of Sciences and Chemistry at the Universidad de la República (Uruguay), sponsored by a private company, aimed at invigorating interest in science among children and youth. Through a specially designed vehicle equipped with necessary scientific apparatus, the LAM has been instrumental in delivering hands-on science education across rural Uruguay since 2015.

Focusing on engaging students aged 6 to 12 in rural primary schools, the LAM project emphasizes the ludic aspect of learning through experimental activities that include the exploration of minerals, rocks, and groundwater. For example, by observing water movement through porous media, students gain insights into aquifer potential in different lithologies, which is crucial for sustainable resource management and environmental conservation. This hands-on approach also includes 'object hunts' to identify geological materials and tools. Such knowledge is not only fundamental to geoscience but is also vital for planning environmentally sustainable development projects on the Earth's surface, ensuring that industrial activities harmonize with ecosystems. These activities are designed not only to impart fundamental geoscience knowledge but also to foster a deeper understanding of the earth's processes and their significance in our daily lives.

The culmination of each session involves interactive games and questions and answers (Q&A) segments, reinforcing the concepts introduced. By rotating through rural schools every 15 days and inviting nearby schools to participate, the LAM has significantly contributed to democratizing geoscience education, reaching areas traditionally underserved in scientific outreach. This initiative underscores the importance of innovative, mobile, and interactive teaching methods in standardizing and globalizing geoscience education.

Through the lens of the LAM experience, this paper advocates for the integration of such dynamic educational models into global strategies for geoscience education, highlighting the potential for localized projects to make significant contributions to the global educational landscape in Earth Sciences.

Keyword

Education, Geosciences, Uruguay

CLIMATIC DYNAMICS AND POPULATION TRENDS OF MICROTUS (IBEROMYS) CABRERAE (THOMAS, 1906) IN THE MEDITERRANEAN: A BIOCLIMATIC NICHE MODELING APPROACH

JULIA JIMENO-ALDA[1]*, University of Valencia (jimeno.a.julia@gmail.com)
PATRICIO GUILLERMO VILLAFAÑE[2], University of Valencia
FRANCISCO JAVIER RUIZ-SANCHEZ[3], University of Valencia

Abstract

Past climate changes have had a lasting impact on global biodiversity and ecosystems. Niche models, which rely on climatic data to predict the geographical distribution of species, are a method for the prediction of how environmental changes affect species. Specifically, small mammals have demonstrated a remarkable sensitivity to climatic variation, besides presenting a more or less uninterrupted palaeontological record. The Cabrera´s vole, *Microtus* (*Iberomys*) *carbrerae*, a micro-mammal unique to the Ibero-Mediterranean region with unique ecological and climatic characteristics, currently suffers from a regressive populational trend and has been categorized as endangered by the IUCN Red List of Endangered Species. In this study, the climatic development of *M.* (*Iberomys*) *carbrerae* distribution area from the LIP (MIS 5) to present was predicted and described with bioclimatic niche modeling. The objectives of our study were: i) Detect the populational regression of *M.* (*Iberomys*) *carbrerae* based on the location of palaeontological records, ii) Asses how past climatic changes impacted the historical distribution *M.* (*Iberomys*) *carbrerae*, and iii) Discern the role of the climatic factor in the declining population trend and population decreasing status of *M.* (*Iberomys*) *carbrerae*. Our results showed that palaeontological records from the LIP (MIS 5) to the sub-recent (upper part of MIS 1) indicated wider historical distribution areas for this species than current ones. Furthermore, the climatic suitability of *M.* (*Iberomys*) *carbrerae* potential distributions increased during warmer periods while decreasing during cooler periods. However, from Iron age-Roman Period (in cultural terms) in advance, despite favourable climatic conditions for expansion, population trends declined. As a result, changes in potential distribution were primarily driven by climate from the LIP (MIS 5) to the upper part of MIS 1), while other factors (eg. Interspecific competition or human influence) may have been playing a more prominent role in controlling potential *M.* (*Iberomys*) *carbrerae* distribution from the upper part of Holocene onward. We present a comprehensive cartographical analysis detailing the potential historical distribution of *M.* (*Iberomys*) *carbrerae* across four distinct periods. Our study reveals significant correlations between shifts in *M.* (*Iberomys*) *carbrerae* distribution and climatic changes. Additionally, we believe that factors beyond climate could have impacted the conservation status of this endemic Mediterranean species. By identifying these influences in future studies, we would be able to formulate effective conservation strategies for the protection and preservation of this endangered species.

Keyword

Micromammals, Climate change, Mediterranean climate, Palaeoecology, Conservation

Evaluation of Interpolation Methods for Mapping Potential Hydrogen for Windhoek Municipal Boreholes

Taleni Silas Taleni David[1]*, Namibia University of Science and Technology
(silasdavid071@gmail.com)

Abstract

Groundwater is one of the most significant spatial phenomena in the world, where its quality and quantity is threatened on. Potential hydrogen is a basic water quality parameter whereby the biological availability of chemical elements and solubility are determined by it. Therefore, mapping the contemporary condition of groundwater quality in boreholes offers a better management in Windhoek municipal boreholes. Furthermore, Interpolation techniques used provide a platform to accurately predict values at un-sampled points and produce a continuous dataset of spatial distributions. In this research, spatial and Geostatistics analytic tools were used to accurately compare the different interpolation methods based on groundwater spatial pattern in Windhoek, using Arc GIS 10.6. Fifty-five municipal boreholes were selected to assess the groundwater potential hydrogen. Moreover, deterministic interpolation method such as Radial Basic Function, Inverse Distance Weighting and geostatistical interpolation method such as kriging were used in both geostatistical and spatial analysis. Additionally, Empirical Bayesian Kriging was used for geostatistical analysis. The method which shows least average standard error, root mean square standardized error, root mean square error and mean square error was selected as the best method to interpolate the spatial variation for potential hydrogen in boreholes. Geostatistical analytic tool such as the Empirical Bayesian Kriging with linear semivariogram model shows the
least error values compared to Universal Kriging in spatial analytic tool. A conclusion can be made that geostatistical interpolation is a superlative method than the deterministic interpolation method for mapping potential hydrogen in Windhoek Municipal Boreholes.

Keyword

GIS, Boreholes, Groundwater, Interpolation, Kriging

Promoting the equality of research and education in geosciences using 3D digital outcrops: implications of the DDE-Outcrop3D platform

Xia WANG[1]*, Chengdu University of Technology (xiawang@cdut.edu.cn)
Hanting Zhong[2], Chengdu University of Technology
Jianhua Chen[3], Chengdu University of Technology
Zongqi Lin[4], Chengdu University of Technology
Bingqian Wang[5], Chengdu University of Technology
Lingzan Meng[6], Chengdu University of Technology

Abstract

The fundamental activities for research and education in geosciences revolve around fieldwork. However, traditional fieldwork often faces challenges related to outcrop accessibility. On one hand, areas with low investigation levels are typically difficult to access and may pose physical risks to investigators. On the other hand, many geological researchers and educators, particularly those from emerging countries, are confined to regional studies because of the high costs associated with fieldwork in distant areas away from their host institutions. Additionally, regional conflicts or global public health emergencies have notably disrupted day-to-day research and education in geosciences in recent years. These difficulties and challenges have accelerated the development of Virtual Field Trips (VFTs) technology over the past 5-10 years.

Unmanned Aerial Vehicles (UAVs), especially commercial drones equipped with high-resolution cameras, offer cost-effective methods for outcrop investigation. Close-range photogrammetry using UAV-captured images enables the creation of precise three-dimensional models, achieving remarkable centimeter-scale accuracy.

Here, we discuss the possibility of using 3D digital outcrop and open-access online VFTs platforms such as the DDE-Outcrop3D to promote equality in geological research and education. The DDE-Outcrop3D platform (outcrop3d.deep-time.org), a part of the Deep-time Digital Earth (DDE) Big Science Program recognized by the International Union of Geological Sciences (IUGS), provides an open-access web platform for real-scene 3D digital outcrops. Built upon the Cesium open-source 3D earth engine, it facilitates multiple data uploads, sharing, editing, and community outreach. With digital outcrop models from all over the world, it offer a new avenue for scientific research and education.

Keyword

Virtual Field Trips, 3D digital outcrops, Unmanned Aerial Vehicles, photogrammetry

The why and how of seismic and geomechanical approaches for effective reservoir characterization

SHIB SANKAR GANGULI[1]*, CSIR – National Geophysical Research Institute (NGRI)
(ganguli.ism@gmail.com)

Abstract

Reservoir characterization involves the comprehensive exploration of all aspects of a hydrocarbon-bearing reservoir. This entails utilizing highly precise measurements from various sources to optimize its long-term performance. It refers to the application of different geophysical methods and techniques to understand subsurface reservoirs. The data obtained from these techniques help geoscientists and engineers to delineate reservoir boundaries, map structural features, estimate reservoir properties such as porosity and permeability, and monitor fluid movement within the reservoir. Seismic and geomechanical methods are key tools that significantly enhance the accuracy and effectiveness of hydrocarbon reservoir characterization among various techniques. They offer substantial insights into subsurface geology, rock attributes, fluid dynamics, and stress conditions, thereby contributing to the effective monitoring of reservoir performance and mitigating drilling risks, aiding in casing point selection, optimizing recovery rates, and more. This talk will provide an overview of the rationale and methodologies underpinning the use of seismic and geomechanical approaches in the pursuit of achieving effective reservoir characterization with some case examples. The examples will encompass studies from both Indian hydrocarbon-bearing reservoirs and those from around the globe to validate the approaches and discuss the lessons learned from each case. The fundamental components of these methods will also be discussed, with their role in translating data into valuable insights on physical properties and rock stress emphasized for enhanced understanding of hydrocarbon-bearing reservoirs.

Keyword

Reservoir characterization, Geophysics, Seismic, Geomechanics, Stress

Science Diplomacy in Action: Unveiling Opportunities and Challenges – A Case Study of Namibia's Endeavor to Integrate Science and Politics

Martha Ndapandula Haludilu[1]*, YES Network (marthahaludilu@gmail.com)

Abstract

Science diplomacy, the intersection of science, diplomacy, and international relations, has emerged as a critical tool for addressing global challenges and fostering cooperation across borders. This article investigates the role of science diplomacy in Namibia, a middle-income country striving to integrate scientific expertise into national policy and international relations. Namibia is a country with a rich tapestry of natural resources and a commitment to sustainable development, that faces a variety of challenges that span from environmental, health, social, and economic dimensions. Science diplomacy can play a crucial role in navigating these challenges by fostering international collaboration, leveraging scientific expertise, and contributing to evidence-based policy solutions. Namibia's journey offers a unique case study, considering its recent oil discoveries and its ambitious green hydrogen endeavors, both of which necessitate strategic navigation of the complex interplay between science, politics, and diplomacy. This article further expands on how Namibia can leverage science diplomacy to Inform policy decisions and secure international partnerships. However, the article also acknowledges the challenges Namibia might face such as reconciling competing interests, building scientific capacity, and ensuring equitable benefits.

By examining both the opportunities and challenges presented by Namibia's case, the article aims to contribute to a nuanced understanding of the role of science diplomacy in the contemporary world, particularly for developing nations navigating the intersection of resource wealth, environmental sustainability, and international cooperation.

Keyword

Science diplomacy, Policy integration, Sustainable development, Namibia

Erosion, Transport, and Deposition of Microplastics

Ino-Ethandje Thomas[1]*, YES Network Namibia (inothomas9999@gmail.com)

Abstract

Microplastics are increasingly prevalent constituents of beach sediments, yet their fate and transport dynamics in the coastal zone remain uncertain. This experimental study investigated the influence of regular surface waves on the mobilization, transport and deposition of microplastics (190-250*pm*) *mixed with beach sand grains* (80-250*pm*) *on an artificial slope using a recirculating flume. The wave generator created regular waves with stroke lengths of* 100*mm*, 50*mm and* 25*mm, corresponding to wavelengths of* 1.373*m*, 0.990*m and* 0.925*m. Sediment cores extracted before and after each run were analyzed via microscopic particle counting to quantify changes in microplastic distribution. Under high energy waves* (100 *mm stroke*, 0.324*m/s max orbital velocity*), *microplastics exhibited significant vertical transport, with surface enrichment up to* 93.3% *compared to* 18.2% *initially. Moderate energy waves* (50*mm stroke-length*) *displayed variable mixing patterns dependent on sediment size. Low energy waves* (25*mm stroke-length*) *showed negligible alteration of microplastic distribution. High energy waves generated vortex ripples that promote mixing and suspension, mobilizing microplastics buried deeper in sediments. Low energy waves produced rolling grain ripples that limit microplastic entrainment. This study reveals that episodic high-energy storm waves can potentially remobilize microplastics buried in beach sediments and enhance their landward transport, as evident by the up-wave migration of surface MP as well as the upward core MP enrichment. The results have implications for modelling microplastic fate and transport in the dynamic coastal zone.*

Keyword

Microplastics, Beach Sediments, Coastal Transport, Wave Energy, Sediment Cores

The subsurface of Valencia. Conceptualization and 3D high-resolution model.

ARIADNA CALLEA[1]*, UNIVERSITAT POLITÈCNICA DE VALÈNCIA.DEPARTAMENTO DE HIDRÁULICA Y MEDIO AMBIENTE. IIAMA. HIDROGEOLOGÍA (arcal@cam.upv.es)
PATRICIO VILLAFAÑE[2], UNIVERSITAT DE VALÈNCIA
CARLOS SANTIESTEBAN BOVÉ[3], UNIVERSITAT DE VALÈNCIA
JUAN BAUTISTA GUMBAU BELLMUNT[4], EVREN Evaluación de Recursos Naturales SLP
EDUARDO CASSIRAGA[5], UNIVERSITAT POLITÈCNICA DE VALÈNCIA.DEPARTAMENTO DE HIDRÁULICA Y MEDIO AMBIENTE. IIAMA. HIDROGEOLOGÍA

Abstract

The lack of detailed information and studies about the subsurface configuration in the city of Valencia, located in the alluvial fan formed by the mouth of the Turia River into the Mediterranean Sea poses significant challenges in the execution of civil and urban projects, especially in the central area where the works reach greater complexity. To date, most studies have focused on superficial geotechnical or sedimentological aspects, providing a limited understanding of the horizontal and lateral changes in sedimentary facies characteristic of alluvial environments.

In order to address this issue, this work aims to develop a high-resolution model of the first section (50 meters) of the subsurface in a central area of the city, detailing the facies that compose it and the architectural interrelation between them. The implemented methodology included a thorough collection of geological and geotechnical data, followed by drilling in the area of interest that provided direct lithological information from the subsurface. The sedimentological, stratigraphic, and paleoenvironmental interpretation of these drillings allowed for a correlation and a 3D reconstruction of the subsurface.

The result is a high-resolution model that exhibits sedimentary facies such as silt-clay, beach sands, lobes, and conglomeratic channels, clearly expressing their architecture and highlighting their vertical and horizontal heterogeneity. This study set the stays for a deeper understanding of the Valencia subsurface, providing a valuable tool for planning and executing future projects in the region.

Keyword

Valencia, subsurface, high-resolution model, alluvial fan, sedimentary facies

PETROGRAPHIC CHARACTERIZATION AND DIAGENESIS OF CARBONATE ROCKS IN THE NAMA BASIN OF SOUTHERN NAMIBIA: IMPLICATION AS VALUABLE RESOURCES.

Sam Shihafeleni SHANGHETA[1]*, University of Namibia - Rosh Pinah Zinc
(semashangheta45@gmail.com)
Collen-Issia Uahengo[2], University of Namibia

Abstract

The Nama Basin in Southern Namibia hosts a significant repository of Ediacaran Nama Group carbonate rocks with substantial potential as valuable resources. This study presents a comprehensive petrographic characterization and diagenetic analysis of carbonate rocks within the basin to understand their composition, structure, and evolution. Petrographic examinations of samples from areas of study revealed diverse lithologies including limestone (light grey, dark grey; calcite and quartz veins-rich limestones), dolomite also referred to as dolostone in some cases (light grey, magnesium-rich dolomites), and various cement phases. Colour alternations observed in the limestone samples indicate changes in microbial activity during the deposition of the limestone. The diagenetic processes such as dolomitization, cementation, and dissolution are identified as one of the key factors shaping the reservoir quality and porosity-permeability characteristics of these rocks. From one of the study's aims, determining the mineralogy and major constituents of the carbonate rocks, classify them according to the Dunham (1962)'s and Folk (1962)'s carbonate classification schemes, five (5) carbonate facies were identified and classified. Namely, crystalline limestone, biomicritic limestone, micritic limestone, planar dolostone and micritic dolostone. Their geochemical analysis indicated (Ca >20%) and (Mg >1%) as the major Understanding the diagenetic history is crucial for assessing the reservoir potential and predicting the distribution of valuable resources such as hydrocarbons and groundwater. Moreover, insights gained from this study contribute to refining exploration and exploitation strategies in the Nama Basin, facilitating sustainable utilization of its geological assets for economic development.

Keyword

Southern Namibia, Nama Basin, Carbonates, Petrography, Economic viability

Re-assessing late Holocene Lake level fluctuations in Lago Cardiel, Southern Patagonia (Argentina) – Geomorphological and archeological implications.

Luis Rubén Horta[1]*, CONICET - UNT (hluisth@csnat.unt.edu.ar)
Micaela Della Vedova[2], CONICET
Rafael Goñi[3], INAPL
Patricio Guillermo Villafañe[4], Universitat de Valencia
Juan Dellepiane[5], INAPL
Daniel Ariztegui [6], Université de Genéve

Abstract

Lake level variations in closed basins provide us with an excellent opportunity to reconstruct past climates at various time scales. In this contribution we present new data from the area known as "Patito Destapado (PD)" that allow to refine the existing Late Holocene fluctuations of Lago Cardiel (Santa Cruz province, Argentinean Patagonia). We aim to reconstruct the paleogeographic evolution of the region during this period and its implications for the regional paleoenvironment and, consequently, for the mobility of the hunter-gatherer populations during this time.

Well-dated microbialite levels containing gastropods are used as proxy to reconstruct Upper Holocene paleoenvironmental changes in a peninsula along the northern coast of the lake (PD). Four microbialite levels were identified, alternating with deposits of coarse sand and gravel at 288, 289, 294, and 295 m.a.s.l., respectively. The lowermost level (288 m.a.s.l) has been dated between 2087±21 years BP, while the microbialites located at 294 m.a.s.l. delivered an age of varying between 3327±26 years BP. The uppermost level (289 m.a.s.l) overlays the archaeological PD site which was dated between 3015±31 yr BP (M4) and 3436±35 cal yr BP (M10). The gastropods contained in the microbialite levels belong to the families Lymnaeidae (Lymnaea diaphana) and Chilinidae (Chilina sp.).

A more detailed paleohydrological reconstruction of the region is proposed based on the elevations of the microbialites that are witnessing changes in moisture. They indicate intervals of stability or drought, alternating with other of higher humidity characterized by clastic deposits instead. Changes in the position of lacustrine shorelines over time have created new areas available for both circulation and human occupation. The latter is consistent with the archeological component of the site containing a bone assemblage of guanaco (Lama guanicoe) indicative of hunting and further processing activities. Thus, the combined paleoenvironmental and archeological data of this site is providing new clues about the dynamic of Late Holocene human population for this area of Patagonia.

Keyword

Late Holocene, Patagonia, Lake Fluctuations, Lake Fluctuations, Archaeology

Neoichnology in Salar de Antofalla, Catamarca province, Argentina: a study case of Diptera living in an extreme environment

Gabriel Ricardo LÓPEZ ISLA[1]*, INSUGEO-CONICET (gabrielopezisla@gmail.com)
Patricio Guillermo Villafañe[2], GIUV2016-303, Departament de Botànica i Geologia, Universitat de València, Calle Dr. Moliner 50, 46100, Burjassot, Valencia, España
Noelia Maza[3], Noelia Maza, Cátedra de Zoología Agrícola, Facultad de Agronomía, Zootecnia y Veterinaria, Universidad Nacional de Tucumán. Av. Roca 1900, Tucumán, Argentina.
Silvina de Valais[4], Instituto de Investigación en Paleobiología y Geología (IIPG; UNRN-CONICET), Av. Roca 1242, General Roca 8332, Río Negro, Argentina.
Luis Horta[5], Instituto Superior de Correlación Geológica (INSUGEO), Av. Presidente Perón S/N, Yerba Buena CP 4107, Tucumán, Argentina.
Ignacio Díaz-Martínez[6], Departamento de Ciencias de la Tierra y Física de la Materia Condensada, Facultad de Ciencias, Universidad de Cantabria, Santander 39005, Cantabria, España.

Abstract

Andean Microbial Systems (AMS) in the Puna region represent an invaluable resource for scientific research. Their ecosystems have promoted significant interest in astrobiological studies and the origin of life, given that the microorganisms thrive in one of the most extreme conditions of the planet. Many of the organisms within these ecosystems give rise to organosedimentary structures that are preserved in the geological record. However, there are a lack of studies on this area regarding the interaction between these structures and metazoans, thus opening an important window to understand biogenic structures associated with the presence of microbialites. The aim of this contribution is to present a study on the relationship between ephydrid flies and MISS found on the margins of Laguna Verde, within the Antofalla Salt Flat, Catamarca province, Argentina. Ephydrid flies (Diptera), also known as shore flies, are adapted to live near water bodies in extreme conditions, including saline and acidic, in benthic and marginal zones, generating a particular interaction with microbial mats. Diverse studies carried out in the Mediterranean Sea and western USA, from Cenozoic to current times, deal with the life strategies of ephydrid larvaes in MISS conditions. In general terms, the first phases of the life cycle of ephydrid flies include a microscopic, non-mobile egg, followed by three larval stages, with the third-stage larva reaching pupal size. The pupa, a stage of quiescence, remains unchanged in size once the larva enters its inactive period. During the larval stages, different types of traces, such as channels, can be left behind, while the pupa only leaves a trace where it was deposited.

The saline soil exhibits different typical surface characteristics of marginal areas, such as desiccation polygons, gas escape structures, and thin layer of stagnant surface water. Four samples of microbial mats were taken, each covered by about 5 cm wide layers consisting of endoevaporitic deposits. The MISS is characterized, from top to bottom in cross-section, by layers of gypsum and sulfates, a green layer of cyanobacteria, an orange layer containing of sulfur photosynthetic bacteria, and a black anoxic layer. Larvae and pupae of ephydrid flies live immersed in the oxic layers of this MISS. Single burrows associated with fly activities, such as escaping or feeding, were identified. They are perpendicular to the stratification, with no

bifurcations or constructed walls, with a variable diameter between 1 mm to 2.5 mm, associated with the diameter of the pupal stage (mean diameter: 1.45 ± 0.03 mm (with a range of 1.18 to 1.64; n=16).
This study explores the dynamics of the community associated to a very extreme environment. However, further studies are necessary to understand the complete life cycle of ephydrid flies in this kind of MISS. This will provide information about the composition of fossil evaporitic lacustrine basin deposits, expand our understanding about the ecology of extreme environments and supply fundamental information for the conservation and management of these unique and fragile environments.

Keyword

Neoichnology, Diptera, Extreme environments, Microbial mats

DECIPHERING THE LIMITS OF HABITABILITY: GEOSPATIAL ANALYSIS OF ANDEAN MICROBIALITIC SYSTEMS AS ANALOGUES FOR THE SEARCH FOR LIFE ON MARS.

Micaela DELLA VEDOVA[1]*, Instituto Superior de Correlación Geológica (INSUGEO), CONICET- UNT, Tucumán, Argentina (micaeladvedova@gmail.com)
Patricio Guillermo Villafañe[2], PVC-GIUV, Department of Botany and Geology, Universitat de València, València, España
Francisco Javier Ruiz Sanchez[3], PVC-GIUV, Department of Botany and Geology, Universitat de València, València, España

Abstract

Since the first Mars missions in the 1960s to the most recent projects, the identification of paleoenvironments with high potential to preserve evidence of biological activity has become a priority. However, aspects such as the validation of instruments and detection methods, comparison with obtained data, and the modeling of geological and biological processes make it imperative to complement studies conducted in the Martian record with terrestrial analogs.

Microbialites are often studied when discussing the origin of life on Earth. Thus, microbial systems developing in various lakes and wetlands of the Central Andes are of interest for astrobiological studies due to their development under extreme environmental and climatic conditions. Despite the diversity of organo-sedimentary structures and producer microorganisms they comprise, these systems share geological and chemical characteristics such as formation in water bodies with high evaporation rates, association with areas with meteoric water input, and their relation to volcanic environments. Therefore, studying the components of these systems will help expand our knowledge of the types of environments that could harbor life on other celestial bodies.

This work presents the study and comparison among the elements of three microbial systems in the Central Andes: i) Laguna El Peinado, ii) Laguna Verde, and iii) Laguna Carachi-Pampa. The combination and interrelation of satellite images, analyzed using geoprocessing software, along with data obtained from chemical and petrographic studies, have allowed the identification of patterns and trends explaining the presence of microbialites. Alluvial fans, volcanic cones, basic volcanic lithologies, hydrothermal input points, physicochemical water conditions, and depth of occurrence are some of the parameters quantified and modeled in this work. The comparison and processing of the obtained information provide a new tool to understand the limits of habitability and the conditions under which life can survive and thrive, allowing for the adjustment of current life search strategies.

Keyword

Holocene Microbialites, Earth Analogs, Mars Environments

Geochemical, isotopic, and mineralogical study of Vega Verde travertine system, central Andes -Argentina.

Guido Ezequiel Ezequiel Alonso[1]*, Instituto Laboratório de Análise de Minerais e Rochas (ILAMIR), Programa de Pós-Graduação em Geologia, Universidade Federal do Paraná (UFPR). Avenida Cel. Francisco. H. dos Santos 100, 81530-000 Curitiba, Paraná, Brazil. (guido.alonso@ufpr.br)
Tatiana Mariel Stepanenko[2], Instituto Laboratório de Análise de Minerais e Rochas (ILAMIR), Programa de Pós-Graduação em Geologia, Universidade Federal do Paraná (UFPR). Avenida Cel. Francisco. H. dos Santos 100, 81530-000 Curitiba, Paraná, Brazil.
Leonardo Cury[3], Instituto Laboratório de Análise de Minerais e Rochas (ILAMIR), Programa de Pós-Graduação em Geologia, Universidade Federal do Paraná (UFPR). Avenida Cel. Francisco. H. dos Santos 100, 81530-000 Curitiba, Paraná, Brazil.

Abstract

Travertines are continental carbonate chemical sedimentary rocks; their precipitation occurs from a Ca-rich bicarbonate fluid mainly triggered by degassing or evasion of CO2 gas from the system upon contact with the atmosphere. These rocks create favorable situations for the proliferation of benthic microbial communities, which can influence the genesis of travertine and/or its final form. The study of these systems has acquired relevance in the last decade due to their importance in local hydrology and the development of microbial ecosystems, besides the fact that they are considered important reservoir rocks in the Pre-salt play of Brazil and Angola. In this case study, we made a geochemical and mineralogical analysis of the Vega Verde travertine system located in Botijuela at the western margin of the Salar de Antofalla in the central Andes of Argentina. The methodology involved descriptions of sedimentology, petrography, analyses by X-ray diffraction (XRD), X-ray fluorescence (XRF), and stable isotopes of δ13C and δ18O (V-DPB) and SEM analyses with EDS. The system is developed in a NW-SE 570-meter-long and 50-meter-wide valley at 4000m above sea level, surrounded by Tertiary volcanic materials ending in the Salar de Antofalla basin. The proximal depositional zone is characterized by a 15-meter-high fossil vent conical mound composed of redish-brownish carbonate massive mudstone facies with bubbles, botryoids, shrubs, and goethite identified in some spots. The intermediate area presents laminated mudstones with 2–6 cm pools and oncoidal and intraclast rudstone/grainstone facies. The distal area is characterized by rudstones and grainstones with karst features intercalated with sandstone facies. Mineralogically, the system is mainly calcite (d-spacing ~ 3.038) and impure calcite, with CaO ~ 51.05% and a loss of ignition of ~46.63%. Stable isotope signatures are δ13C (1.97–10.84) and δ18O (-0.67–-8.91). SEM and EDS image analyses showed the presence of pure calcite and Fe-bearing calcite (impure calcite) in those samples, as well as Fe-bearing clays. Data analysis shows a correlation of Fe2O3 with CaO of R2=0.86 in the vent area. Geochemical and stable isotope analyses suggest an hypogene source contribution. The Fe2O3 and As content in all the systems has an R2 of 0.96, suggesting that FeOH acts as a preferential scavenger of As, as well as other metals like Cu and Zn. Acidic to slightly acidic pH in subterranean water would cause the

dissolution of metals such as Fe, As, Cu, and Zn in the surrounding igneous rocks. The Fe2+ in solution, upon contact with the atmosphere, would precipitate ferrihydrite, with further transformation to goethite, and some of it would also be included as impurities in the calcite. The data analyzed suggest that there is a geochemical halo of Fe-bearing calcite, whose highest concentration is located in the fossil vent of the proximal depositional zone and is gradually decreasing towards the intermediate and distal depositional zones. High-resolution facies analysis of travertine systems and the integration of chemistry and mineralogy data constitute a step forward in the understanding of the evolution and geochemical-faciological distribution of these deposits as well as their origin.

Keyword

carbonate, precipitate, Fe-bearing calcite, halo

Heritage Stones, and their cultural and historical legacy in the Indian subcontinent

VINOD KUMAR SHARMA[1]*, Geological Survey of India (vksharma_gsi@yahoo.co.in)

Abstract

Stones have played a significant role in shaping cultural and social legacy in Indian Subcontinent. Building stones (decorative stone and dimension stone) have been documented as one of the heritage features that describe the cultural, historical, architectural, and artistic legacy of the Subcontinent. Ancient Indian artifacts and stone tools have greatly reflected the innovation and adaptability of early human societies. Different types of stones like flint, quartzite, and chert were used to make these tools. These tools provide a glimpse into prehistoric ancestors' daily activities, survival strategies, and cultural practices. The legacy of stones in India is vast and deeply intertwined with the country's rich history and diverse culture.

Stone played a major role in the Indus Valley civilization or Harappan material culture. During the period intricate handicrafts, especially using products made of the semi-precious gemstone Carnelian have been duly recorded. The best-known artifacts of the Indus civilization are small seals, generally cut from steatite (soapstone), Despite the abundance of stone artifacts, stone sculpture is extremely rare in the Indus Valley Civilization.

The Buddhist architecture comprises many stupas using natural stones with elegantly carved gateways, rock-cut caves, stone pillars, and polished sculptures of sandstones largely using the Vindhyan Supergroup of rocks. Buddhist cave monuments built in Ajanta and Ellora caves are cut into the face of a mountain of Deccan Basalts Province and form unique artistic traditions of rock-cut temples, which are a testament to the artistic and architectural expertise of ancient India.

The grandest achievement of the artistic and architectural genius is the Sun temple at Konark is a vast and wonderful structure, magnificently conceived as a gigantic chariot carved in Khondalite. The Lingaraja temple is perhaps the most marvelous temple erected in the 10th century, the grandest and the loftiest marking the culmination of the architectural activities in Orrisa.

Khajuraho Group of Monuments built between the 9th and 10th Century by the Chandela dynasty in central India, are known for their Nagara-style architecture and intricate carvings in sandstone that depict various aspects of life, including gods, goddesses, animals, musicians, dancers, and monolithic structures, are also famous for their erotic sculptures.

Hoysalas ensembles of temples are veritable treasure houses of ornamental and decorative elements, carved in niches, and intricate vegetal and floral carvings reveal the cultural opulence during the period.

Indo-Islamic architecture of the 12th century started new experiments with stones, ornamental, and semi-precious stones. As the entire work was carried out by native Indian craftsmen, the ornamentation of the screens shows typical Hindu decorative floral elements. The bulk of Indo-Islamic structures, Monuments, and temples used sandstones of the Vindhyan Supergroup, and Marble from the Delhi Supergroup as dimensional and ornamental stones.

The stone usage grew with the development of a social and cultural ethos, opulence, and skills of the societies through the ages. The application of natural stones has developed over time. Preservation of heritage stones is, thus, vital for safeguarding our cultural and social legacy, as these rocks represent historical significance, architectural style, and cultural identity.

Keyword

heritage stone, Indian Subcontinent, stone legacy, stone architecture

Trail of Heritage Stones along the trade routes through the ages

Angela EHLING[1]*, Federal Institute for Geosciences and Natural Resources
(angela.ehling@bgr.de)
Angela Ehling[2], Federal Institute for Geosciences and Natural Resources

Abstract

People were trading very early on in their history. Despite their weight, stones were also transported and traded along trade routes within or between empires. For special uses and representative purposes, even over long distances. In early times, trade routes were based on rivers and geographical features, and in modern times on the development of means of transport.

There are already examples from the Stone Age with the evidence of flint, amber and marble trading in Europe. Trading stones for building purposes is linked to the emergence of great empires and their representative buildings. In ancient times, there was lively trade around the Mediterranean. This is evidenced by the buildings in ancient Greece and in the cities of the Roman Empire.

One example is the Afyon Marble in Turkey. Afyon, in Greek and Roman times Akroinon, was located at the intersection of important caravan routes. The marble was probably already mined by the Phrygians (around 800 BC), later then by the Greeks and above all by the Romans. Especially the purplish-red coloured varieties that were popular at that time were transported to the port of Ephesus and sent to many Roman cities around the Mediterranean Sea. The last heyday of its use was in the Byzantine Empire (Hagia Sophia).

Other famous (Heritage) stones of Antique times are the Red and Green Porphyry (Egypt and Greek), Greek Marble, Verde Antico Serpentinite (Greek), Egypt Alabaster, Giallo Antico Marble (Tunesia), as well as Carrara Marble (Italy).

The stone trade in the Middle Ages in Europe is evidenced in the churches and castles from this period. Main transport routes were along the rivers. One example is the Solnhofen Limestone which was transported along the river Danube for flooring churches and palaces.

Trade organizations like the Hanseatic League in Europe plaid an important role for the distribution of stones in the Middle Ages. Along their trading routes, stones like the Kolmarden Marble (Sweden), Gotland Limestones, German sandstones, English Alabster had been transported and used throughout Europe.

With the rise of trade routes on the world's oceans, stones often have been transported as ballast. The famous Welsh slate found distribution throughout the British Empire as far as New Zealand. Stones from Portugal (Estremoz Marble, Lioz Limestone, Brecha da Arrabida), Spain and Italy were sent to South America since the 17th century.

Heritage Stones in big countries like the Makrana Marble in India or the Tennessee Marble in the USA had and have a wide distribution, even if they were only used within the country.

Today, there is an intensive natural stone trade across the world's oceans, especially from China, India and Brasil.

Keyword

heritage stone, dimensions stones, stone transport

Portuguese limestones from the Middle Jurassic of the MCE candidate for heritage stone

Luis LOPES[1]*, University of Évora and Earth Sciences Institute, Portugal (lopes@uevora.pt)
Jorge Carvalho[2], LNEG - National Laboratory of Energy and Geology, Portugal

Abstract

The Monastery of Alcobaça (1152 AD), the Convent of Christ in Tomar (1160 AD) and the Monastery of Batalha (1386 AD), are classified as UNESCO World Heritage Sites, having in common the construction materials that built them - Limestones from the Middle Jurassic of the Estremenho Limestone Massif (MCE). The use of these rocks, first as a structural element and later as an ornamental rock, continues today.

In fact, considering the volumes of ornamental rock exploited in Portugal, these rocks have the highest values and are exported annually to more than a hundred countries, playing a decisive role in placing Portugal in the top ten world exporters of ornamental rocks.

Naturally, as they are sedimentary rocks deposited in a basin in distension in the Middle Jurassic – the Lusitanian Basin, they denote lateral and vertical facies variations that translate into variations in texture and colour in the limestones that correspond to the commercial varieties offered by dozens of companies that explore, process and sell them. Note, however, that colour variations are also conditioned by subsequent meteoric changes when, in some way, the rocks encounter the atmosphere and/or fracture zones with water circulation. These variations are evident in the dozens of active quarries, and it is common for the same rock to vary in colour from place to place and, for this reason, to be sold with different names depending on the colour, for example "Ataíja Beije" and "Ataíja Azul ".

It is important to note that because companies are obliged to comply with the most demanding product characterization and certification standards, for each of the varieties offered there is a very complete technical sheet that defends both the supplier and the buyer. Furthermore, the main commercial varieties of limestone from the Middle Jurassic of the MCE are included in the Database of Portuguese Ornamental Rocks published by LNEG (https://geoportal.lneg.pt/en/databases/rop/).

The MCE Middle Jurassic Limestones, in use for over eight hundred years, meet all terms of reference to be classified as a Heritage Stone by the IUGS Commission on Heritage.

Keyword

Middle Jurassic Limestone, Dimension Stone, Natural Stone, Heritage Stone, MCE Portugal

A new look at the geology collections of the National museum of natural history - Paris, heritage stones from buildings or sites

Grégoire EGOROFF[1]*, Muséum National d'Histoire Naturelle - Paris (gregoire.egoroff@mnhn.fr)
Pierre Sans-Jofre[2], Muséum National d'Histoire Naturelle - Paris
Caroline Noyes[3], Muséum National d'Histoire Naturelle - Paris
Elisabeth Nicot[4], Muséum National d'Histoire Naturelle - Paris
Isabelle Rouget[5], Muséum National d'Histoire Naturelle - Paris

Abstract

In France, many heritage conservation projects involve the restoration of historic monuments. A recent example is the Notre Dame Cathedral in Paris, which suffered a fire in 2019 whose damage necessitated a major replacement of stones. This iconic project has highlighted the need to find or conserve samples of stones who are coming from historical buildings, quarries or emblematic construction sites, and to make their data available. Comparative collections are essential for finding good substitute equivalents when the sites of origin are depleted. This context has prompted specific work on the collections of the French National museum of natural history – Paris, where it was known that samples of construction rock existed but had been neglected. Indeed, since the 19th century, geologists at the Museum have enriched its geological collections, either by receiving donations from national monuments or by collecting samples from large-scale construction site. Until now, this material had been overlooked and the lack of digitized inventory of such collections hindered their use in research and restoration work.

Since 2022, a work has been carried out to find samples of building stone from among the hundreds of thousands of rocks in the geology collections.

This has led to the discoveries of several hundred building stone samples collected from 19th to 20th century. Some come from construction sites, such as the Paris metro or historic hydrological boreholes while other were collected in quarries. We have also discovered a large number of rocks from monument such as the tomb of Emperor Napoleon 1st. All these samples have collection numbers and associated information in a paper catalog, but no computerization had been done until now.

Today, part of these stones has been cleaned and digitally recorded. This step is the prerequisite for scientific use and dissemination.

We present here an overview of the contents of this "building stone" collection at the French National museum of natural history - Paris, illustrating the variety of rocks used and the historical and cultural evidence they provide. We show that it can be used for research, the history of science and archaeology and support applications for the IUGS "Heritage Stone" designation.

Keyword

heritage stones, database, collection

Cultural and Social Legacy of Alpedrete Granite Heritage Stone

David Martín FREIRE-LISTA[1]*, Universidade de Trás-os-Montes e Alto Douro, UTAD, Departmento de Geologia, Quinta de Prados, 5001-801 Vila Real, Portugal. Centro de Geociências da Universidade de Coimbra, CGeo (davidfreire@utad.pt)
Rafael Fort[2], Instituto de Geociencias IGEO (CSIC, UCM) Spanish. Research Council CSIC—Complutense University of Madrid. UCM, 28040 Madrid, Spain
María José Varas-Muriel[3], School of Geology. Complutense University of Madrid UCM. 28040 Madrid, Spain

Abstract

The traditional building stones are part of cities and villages tangible and intangible heritage. Their conservation is essential to maintaining the integrity of their historical centres. For the conservation and valuation of built heritage to attain optimal results, it is necessary to articulate them considering cultural, social and economic factors, in addition to lithological aspects, such as of petrography, durability, and quality. Therefore, a multidisciplinary team with broad inclusion criteria is necessary. Variables such as rarity, accessibility, demand and territorial insertion of each asset must be considered when designing a conservation and appreciation strategy. The diagnosis of the state of conservation and the analysis of the conditions in which the building stone under analysis is located is essential to define how to intervene. A multidisciplinary heritage appreciation methodology must consider the perception of different actors about a certain asset, evaluating the viability, problems inherent to the asset, and the objectives of national and European policies. For the dissemination of the asset to have the appropriate response, the link between heritage and its significance for the public to which it is directed must be studied and defined correctly.

Alpedrete granite was designated Heritage Stone in 2019. It is the main traditional building granite of Madrid (Freire-Lista et al. 2015). It has particular relevance in the "Landscape of Light" UNESCO World Heritage Site declared in July 2021 in the category of Cultural Landscape. "Landscape of Light" is made up of Paseo del Prado (between Plaza de Cibeles and Plaza de Carlos V), El Retiro Park and the Jerónimos neighbourhood of Madrid where the silver Alpedrete granite gives luminosity to the monuments. Alpedrete granite is a monzogranite quarried in the Sierra de Guadarrana (Spanish Central System) foothills in and around Alpedrete, in the province of Madrid, Spain. Used as a building material since prehistory, Alpedrete and the surrounding region are characterised by a quarrying culture that has been maintained for centuries. The area is strewn with historic quarries, along with the one presently in operation. Traditional stone cutters who produce hand-finished granite ashlars are still to be found, while others use more modern techniques to achieve new types of products. Representative monuments including Royal Palace of Madrid, Alcalá Gate and the National Library owe their good conservation state largely to the petrophysical properties and durability of Alpedrete granite. In addition to its use in a substantial number of heritage buildings in Madrid, this stone is also found in most of the city's housing, urban furniture, and nearly all the rural architecture in the Alpedrete area.

This work was financed by A Fundação para a Ciência e a Tecnologia of Portugal (FCT), under the project with the reference CEECIND/03568/2017; [UIDB/00073/2020] projects of the I, D unit Geosciences Centre (CGEO) of Coimbra University (Portugal) and Community of Madrid programme (TOP Heritage-CM, P2018/NMT-4372).

Freire-Lista, D.M., Fort, R., Varas-Muriel, M.J., 2015. Alpedrete granite (Spain). A nomination for the “Global Heritage Stone Resource” designation. Episodes. 38 (2):106-113. https://doi.org/10.18814/epiiugs/2015/v38i2/006.

Keyword

Heritage Stone, Historical quarries, Conservation, Decay

Geoheritage value of the Fonte Fenix and the Boca de Vaca springs from Panjim: hidden jewels from Goa, India

Vrushali Vilas Dumale[1], Department of Environmental Sciences, Savitribai Phule Pune University, Pune 411007 India
Hemant B Pednekar[2], Department of Geology, Savitribai Phule Pune University, Pune 411007
Raymond Ashirwad DURAISWAMI[3]*, Department of Environmental Sciences, Savitribai Phule Pune University, Pune 411007 (raduraiswami@gmail.com)

Abstract

The Portuguese constructed several churches, chapels, educational institutions, hospitals, roads, bridges, drainage systems, etc. in Goa some such as the Basilica of Bom Jesus, Sé Catedral de Santa Catarina, Church of Saint Augustine, Saint Catherine's Chapel, Church of St. Francis of Assisi, Church of Our Lady of the Rosary, Church of Saint Cajetan that have been designated as UNESCO World heritage sites. Besides these grand sites, the Boca de Vaca spring (1830) and the Fonte Fenix spring (1851-1855) are two very important springs constructed during the Portuguese era as water supply sources for the Panjim city. In this paper, we describe the hydrogeology, architecture and geoheritage of these important springs present on the lateritic Altinho hill in Panjim. The springs are perennial and are in use even today. The Fonte Fenix spring was built as a three-tiered structure with semi-circular arched openings and doorways leads to an underground tunnel. The water in the channel is kept fresh and ventilated by a series of three domed air vents. Steps made from basalt rock lead down to the water source. Earlier, the fountain sported a phoenix which was symbolically destroyed during the Goa liberation. Fontainas neighbourhood, with its brightly coloured alleys, infrastructure development, and lavish houses of bureaucrats is named after the popular Fonte Phoenix spring. Recently, a painting exhibition was held inside the tunnel to promote conservation of spring during the 2022 Ganesh Festival.

The Boca de Vaca (Cow's Mouth) or the Fonte Cabeca de Vaca (Cow's Head) is a spring complex with at least two sprouts and collectively has a higher discharge than the Fonte Fenix and is the most important spring providing drinking water to the public. The spring eventually formed a natural cavern and was fitted with a granitic GOMUKH (face of cow) in an arch-type open structure called Fonte Cabeca de Vaca. Later (in 1851-1855), the horseshoe shaped tunnel complex (95 m long, 2.4 m high and 1.83 m in diameter) was built using laterite and lime-surki (mortar) around the Gomukh and re-named as Boca-de-Vaca. Some efforts to conserve and promote this site as a tourist spot was undertaken by the Goa Tourism Development Corporation limited (GTDCl). The springs described in this paper are important geoheritage sites within the limits of the Panjim city. They need to be promoted as archetypes of several other springs in Goa and need to be protected as cultural citadels of the past and as alternative sustainable water sources for the future generations.

Keyword

Geoheritage, Fonte Fenix spring, Boca de Vaca spring, Fontainas, Goa, India

A New Approach to Key Mineral Analysis for Tracking the Provenance of Stone Heritage

Myoungju CHOIE[1]*, National Research Institute of Cultural Heritage, Republic of Korea (mjchoie@gmail.com)
Myeong Seong LEE[2], National Research Institute of Cultural Heritage, Republic of Korea

Abstract

80% of the Korean peninsula consists of mountainous terrain, and as such, the notions of Baesan Imsu (mountain in the back and a river in the front) and Jusan (main mountain) were traditionally appealed to when deciding on the locations of villages and capitals throughout the Bronze and Middle ages. Therefore, Korea's topography and geology are significantly related to the stone heritage of the Korean peninsula insofar as they determine the locations and building materials selected by ancient people. In particular, the 'tumulus', a building that played an important role in the funeral culture and practices of the ruling class, provides an excellent example of ancient material selection, given that these structures are built of durable material.

The stone team of the NRICH, is focused on interpreting ancient quarry sites through geochemical analysis and understanding the stone selection techniques practised by ancient people. However, the area associated with the monuments could have been a simple rock type of single magma origin and was created at a similar time or has been a complex geological setting due to several metamorphic processes over a long time. In this case, the researchers, therefore, had to limit the tracking of quarry sites using only the whole rock geochemical composition method because there are not enough geochemistry indication factors.

This study was conducted to identify the specific quarry site of the two tombs in South Korea using key minerals and explore and apply analytical methods to secure distinction factors. To assess the feasibility of this research method, we located two tombs in South Korea, one situated in a simple geological setting and the other in a complex setting.

The first tomb selected for the study is the 'Twin Tombs' (early 7c), a royal tomb constructed during the Sabi period of Baekja, Iksan. It is constructed on and from Mesozoic granite, which has a simple geochemical composition of a single batholith, which makes it a durable, attractive, and thus desirable material even by modern construction standards. Titanite was chosen as the key mineral of interest in this study and was analyzed using FE-EMPA and LA-ICP-MS analysis methods to yield data on its REE composition.

The second tomb selected for the study is tomb No. 28-1 (5c), the largest among the Jangsu tumulus tombs, Gaya period; it is constructed of Precambrian gneiss in Jangsu, which has a heterogeneous geochemical composition and various lithofacies, despite being situated within a rock body. In this case, the key mineral of interest, zircon, was found within the Precambrian gneiss, and the location of the quarry site was interpreted using the U/Pb dating method with SEM-CL and SHRIMP analysis methods.

In these two study cases, the key mineral analysis method was shown to be able to obtain data

about the age of rocks, chemical changes in the magma chamber, and metamorphic events for interpretation of ancient quarry sites and tumuli, thus demonstrating it to be a practical approach for evaluating the mutual geochemical similarity of the stone from monuments and specific outcrops.

Keyword

Stone heritage, Ancient quarry site, Key mineral, LA-ICP-MS, SHRIMP

The natural stones of the cemeteries in the PNDO (Ardennes, Wallonia, Belgium): a geoheritage approach linking geodiversity and biodiversity

Xavier DEVLEESCHOUWER[1]*, Institute of Natural Sciences, Geological Survey of Belgium (xdevleeschouwer@naturalsciences.be)
Tiago Basyn[2], Université Libre de Bruxelles
Géraldine Maulet[3], Institute of Natural Sciences
Nadine Mattielli[4], Université Libre de Bruxelles, DGES

Abstract

The "Parc Naturel des Deux Ourthes - PNDO" is a natural park situated in the northeastern region of the Province of Luxembourg within Wallonia, Belgium. Covering a sprawling 76,000 hectares across six districts from Gouvy in the east to Tenneville in the west, it is home to approximately 25,000 inhabitants. The park encompasses the alluvial valleys of the Ourthe rivers, which cut through the highest plateaus of the Ardennes, reaching altitudes of 600 meters, while the lowest points sit around 210 meters.

Throughout the villages within the park, one can find historic churches accompanied by ancient churchyards. These churchyards typically house weathered gravestones and ledger stones, scattered amidst the grass. Dating back to the 19th century, these churchyards contrast with the modern cemeteries established on the outskirts of the villages during the 20th century.

During the 19th century, gravestones and ledgers were predominantly crafted from locally sourced rocks, often extracted from nearby quarries. Within the PNDO, many of these old gravestones and ledgers are fashioned from two types of Ordovician phyllites. The thicker slabs, exhibiting a purplish hue, originate from the Ottré Formation, primarily from the Colanhan and Les Plattes Members. In contrast, thinner slabs, characterized by dark grey to black tones, hail from the Ordovician Jalhay Formation, predating their purplish counterparts. The "Les Plattes" Member is renowned for its coticule layers and the dark black slates of Vielsalm. Coticule, a metamorphic and sedimentary rock, is notable for its fine-grained texture and contains approximately 35-40% small spessartine garnets.

Since the late 19th century, the primary material for graveyards shifted to a Belgian rock known as blue Petit Granit, sourced from numerous quarries across Wallonia. In the 20th century, ornamental stones from various global locations became prevalent in modern cemeteries, marking a transition from local to diverse stone selections for graveyards.

The ongoing project led by the Institute of Natural Sciences focuses on several objectives: first, to characterize the oldest phyllite stones used in gravestones and ledgers, examining their properties and historical applications in both churchyards and domestic architecture, considering their status as a nearly extinct geoheritage rock due to discontinued quarry operations. Second, the project aims to assess lichen diversity on these natural stones, as they harbor a plethora of saxicolous lichens, some of which are indicative of atmospheric pollution sensitivity. Lastly, the project seeks to evaluate geodiversity based on the natural rocks utilized in both old and modern cemeteries within the PNDO area. Additionally, the project will incorporate an air quality assessment,

considering epiphytic lichen species residing on trees surrounding the cemeteries to gauge air pollution levels. Geochemical analyses of major and trace elements have commenced on select saxicolous lichens and phyllites to characterize both the rocks and the geochemical background of the lichen species under examination.

Keyword

natural stone, phyllites, cemeteries, lichens, gravestones

[Keynote] Heritage Stone Subcommission: Showcasing the first 50 IUGS Heritage Stones

Gurmeet Kaur[1]*, Panjab University (gurmeet28374@gmail.com)

Abstract

The International Union of Geological Sciences (IUGS) highlights the essential role natural stones play in architecture and culture. Through the international designation of "IUGS-Heritage Stone," these stones gain global recognition for their historical significance in disseminating cultures and traditions. The establishment of a systematic approach by the International Commission on Geoheritage ensures that only stones with profound architectural and cultural importance receive this honor. This initiative not only preserves and promotes heritage stones but also deepens our understanding and appreciation of the architectural and cultural narratives they embody. To date, 32 stones from around the globe have been ratified as IUGS-Heritage stones and eighteen more stones are expected to be ratified by April 2024.

Releasing the first 50 IUGS Heritage Stone volume at the 37th International Geological Congress (IGC) in Busan, Korea, would be a significant event for the geological community. It would provide a valuable resource for researchers, educators, and anyone interested in the geological heritage of different regions around the world. The IGC will be a perfect platform to showcase such an initiative, given its international reach and the diverse audience it attracts. It would be interesting to see how this event unfolds and the impact it has on promoting awareness and conservation of geological heritage globally.

Keyword

IUGS Heritage Stone, Natural Stone, culture, architecture

GOREE ISLAND (Dakar, Senegal, West Africa), UNESCO World Heritage Site without GEODIVERSITY ? Inventory AND Assessment of a GEOMORPHOSITE Sensitive to Coastal Erosion

Cheikh Ibrahima YOUM[1]*, Université Cheikh Anta DIOP Dakar/SENEGAL (cheikhibrahima.youm@ucad.edu.sn)
Rokhaya Samba Diène[2], 5Ministry of Mines and Geology of Senegal (MMG)

Abstract

The Goree Island (28 hectares), located less than 5 km from Dakar was first occupied by black natives and served as a transit point for black slaves who were to be deported to America for about four centuries. The first Europeans to discover it were the Portuguese in 1445 before the Dutch settled there later, followed by an alternation of occupation between the French and the British in the second half of the eighteenth century and the beginning of the nineteenth century. Today, Gorée has become a must-see tourist attraction in Senegal due to its role during the slave trade and remains one of the places where you can still find vestiges of this tragic era. A guided tour of the must-see places of Gorée plunges you directly into the deplorable history of the slave trade: the slave house founded in 1776, the historical museum, attached to the Fundamental Institute of Black Africa (IFAN), the Women's Museum, the Museum of the Sea (IFAN) and restored in 1995, the Former Governor's Palace, the William Ponty School and finally the Castel, It is in a strategic position and offers a panoramic view. Having become a place of passage and contemplation, the island of Gorée welcomes thousands of tourists every year and has received some of the world's greats on an official visit to Senegal. This makes it a place of remembrance of slavery and reconciliation for the respect of human beings, hence its inscription on the UNESCO World Heritage List since 1978.

Geologically, the island of Gorée is part of the Tertiary eruptive system of Dakar represented mainly by basanite and nephelinite flows. It is mainly made up of rocks of sedimentary origin. The southern third of the island is made up of prism-shaped volcanic rocks that form a plateau 40 m above sea level and bounded by sheer cliffs. Their surface features relics of lateritic breastplates. The volcanic rock is an augite-rich basanite, tending towards nephelinite, but with a dolerite structure. It was dated by K-Ar on mesostasis to 13.03 ± 0.28 Ma. From now on, Gorée trembles under the onslaught of the waves: the wall of the mosque and the Mariama Ba educational house as well as the only electric cable have paid the price.

In the long term, this work will make it possible to support the State of Senegal in its geopark implementation programme and to give Gorée the status of an exceptional geological site in Senegal

Keyword

Gorée Island, Geodiversity, Geomorphosite, Senegal, Coastal erosion

SOCIAL LICENSE TO OPERATE FOR HERITAGE STONES QUARRIES: IS THIS APPROACH POSSIBLE?

Paola MARINI[1]*, Politecnico di Torino (paola.marini@polito.it)
Rossana BELLOPEDE[2], Politecnico di Torino
Gabriele BALDASSARRE[3], Politecnico di Torino
Alvise MATTOZZI[4], Politecnico di Torino

Abstract

The Social License to Operate, often briefly referred to by the acronym SLO, represents a tool that, although it has been discussed for some time in the extractive sector, continues to be of extreme importance today. The path for SLO can be defined dynamic process, which must be verified and monitored over time and involves, alongside the economic and environmental aspects, also the social one such as the respect and well-being of the community: right to culture, gender equality, human rights.
This approach is used for mining sector and for the infrastructures with relevant impact but is not cited in literature for natural stones quarries. In addition, the SLO approach for ornamental stones quarries is poorly studied, cited and applied. Often the SLO is commonly explained as social acceptability.
At legislation and standardization level, the standard ANSI 373 2022, on Natural Stone sustainability contains a part related to social acceptability, under the aspect of social governance, where several goals are enhanced as demonstration of fair hiring practices; education for applicable employees social accountability issues or practices; corporate ethics and so on. However, this standard doesn't recommend specific methodological tools to evaluate the social acceptability for Natural stones quarries.

We developed a method to ask for SLO and negotiate social acceptability based on the methodology of "controversy mapping", as it has been thought within the field of Social Studies of Science and Technology in the last 20 years, together with a procedure for the application of cases related to heritage stones.
This research will correlate some selected heritage stone quarries in different part of world, the controversy mapping tool and the related standard, in order to evaluate the right instrument to apply this process to the Heritage Stone quarries.

Keyword

human rights, SLO, Natural Stones

Itria Valley Heritage stones: the new studies on Natural Stone and World Heritage for the Apulian limestones

Paola MARINI[1]*, Politecnico di Torino (paola.marini@polito.it)
Angela Maria QUARTULLI[2], Ministry of culture, Superintendence for the metropolitan city of Bari
Rossana BELLOPEDE[3], Politecnico di Torino

Abstract

The Apulian limestones, wholly constitute the historic building constructions of the Puglia region (south of Italy) named Trulli, representing an outstanding universal value for UNESCO (https://whc.unesco.org/en/list/787), but also other stone buildings of the well-know Itria Valley. The Trulli are drywall (mortarless) constructions made of roughly worked limestone blocks collected from neighbouring fields. These kinds of historical buildings, characterized by a quadrangular shape and a conical roof, are present also in other sides of Apulia region and from the fourteenth century were used mainly as settlements for temporary housing or agricultural storage, but nowadays are widely used as buildings for farm holyday as well as summer residence. The limestones for Trulli are quarried from different Apulian places and, together with other local lithotype, are the stone heritage of Itria Valley. Other stone constructions characterize the landscape of the area of Itria Valley: rural buildings, lamias, boundary walls, cisterns, farmyards, agricultural depots.

The study consists in an introduction on the region of the southern of Italy where Trulli and other typical stone architectures can be found. Itria Valley with its towns e landascape and the Alberobello town will be described from architectural point of view. A second section concerns the different example of building constructions in local stone of the Itria Valley focusing on the ancient and the contemporary quarries. Petrographic and physical mechanical characteristics of the main kind of limestone are reported and discussed. A third part focuses on the main example of stone architecture of Itria Valley, distinguishing the historical rural building from the other historical civil ones. In this section a particular attention will be given to: example of best practice of evaluation action, protection rules and restauration methods for Stone Heritage in Itria Valley and Alberobello.

Keyword

Roof stones, trulli, Unesco, stone constructions, quarries

Crossing Heritages. Geosites, Geoheritage and their History through Images

Maddalena NAPOLITANI[1]*, Museo Galileo (maddalena.napolitani@gmail.com)

Abstract

This contribution explores how historical geosites have been represented by visual arts.
Although the concept of Geological Heritage Site, and the issues related to their preservation and management have been recently defined and studied (see Brilha and Reynard, 2018; Brilha, 2014; and especially the volume dedicated to the first 100 IUGS Geological Heritage Sites, 2021), the history of their visual representation shed further light on their history, their evolution and the dissemination of scientific knowledge related to them.
The analysis will focus on the 19th century, marked by significant progress in Earth sciences – especially geology and paleontology.
As a consequence, during the second half of the century the divulgation press also experienced a major development. Journals and books offer a wide range of images (landscapes, fossils' reconstructions, maps, tools, etc.), that could be implemented by and compared with both the illustrated scientific treatises and the pictorial production of the time. This rich and varied iconographical corpus shows a renewed visual sensibility for the representation of geosites as a whole, and appear as the result of regular and close collaborations between geologists, engineers and visual artists that shared the fieldwork.
Through the analysis of some case studies illustrating such collaborations (for instance, that of the monumental work of Sartorius von Waltershausen on the Etna, "Der Aetna" (1880)), the aim is to analyze how images and their combined scientific and aesthetic features contributed both to spread scientific knowledge on important geological sites and to build the history of these sites, and finally how images' dissemination fostered scientific expeditions and leisure travel on the sites – what is presently defined as geoturism.
Our purpose is also to cross the geological heritage with the artistic and visual one, and to finally reflect on how, nowadays, they can enhance each other. We will thus conclude the analysis and open-up the research perspectives with examples of art works of the 20th century marked by a renewed environmental consciousness towards geological processes: that is the case, for instance, of the Land Art movement and the so-defined – and sometimes controversial – Earthworks.

Keyword

geosites, visual representations, geoheritage, figurative arts

Maruia Falls (New Zealand) – a Historical Geosite for the Discovery of the Inner Earth Core

Martina KÖLBL-EBERT[1]*, Ludwig-Maximilian Universität Munich (m.koelbl@lmu.de)

Abstract

On 17 June 1929, the MS 7.8 Murchison earthquake triggered numerous landslides in the north-western South Island of New Zealand. One of them diverted the course of the Maruia River westward, where it encountered unconsolidated gravel deposits, which it eroded over the years forming a waterfall. While Maruia Falls is a beautiful geological site in its own right, its significance goes far beyond local geology: Seismic P waves of large earthquakes travel through the whole Earth. By 1929, it was already known that the Earth had a fluid core, as P waves reach the far side of the globe significantly later than would be expected in a homogeneous globe. Also, the core focussed seismic waves acting as a huge lens, creating a shadow zone further out, in which no seismic waves were recorded. In the 1930s, better seismic detectors showed that this shadow zone was not devoid of seismic activity. P-Waves where weak only in terms of surface parallel movements. The vertical movement however, was quite strong. In 1936, explaining seismic activity within the “shadow zone”, using data from the Murchison earthquake, which were recorded at seismic stations in Greenland, the Danish seismologist Inge Lehmann (1888–1993) postulated the existence of an inner Earth’s core, with a faster velocity of seismic waves compared to the outer one.

Keyword

seismology, history of geoscience, Inge Lehmann

The Agno Valley and Giovanni Arduino's 1758 cross section: an iconic site and a classic image for the birth of lithostratigraphy

Ezio VACCARI[1]*, INHIGEO - IUGS Commission on the History of Geological Sciences / University of Insubria, Italy (ezio.vaccari@uninsubria.it)

Abstract

Giovanni Arduino (1714-1795) was a leading figure in the Italian scientific community in the second half of the 18th century. Among the contributions made by the European scientists to the origin of stratigraphy, Arduino's system of subdividing rocks into four basic units called "ordini" attained a unique level of precision. His lithostratigraphical theory, presented in 1760 and refined in 1775, has been regarded by several geologists and historians as starting point of the modern chronological subdivisions of the Earth's geological history. Arduino's 'classification' was based on extremely accurate fieldwork. In fact, his essay Due Lettere to Antonio Vallisnieri junior (published in 1760) contained the scientific results of a geological travel through the Agno Valley, in the Venetian Prealps of northern Italy: the data collected during this fieldtrip, undertaken in October 1758, may be found in his handwritten notes and in two sketches, kept in the Public Library of Verona (Italy). These valuable papers show clearly the origin of Arduino's lithostratigraphical theory. In particular, the impressive drawing entitled "Representation of the strata of different kinds of rocks, observed on right riverside and on left riverside of Agno, from Montecchio Maggiore to the highest tops of the Alpi, above Recoaro, during my journey on 19-20-21-22 and 23 October 1758, of these strata are made the hills and the mountains" has become a classic image for the early history of geology. It is a real and graphically modern geological cross-section of the Agno Valley in only one plane, giving sixteen lithostratigraphical units, which are carefully described by Arduino in the handwritten captions below the sketch. The aim of this paper is to reappraise Arduino's cross-section in the light of an 'experimental' approach, which will try to reconstruct the fieldwork carried out by Arduino in the Agno Valley, in order to identify his routes and observations, as well as understand the genesis of his famous visual representation in connection with his lithostratigraphical theory.

Keyword

history of geology, historical geosites, Giovanni Arduino, 18th century, Italy

Archibald Geikie and Edward Hull Tour 1887: in search of historical georoutes and geosites in County Donegal (Ireland)

Catherine (Kathleen) HISTON[1]*, IUGS INHIGEO (hiscat@interfree.it)

Abstract

Geological field mapping of County Donegal by the Geological Survey of Ireland began in the 1850's and the geological maps and memoirs were published under the authorship of then local director Edward Hull (1829-1917), and survey geologists James Robinson Kilroe (1848-1927) and George Henry Kinahan (1829-1908) for East and South Donegal (1890) and Northwest and Central Donegal (1891). However, interpretation of the geology of Donegal and especially the Donegal granites caused much heated debate among the Geological Survey of Ireland staff. Comparisons with rocks in Scotland and in Canada gave rise to debates about the evidence in Donegal for the age and stratigraphic sequence of the rocks and many studies were done on the origin of the granites.

Archibald Geikie (1835-1924) was appointed local director of the Geological Survey of Scotland in 1867 and held the position of Director General of the Geological Survey of the United Kingdom from 1882 until his retirement in 1901. His interest in the comparison of certain aspects of the geology of Scotland and that of Donegal regarding volcanics, glaciation and denudation of the landscape led him to visit Ireland on many occasions, especially in his role as Director General of the British Geological Survey for inspections related to the progress of the geological mapping campaign of Ireland.

Both Hull and Geikie had published extensively on the physical geography and geology of the British Isles and proposed interpretations related to international debates based on their fieldwork in both Ireland and Scotland.

The aim of this presentation is to trace the route and sites of geohistorical importance visited by both directors during a two-week joint travel around County Donegal in October 1887 and examine how their observations contributed to resolving or not the problems in interpretation encountered during the geological mapping of the county.

Keyword

History of Geology, historical georoutes, historical geosites, Ireland, Donegal

MONTE AMIATA (TUSCANY, ITALY) IN THE HISTORY OF VOLCANOLOGY

Luigina Vezzoli[1], Istituto di Geoscienze e Georisorse - CNR, Pisa
Claudia Principe[2]*, Istituto di Geoscienze e Georisorse - CNR, Pisa (c.principe@igg.cnr.it)

Abstract

A review of the main contributions to the scientific literature between the eighteenth and twentieth centuries concerning the geology and volcanology of Monte Amiata volcano (Tuscany, central Italy) is presented. Monte Amiata, and the nearby volcano of Radicofani, are of great interest to the history of volcanology because they have the primacy of being the first to be recognized of volcanic origin in a region (Tuscany) that was not volcanically active, thirty years before Guettard's studies on the Auvergne region in France. Indeed, the Florentine botanist Pier Antonio Micheli identified as extinct volcanoes Radicofani in 1722 and Monte Amiata in 1733. Moreover, the merit of Micheli's work resides in interpreting Monte Amiata as an extinct volcano despite the absence of a conventional cone-shaped volcano morphology, and in his recognizing its rocks as lavas despite their marked differences from those produced by the known active volcanoes of its times, such as the iconic Vesuvius. During the eighteenth century and until the first half of the nineteenth century, Monte Amiata was a destination for scientific journeys by Tuscan and foreign scholars (e.g. Micheli, Baldassarri, Arduino, Fortis, Ferber, Dolomieu, Santi, Repetti, Hoffmann). In addition, its rocks were part of important collections throughout Europe visited by illustrious mineralogists. Furthermore, samples from Monte Amiata were used to illustrate the general discussions on the nature and origin of rocks such as basalt and granite. In the nineteenth century, Monte Amiata was included in the lists of known volcanoes recorded in the early treatises on volcanology made by Scrope, Daubeny, and Hoffmann, and its 'trachyte' was the subject of early essays on microscope petrography and chemical analysis of rocks, performed by vom Rath, Rosenbusch, Williams, Lacroix, and Washington. Between the end of the nineteenth century and the first quarter of the twentieth century, the volcano geologists of the Comitato Geologico Italiano, especially Verri, Lotti, and Sabatini, carried out field surveys on Monte Amiata resulting in geological maps and volcano-stratigraphies. Moreover, modern petrographic (Novarese, Artini, Rodolico) and geographical (Dainelli and Olinto Marinelli) scientific studies were carried out on this volcano. Nevertheless, up to the middle part of the twentieth century, the major interest in Monte Amiata was related not to its volcanological aspects but to its natural resources: drinking waters, diatomaceous earths, earth pigments, and mercury ore minerals.

Keyword

history of volcanology, scientific travels in the eighteenth century, extinct volcano, peperino, granite, basalt, acidic lava flows, Monte Amiata, volcanoes of Italy

Monte Amiata, history of volcanology, scientific travels in the eighteenth century, Volcanic facies architecture, extinct volcano

VESUVIUS GEOROUTES

Claudia Principe[1]*, Istituto di Geoscienze e Georisorse - CNR, Pisa (c.principe@igg.cnr.it)

Abstract

Vesuvius is the most famous volcano in the world and a historical geosite of international importance also thanks to the numerous geohistorical routes that can be traced there, first of all, the excursions carried out by travelers of the past, which culminated between the 18th and 19th centuries with the “Grand Tour” trips. The development and potential of the geological sciences, as well as their role in human society, owe much to this territory, where in the past centuries there was an enormous flourishing of scientific culture. This is particularly true for volcanology, in which case Vesuvius became, starting from the awakening of the volcano in 1631, the paradigm of volcanic activity understood, that is, the place to go to learn "how a volcano is made". Beyond the classic routes (e.g., Naples, Pompeii, the Gran Cono with its Gran Cratere and the cliff of Monte Somma), followed by all visitors, the volcano presents still unexpressed potential for the valorization of many geohistorical sites and routes, which extend to the entire circum-Vesuvian area. Places subject to attention during field studies and mapping during and after the numerous eruptions of a mixed effusive and explosive nature that characterized the volcano activity. It is a vast panorama, populated by several figures of scientists and scholars of the past, each of whom has linked to various aspects and places of Vesuvius volcano a more or less large part of one's life.

Keyword

Vesuvius, Georoute, history of volcanology

[Keynote] IUGS Geological Heritage Sites. A recognition to the history of our science

Asier Hilario[1]*, IUGS International Commission on Geoheritage (flysch@gipuzkoa.eus)

Abstract

The IUGS has activated a joint and global endeavor to give recognition to those sites that have been essential for the development of geological sciences. More than 700 authors from 85 countries participated in the "First and the Second 100". "An IUGS Geological Heritage Site is a key place with extraordinary geological elements or processes of the highest scientific international relevance, used as a global reference, and/or with a substantial contribution to the development of geological sciences through history ".

The IUGs International Commission on Geoheritage is leading a global endeavor with 17 international organizations representing the main geological disciplines. INHIGEO is one of our key partners charge of recognizing the historical value of several sites.

The reconnaissance of geosites of historical relevance is of great importance, as it allows us to recognize the foundation, the development and consequently the scientific potential of the geological sciences, as well as their role in human society. The history of geosciences, from Antiquity to the Contemporary Age, is based not only on archival documents and printed material - such as books, periodicals, papers, letters and manuscripts - but also on places, routes and landscapes which have been described and studied by scholars and scientists since the origins of the geological sciences.

Each geological heritage site has its own history, because it was discovered or identified on a certain date and has also been the subject of a number of scientific investigations throughout time. However, an historical geosite is not just a site with a history, but a site that has made history in the field of the geological sciences: a place where the observation of some specific features determined new ideas, theories and interpretations which have changed human understanding of the geological phenomena and of the history of the Earth. It is evident that an historical geosite is a landmark for the history of science, as well as a milestone for modern geology.

Essential Sites like Phlegrean Fields in Italy, Puy-de-Dôme in France, Caldera de Taburiente in Spain, Giant's Causeway in Northen Ireland , The Moine Thrust or Siccar Point in Scotland, Genbudo Cave in Japan, Maruia fallas in New Zealand or Funafuti Atoll in Tuvalu have been recognized in the first chapter of each book dedicated to "History of Geosciences".

The IUGS Geological Heritage Sites initiative is a good example of a collaborative work among different IUGS commissions and affiliated organizations, with INHIGEO playing a prominent

role.

Keyword

Geological heritage, site, IUGS, INHIGEO

The Argonauts Campaign to the Ancient Colchis Kingdom: One of the first documented geological exploration in the Human history

Avtandil OKROSTSVARIDZE[1]*, Doctor of Geological Sciences (okrostsvari@gmail.com)
Daniel Tormey[2], Catalyst Environmental Solutions, Santa Monica, USA.
David Bluashvili[3], Faculty of Geology and Mining, Georgian Technical University, 0171 Tbilisi, Georgia.
Mirian Makadze[4], Tbilisi State University, Faculty of Exact and Natural Sciences, Tbilisi, Georgia

Abstract

The exploration for and use of mineral resources has been important since the use of specific occurrences of obsidian and flint for stone tools. These activities were also part of the birth of geology as an important area of exploration. One of the first historical occurrences of exploration for metals was the Argonauts: a group of heroes led by Jason on a quest to find the “Golden Fleece”. Since the Middle Ages Christian Europe has cast the account as mythical, although ancient sources account it as true [1]. The goal of the exploration required the mastery, of alluvial gold mining in the ancient Colchis Kingdom [2]. However, since the Middle Ages, Christian Europe has given this journey a mythical shroud, even though all ancient sources consider it a real story.

We studied considered the account of the Argonauts' expedition according to geological factors. For this purpose, we investigated the provinces of the ancient Colchis Kingdom, in order to determine the presence and mining potential of alluvial gold. We conducted research using both traditional geological and remote sensing methods. The research showed that modern Svaneti (Svania in ancient sources) represents such a province. It is located on the main ridge of the Greater Caucasus and includes the upper part of Enguri river and its tributaries. The results of these studies are also confirmed by the manuscripts of Greek and Roman accounts of the ancient period. In addition, archaeological and ethnographic studies of Svaneti show that this province is rich in narratives and artifacts about Argonauts.

Reconciliation of archaeological, historical, ethnographic and mythological information with geological arguments places the campaign of Argonauts in the kingdom of ancient Colchis was a real event. This expedition would have taken place before the appearance of iron in the region (XIII-XII centuries BC), since in all versions of the legend they were equipped with bronze weapons. According to modern studies, the eruption (1480±10 BC) of the supervolcano Strongea (its remnants are the present-day island of Santorini) effectively destroyed the Aegean civilization. According to Homer, the Argonauts were representatives of the Aegean civilization, and such, after this event, they would not be able to carry out such a large-scale campaign. Because of this, the campaign of the Argonauts must have been carried out, most likely, before the eruption of the supervolcano Strongea, at the turn of the 16th-15th centuries BC.

Our study supports the contention that the campaign of the Argonauts in the ancient Colchis kingdom was a real event, the main goal of which was to explore for gold and master the

technology of alluvial gold mining. If so, this campaign was one of the first documented and consequential geological exploration in the human history, which took place about 3500 years ago.

References

1. Golavito J., 2014. Jason and the Argonauts through the Ages. McFarland Publishers, 178 p.
2. Okrostsvaridze A., Gagnidze N., Bluashvili D., 2014. Field investigation of the mythical “Gold Sands” of the ancient Colchis Kingdom and modern discussion on Argonauts mission. Episodes, vo.37,

Keyword

The Argonauts, Colchis Kingdom, Svaneti, Golden Fleece, exploration

Digital Preservation and Sharing of Classic Geosites and Georoutes via DDE-Outcrop3D Platform

HANTING ZHONG[1]*, Chengdu University of Technology (zhonghanting@cdut.edu.cn)
JIANHUA CHEN[2], Chengdu University of Technology
XIA WANG[3], Chengdu University of Technology
ZONGQI LIN[4], Chengdu University of Technology
MINGCAI HOU[5], Chengdu University of Technology
CHENGSHAN WANG[6], China University of Geoscience, Beijing

Abstract

Since the 18th century, numerous scholars have contributed to the study of geological heritages, outcrops, and landscapes, which play a critical role in the advancement of geology. However, many such sites are being irreversibly damaged due to infrastructure development, reservoir impoundment, and resource exploitation.

To preserve these historically significant geological resources in digital form and make them more accessible to the public, our group (DDE Digital Outcrop Group) has conducted comprehensive digital collection and modeling of over 120 classic geosites from 12 countries including China, the UAE, Italy, France, Germany, Spain, Namibia, and so on. The primary methods employed include high-precision tilt photography by drones, Insta360 panoramic camera photography, DSLR camera photography, and video recordings of geologists' lectures.

In China, 96 geological outcrops were collected, primarily along the georoutes of the 21st International Sedimentological Congress. Europe contributed 24 geosites, while Africa had 3, including UNESCO Global Geoparks, The First 100 IUGS Geological Heritages Sites, and post-conference georoutes of the International Association of Sedimentologists (IAS).

Currently, all collected information of the geosites have been uploaded onto the DDE-Outcrop3D platform (https://outcrop3d.deep-time.org/), which enables the visualization of high-precision 3D models of geological outcrops, combining information such as text, images, videos, panoramas, documents, observation points, geological maps, etc. with 3D models. The platform realizes the co-construction and sharing of geosites and georoutes, allowing scholars and geoscience enthusiasts all over the world to enjoy the world-famous geological heritages, outcrops, and landscapes without leaving their homes, and to share and discuss them with other users.

Keyword

Geoheritage, Geological outcrop, 3D modeling, Deep-time Digital Earth, DDE

Remote sensing assessment of biological activities on built historical structures in a tropical region: Case of the Osun-Osogbo Sacred Grove UNESCO World Heritage Site, South-Western Nigeria.

Jokotola Toyyebat OMIDIJI[1]*, Geography Department, University of Lagos Akoka, Lagos (jokotola.omidiji@gmail.com)
Amidu AYENI[2], Geography Department, University of Lagos Akoka, Lagos
Edward BOAMAH[3], Digital Earth Africa

Abstract

The relationship between biological communities and the deterioration of cultural heritage in temperate and tropical countries remains a subject of debate. In humid tropical climates, plant growth plays a crucial role in both natural and built environments by contributing to increased biodiversity, stormwater and micro-climate regulation, soil protection, food and medicine provision, and global warming mitigation through carbon sequestration. Despite these significant contributions, there is a lack of understanding regarding the role of vegetation on historic cultural heritage sites in tropical countries and how the distribution of greenery impacts the thermal and physical conditions of heritage buildings and monuments. While laboratory and field studies in temperate regions have shown the complex relationship between greenery (algae, moss, ivy) and stone/rock heritage structures, including bio-erosion, protection, and conservation, rather than solely biodeterioration, similar research is lacking in Nigeria. One such example is the Osun-Osogbo sacred grove, a UNESCO World Heritage site surrounded by dense sacred trees and heritage structures colonized by algae and moss. The influence of these greenery and weathering processes on the physical conditions of walls and monuments has not previously been assessed. This research addresses this gap by using a mixed methods approach, including satellite imageries, air and land surface temperature data, rock surface temperature and humidity measurements and millimetre-scale surface change data to examine the effects of greenery on heritage structures within the Osun-Osogbo Sacred Grove UNESCO World Heritage Site (WHS) to improve historical documentation of the Geoheritage site conservation and degradation processes. The heritage features of interest are the forests, walls and sculptures at the heritage site that are in deteriorating conditions aggravated by the devastating floods in 2019 and climate change. The Landsat (30 m) time-series imageries will be used to investigate the spatial and temporal distribution of forest cover and reveal air and surface temperature trends and wet/dry periods within the sacred grove site. To map and develop a weathering/erosion database, crowd-sourced historical photographs, repeat photographs subjected to Structure-from-Motion (SfM) photogrammetry and LiDAR data (2019 - 2023) will be used and integrated into a geographic information system (GIS) to complement micro-climatic records. Surface change (soiling, cracks) and erosion patterns of heritage structures influenced by biology and other weathering processes will be isolated and assessed using three-dimensional (3D) point clouds, digital elevation models (DEMs) and orthophotographs. Findings from this study have the potential to serve as a guiding

framework for identifying the extent and nature of monument degradation to inform sustainable remedial practices and improve heritage site conservation in Nigeria and Africa.

Keyword

Built Heritage, Biology, Conservation, Climate Change, Sacred grove

From Cultural Landscape to Aspiring Geopark: 18 Years of Community-Based Landscape Tourism Development in Fengnan Village, Hualien County, Taiwan (2006–2024)

Kuang Chung LEE[1]*, National Dong Hwa University (kclee2000@gmail.com)
Paulina G. Karimova[2], National Dong Hwa University

Abstract

Geoconservation plays a key role in valuing and conserving abiotic nature, while geotourism can be an effective means of achieving this objective. Connectivity between biophysical and socio-economic components and a community-based perspective on appreciation and interpretation of landscape resources are important yet not well understood. This study is a retrospective analysis of 18 years (2006–2024) of integrated landscape management in Fengnan Village, Hualien County, Taiwan, with a focus on the evolution of multi-stakeholder perception of local geodiversity and emergence of geotourism as part of community-based landscape tourism in the area. A qualitative multiple-method approach to data collection and analysis was based on the "know–cherish–show" interpretation model and the theory of collaborative planning.

The results demonstrate the following observations. (a) Geoconservation and geotourism have evolved to become an integral part of the Fengnan living landscape, while connectivity between nature–culture attributes has strengthened over the years. Community-based approach to geotourism and capacity-building activities for bridging Indigenous and local knowledge and expert knowledge have played a central role in empowering Fengnan locals as the hosts and geo-interpreters of their native landscape. (b) Institutional arrangement between primary and secondary stakeholders have evolved over time and benefitted from facilitating efforts of the bridging stakeholder (the authors). (c) Facilitating role of the bridging stakeholder (the authors) was central to the timely introduction of various landscape concepts for long-term geoconservation in the area. Time-, space-, and stakeholder sensitive introduction of relevant landscape concepts ensured trust and reciprocity in the long-term multi-stakeholder partnership. There are several challenges and opportunities ahead: (1) In the future, the Turtle River Aspiring Geopark multi-stakeholder platform will be a central mechanism for ensuring a fair division of responsibilities, benefit-sharing, and diversification of income generating activities (e.g., geo-product development) in Fengnan Village. (2) The support of the government agencies will continue to be important, while the regional government—Hualien County government—will need to start playing a more prominent role as the main geopark authority. Therefore, the sooner it becomes aware of and is involved in the ongoing geopark processes, the smoother the potential designation is likely to be. (3) Eighteen years of continuous on-the-ground engagement in one site and community is a rarely seen phenomenon across action research case studies. The longevity of our partnership with the Fengnan community speaks for their level of approval and trust in us as the bridging stakeholder and in local integrated landscape management processes. However, we need to be observant of strengthening the bottom-up capacity of the local people and their

readiness to manage on their own. As we are now gradually letting go of the facilitating role in the area, we are transitioning into consulting (mentoring) role based on the community's vision and needs.

Keyword

geoconservation, cultural landscape, geopark, community-based landscape tourism, multi-stakeholder partnership

The open air Museum - A significant geoconservation in the Lesvos Petrified Forest - Lesvos island UNESCO Global Geopark, Greece.

Nikolaos ZOUROS[1]*, University of the Aegean (nzour@aegean.gr)
Ilias VALIAKOS[2], Natural History Museum of the Lesvos Petrified Forest
Konstantina BENTANA[3], Natural History Museum of the Lesvos Petrified Forest
Eleni THEODOROU[4], Natural History Museum of the Lesvos Petrified Forest
Efstratios ZGOURNIOS[5], Natural History Museum of the Lesvos Petrified Forest
Evita TSONIDOU[6], Natural History Museum of the Lesvos Petrified Forest
Aggelos LAMPRAKOPOULOS[7], University of the Aegean
Emmanouil ANTONAKIS[8], University of the Aegean
Nikolaos SOULAKELLIS[9], University of the Aegean

Abstract

The Petrified Forest of Lesvos is a unique natural monument formed 20 million years ago due to the intensive volcanic activity in the North Eastern Aegean area and consists of the main geological heritage feature of international significance for the recognition of Lesvos island as a UNESCO Global Geopark (2000, 2012, 2015). The protected area of the Lesvos petrified forest covers an area of 15.000 ha located in the western part of Lesvos island, Greece.

The Natural History Museum of the Lesvos Petrified Forest is a public institution aiming at the protection and rational management of the Lesvos Petrified Forest. Rescue excavations are conducted by the Museum in the protected area of the Lesvos Petrified Forest in case of fossil findings during the construction of public and private works.

During the last decade, a new road is constructed connecting Kalloni with Sigri which is the westernmost village of the Island, crossing the protected area of the Lesvos petrified forest. During the construction of this new road, a large number of astonishing fossil sites with impressive fossilized tree trunks have been unearthed, which lay on the verge of the road. The Museum in collaboration with the Ministry of Public Works took all the necessary measures to change the road construction plan, to secure the preservation of the most significant fossil sites along the road.

The Museum implemented a comprehensive plan to enhance the new fossil sites, to protect them, and to create new visiting parks along the Kalloni-Sigri road. This geoconservation plan includes a series of interventions for the protection of the improvement of the accessibility to the fossiliferous sites, interpretation and information, signage, and infrastructure for visitor services. The various fossiliferous sites along the Kalloni-Sigri road, are now part of a new open-air museum, unique in the world, which will offer to the Lesvos Geopark visitors a new geotouristic attraction. In addition to various awareness-raising activities, a new campaign entitled “Walk the Forest” introduces the new petrified forest parks to the public. The project is funded by the Regional Operational Program “North Aegean 2014-2020”.

Keyword

geoconservation, geosite protection, geopark, geodiversity, Lesvos Island

Geosensitivity based Geoheritage threat mapping using RS and GIS in the Darjeeling hill region, India

Lakpa TAMANG[1]*, University of Calcutta (ltgeog@caluniv.ac.in)

Abstract

Interest in the perspectives of both studies and management policies has grown substantially about geoheritage research, protection, and conservation, as well as the development and diffusion of geoheritage information. The impact of tourism activities has undermined the global geodiversity which necessitates the formulation of geoconservation strategies by identifying geosensitivity. The Darjeeling hill region faces severe threats with increasing tourism and the knowledge of the regional geodiversity has not yet been addressed properly resulting into depletion of the geoheritage richness. Thus, the objective of this study is to propose an efficient method of quantification and mapping of "geosensitive zones" using a simple Remote Sensing and GIS procedure which would be useful towards the formulation of proper geoconservation strategies for the tourism induced landscape. Thus, an integrated method of Geosensitivity Index (SI) based on geodiversity index (GI) and threat index (TI) using RS and GIS has been undertaken using the sum of four sub-indices: geological diversity, geomorphological diversity, pedological diversity & hydrological diversity, whereas the TI is based upon the summation of three sub-indices: land protection index, degradation index & land use index. The outcome demonstrates its efficacy in determining regional priorities for geoconservation and allows for a quick and easy visualization of areas with varying degrees of geosensitivity with Very high (8%), high (11%), moderate (20%), low (28%) & very low (33%). Besides, this automatic procedure could help in collecting a large quantity of information which ease the process to formulate immediate preservative strategies for the high & very high geosensitive zones and at the same time the geo-environmental concern regarding those regions which are less effected or may get severely affected if mass tourism continues.

Keyword

Geodiversity, Geosensitivity index, Threat Index, Geoheritage, Geoconservation

Managing natural heritage: geoconservation efforts across Latin America and the Caribbean's landscapes

MARIA DA GLORIA GARCIA[1]*, University of São Paulo, Brazil (mgmgarcia@usp.br)
MARCOS NASCIMENTO[2], Federal University of Rio Grande do Norte, Seridó UGGp, Brazil
JUAN ESTEBAN QUINTERO MARÍN[3], Grupo de investigación en Geología Ambiental (GEA), Universidad Nacional de Colombia, Medellín
MAURÍCIO FARAONE PIMIENTA[4], DINAMIGE - Dirección Nacional de Minería y Geología, Área Geología, Uruguay

Abstract

The geodiversity of Latin America and the Caribbean (LAC), shaped by different tectonic settings including the South American Platform, Andean chain, the Caribbean Plate and the Patagonian block, reflects a rich geological history. This diversity is visible in ancient rocks, sediments, an enormous diversity of contrasting landscapes, and active geological processes, and it has determined the region's unique biodiversity, culture, and economic activities. Understanding and managing this geodiversity is crucial for effective environmental conservation, policy-making, and to tackle some of the major challenges of our era, such as natural resource and energetic management, disaster risk reduction, and adaptation to climate change. Given the region's particularities such as large wealth inequality, the most biodiverse hotspot in the world, high percentages of ethnic groups, and major geological hazards, geodiversity management and policies must be tailored to these characteristics.

Geoconservation efforts in the region vary, influenced by geographical differences, differing geological knowledge, socio-political context, and multiple levels of community engagement. Significant milestones in this field include the establishment of the first geopark in 2006 - Araripe Geopark in Brazil, the first compilatory book about geoconservation and geoheritage in the region in 2016, the creation of the UNESCO Global Geoparks Network for LAC in 2017, and the ProGEO branch initiative in the region in 2023, which highlights the growth of geoconservation initiatives. Presently, the GEOLAC network includes twelve UNESCO Global Geoparks (UGGp) in seven countries, as well as several Geopark projects at different stages of development. Research in LAC has concentrated on aspects such as the evaluation and management of geodiversity and geological heritage, geotourism, and geoparks. Efforts by organisations like the Association of Iberoamerican Geological and Mining Surveys (ASGMI) have focused on the development of a common methodology for the geological heritage assessment, disclosure of geological heritage in Ibero-America, and creation of regional geoheritage maps. Ten geological surveys in LAC are conducting geological site inventories at the national level.

The management of designated protected areas is also challenging. Currently, the region has 150 properties from 28 countries on the World Heritage List, distributed among 33 States Parties, being 104 Cultural, 38 Natural and 8 Mixed. The region is also home to 216 Ramsar Sites covering 61,904,530 ha. In addition, there are currently 134 Biosphere Reserves in 22 countries, which are part of the Ibero-American MAB Network (IberoMAB), created in 1992. Moreover, in

terms of area covered, Latin America and the Caribbean is the most protected region in the world. All these areas involve stakeholders to whom geoconservation strategies should be proposed to be integrated with nature conservation.
Significant contributions to geoconservation research and outreach come from several countries, addressing regional challenges and strategies for managing geological heritage. Establishing a ProGEO regional working group in LAC marks a step towards coordinated geoconservation efforts, aiming to address socio-environmental challenges and promote sustainable development in the region. Overall, these initiatives are a collective endeavour to protect and manage the geological heritage of Latin America and the Caribbean, ensuring its sustainable use and appreciation by future generations.

Keyword

ProGEO LAC, geodiversity, geoheritage

How can we arrange a geoconservation strategy in our area? some tips based in the Basque Country (Spain).

Manu R. MONGE-GANUZAS[1]*, ProGEO EUROPE (erakatxo@gmail.com)

Abstract

We will present the key milestones to be considered to design a participatory and consensual strategy for geo-conservation in a certain area. We will take as a model the applied case of the territory of the Autonomous Community of the Basque Country in Spain. The Basque Country starts his strategical design for geo-conservation by arranging a participatory process carried out among academia, citizens and public administrations. Its first step is to arrange the diagnosis of the geological heritage of the Area based on a geosite Inventory. After identifying the main actors related to geo-conservation, the second step is to find out how society is in contact with Earth Sciences. The subsequent third step is to analise the normative that applies in the Area and have influence on the management of the geoheritage at different territorial and jurisdictional scales. The fourth step is to establish strategic and operative objectives and a series of proposals for action in order to achieve those main objectives. Finally, it is proposed a method for the evaluation and the monitoring of the strategy. In the case of the Basque Government, it carried out its strategy with the following objectives: (1) To identify and describe the geoheritage of the Basque Country; (2) To obtain a systematised inventory that characterises the geological sites of Basque Country; (3) To delimit and map these places and incorporate the geographical information obtained into the GIS; (4) To establish a geosites assessment of the selected from a scientific, didactic-educational and tourist-recreational point of view that serves to prioritise protection or use measures; (5) To analyse the fragility, vulnerability and risk of degradation of the identified geological heritage; and (6) To define a geoconservation strategy for the conservation and public use of this heritage. To achieve these objectives, The Basque Country proposes 4 strategic objectives, 9 operative objectives, 22 operative sub-objectives and 45 actions. Its evaluation will provide a regular monitoring report assessing its degree of compliance and will propose, if needed, corrective measures. This experience aims to become a management model to be replicated by any Area of the Planet.

Keyword

geoconservation, strategy, Participation, replicability, Basque Country

Integrating geoconservation and sustainability: a focus on natural resource management in the Brazilian Amazon

MARIA DA GLORIA GARCIA[1]*, University of São Paulo, Brazil (mgmgarcia@usp.br)
André de Oliveira Sawakuchi[2], University of São Paulo, Brazil
Raimundo Humberto Cavalcante Lima[3], Federal University of Amazonas, Brazil
Daniel Souza dos Santos[4], University of São Paulo, Brazil
Thiago Alves Evangelista[5], Federal University of Ceará, Brazil
Raquel Mamblona Marques Romão[6], University of São Paulo, Brazil

Abstract

The Amazon region corresponds to the limits of the world's largest and most biodiverse rainforest, which covers a significant portion of the South American continent across multiple countries. It is home to a vast array of flora and fauna, and plays a crucial role in the global climate system, acting as a significant carbon reservoir and influencing hydroclimate patterns both regionally and globally. The development of Amazonian landscapes underpins the region's exceptional biodiversity, as it influences several ecological processes and habitat diversity. Preserving this rich natural diversity is crucial, yet economic pressures pose significant challenges to conservation efforts. In this scenario, geoconservation arises as an innovative and sustainable socioeconomic alternative. This study explores five projects in which geoconservation strategies are being employed to achieve goals that range from natural heritage management to outreach in the region.
The projects are settled in four Brazilian states. In Roraima, identification and evaluation of geological sites are being used to create a field guide with educational and geotourism purposes in the Takutu Basin, a Mesozoic intracontinental rift between Brazil and Guyana holding important geological information related to the process of the opening of the Atlantic Ocean, with oil and gas exploration potential. In Amazonas, two projects are being carried out. In the region of the lower Rio Negro river, which holds important protected areas such as Anavilhanas and Jaú national parks and is home for riverine people, geoheritage inventories and surveys on abiotic ecosystem services provide data to the implementation of geotourism strategies through the production of virtual materials and interpretative panels. In the town of Presidente Figueiredo, known as "the land of waterfalls" and home for a geopark project by the Geological Survey of Brazil, a Geodiversity Action Plan (GAP) is currently underway. Both of these involve workshops and courses for schools and communities using social learning and participatory methodologies. Geoconservation strategies are also being used to achieve outreach practices in the Trans-Amazon Drilling Project, focused in the states of Acre and Pará, which seeks to answer fundamental questions about the geological, environmental, and climatic development of the Amazon. In these areas, inventory and assessment of geological sites compound the bases for producing educational and dissemination materials using the Design Thinking approach. Also in Pará, geodiversity characterisation combined with multidisciplinary studies in Volta Grande do Xingu, the largest rapids within the Amazon, aims to identify sustainable conservation solutions for a socio-ecological system formed by biodiversity, geodiversity, and traditional and indigenous

communities, threatened by the dewatering effects in the seasonally flooded and aquatic ecosystems due to river diversion to attend the Belo Monte hydropower plant.
Taking into account the whole geoconservation chain, in all the case studies the diagnosis of geodiversity and geoheritage plays a prime role to subside both future statutory conservation and promotion actions. Moreover, these results seek to discover ways to use these elements as means of generating income and sharing knowledge to local communities, through the sustainable use of natural resources.

Keyword

Geodiversity, Geoheritage, Geotourism, Sustainable development, Nature conservation

Addressing geohazards in populated geoheritage sites: the case of Dovžan Gorge Natural Monument in Slovenia

Matevž Novak[1]*, Geological Survey of Slovenia (matevz.novak@geo-zs.si)

Abstract

Dovžanova soteska (Dovžan Gorge) is one of the most interesting geological sites in Slovenia. The Tržiška Bistrica Creek, with the aid of tectonic forces, has carved deep into the Karavanke Mountains, revealing a long cross-section of Late Paleozoic rocks. It is one of the most fossil-rich areas in the Southern Alps and has high scientific and historical significance as the locus typicus of many newly described species. Although several faults transect the section, the original succession is preserved in almost complete stratigraphic order. This enables the recording of the paleoenvironmental evolution of the depositional setting and the paleobiological evolution of several fossil genera.

Since 1988, Dovžanova soteska (Dovžan Gorge) has been protected as a natural monument due to its exceptional geological and geomorphological features. The gorge is inhabited and has a traffic connection between the town of Tržič and its hilly hinterland with extensive, economically important forest areas. Due to the geological structure and topography of the terrain, characterized by steep slopes and the torrential flow of the Tržiška Bistrica, the area is subject to rapid and significant natural changes, which are particularly intense during extreme weather events and can cause material damage. Considerable attention and resources are devoted to reducing the risk of falling rocks. Protective wire meshes, large catching structures and high protective fences enclose virtually all rock walls and gullies along and above the main road and walking paths in the most beautiful and geologically interesting parts of the gorge.

Protected geoheritage areas that are inhabited face the challenge of balancing preservation of the natural environment with human interventions for economic needs and safety purposes. The extreme weather event in October 2018 caused significant changes in the Tržiška Bistrica river basin, which were most noticable in the Dovžan Gorge Natural Monument. This event highlighted several aspects of this issue. The Dovžan Gorge has been proven to be an excellent site for studying natural processes, anthropogenic influences, and human perception of natural disasters and historical memory of them. This is based on the analysis of a weather event and changes in the surface, as documented through photos and historical archives.

The observation that as many as six extreme rainfall events (in 2003, 2007, 2009, 2010 2018, and most recently in 2023), with a return period of 50 or 100 years, have occurred in the last 20 years, and that the resulting material damage and its remediation have been very similar in all cases, suggests that historical and recent data will need to be taken into account in climate change adaptation strategies.

Keyword

geoheritage preservation, geohazard, extreme weather events

The current status of geoheritage management in Korea: a decade of progress and future directions

Wansang RYU[1]*, National Geoparks Secretariat of Korea (wansryu@knps.or.kr)
Hosahng Rhew[2], Jeonbuk National University
Hyejin Kim[3], Seoul National University
Jeong Young Lee[4], Korea National Park Service

Abstract

The process of documenting geoheritage in Korea began in 2014 with a thorough nationwide survey to create an inventory of geoheritage sites. This was part of the National Geopark Secretariat's initiative funded by the Ministry of Environment (MoE), with the aim of giving support to geoparks. Over the last 10 years, a total of 1,004 sites on mainland and Jeju island have been officially registered, and additional c.a. 400 sites will be included by 2025 when the survey for geoheritage in inhabited islands is finished. The surveyed geoheritage is organized into a GIS database, which offers online services displaying the spatial distribution of each site, along with its current rating. The geoheritage DB serves as a source of e-books for raising awareness about geoconservation and geotourism among the public. The geoheritage evaluation system comprises three modules: fundamental value, associated value, and institutional conditions. It has a total of 20 criteria. The fundamental value module comprises 10 criteria that encompasses scientific, educational, and scenic value. In contrast, the associated value module includes 7 criteria that pertain to ecological , economical, historical and cultural significance. Institutional conditions deals with factors such as the ease of access, the quality of infrastructure, and legal status. While the surveyor assessed all of the criteria on field, just 10 criteria from fundamental value section were utilized to evaluate geoheritage on a five-grade scale, with a specific emphasis on the 'geological' value. Although geoheritage inventory system has developed over the past decade, the corresponding legal framework has not been adequately enforced. From a managerial standpoint, the current inventory system lacks sufficient evaluation criteria to indicate the level of degradation risk caused by natural and anthropogenic factors. To improve these conditions, we have created a diagnositc chart that assesses management priority based on the value of geoheritage and the risk of degradation, together with an legislative effort to support the management and geoconservation of geoheritage. In 2024, we will try to develop a monitoring protocol for the wise use and better conservation of geoheritage within geoparks.

Keyword

geoheritage, geoconservation, management priority, geopark

Geoheritage and Geoconservation as a resource and a tool for promoting the United Nations 17 Sustainable Develop Goals (SDGs)

Kevin Neil Page[1]*, ProGEO (kevinnpage@gmail.com)

Abstract

Over the last 15 years or so, there has been a massive international increase in awareness of geodiversity, not least due to the formal adoption of Global Geoparks as a UNESCO programme in 2015. There are now around 195 UNESCO Global Geoparks (UGGs) across 48 countries all promoting geoheritage as the basis for sustainable economic development according to statutes established by UNESCO (https://www.unesco.org/en/iggp/geoparks/about). In addition, the global significance of geological heritage and its conservation, is now recognised by IUGS through the establishment of its International Commission for Geoheritage (ICG; https://iugs-geoheritage.org/) and IUCN through the activities of the Geodiversity Specialist Group (https://www.iucn.org/our-union/commissions/group/iucn-wcpa-geoheritage-specialist-group), part of the World Commission for Protected Areas. However, in a world where the negative environmental effects of human activities are becoming increasingly difficult for governments to ignore, the principles of sustainability are now often being explicitly cited as justifications for nature conservation – including within national and regional geoconservation activity. Crucially, in 2015, the United Nation's Agenda for Sustainable Development, established 17 Sustainable Development Goals (SDGs) (https://en.unesco.org/sustainabledevelopmentgoals) , as both targets and guides against which achievements could be measured or assessed. But can we assess, even measure the global contribution of geological heritage and its conservation to the UN STGs, especially taking into account the vast number of projects and initiatives outwith the very small number of UGGs globally? The answer comes in the form of the published scientific literature, as this change in attitudes towards the role of geological heritage in society, is also represented in a widespread change in academic attitudes towards the subject which is now in many countries considered as a key part of the broader geosciences – hence research and publishing on the subject is widely supported. The journal Geoheritage (www.springer.com/12371), in particular, is a useful guide, as it was set up as a collaboration between the global NGO in the field, ProGEO (www.progeo.ngo), to promote the discipline globally. Now in its 25th year, around 1000 published papers from over 86 countries, reveal that at around 45% describe contributions to one or more SDGs, with Geotourism (12%, i.e. SDGs 1, 4, 5, 8, 10, 11), Urban Geodiversity (10%, i.e. SDGs 4, 11) and Sustainability and Communities (8%, i.e. SDGs 4, 5, 6, 10, 11) being the most frequent themes, along with Education (6%, i.e. SDs 4, 5, 6, 10, 11), Geoparks (5%, i.e. SDGs 1, 4, 5, 8, 10, 11) and Integration with Biodiversity (2%, i.e. SDGs 11, 14. 15) being the other relevant themes. This simple assessment reveals that rather than being considered to be an unimportant 'sideline' for some national academic institutions, or a 'Cinderella' subject within nature conservation (i.e. of little relevance to ecological and species issues), geoconservation activities have a major role to play in addressing the major problems addressing all global societies.

Keyword

geoheritage, SDG, sustainability, ProGEO, geodiversity

Integrating geo- and biodiversity: Towards a more holistic approach to nature conservation

Kevin Neil Page[1]*, ProGEO (kevinnpage@gmail.com)

Abstract

Although the conservation of geodiversity as part of nature conservation has seen major advances in recent decades, the process has not been straightforward as there often remains a misunderstanding on both the geological and ecological sides, of the objectives and practice of the other discipline. These problems are exacerbated by the frequent development of parallel conservation systems, including at the level of both legislation and administration. In the UK, however, the conservation of geological and ecological heritage nationally has always been carried through the same legal framework. Despite, this promising scenario, however, site management has often been insufficiently integrated, even where prescriptions for geological and biological features could be developed in such a way to benefit both categories of feature. In the 1990s and into the early 2000s, however, initiatives were developed by national and regional governmental authorities with the intention of creating a more holistic framework for nature conservation. These included English Nature's, 'Natural Areas' project, which demonstrated that, nationally, bedrock and superficial geology controls the broad distribution of characteristic habitats, and Countryside Council for Wales 'LANDMAP' programme, which produced a multi-layed GIS mapping and characterisation of Welsh landscapes as a guide for landscape-scale management. As this was the era in which the term biodiversity first became prominent after the 1992 Earth Summit in Rio de Janeiro, it also saw a proliferation of Biodiversity Action Plans, or BAPs, to set target for conservation actions at all level from local to international. Unique, amongst these in the UK was the Devon Biodiversity Action Plan, developed and promoted by the regional government, Devon County Council. The Devon BAP used 'Habitat' Action Plans to set priorities for the management of a range of site types, crucially identifying geological and geomorphological, as well as ecological aims and objectives. The methodology is particularly powerful where geomorphological processes underpin ecosystems, such as 'Active River Systems', but is equally valuable where the primary features may be geological (e.g. in 'Pits, Quarries and Cuttings'), but may be associated with national rare or protected species. Although now replaced by later initiatives, the Devon BAP admirably demonstrated how apparently contradictory geo- and biodiversity aims and objectives can often be reconciliated and even integrated to achieve mutual goals. These common links are now being independent developed at an international scale within a broader concept of Ecosystem Services' which also recognises the importance of nature to human life and wellbeing, including as 'Geosystem Services – although there is still an inherent risk here of developing parallel geodiversity and biodiversity perspectives without adequate integration as has been a problem in the past. Similarly, the development of a programme of Key Geodiversity Areas within IUCN as a parallel to Key Biodiversity Areas, also risks perpetuating an entirely artificial divide within nature conservation practice. Crucially, a

fundamental change in attitudes to nature conservation is needed on both sides, with geoconservationists needing to be more ecologically aware and ecological conservationists needing to consider the physical structures and processes without which there would be no ecosystems..

Keyword

geodiversity, biodiversity, Ecosystem Services, Devon

Geoparks' way of survival in National Parks management system- perspectives from Australia and China

Qian Li[1]*, Shanxi University of Finance and Economics (314126052@qq.com)

Abstract

Geoparks have developed for decades. There are 195 Global Geoparks worldwide which distribute in 48 countries, spanning 4 860 000 km2 in total. It is not just a geological featured area responsible for native economic benefits and scientific education, but also an essential park brand. Australia is home to over 500 national parks, each with its unique features and attractions. National parks in Australia originated from 1879, making it as the second oldest in national parks history. It used to be home to the only one Global Geopark in the Southern Hemisphere. Kanawinka Global Geopark was established as Australia's first geopark by supporters effort in 2008, then unfortunately it was delisted by UNESCO in 2012 due to failing in four-yearly geopark review. The short history of Australia geoparks has been reviewed by Ian D Lewis. This paper mainly reviews Australia's national parks management framework, community participation, infrastructure and social influence, and analyses why and how geoparks couldn't make it in the condition. In contrast, China has hundreds of geoparks and only a few national parks. The number of UNESCO Gobal Geoparks in China had grown to 41 by 2022, while the number of National Geoparks had been 271. Early in 2013, China government proposed national parks establishment plan, then NPs with natural protected areas reform. After NPs pilots process, it was proclaimed in Conference of Parties to the Convention on Biological Diversity that China had established the first 5 national parks successfully in 2021. How could Geoparks survive in the condition of National Parks Management System in China? According to the story of national parks on the earth, It will take a long time to answer. This paper examines China's geopaks as well as national parks short history, management framework, community participation, infrastructure and scientific education, while compares with Australia to gain experience or learn lessons for now.

Keyword

geoparks, national parks, management, Australia, China

When citizens contribute to the discovery of geosites and to geoconservation

Isabelle ROUGET[1]*, Muséum National d'Histoire Naturelle- Paris (isabelle.rouget@mnhn.fr)
Grégoire Egoroff[2], Muséum National d'Histoire Naturelle - Paris
Asma Seinhausser[3], Muséum National d'Histoire Naturelle - Paris
Dominique Frizon de Lamotte[4], CY Cergy Paris Université, Géosciences & Environnement

Abstract

New outcrops of potential geological interest are regularly uncovered by natural or anthropogenic actions such as land-use planning and public works. These outcrops are most often exposed temporarily as they are deemed to be scars on the landscape and are sooner or later revegetated, filled, or concreted. In France, the number of outcrops uncovered each year that may be of geological interest remains unknown. This can be explained by the fact there is no procedure for examining geological objects during construction projects. In contrast, the context is different for archaeologi-cal remains which are protected by the law on “preventive archaeology”.
Arising from the European Convention signed in Malta in 1992, this law was enacted in 2001 and provides for archaeological interventions on development sites and allows for evaluation and, if necessary, excavation.

To remedy this lack of knowledge, a participatory science program, called “Vigie-Terre”, was set up by the Muséum National d'Histoire Naturelle in June 2000 (https://www.vigie-terre.org/). The program aims to enable volunteers to quickly identify relevant outcrops and bring them to the atten-tion of researchers, enabling data to be saved (i.e. sampling, photos, field surveys).

To participate in “Vigie-Terre”, an online reporting protocol has been set up so that citizen scientists can provide locality and outcrop information for the sites of interest. A network of volunteer experts throughout the territory can then examine the sites and, based on the information provided, assess whether the outcrop is of scientific and/or educational interest, and/or whether it is worth visiting the site to take samples or inform the local authorities.

In the frame of “Vigie-Terre”, researchers from CY Cergy Paris Université came up with the idea of using participatory science to locate old or active landslides in the Vexin Français region (north-west of Paris). The objective is to collect research data and also to raise awareness of regional ge-ology among local populations through dialogue with local authorities. With a few simple adapta-tions, “Vigie-Terre” could be used to meet this new need. This cooperation opens up new pro-spects for extending the scope of the initial “Vigie-Terre” project and using participatory science both to collect data and as a tool for geological outreach.

This presentation will provide feedback on this citizen science project. We will give an overview of the results acquired during the four years since its inception and discuss the benefits and

limitations of such a we have identified.

Keyword

participative science, rescue geology, education, ancient landslide

Key Geoheritage Areas: a promising IUCN initiative for global geoconservation

José B. R. BRILHA[1]*, University of Minho / ProGEO (jbrilha@dct.uminho.pt)
Kyung-Sik Woo[2], GSG-WCPA/IUCN
Tim Badman[3], IUCN
Antonio Pizarro[4], SEDPGYM
Lars Erikstad[5], ProGEO
Manuel Monge-Ganuzas[6], SGE
Benjamin van Wyk de Vries[7], IGC-IUGS
Darlington Munyikwa[8], National Museums and Monuments of Zimbabwe
Gabi Schneider[9], Namibian Uranium Institute
Hassan El Hadi[10], Université Hassan II de Casablanca
John Gunn[11], GSG-WCPA/IUCN
Kevin Page[12], ProGEO
Maria da Glória Garcia[13], University of São Paulo
Marie-Luise Frey[14], GGN
Nigel Dudley[15], Equilibrium Research
Paul Williams[16], University of Auckland
Piotr Migoń[17], University of Wrocław
Thomas Casadevall[18], GSG-WCPA/IUCN
Wesley Hill[19], GSG-WCPA/IUCN

Abstract

During the last fifty years, numerous international designations have been established with a focus on biodiversity and/or natural heritage conservation, but only a small number are dedicated to geoconservation. This discrepancy underscores the relatively low level of public awareness regarding the importance of geodiversity and geoheritage. Apart from UNESCO's World Heritage and Global Geoparks initiatives, and the recent IUGS Geological Heritage Sites list, there are no other international designations specifically aimed at recognizing geoheritage. As more countries develop their own national inventories of geoheritage, additional geosites are being identified and protected, leading to a growing realization that the number of geosites with international significance far exceeds those recognized by UNESCO and IUGS. Moreover, many key geosites may never be included in these lists due to failure to meet the necessary selection criteria.

In 2020, the International Union for Conservation of Nature (IUCN) adopted Resolution 74, calling for a scoping study on a new initiative termed Key Geoheritage Areas (KGAs). Subsequently, a working group was established to conduct this study and propose guidelines for KGAs. A public consultation was conducted from July to September 2023, and a final version of the KGA Guidelines is currently being prepared, incorporating many of the suggestions raised during the consultation.

A KGA is an area with well-defined boundaries where significant geological features (rocks, minerals, fossils, sediments, soils, landforms and landscapes) represent past or on-going Earth processes contributing substantially to the global understanding of the planet's history and its life-support systems. The primary objective of the initiative is to recognize and conserve geoheritage

values of international significance and to disseminate and promote this information to advance geoconservation efforts worldwide. The KGA initiative does not merely comprise a list of geosites; rather, it is strongly committed to persuading national and local authorities to protect the most relevant geosites and implement IUCN geoconservation guidelines, ideally with active involvement from local communities.
The final establishment of the KGAs initiative is expected to occur in October 2025, following its final adoption by IUCN.

Keyword

Geoconservation, International designation, Geoheritage, KGA, IUCN

[Keynote] Conservation of geodiversity and geoheritage in protected and conserved areas underpins natural systems and contributes to a sustainable future

John E. Gordon[1]*, School of Geography and Sustainable Development, University of St Andrews (jeg4@st-andrews.ac.uk)

Abstract

Direct and indirect human impacts on the planet present huge challenges for a sustainable future. They include climate change, biodiversity loss and delivering the UN Sustainable Development Goals. Conservation of geodiversity and geoheritage in protected and conserved areas (PCAs) has a key part to play in addressing these challenges. Geodiversity underpins the characteristics, functioning and evolution of terrestrial and marine ecosystems at all scales from the local to the whole planet. Geodiversity also delivers vital ecosystem services through its influence on landscape, habitats and species, economic activities, historical and cultural heritage and people's health and well-being. Furthermore, understanding the physical environment and lessons from the geological record are fundamental to informing climate change adaptation and sustainable management of natural resources, including the land, water, coasts and seas. Therefore, in the face of a variety of pressures and threats, conservation management of geodiversity and geoheritage in PCAs is essential to: 1) preserve the 'memory of the Earth' and its geoheritage values; 2) maintain the physical template for habitats and species and the abiotic ecosystem processes without which biodiversity could not exist and ecosystem services would be compromised; 3) protect the environmental archives that provide the knowledge base for informing ecosystem management, recovery and adaptation to climate change. The presentation examines what this means and requires in practice. It sets out key principles and examines recent progress in geoconservation and the challenges that lie ahead, including climate change and overcoming barriers towards more integrated nature conservation and mainstreaming geoconservation into nature conservation policy and practice.

Keyword

Geoconservation, sustainability, climate change, agenda for the future

New geoheritage research initiative of the Saudi Geological Survey aiming to act as national guardian of the abiotic natural values of the Kingdom of Saudi Arabia

Turki Sehli[1], Saudi Geological Survey
Karoly NEMETH[2]*, Saudi Geological Survey (knemeth@geoconservation.org)
Rashad M Moufti[3], Afaaq Geoconsulting, Jeddah
Naser S Jahdali[4], Saudi Geological Survey
Iyaed S Zalmout[5], Saudi Geological Survey
Yahya A Mufarreh[6], Saudi Geological Survey
Mahmoud S Ashor[7], Saudi Geological Suirvey
Abdulrahman G Sowaigh[8], Saudi Geological Survey

Abstract

The Kingdom of Saudi Arabia is the nation with the largest territory within the Arabian Peninsula. Its geological formations in the west dominated by Neoproterozoic rocks on the surface as part of the old Arabian Shield continental margin that is flanked by some Paleozoic volcanic arc related successions gradually covered by typical carbonate dominated platform rocks formed in the Tethys realm. In the western part of the country is dominated by Neogene volcanic products post-dating the Red Sea Rifting in a form of continental rifting offset of it, forming characteristic black rock or ash deserts as a dramatic arid landscape. The Kingdom's geology is diverse and largely unexplored while tis aesthetic values recently exploited due to the new initiatives to utilize the country natural heritage through geotourism. This new trend resulted major developments around dedicated tourism hot spots such as Al Ula or Khayber in the north, but it can also be seen in other regions such as just around the capital city of Riyadh. These new developments are clearly angling tourism from the biotic (e.g., biodiversity), archaeology (e.g., presence of mystic archaeological sites) or cultural (e.g., living culture, architecture) aspects while geology or even dedicated geomorphology is either expressed in very basic level or not even explored yet in a level they deserved to be. To narrow this knowledge and operational gap, the Saudi Geological Survey established new research initiatives that aim to develop a geological and geomorphological inventory of geosites and pursue research on mapping the geodiversity of the Kingdom. Alongside of this basic research activity, this new initiative within the Survey aim to develop methods to transfer geological and geomorphological knowledge to geotourism operation and design geotrails, geoeducation centers, explanatory boards both in real and virtual environments. The rationale of this new initiative is multi-faced. The Saudi Geological Survey holds a very extensive and valuable geological database in forms of geological maps, reports, sample inventory that are ready to be utilized for specific geosite evaluation. The Saudi Geological Survey is also a national level organization that has the right infrastructure to build geosite inventory. In addition. It has the human resources to be as an advisor or service provider for other end-users such developers or tour operators. The Saudi Geological Survey has also recently recognized the useful aspects of geoheritage to use it to disseminate geological knowledge to the community to enforce geohazard

resilience particularly in volcanic, seismic, and mass flow hazards.

Keyword

geosite, geoheritage, geodiversity, inventory, geoconservation

How to save a discovery in an active mine? Cooperation with the mine and its workers to protect the dinosaur heritage

Grzegorz Niedźwiedzki[1], Regional Geology Department, Polish Geological Institute - National Research Institute, 4 Rakowiecka St., 00-975 Warszawa, Poland; Subdepartment of Evolution and Development, Department of Organismal Biology, Uppsala University Norbyvägen 18A SE-752 36 Uppsala, Sweden
Piotr SZREK[2]*, Polish Geological Institute - National Research Institute (piotrszrek@yahoo.com)

Abstract

The Borkowice site has provided several thousand dinosaur footprints, numerous dinosaur bones and coprolites. It is a research material that has just come to light and is already the center of interesting studies. A large part of the footprint specimens shows (especially visible in 3D scans) three-dimensional natural casts of dinosaur feet, on which anatomical features and impressions of the scaly skin are preserved in unusual details. These are the best-preserved traces of dinosaurs so far discovered in Poland and the quality of their preservation is equal to the best-known discoveries worldwide. The collection also includes records of ethology (behaviour) left by dinosaurs running, swimming, resting and sitting on a muddy sediment, as well as many enigmatic biogenic structures, probably related to various life activities of dinosaurs living there. So far, dinosaur tracks representing at least seven different taxonomic groups have been collected and secured in Borkowice, as well as casts of bone remains of ornithischian dinosaurs.
Due to the uniqueness and great significance of the find, the cooperation between the businessman using the clay deposit containing the sandstone with the tracks, local and central government authorities and scientists is noteworthy. Together we are working out unprecedented legal solutions in Poland to protect the site while at the same time developing it for the purposes of natural science education. Numerous challenges are involved in reconciling the property rights of the site. This is because it is leased for mining purposes, but is owned by the Polish State Forests, which have separate regulations for recultivation mation. A major investment is planned, to be financed for the municipality by the central authorities. The currently established form of protection as a documentation site will be developed together with the Polish representatives at UNESCO. The aim is to lead to the establishment of a natural monument, which could be given the title of a natural heritage site in the future.

Keyword

dinosaurs footprints, rock resources, geoheritage, protection

Toward global modelling of geoheritage and geodiversity loss

Mihai Niculiță[1]*, Alexandru Ioan Cuza University of Iași (mihai.niculita@uaic.ro)

Abstract

Geoheritage and geodiversity are a hot topic these days, especially in the context of their loss. While geoheritage loss is a natural phenomenon, due to the natural evolution of the processes, anthropic changes and climate changes are driving geodiversity loss so a mapping approach at a global scale would be beneficial in terms of the amount of work needed to ramp up the protection approach. For such an endeavor, we have identified first the areas which are not protected yet, and focused the analysis on geodiversity loss, based on a land-cover change analysis. Land cover is used as a substitute, based on the idea that in areas where there is no change in surface conditions, there is a low probability of geodiversity loess, although we also showed that in some areas the loss is happening although there is not much visible change. These areas should be considered for an in-depth analysis were more factors should be considered. Further, we introduced factors such as landforms, geology, habitat type, climate, and climatic variables, to run a statistical analysis that would emphasize the complexity of the geo-environment and finally mapped the areas of change to identify hot spots of environment change and geodiversity. Besides land, we have focused also on coastal and marine areas. The availability of the data, especially in marine areas is a barrier in the analysis of these areas, where even the geodiversity is hard to assess. Anyway, despite these hurdles, actually this environment is the most sensitive to geodiversity loss, given its particularities. The results of this approach are summarized with maps of factors and maps of hot spots that need to be considered in the geoheritage approach. The usability of such a study we believe relates to the need to drive this hot topic toward the areas that need the most geoheritage evaluation and protection.

Keyword

geoheritage, geodiversity, loess, global

Interpretation of Underground Structure and Provenance for Rock Properties in Three-story Stone Pagoda and Flagpole Support Stones from Jungchosaji Temple Site of Anyang, Korea

HyeJi Choi[1]*, Department of Cultural Heritage Conservation Sciences, Kongju National University (conan-doil@naver.com)
YOONOH JEONG[2], Department of Cultural Heritage Conservation Sciences, Kongju National University
CHANHEE LEE[3], Department of Cultural Heritage Conservation Sciences, Kongju National University
HEESOO CHOI[4], Top Heritech, Industry-University Research Center, Kongju National University

Abstract

The Jungchosaji temple site in Anyang is the historical site where both Jungchosa and Anyangsa temple built during Unified Silla (676 to 935 AD) and Goryeo Dynasty (918 to 1392 AD) respectively in Korea. The flagpole support stones and three-story stone pagoda are the left heritages of those temple sites. Since 123 characters are engraved on the surface of the flagpole support stone which state its original name, founding date and participants, it is historically and academically valuable. However, it had experienced several conservation and restoration process due to long term weathering and constant deterioration. Furthermore, the three-story stone pagoda has lost some parts of body stones, and has damaged throughout the entire stone components.

In this study, the geological status and petrological weathering characteristics of the stone components were geochemically analyzed to figure out the suitable conservation scheme. Provenance interpretation of the stones were interpreted, and nondestructive diagnosis were conducted to quantitatively assess the extent of stone damages. Especially, the underground of the site was explored in geophysical way to evaluate the structural stability. As a result, all stone components are composed of medium to coarse grained granite, consisting of quartz, plagioclase, alkali feldspar and biotite. These are assigned as large scale Jurassic granite which is distributed in the vicinity. Some quarry marks were discovered at the presumed quarry site, and lithological and geochemical analysis confirmed the homogeneity between the granites of stone components and quarry sites.

In GPR (ground penetrating radar) survey, a variety of reflection intensities were detected through the north to south and east to west profiles right under the heritage sites, which is the evidence of ground stratification. The P-wave velocities were measured as three layers which were divided as follows: weathered soil layer below 700 m/s, weathered rock layer between 700 and 1,200 m/s, and the unweathered rock layer above 1,200 m/s. The electrical resistivity values ranged from 106 to 18,443 Ωm, with relatively higher values beneath the stone pagoda and flagpole support stones. Considering all the result, the underground conditions were estimated to be stable.

According to the stress analysis of the stone pagoda regarding the ground state, the maximum compressive stress was calculated to be 1.31. Structural modeling and numerical analysis results revealed that there are no structural problems. In order to assess the impact of vibration from the

surrounding traffics, the predominant frequency at primary and secondary mode are measured as 6.7Hz and 7.5Hz, respectively. However, these values are interpreted as minimal. Based on the results, this series of study will contribute to the conservation scheme of cultural heritages in Jungchosaji temple site.

Keyword

Jungchosaji Temple Site, Stone Components, Provenance, Underground Structure, Conservation Scheme

U.S. Geological Survey Geoheritage Sites of the Nation Inventory

Christina A DEVERA[1]*, U.S. Geological Survey (cdevera@usgs.gov)
Paco Van Sistine[2], U.S. Geological Survey
Thomas J Casadevall[3], U.S. Geological Survey
Timothy C Henderson[4], Colorado State University, U.S. National Park Service
Leslie F Ruppert[5], U.S. Geological Survey

Abstract

The U.S. Geological Survey (USGS) National Cooperative Geologic Mapping Program (NCGMP) is developing a geoheritage site inventory to showcase the geodiversity and natural heritage throughout the United States (U.S.) and its territories. The site inventory will be produced as a geoheritage geospatial product (GGP) to accompany the seamless 2D and 3D geologic map and model being developed by the NCGMP U.S. GeoFramework Initiative. An interactive WebMap application is being developed to host the GGP with the goals of serving as an education and outreach tool to raise awareness of significant geologic sites across the U.S., communicating the role of geology in our natural heritage, and increasing public accessibility and relevance of geologic mapping and geoscience topics broadly.

Geoheritage sites for this inventory were selected from in situ geologic features that have been previously identified as geologic points of interest on Federally designated public lands managed by the U.S. Federal Government. Due to the non-regulatory nature of the USGS mission, selecting sites on Federal public lands ensures that land management practices are already in place to preserve the integrity of the site. To be included in the inventory, these sites must demonstrate scientific significance of the geologic phenomena and can provide educational opportunities for both formal and informal learning, illuminate cultural connections to the landscape, showcase both historic and present-day examples of economic opportunities, and have an aesthetic allure that generates a geotourism economy within our Federal public lands. USGS and U.S. National Park Service (NPS) collaborators have selected one geoheritage site on Federal public lands within each U.S. state and territory to provide a geographically distributed dataset that highlights the geodiversity of the nation (n=55). There is ongoing effort to expand the initial geoheritage site inventory as the USGS collaborates with other Federal land managing agencies, State geological surveys, academia, non-governmental agencies, and Indigenous groups to identify additional sites that meet our geoheritage selection criteria.

The GGP will provide direct linkages to spatially relevant geologic maps contained in the USGS National Geologic Map Database along with USGS- and partner-produced resources for each geoheritage site hosted on the interactive geoheritage WebMap application, allowing for improved public access to complementary information. The GGP can be queried based on user interests using keywords from controlled vocabularies that describe the scientific, educational, cultural, economic, and aesthetic geoheritage values of the site. These keywords are derived from USGS and NPS geologic glossaries, the American Geosciences Institute Glossary of Geology, Next Generation Science Standards Crosscutting Concepts, and terms employed by U.S. and

international researchers of geodiversity, geoconservation, and geoheritage. Each site features brief, plain language descriptions and includes applicable superlatives presented in a narrative form that enable geologic concepts to be easily understood by the public. Broadening the relevance and accessibility of USGS geologic mapping through a geoheritage inventory can highlight the geodiversity of the U.S., inform geoconservation decisions made by land managing agencies to preserve the unique geoheritage of the country, and foster a deeper understanding of the role geology plays in society.

Keyword

geoheritage, geodiversity, geospatial datasets, education, outreach

Lithological Characteristics and Provenance Interpretation of Stone Properties for Jotap-ri Five-story Brick Pagoda in Andong, Korea

Dong Hee JEONG[1]*, Department of Cultural Heritage Conservation Sciences, Kongju National University (ehdgml361@naver.com)
Il Kyu Choi[2], Department of Cultural Heritage Conservation Sciences, Kongju National University
Seok Tae Park[3], Department of Cultural Heritage Conservation Sciences, Kongju National University
Chan Hee Lee[4], Department of Cultural Heritage Conservation Sciences, Kongju National University

Abstract

The Five-story Brick Pagoda in Jotap-ri of Andong is a cultural heritage from the Unified Silla (676 to 935 AD) in ancient Korea. Unlike other brick pagodas, the sandstones were used for the entire body part of the first floor. A rectangular tabernacle was built on the south side of the pagoda body, and statues of the guardians were carved on the left and right sides. The roofs above the first floor were made of bricks, and the bricks with patterns that appear to have been from the time of the first construction remain and in recognition of their value, it was designated as treasures.

The geology around the Jotap-ri pagoda consists of sedimentary rocks with Gyeongsang Supergroup in Cretaceous based on granitic gneisses of Precambrian, and is occupied by the Jinju Formation which is part of the Sindong Group, and the Formations of Iljik, Hupyeongdong and Jeomgok which are part of the Hayang Group. The Jotap-ri area where the pagoda is located a sandstone layers of Iljik Formation, and is composed of various types of sandstone.

The stone properties of the pagoda are made up by four types of sandstone: light gray to green sandstone, conglomeratic sandstone, dark gray sandstone and purple sandstone. The number of stones in the pagoda is 88 properties, and when calculated with elevation by direction, a total of 119 sides are exposed. It is believed that this sandstone was used in the construction process of the pagoda without regard to the location or purpose of the stones, and among these, light gray to green sandstone is confirmed to be the dominant species, accounting for 69.32% of the total stones. However, the two guardian statues on the left and right of the tabernacle were made up purple sandstone of a unique color, giving them special meaning.

In order to secure replacement stones for the original stone properties on the pagoda needed in the repair and restoration processes, geological survey was conducted near Jotap-ri to find stones that were almost identical in lithology, mineralogy, texture, color and magnetic susceptibility to the sandstones of the same type as the pagoda. The estimated production area was explored. Additionally, the identity of the two sandstones were proven through quantitative petrographic and geochemical analysis.

As a result, all four types of sandstones were interpreted to be of the same origin as the sandstones discovered within 2km near Jotap-ri. Some of the sandstones, which are presumed to be of the same type, are used as foundation stones for private houses or are left exposed to the outside.

These stones are evaluated as potential heritage and require special management to prevent damage. It is expected that replacement stones for the Jotap-ri pagoda can conserve the authenticity of cultural heritage by utilizing the provenance interpretation reviewed in this study.

Keyword

Brick Pagoda in Jotap-ri, Sandstone, Provenance, Replacement Stone, Authenticity

Stability Interpretation for Rock-carved Standing Buddha Triad of Dongmun-ri in Taean, Korea, based on Geophysical Exploration and Slope Analysis

ILKYU CHOI[1]*, Department of Cultural Heritage Conservation Sciences, Kongju National University (illgyu21@naver.com)
HEE SOO CHOI[2], Top Heritech, Industry-University Research Center, Kongju National University
JUN HYOUNG PARK[3], Corporate Research Institute of Creation, Radpion Inc.
CHAN HEE LEE[4], Department of Cultural Heritage Conservation Sciences, Kongju National University

Abstract

The Rock-carved Buddha Triad of Dongmun-ri in Taean is a stone cultural heritage with Baekje Kingdom (18 BC to 660 AD) in ancient Korea which was built in southwest slope of the rock surface. Unlike general rock-carved Buddha statues, this Buddha Triad has the unique formative characteristics of a small Bodhisattva placed between the two Buddha statues. This Buddha Triad is located at a strategic point with China, and is very important in understanding the relationship and influence of the northern Chinese style Buddha statues from middle in the 6th century. As it is the oldest rock-carved Buddha statue from the Baekje period, it is preserved and managed as a national treasure in Korea.

The lower part of the Buddha Triad was buried when it was first discovered in 1962, and the lotus pedestal and cornerstone were confirmed through excavation. In 1989, due to concerns about the collapse of the Buddha Triad, various investigation were conducted, and the buried lower part was covered and preserved. In 1995, the lower part of the Buddha Triad was exposed through repair works and conservation treatment.

This Buddha Triad has undergone several maintenance works since its initial discovery, and it is currently located in a safeguarding facility and protected from the external environment. However, rock slopes and cliffs are distributed around the Buddha Triad, and a collapse of the slope may occur. In this study, geophysical investigations were conducted on the underground around the Buddha Triad to review the overall geological structure and anomaly zone. In addition, the possibility of plane, wedge and toppling failure of the Buddha Triad and surrounding bedrock were examined through slope stability evaluation.

As a result, the boundary between low electrical resistivity and reflection signals were detected in the southern part of ground, and the sloping stratigraphic structure of the north and south elevations confirmed in the excavation in 1994 was the same. This is different from the direction of bedrock in the Buddha Triad, which raised the collapse risk, so possibility of destruction by the ground is interpreted to be low.

Slope stability evaluation of rock mass to the Buddha Triad has a low possibility of slope failure, but the rock mass nearby is exposed to risk. Since the areas that can be destroyed are concentrated around the road above the Buddha Triad, it is necessary to review measures to prepare for the occurrence of safety accidents in the future. This result is significant as it is the first scientific study applied to the bedrock and ground where the Buddha Triad is located, and preservation

schemes and preventive conservation should be prepared based on this data.

Keyword

Rock-carved Standing Buddha Triad, Bedrock, Geophysical Investigation, Slope Stability, Preventive Conservation

Provenance Interpretation and Petrological Characteristics from Hongjueupseong Fortress Wall and Stone Block Foundation of Joyangmun Gate in Hongseong, Korea

JUN HO SONG[1]*, Department of Cultural Heritage Conservation Sciences, Kongju National University (catosaurus@naver.com)
Seok Tae Park[2], Department of Cultural Heritage Conservation Sciences, Kongju National University
Chan Hee Lee[3], Department of Cultural Heritage Conservation Sciences, Kongju National University

Abstract

The Hongjueupseong Walled Town is a stone fortress built during the Joseon Dynasty (1392 to 1910 AD) in Korea. It was the administrative and military center of the Naepo region for hundreds of years, and was the place where the Anti-Japanese Movement, Donghak Peasant Movement, Eulmi and Eulsa Independence Movement took place. It is a cultural heritage with great historical research and conservation value in that it retains the appearance of the Joseon Dynasty fortress and government office. The Joyangmun is the east gate and the most important main gate of Hongjueupseong Walled Town. It served as the starting point for a central road that ran through the fortress and a network of roads leading to other area.

Most stone cultural heritage is damaged by various factors after construction, and its original historical authenticity is gradually lost. This walled town also continued to suffer various damages after construction, and some of its walls even collapsed. Of the total length in the fortress of about 1,772m, the remaining wall is only about 800m. In 2016, a detailed diagnosis was conducted on the fortress walls of Hongjueupseong and Joyangmun Gate. As a result, both structural changes in the wall and ground subsidence were found to be serious.

This walled town has always been a risk to stability, and in 2023, the walls collapsed due to heavy rain. The Joyangmun Gate is also structurally unstable, and the physical properties of the stone block foundation are weak. Thus, it is highly likely that it will be replaced with a new stone when the conservation and restoration project is carried out in the future. The restoration stone must be identical rock from the same source as the original rock. This respects the original form of cultural heritage and enhances the authenticity of the restored stones.

As a result of investigations the rock types and occupancy rates of the Joyangmun Gate, light gray biotite granite (57.05%) was found to be the most used stone. Pinkish biotite granite accounts for 42.62% and is divided into original stone (2.85%) and restored stone (39.77%). Although the three rock types are slightly different, whole rock magnetic susceptibility, petrological, mineralogical and geochemical analyzes indicate that they have the same origin.

The mountainous area surrounding the Hongjueupseong Walled Town is mostly composed of granite. It is believed that stones were also procured from nearby areas in earlier times. Pink feldspar granite collected from the nearby Suamsan and Yongbongsan Mountain area show magnetic susceptibility and geochemical properties similar to the granites that make up the stone

block foundation of the Joyangmun Gate. In the future, when establishing a conservation and restoration scheme for Joyangmun Gate in Hongjueupseong Walled Town, restoration stones will need to be procured from the relevant area.

Keyword

Provenance Interpretation, Stone Heritage, Biotite Granite, Pink Feldspar Granite, Restoration Stone

Cultural ecosystem services as a good presentation of geodiversity in the geopark– A case study in Taitung Geopark, southeast Taiwan

Chuanyao CHI[1]*, Genesis Geological Consultant Ltd. (cychi.geo@gmail.com)

Abstract

Geoparks are promoted through bottom-up approach. Many studies point out it is difficult to promote the geodiversity of a geopark to the public only by the scientific point of view. Thus we need transform the scientific knowledge to what local people are concerned. Recent years many researches used the Ecosystem Services concept to demonstrate the importance and benefits of geodiversity. The cultural services-- one of the Ecosystem Services, which contains value placed by society on some aspect of the physical environment by reason of its social or community significance are highly related to the local people and sense of place. They could be good examples for explaining the geodiversity in the geopark.

Our study focus on the Taitung Geopark located in southeast Taiwan. It is located between Beinan River and East Coast, and is the south-tip of Coastal Range. The geological setting is in the suture zone of Eurasia plate and Philippine sea plate. The bedrock belongs to Lichi mélange which is a tectonic mélange with mudstone matrix and contains exotic rocks of different origins. This study finds out that the long history of man-land relation creates different kinds of cultural services of geodiversity. There are abundant cases which can reveal the characteristics of geological environment such as place names of indigenous people, folklores, spectacular landscapes, historical photos. All of this are good examples for showing the local culture which is based on the geodiversity, and we can furtherly use these cases to explain how geological environment is related to our life. It could increase the local identity and the understanding of concept of geopark.

Keyword

abiotic ecosystem services, cultural service, geodiversity, geopark

Integrated geological and geophysical monitoring of the Udo beach sediments (Natural Monument) for geoheritage conservation

WOOSEOK YOON[1]*, Jeju National University (geoyoonws@jejunu.ac.kr)
SEOK-HOON YOON[2], Jeju National University
JAE-HONG MOON[3], Jeju National University
SEONG HUN BYUN[4], Jeju Special Self-Governing Province
KYUNG SIK WOO[5], Kangwon National University

Abstract

This study is to introduce the monitoring results of the beach sediments from 2016 to 2023 in Udo Island, which is located about 2.6 km east of Jeju Island, Republic of Korea. The monitoring site has been designated as a Natural Monument since 2004, because the beach sediments is almost entirely of composed of rhodoliths (red algal nodules), which is unique in Korea. The monitoring has been carried out to understand the distribution and volume change of the sediments upon request by local residents. The integrated monitoring consists of coastal geological and geomorphic changes. The monitoring results are based upon the topographic data of terrestrial LiDAR scanning and drone photogrammetry, referring to weather and oceanographic conditions such as wind direction and intensity of waves, currents, and winds, and are also based on offshore bottom topography and the sediment distribution in shallow marine areas. As the intensity of waves and currents fluctuated and influenced obliquely toward the N-S trending coastline, the beach sediments have been continuously reworked and transported southward or northward mainly by longshore currents, which appear to act as a major control mechanism for any topographic changes of the beach. The volume of the beach sediments varies depending on the characteristics of weather or sea conditions during seasonal basis but remains more or less constant in the long run, while the areal distribution tends to decrease. This indicates that the coastline slowly retreats as a result of sediment erosion in the lower foreshore and the subtidal zone although the subaerial part of the beach sediments maintain the overall volume. This appears to result from a combined effect of enhanced beach erosion by natural and artificial factors. Those are gradual sea-level rise and abnormal high waves due to long-term climate change, and the loss of buffer zone toward land due to the construction of seawall, road and buildings. The integrated monitoring of the Udo beach enable to understand natural environmental change due to natural and man-made influences, and this result may help predict the future environmental changes of the study area and establish effective conservation and management plan for the future.

Keyword

Geoconversion, monitoring, Topographic changes, Geoheritage, Rhodoliths Beach

Can computational geoscientists and digital innovation contribute to geoconservation strategies?

Antoine BOUZIAT[1]*, IFP Energies nouvelles (antoine.bouziat@ifpen.fr)
Julien SCHMITZ[2], IFP Energies nouvelles
Vanessa TELES[3], IFP Energies nouvelles
Youri HAMON[4], IFP Energies nouvelles
Damien BONTE[5], IFP Energies nouvelles
Christophe CORNET[6], IFP Energies nouvelles
Aziz BEN AMMAR[7], IFP Energies nouvelles
Abdelaziz SNOUSSI[8], IFP Energies nouvelles
Angélique MONGUILLON[9], Réserve Naturelle Régionale du site géologique de Limay
Valérie CHALUMEAU[10], Réserve Naturelle Régionale des Coteaux du Pont-Barré

Abstract

One key aspect of an effective protection of natural systems is to increase awareness and knowledge about geodiversity and its importance in the preservation of these systems. This ambitious but critical objective needs contributions from the global geoscience community, involving a diversity of profiles. In this context, a possible role for computational geoscientists and digital innovation specialists consists in developing innovative technologies to support communication and education about geoconservation and the monitoring of geoheritage. For example, such technologies can be used by geosite conservation officers as additional means of scientific outreach and to track the condition of key outcrops through years.

At IFP Energies Nouvelles (IFPEN), a French public center for applied research in the fields of energy and the environment, computational geoscientists and digital innovation specialists closely collaborate with nature reserves in innovation projects. These initiatives aim to develop customized tools to enhance the educational activities of these reserves towards school pupils or the general public. On-going projects include multiple technologies and services: virtual models of geosites, augmented reality for outcrop exploration, 3D printed replicas of geological structures, and a mobile application for rock recognition with Artificial Intelligence.

In the case of areas with access restriction due to security or biodiversity protection, such as the nature reserve of the geosite of Limay (France), virtual 3D models based upon photogrammetry principles are informed with additional geolocated data on geology, biodiversity, geological paleoenvironment and fossils. These Digital outcrop models (DOM) can then be displayed on web platforms or in virtual reality environments. Augmented reality is also being developed to provide basic geological information minimizing on-site facilities and displays. Both technologies enable non-specialists to access educational contents along the detailed 3D representations of the outcrop or the outcrop itself . Besides, DOMs built at different years from new photo acquisitions can register changes in the reserve’s geoheritage, to be considered in geoconservation roadmaps.

In the case of open nature reserves where the outcropping rocks are linked with a complex geological history, such as the one of Coteaux du Pont-Barré (France), printed 3D blocks give an overview of the geological context. Besides, the prototype mobile application called RockNet®, which relies on a deep artificial neural network, can be trained to automatically categorize photos of the local rocks. The idea is to facilitate access from the public to lithology recognition and a first level of geological information.

Finally, a dedicated consortium named SELENA will be launched soon to connect professionals interested in geodiversity and digital technologies. This should foster the sharing of ideas, experience and good practices, and ensure that the contribution from computational geoscientists and digitalization specialists are as relevant as possible to address concrete geoconservation needs.

Keyword

Geoheritage, Geodiversity, Digital, Outreach, Nature reserves

Geoheritage and Geotourism prospect of Ramu Upazila Cox's Bazar District, Bangladesh

Md. Faruk HASAN[1]*, Geological Survey of Bangladesh (faruk.hasan1981@gmail.com)
Mohammad Omer Faruk Khan[2], Geological Survey of Bangladesh

Abstract

Geoheritage and geotourism studies are gaining increasing popularity among geologists, and Bangladeshi researchers are no exception. Inspired by this trend, a comprehensive assessment of the geoheritage and geotourism potential within Ramu Upazila, Cox's Bazar District, Bangladesh has been conducted. Encompassing an area of approximately 391.71 sq. km, the study zone spans from 21°17' to 21°37' north and 92°00' to 92°15' east. Building upon extensive fieldwork conducted by the Geological Survey of Bangladesh for mineral resource exploration, the investigation meticulously analyzes various geological, climatic, and physiographic aspects alongside the region's rocks and minerals. Notably, the focus lies on identifying geological features with promising geoheritage and geotourism potential. Several geological attributes contribute to the geoheritage potential of Ramu Upazila, including its hilly terrain, diverse and colorful rock formations, and stunning sandy beaches. The hilly landscape itself boasts an abundance of features with significant touristic value, such as numerous streams, valleys, hillocks, gorges, rapids, rock exposures, and cliffs. These potential sites offer immense possibilities for geotourism development; marine drive flanked by a vertical cliff on one side and the boundless sea on the other, hilly stream cascading through a narrow gorge, thrilling rough track winding through the hilltops, rocky hilltop commanding panoramic views of the ocean, tranquil path traversing a forested stream, scenic hilly road carved through rock cuts exposing the contact between the Tipam and Girujan Clay formations, captivating trail traversing the entire geological sequence from Dupi Tila to Bhuban and charming cliff sculpted by a gurgling hilly stream. However, it is crucial to acknowledge that implementing appropriate conservation measures is paramount for ensuring the long-term sustainability of the region's geo-environmental conditions. By striking a harmonious balance between responsible tourism and meticulous preservation, Ramu Upazila can blossom into a thriving geotourism destination while safeguarding its invaluable geological heritage for future generations.

Keyword

Geoheritage, Geotourism, Geology, Conservation, Ramu

Preserving Belitong Island UNESCO Global Geopark Unique Heritage: Geomorphosites and Anthropogenic Landforms

Santi Dwi Dwi PRATIWI[1]*, Faculty of Geological Engineering, Universitas Padjadjaran, Indonesia.Jl. Raya Bandung Sumedang Km. 21, Jatinangor, Sumedang 45363, West Java, Indonesia (santi.dwi.pratiwi@unpad.ac.id)
Dina Oktavia[2], Graduate School, Universitas Padjadjaran - INDONESIA. Jl. Dipatiukur 35, Bandung, West Java, Bandung 40132, West Java, Indonesia

Abstract

Geomorphosites represent one category among various geosites, carrying both scientific and additional values (such as cultural, historical, religious, ecological, social/economic, and aesthetic) that contribute to the development of geoparks. The research on geomorphosites and geoheritage within the Belitong Island UNESCO Global Geopark has been limited since its establishment in 2017, encompassing 17 designated geosites. Located around 400 km north of Jakarta, the capital of Indonesia, Belitong Island is encircled by the Karimata Strait to the north, the Java region to the east and south, and the Gaspar Strait to the west.The geological composition of Belitong Island encompasses unique tektites created through meteorite impacts and within the Geopark reside more than 300,000 people representing diverse cultures, including the Sawang Tribe. The area is also home to exclusive plant and animal species, such as Cephalopachus bancanus saltator. Notably, the Kerangas Forest, characterized by stunted vegetation, stands out as a unique natural feature in the geopark, offering various benefits, including medicinal plants for the local community. Our investigation focused on evaluating the geotourism potential in East Belitung using a geomorphosite assessment that considers Scientific and Intrinsic Value (ScIV), Educational Value (EdV), Economical Value (EcV), Conservation Value (CV), Added Value (AV), and a geomorphological description at three key geosites (Samak Hill, Burungmandi, and Open Pit Kelapa Kampit). The study aims to ascertain the scientific value of these geosites and present their potential for geomorphotourism and geoconservation in the Belitong Island geopark. Results revealed that East Belitung comprises four geomorphological units: moderately steep hills (12% of the total area), rolling hills (63%), undulating plains (8%), and flat plains (17%). Samak Hill, featuring a Carbonaceous to Permian rock sequence, represents a plateau with sandstone, claystone, and shale lithology. The Bukit Samak Geosite, preserving Dutch Heritage Housing from the Kelapa Kampit Formation, holds historical significance dating back to Dutch colonial trade and reflects cultural integration between the Chinese communities and the local Belitung Malay population. The Granodiorite Burungmandi, characterized by steep hill geomorphology, possesses anthropogenic value, notably the Kwan Im Temple (1774), symbolizing the Chinese diaspora and China's initial expansion in Belitung. The Open Pit Kelapa Kampit geosite, situated in rolling hillside topography with red sandstones, quartzite, and metamorphosed lithology, offers high scientific value, showcasing anthropogenic landscapes and recording geological data dating back 350 million years ago (Paleozoic). Our findings suggest that these areas harbor valuable resources related to geomorphologic heritage, making them suitable for geoconservation and

geoeducation development within the Belitong Island geopark. Furthermore, a comprehensive review of anthropogenic landforms and geomorphosites strongly advocates for the preservation of Belitong Island geopark, emphasizing its unique status worldwide. Therefore, the establishment of a geopark is encouraged as a conservation effort to safeguard natural resources, habitats, and the well-being of both the environment and local inhabitants in Belitong.

Keyword

Geomorphosites, Belitong Island UNESCO Global Geopark, Paleozoic, Geotourism, Geoeducation

Sustainable use of materials from an abandoned quarry in a Unesco Global Geopark in Spain. A proposal.

Lola PEREIRA[1]*, University of Salamanca (mdp@usal.es)
Andrea Bloise[2], University of Calabria

Abstract

Serpentinite is a very valued stone for the information that can be retrieved from it about the petrogenesis and the evolution of the ultramafic rocks, but also for the use as construction material. However, extraction of this rock may be a challenge for the construction industry sector. The many heterogeneities that the serpentinite may show up during its extraction (e.g., carbonation, talc lenses, fractures, shearing, brecciation…) can convert the commercialization of the rock in a defy for the companies. Cabo Ortegal ultramafic complex, in Spain, is very well known scientifically for the splendid outcrops that have been studied from the geochemistry, mineralogy, physical and mechanical behaviour, but also for its relationship with architectonic and cultural heritage of the area. In fact, all this information was the main support for the recognition of Cabo Ortegal as a UNESCO Global Geopark in 2023. Serpentinites were commercialised as building stone during last century. They had been used to build the architectonic heritage of many villages around. The carbonation and conversion into talcose rocks made serpentinite an easily carving stone to build façades and monuments. These same characteristics made the stone very fragile in terms of weathering, and quarries were abandoned in the 21st century, leaving behind large blocks that could not be commercialised for construction. Now that Cabo Ortegal has been designated as UNESCO Global Geopark it will become an attraction for tourists. We propose to take advantage of the abandoned blocks of serpentinite (and carbonated serpentinite and talcose serpentinite) to be used for local artisanal activities. These activities are well known since millennia ago in many places around the world, and many cultures took advantage of the easy carving of the stone to build from small domestic artifacts to figurines representing local activities (e.g., fishing, hunting) and culture (e.g., the serpentine cylinder seal of Shilishu, Mesopotamia; from about 2400 BC) (Calas, 2003), the Inuit serpentinite carvings that are showed in many art museums (Coward Wight, 2003).

It is very important to characterize these rocks to avoid that they can trigger any health issues to artists or sculptors or any other workers dealing with the stone. For this reason, the authors have studied different samples representing the lithologies of interest to assess that the content of hazardous minerals (e.g., asbestos) and/or potential toxic elements, if detected, are within the limits permitted by Spanish law. For this purpose, we have collected seven samples and cross-referenced the data obtained from different analytical techniques (i.e., Petrography, XRPD, SEM–TEM–EDS, DTG–DSC, ICP-MS) to obtain a detailed characterization.

Research funded by: Grant PID2021-123948OB-I00 by the Spanish government.

Keyword

Cabo Ortegal, Unesco Global Geopark, serpentinite, talc, abandoned quarries

Paleontological Zoning: a new paradigm for geoconservation in the Uberaba Geopark, Brazil

Thiago da Silva MARINHO[1]*, Universidade Federal do Triângulo Mineiro (thiago.marinho@uftm.edu.br)
Maria Isabel Arcanjo Dias[2], Prefeitura Municipal de Belo Horizonte
Josenilson Bernardo da Silva[3], Universidade Federal do Triângulo Mineiro
Luca dos Santos Lopes[4], Universidade Federal do Triângulo Mineiro
João Vitor Ferreira dos Santos[5], Universidade Federal do Triângulo Mineiro
Januário Chirieleison Fernandes[6], Universidade Federal do Triângulo Mineiro
Ricardo Vicente Ferreira[7], Universidade Federal do Triângulo Mineiro
Luiz Carlos Borges Ribeiro[8], Universidade Federal do Triângulo Mineiro
Fabricio Anibal Corradini[9], Universidade Federal do Triângulo Mineiro
Carlos Alberto Valera[10], Ministério Público de Minas Gerais

Abstract

Fossil occurrences in the municipality of Uberaba, Minas Gerais, Brazil, are internationally recognized. Dozens of taxa of vertebrates, invertebrates, plants, and trace fossils have already been identified in rocks from the Upper Cretaceous Uberaba (Campanian) and Serra da Galga (Maastrichtian) formations, both exclusive to the region. The fossil content of the Serra da Galga Formation stands out in diversity and the number of collected fossils, while understanding of the Uberaba Formation has improved in recent years. Part of this difference can be attributed to the distribution of these two units: the Serra da Galga Formation outcrops in the rural zone of the municipality, while the Uberaba Formation occurs mainly beneath the city of Uberaba, accessed primarily through construction works within the urban perimeter. Even in this scenario, occurrences of Megaraptora and Titanosauria dinosaurs, theropod dinosaur eggs, and at least three different groups of Crocodyliformes, including the only identified species, *Eptalofosuchus viridi*, are currently recognized in the Uberaba Formation. The establishment of 'Geopark Uberaba: Land of Giants' has led to the implementation of geoconservation and heritage education measures in the municipality. Since then, there has been a significant improvement in the relationship between entrepreneurs and paleontologists, reflected in the rescue and description of new fossil occurrences. The Paleontological Zoning of the Municipality of Uberaba aims to map the urban perimeter and expansion areas into three zones based on paleontological potential. These zones will determine the procedures for works involving rock interference in the territory. This initiative, combined with legislation such as 'Portaria Conjunta 003/2015' by the municipal prefecture of Uberaba and the National Mining Agency, reinforces almost eight decades of efforts in the territory's geoconservation. Through Paleontological Zoning, combined with heritage education measures promoted by Uberaba Geopark, a new paradigm for geoconservation in the municipality of Uberaba is expected to emerge, ensuring sustainable urban development.

Keyword

Upper Cretaceous, Geoconservation, Geoheritage, Sustainable development, Fossils

The Geological Setting of Tanzania with Possibilities of Hosting Potential Geoparks Worldwide

John Desderius Kalimenze[1]*, Member (jokakally@yahoo.com)

Abstract

The geological setting of Tanzania is favorable to host diverse mineral deposits of economic significance and yet still favorable for providing a beautiful scenario for holistic features of geopark possibilities such as landscapes, waterfalls, mountains, lakes, meteorites, minerals, and calderas. In 2012, being the custodian of the national geoscientific data and information, the Geological Survey of Tanzania started initiatives for promoting geo-tourism in Tanzania by identifying a few potential sites of tourist attractions related to geology. The first flyer included sites such as Olduvai Gorge, Kilimanjaro Mt, The East African Rift Valley, Ngorongoro Crater, Oldoinyo Lengai Mt, Calderas (Embakai, Chala, and Ngozi), Mautia Hill, Waterfalls, Meteorites, Hot springs, Eclogites, Rock paintings and some mine sites (Mwadui, Mirerani) just to mention a few. Since the beginning of the new concept of geopark, geo-heritage, and geosites there were serious procedures taken to develop aspiring geoparks and eventually global geopark. In 2018, Tanzania managed to get the first UNESCO global geopark named the Ngorongoro Lengai UNESCO Global Geopark (NLUGG) of which some of the sites mentioned in the first flyer for promoting geo-tourism formed part of the NLUGG territory.

Recently, Tanzania is also running for the second geopark named the aspiring Arusha Meru geopark which covers most parts of Mount Meru, Arusha National Park, Waterfalls, and all historical-cultural heritage within the territory. Geopark phenomena are all about geo-tourism promotion and geo-heritage conservation and protection. While considering geopark should take into account the whole geographical setting of the region and shall not merely include sites of geological implication alone, the potential site should also meet the concept of protection, education, and sustainable development for scientific popularization and socio-economic development. This understanding of the geopark concept together with a favorable geological environment drives the Geological Survey of Tanzania to start an inventory program to identify all potential sites of geo-heritage significance for geo-tourism promotion as well as geo-heritage preservation, conservation, and protection.

Keyword

Geopark, Tanzania, Geoheritage, Conservation, Protection

Importance of Rock hive/Tafoni structure as geotourism point of view at Harihareshwar beach in Raigad district of Maharashtra, India

SHARAD GAJANANRAO PORATE[1]*, GEOLOGICAL SURVEY OF INDIA
(sharad.porate@gsi.gov.in)
GAURI VAIBHAO MOTGHARE[2], GEOLOGICAL SURVEY OF INDIA
JAYA RASHTRAPAL CHAVHAN[3], GEOLOGICAL SURVEY OF INDIA

Abstract

Rock hive/Tafoni are the weathering feature of many lithologies of the world where they are very common in sandstone, limestone and granites. Tafoni are ellipsoidal, pan- to bowl-shaped, natural rock cavities. These cavernous weathering features include tiny pits, softball-sized cavities, truck-sized caves, and nested and cellular honeycomb forms. Tafoni typically develop on inclined or vertical surfaces and occur in groups. These exquisite and fascinating cavernous weathering landforms are present on the surfaces of many different kinds of rocks located in a multitude of geographic regions around the world.

In the west coast of India, near Harihareshwar, this tafoni is formed in basalt which is very rare to find. The tafoni is generally formed due to salt weathering though many factors are responsible for the development of tafoni such as differential weathering, porosity and permeability of rocks and climatic factors. When waters get absorbed by the rock in the cracks, cleavages, fractures etc. it precipitates and crystals of salt develops. When this crystallized salt creates pressure on surrounding rocks, slowly by slowly the rock gets weathered and tafoni are formed.

At Harihareshwar coast, compound pahoehoe lava exposed with number of small lava lobes. Small lava lobes or units combinedly formed the massive compound pahoehoe flow which can be considered as single lava episode. Also, the small lava lobes or units are having different cooling rates and amygdular nature. As the rock is not homogeneous in nature, the salt weathering of lava lobes also supports the tafoni formation by removing surrounding amygdular top and base where the middle portion of lobe stand behind firmly. The chilled margin remains at its place due to its hardness. A point reaches where this middle portion of the lava lobe lose support from surrounding rock due to continuous weathering processes, thus it gets dislodged and a pit, hole or small tafoni are formed. These are very important and interesting feature for the study of geology and geomorphology of the coastal area.

The tafoni structure in Harihareshwar beach is about 400-500m in length and about 5-7m in width. Though tafoni structure is common along the area of west coast of Raigad district of Maharashtra, what makes this place unique is because of the different sizes of the rock hives. The size of the rock hives varies from 0.1cm to about 0.5m in diameter. The compound pahoehoe flow in the area is also intruded by the basaltic dyke which is about 5-6m in width and continues into the westwards in the sea. The dyke may also trigger this weathering by creating extension in the compound pahoehoe flow.

The place can be visit in view of Geotourism. One has to travel from Mumbai or Pune to

Shrivardhan which are the nearest places for airports. From Shrivardhan, Harihareshwar is about 17Km towards southwest direction. One shiv temple is also famous in the pilgrims. People used to visit this place and circumambulate the tafoni structure.

Keyword

Tafoni, geotourism, Harihareshwar, rock hive, lava

Investigation and Promotion of Geological Heritage of the Karaburun Peninsula in Türkiye

Oyküm Berfin GULERGUL[1]*, Department of International Water Resources, İzmir Institute of Technology, Gülbahçe Urla, Izmir, Turkey (oykumgulergul@iyte.edu.tr)
Aslıhan YILMAZER[2], Department of Architectural Restoration, İzmir Institute of Technology, Gülbahçe Urla, Izmir, Türkiye
Selen GULER[3], Department of Architectural Restoration, İzmir Institute of Technology, Gülbahçe Urla, Izmir, Türkiye
Taygun UZELLI[4], Geothermal Energy Research and Application Center, İzmir Institute of Technology, Gülbahçe Urla, Izmir, Türkiye
Yasemin OZCAN GONULAL[5], Department of General Culture Courses, İzmir Institute of Technology, Gülbahçe Urla, Izmir, Türkiye
Hülya YUCEER[6], Department of Architectural Restoration, İzmir Institute of Technology, Gülbahçe Urla, Izmir, Türkiye
Alper BABA[7], Department of International Water Resources, İzmir Institute of Technology, Gülbahçe Urla, Izmir, Türkiye

Abstract

Providing significant information about the geological evolution of the earth, geological heritage, when promoted, can have a considerable impact on the various dynamics of rural areas. In this brief framework, this study aims to explore and promote the geological heritage of the Karaburun Peninsula through suggesting geo-routes and geo-parks. A lesser-known by the public, yet significant geological feature of the peninsula is that it is one of the few places in Anatolia where geological units up to the Carboniferous period can be seen as a continuous stack. In addition to these features, mineral deposits, conductive fossils, important faults and water resources formed by regional tectonic movements constitute the geological heritage of Karaburun. Thus, the groundwater and soil properties together with geological formations of the Karaburun peninsula are examined by researchers from various disciplines as part of the study. In relation to these geological richness, now abandoned mine formations, settlements, and buildings are identified, documented and evaluated. Scattered throughout the peninsula these important nodes including marble quarries, manganese galleries, and clay pits are linked by a suggested geo-route. These nodes have different characteristics and were processed in historical periods for use in ancient settlements in Anatolia and abroad, such as Ephesus and Vatican. All these geological formations have also played an important role in trade and port activities between still inhabited Ildır (Erythrai) and Urla (Klazomenai) throughout history, especially in terms of mining. These activities continued during the Ottoman Empire and the early years of the modern Republic of Türkiye. In line with the findings, the proposed geo-route assesses the impact of geological heritage on today's rural life processes and safeguards the sustainable transmission of this heritage to future generations. As a result, the study contributes to the existing literature on the geological, hydrogeological, ecological, and mining features of the Karaburun Peninsula, provides new

resources for cultural, educational, and research-based activities, and assesses the region's potential for inclusion in UNESCO Global Geopark status.

Keyword

Geological Heritage (Geoheritage), Georoute, Geopark, Historic Mines, Karaburun Peninsula

Exploring Hydrogeochemical Characteristics and Impact on Geoheritage Monuments in Odisha: A GIS and Statistical Approach

ROSALIN DAS[1]*, Fakir Mohan University (rosalindas.geology@gmail.com)
MADHUMITA DAS[2], UTKAL UNIVERSITY, BHUBANESWAR
Shreerup Goswami[3], Utkal University, Bhubaneswar

Abstract

Many world heritage sites boast not only cultural but also significant geological importance. These monuments, crafted from distinctive rocks, are vulnerable to environmental factors affecting their stability. This research investigates the hydrogeochemical characteristics of such sites, aiming to assess their impact on monument foundations and longevity. Employing GIS and statistical methodologies, the study delineates groundwater hydrochemical properties, particularly focusing on monuments constructed from Athgarh sandstones prevalent in Odisha's major heritage sites.

Prominent among these monuments is the Konark Sun Temple, a UNESCO World Heritage Site, renowned for its cultural, architectural, and geological significance. Other notable landmarks in Odisha's Upper Gondwana Athgarh formation area include the Lingaraj Temple, Rajarani Temple, Mukteswar Temple, and Udayagiri and Khandagiri caves. These ancient rock-cut caves near Bhubaneswar house numerous inscriptions, sculptures, and reliefs, some fashioned from sandstone, underscoring the region's rich cultural and architectural legacy.

By integrating Geographic Information System (GIS) technology with statistical analyses, this study thoroughly characterizes the hydrogeochemical properties of the Upper Gondwana Athgarh Basin, covering approximately 800 sq. km. Geographically situated between Latitude 20° 45’N to 20°N and Longitude 85°30’E to 86°E, the area features diverse freshwater fluviatile and lacustrine sediments, reflecting climatic variations from arid to humid tropical conditions, with conglomerate, arenite, and extensive fireclay deposits predominating. It represents the northernmost extension of the east-coast Upper Gondwana sediment.

Although portions of the Athgarh sandstone remain concealed beneath laterite and alluvium, subsurface occurrences are evident, especially in offshore regions along the Bay of Bengal. Despite its geological and heritage significance, the Athgarh Basin confronts mounting pressures from human activities and environmental changes. Hence, understanding the hydrogeochemical composition of its water resources is vital for sustainable water management and preserving its geological heritage.

This study conducts a comprehensive evaluation of groundwater quality in the Athgarh basin, employing the Water Quality Index (WQI) and statistical correlations. Analysis of water samples and assessment of major ions and trace elements unveil spatial patterns and potential contamination sources through GIS-generated spatial distribution maps. Statistical techniques such as cluster analysis and correlation analysis identify underlying patterns and relationships among hydrogeochemical variables, complemented by evaluations using Piper's trilinear diagram and Chadha's diagram.

By correlating water quality parameters with the degradation of geological monuments, the study underscores the vulnerability of these sites to changes in water quality. Ultimately, the integration of GIS technology with statistical analyses offers valuable insights into the hydrogeochemical characteristics of the Upper Gondwana Athgarh Basin, informing strategies for preserving Odisha's geological heritage.

Keyword

Water Quality Index, Geochemical facies, Correlation Coefficient, Athgarh Basin

Wugongshan Geopark: A natural museum to study the granite dome and associated geological landforms

QINGCHENG HE[1]*, Chinese Academy of Geological Sciences (479400160@qq.com)
FANG REN[2], Chinese Academy of Geological Sciences
CHUNLIN LI[3], Chinese Academy of Geological Sciences
MEIYING HAO[4], Chinese Academy of Geological Sciences

Abstract

The Wugongshan Geopark covers an area of 1470.82 km2 and is 150.0–1918.3 m above sea level. It is characterized by a typical granite dome, and its geological heritages associated with the development of granite dome include the granite weathering crust alpine meadow, granite peak forest, Z-shaped steep waterfall group, and annular "hot spring chain". Meanwhile, the stratigraphic sections, diversified granites, structural deformation, granite tors, tungsten ore depositstungsten ore pit sitekarst caves, etc. present in the Wugongshan Geopark make it as a natural museum to study the granite dome and associated geological landforms.

The formation and distribution of geological heritages and geomorphic landscapes in Wugongshan Geopark are controlled by the tectonic evolution of the granite dome. According to the difference in elevation and tectonic position, the landscapes and heritages can be divided into the Alpine meadow of gneissic granite weathering crust on the top of the dome (> 1600 m), granite peak forest on the core of the dome (1600–1200 m), Z-shaped steep waterfall group at the core of the dome (1200-500 m), and the "hot spring chain" (< 500 m) at the detachment fault zones. The granite dome and the geological heritages constitute an organic whole, which is unique among the UNESCO Global Geoparks.

During the late Mesozoic, the Wugongshan granite dome formed in a large-scale extension setting. This extension event resulted in varying degrees of ductile and brittle deformation and metamorphism of the dome, and caused the formation of penetrating subhorizontal foliation in the Silurian granite. Because of the Protection of the subhorizontal foliation, the weathering rate is relatively slow, merely forming a completely weathering layer with a thickness of 20–40 cm on the surface. In addition, due to the influence of climatic factors such as cold climate and long frost periods on the summit, the top of the Wugongshan granite dome is not suitable for the growth of tall trees, only suitable for the growth of herbs.

The granite peak forest landform on the dome core developed in late Jurassic granite. The granite is characterized by a hard rock texture (high quartz content), which retained an intact primary structure. During the uplift of the Wugongshan granite dome, the domal core formed the near-vertical joints and a certain number of subhorizontal joints due to the depressurization caused by the denudation of overlying strata. The surface water flows from top to bottom along the joints. Visually, a unique Z-shaped waterfall group is formed. With the uplift of the magmatic core and the decrease in temperature and pressure, the deformation of the detachment fault zone gradually changed from ductile to brittle, forming a huge normal fault system. Surface water and

atmospheric precipitation enter the underground along fractures in the domal core, being heated by deep heat sources, return to the surface along the normal fault system at relatively low altitudes to form hot springs. 16 hot springs found and constituted a huge annular "hot spring chain" on the plane, which have not been reported in the world so far.

Keyword

granite dome, granite peak forest, hot spring chain, Z-shaped waterfall group, natural museum

Study on Features and the Formation Mechanism of the Geomorphic Landscape of Slit-typed Danxia Gorge in the Loess Plateau in China

Hua DING[1]*, Chang'an University (dinghua@chd.edu.cn)

Abstract

The Danxia landform landscape belt in the Loess Plateau region of Northern Shaanxi was discovered in 2015, and is the largest known Danxia landform landscape belt in China with a total area of over 3700km2 and a "S" - shaped strip distribution. Among them, the narrow slit-typed Danxia landform of the Loess Plateau (represented by in Ganquan County of Yan'an City), is the rare geological and geomorphic wonder in China and abroad. The Yucha Canyon Groups with both world scientific research value and tourism value are also known as the "Antelope Valley of China" and the "Loess Rift Wonder". The landscape type is dominated by wave valley of negative topography, and supplemented by the Danxia cliff, thin strip of sky, pothole, and pictographic stones. In landscape category, the canyons of Danxia landscape are the kind of “loess-covered” Danxia landscape with international comparative research value. The landscape aesthetics characteristics of canyons present “narrow, multi curved, vertically high and steep”, as well as “thick, homogeneous, rhythmic and colorful”. However, due to the late discovery of Danxia landform in the area, basic research on landscape characteristics and formation mechanisms is very weak and there are very few systematic achievements.

With the support and sponsor of the National Natural Science Foundation of China, the research team of Chang'an University systematically studied the rock structure, joint characteristics, geologic age and landform evolution stages according to the research theme of "patter-erosion-evolution-mechanism". We proposed the formation mechanism of narrow slit-typed Danxia landform landscape which included the mechanisms of fissure formation, rocks’ differential erosion and their dominant forces, and landscape evolution stages. In the view of the geological structure unit, this area belongs to the Yishan slope of Ordos Basin where the fault structures are not well-developed, but vertical joints are widely developed. The characteristic of "joints controlling valley" is obvious. The dominant joints formed by the Yanshan Tectonic Movement and the Himalayan Tectonic Movement (especially the north-east oriented joints) control the direction of the narrow slit-typed Danxia valley and provide channels for external forces such as flowing water and freeze-thaw cycles. The spacing between joints plays the key role in the uneven distribution and curvature of Danxia landscape. Through rock mechanics experiments of rock infiltration, acid wet-dry cycles and freeze-thaw cycles, landscape formation is mainly influenced by acid erosion and freeze-thaw processes. The landscapes are in the young or middle-aged stage of Danxia landform evolution in general.

Keyword

Danxia landform, Slit-typed Danxia Gorge, Formation mechanism, Landscape features, Loess

Plateau

Karstological planning and construction control of new motorways and railway line crossing Classical Karst (Slovenia)

Martin Knez[1]*, ZRC SAZU Karst Research Institute (knez@zrc-sazu.si)
Mitja Prelovšek[2], ZRC SAZU Karst Research Institute
Tadej Slabe[3], ZRC SAZU Karst Research Institute

Abstract

Slovenia lies at a crossroad of major traffic routes connecting Central Europe with the Mediterranean Area, Pannonian Basin, and Alps, lies in the direction of two major European traffic corridors, the X. and the V. Pan-European corridor. Almost half of Slovenia consists of karst and more than half of the country's water supply comes from karst aquifer. Slovenia is the country of the Classical Karst, which gave its name to a peculiar landscape on carbonate rocks in numerous languages, and is, in fact, cradle of karstology. The delicate karst landform requires thorough knowledge of its characteristics, and concerted preservation efforts for it is an integral part of Slovenia's natural and cultural heritage.

The karstologists of the Karst Research Institute are actively involved into planning and construction of the Slovene motorways over karst. More than 350 karst caves were discovered during the building of 60 km of new motorways. Two of the most important caves are accessible to researchers from the roadside by concrete tubes. The largest, almost 500 m long cave system, was discovered during the construction of one of the tunnels, and is almost entirely preserved. The protection of this cave may serve as a good example how to preserve natural heritage. Caves, discovered during the building of the motorway assisted at gaining a new knowledge about development and karstification of this part of karst.

When siting the railway route, it was discovered that it crossed one of the larger known water caves at a contact between the carbonates and flysch, and that in its vicinity the groundwater table was occasionally higher than the railway line. That is why it was moved this section of the route away from the area with known cave passages and envisaged the design of a non-draining tunnel with potential bypass water tubes. By studying the karst terrain and taking into account all the karstological data known so far, it was predicted the number of caves and the largest diameters of cave passages for individual sections of the route of the railway line. By conducting several tracer tests of groundwater, it was greatly contributed to the knowledge of the water flow in this part of the Classical Karst and the cross-border aquifer between Slovenia and Italy, and demonstrated the importance of protecting the karst aquifer.

Keyword

motorway and railway karstological planning and construction control, Classical Karst, Slovenia

STATE AND DEVELOPMENT OF GEOPARKS IN THE REPUBLIC OF UZBEKISTAN

Jurabek Nafiddinovich AZIMOV[1]*, The Ministry of Mining Industry and Geology
(zarafshan3335@gmail.com)

Abstract

Nowadays, the territory of the Republic of Uzbekistan has an advantage for considerable geotourism potential, in particular rich history and geological heritage sites.

From the standpoint of modern geology, the territory of the Republic of Uzbekistan represents an area that was formed over more than 1,000,000,000 years as a result of the manifestations of all known geological processes and environments, indicating the complex processes of the development of our planet.

In recent years, geologists have been doing large-scale research on the geological heritage. Analysis of geodynamic, geomorphological, petrographic, mineralogical, and structural factors allows us to identify interesting geological objects and landscape regions. Shortly, based on these geological objects, there is a possibility to organize complex geoparks and geotours of national and international significance.

In total, about 2,000 paleontological objects have been studied and inventoried. Based on the study results, more than 150 locations with remains of ancient fauna and flora were selected, which, in terms of their scientific, educational, and other features, were recognized as extraordinary and recommended for assignment to the status of state geological natural monuments. In the interests of future generations A list of objects was also compiled that, for one reason or another (usually anthropogenic), they need urgent protection and conservation.

The Ministry of Ming Industry and Geology of the Republic of Uzbekistan has the necessary information for the scientific substantiation and organization of geoparks on the territory of the Republic of Uzbekistan, as well as the ability to identify new geological formations to expand the geotourism base and, within its competence, is ready to participate in the implementation of sustainable development and responsible tourism in the Republic of Uzbekistan.

Keyword

geoturism, heritage, geology, formation

Geoheritages of Georgia (The Caucasus) and potential for aspiring UNESCO Geoparks

Avtandil OKROSTSVARIDZE[1]*, Doctor of Geological Sciences (okrostsvari@gmail.com)
Irakli Gamkrelidze[2], Georgian National Academy of Sciences, Georgia
Daniel Tormey[3], Catalyst Environmental Solutions, Santa Monica, USA
Giorgi Boichenko[4], Institute of Earth Sciences, Ilia State University., Georgia.
Salome Gogoladze[5], Institute of Earth Sciences, Ilia State University., Georgia.
Rabi Gabrielashvili[6], Institute of Earth Sciences, Ilia State University., Georgia.

Abstract

The Caucasus orogeny is an active Alpine collisional zone, between Eurasian and Arabian lithospheric plates and extends about 1200 km from the Caspian to the Black Sea. It consists of three main structural units: The Greater and the Lesser Caucasian fold-and-thrust belts and Inner Transcaucasian microplate. In the IUCN Volcanic Thematic Report identified the Caucasus region in a continental collision zone as underrepresented on the World Heritage Site List [1].

The territory of Georgia is located in the central part of the Caucasus and covers the southern part of the Greater Caucasus, the Transcaucasus and northern part of the Lesser Caucasus. Because of this, the small territory of Georgia (69700 km2) hosts a wide variety of geological formations, representing a large time frame, from Precambrian to Quaternary. Due to its geological diversity, tectonic significance and excellent exposures, researchers often call it a "natural geological laboratory" for understanding collisional tectonics.

More than 300 natural monuments have been identified in Georgia and are the subject of active scientific investigation. Many of them represent globally significant geological heritage, preserving the history of Earth's important geological processes. Among these monuments we can highlight: A magnificent Shkhara Late Paleozoic granitoid massif, 5203 m e.s.l.; A Middle Jurassic remarkable granodiorite pluton of the Ushba, 4700 m e.s.l.; Middle Jurassic diabase-pillow lava beautiful Chiukhi massif, 3864 m e.s.l.; "the bride" of the Greater Caucasus and mythical home to Prometheus, the glacier-covered Pliocene volcano of Kazbegi (5054 m e.s.l.); tectonic wedge of Darial Late Paleozoic granitoid massif; hydrothermally altered rocks of Storey Canyon; dinosaur footprints of Sataplia, with two types of footprints (of an herbivore and a predator); Kumistavi Grand Cave in Upper Cretaceous limestone; Quaternary mud volcanoes of Kilakupra and Takhti-Tepa; reliks of Upper Miocene Niala Megacaldera and its an ignimbrite flow (35 km length); Goderdzi fossilized forest in Upper Miocene volcanic tuffs; Quaternary continental basaltic flows of Tsalka and Samshvilde and their canyons; Dmanisi hominids site and others [2].

Most of these sites of geoheritage harmoniously coexist with cultural heritage objects as well. Vardzia rock-cut city in southern Georgia is a good example of that, which is a cliff-dwelling complex carved in the walls of upper Miocene ignimbrites. We believe that there is excellent potential for international recognition of the significant geoheritage of Georgia with an emphasis on aspiring UNESCO Global Geoparks. On these many sites Vardzia and its surrounding area

may be the most promising regions for establishing such a Geopark.

Keyword

Geoheritage, Georgia, The Caucasus, UNESCO, Geoparks

Establishing a Geoheritage Museum in Nanchang, China: A Nexus for Scientific Research, Educational Outreach, Artistic Display, and Touristic Interaction – A Case Study

Guanghua Liu[1]*, Jiangxi University of Applied Science and Technology (gstone1698@gmail.com)
Zhuqing Ding[2], Guanghua Institute of Gemology and Mineral Resources (GIGM), Jiangxi University of Applied Science, Nanchang,301000, China;
Shaoli Gong[3], Guanghua Institute of Gemology and Mineral Resources (GIGM), Jiangxi University of Applied Science, Nanchang,301000, China;
Ping He[4], Guanghua Institute of Gemology and Mineral Resources (GIGM), Jiangxi University of Applied Science, Nanchang,301000, China;
xiaoxu Zhou[5], Guanghua Institute of Gemology and Mineral Resources (GIGM), Jiangxi University of Applied Science, Nanchang,301000, China;

Abstract

This paper embarks on an overview of the historical development of natural history museums, tracing the origins of these museums with an emphasis on mineralogical collections back to the mid-16th century. Initially, these institutions primarily functioned as private collections, offering limited access to the general public. A pivotal moment occurred with the inauguration of the Paris Natural History Museum in 1635, representing one of the earliest instances of museums opening their doors to the broader public. This movement gained momentum with the establishment of further museums in England and Germany between 1680s and 1760s. Over the subsequent centuries, the spread of mineral and paleontological museums across Europe and North America has resulted in their ubiquitous presence worldwide. Currently, most of these institutions are established by scientific bodies, the mining industry, or associated entities, with a focus on facilitating scientific research and presenting professional exhibitions. Nonetheless, the academic and technical emphasis of these exhibits, characterized by extensive scientific terminology and intricate narratives, often fails to resonate with a wider audience, offering limited appeal to non-specialists and students. Consequently, many museums today face challenges in attracting visitors due to their overly scholarly content, cluttered and aesthetically unpleasing displays, outdated exhibition techniques, and a scarcity of interactive and engaging exhibit technologies. These issues significantly impede the museums' potential for sustainable development and commercial viability.

In an innovative response to these challenges, the Dr. Guanghua Liu Museum of Natural Heritage in Nanchang, China, was established, transcending traditional educational and research roles to integrate elements of art and tourism. Situated within the Jiangxi University of Science and Technology, the museum spans 6,000 square meters and is divided into three primary exhibition halls, showcasing over two thousand specimens collected globally by the geologist Dr. Guanghua Liu. The Gem & Mineral Hall, the centerpiece of the museum, covers approximately 4,000 square meters and features around 1,500 specimens.

This paper focuses on the Gem & Mineral Hall, detailing the advanced design and presentation tactics utilized to accomplish its wide-ranging goals. The museum adopts a contemporary and artistic design ethos, striving to create an atmosphere that is both elevated and accessible. Exhibit selection emphasizes both aesthetic beauty and educational value, including rare and commercially valuable specimens, ensuring the exhibition is captivating and informative. The use of cutting-edge display technologies and interactive installations significantly enhances the visual appeal and educational effectiveness of the exhibit. Named "Earth’s Treasure," the Gem & Mineral Hall is organized into eleven thematic zones, each dedicated to different facets of mineralogy and gemology.

Since its opening on May 20th, 2021, the Guanghua Liu Museum of Natural Heritage has attracted significant attention, drawing a large number of visitors and earning acclaim for the quality and educational value of its exhibits. This paper highlights the museum's achievement in integrating education, research, art, and tourism, serving as a benchmark for future developments in museum projects.

Keyword

Geoheritage museum, aesthetic minneral exhibits, new display technologies, artistic design, touristic atraction

Middle Jurassic Chaukhi Gabbro-Diabase-Pillow lava massif: An Impressive Geoheritage of the Greater Caucasus, Georgia

Avtandil Okrostsvaridze[1], Institute of Earth Sciences, Ilia State University
Giorgi Boichenko[2], Institute of Earth Sciences, Ilia State University
Salome GOGOLADZE[3]*, Institute of Earth Sciences, Ilia State University
(salome.gogoladze@iliauni.edu.ge)
Rabi Gabrielashvili[4], Institute of Earth Sciences, Ilia State University
Zurab Baratashvili[5], Ilia State University

Abstract

The Greater Caucasus fold-thrust belt occupies the northern segment of the Caucasus collisional orogen and traces along the Scythian platform an NW-SE direction over 1,100 km between the Black and Caspian Seas. The belt began rapid uplift and exhumation during ~5 Ma ago [1] and it is currently one of the most beautiful mountains of our planet. Two major formations are distinguished in its geological structure: pre-Jurassic crystalline basement and Meso-Cenozoic sedimentary formations. The pre-Jurassic basement in the Paleozoic was an active continental margin, along which Paleo-Tethys oceanic crust was subducted to the north (Variscan orogeny) At the end of the Late Triassic, the oceanic basin of the Southern slope of the Greater Caucasus closed. At the beginning of the Jurassic, the Southern slope crust extending began and a thick series predominantly of shales and sandstones was deposited in this basin. In the Middle Jurassic these sedimentary rocks were intruded by gabbro-diabase dykes, of mantle generation [2]. These dykes form a magmatic belt along the entire southern slope of the Greater Caucasus. Their thickness ranges from a few meters to tens of meters, and extends from tens of meters to hundreds of meters. However, there is an exception: a unique and impressive Chaukhi massif. This beautiful massif is exposed on the Eastern Greater Caucasus, between the villages of Roshka and Juta, in Georgia. It runs for about 18 km in the NW-SE direction and forms two parallel rocky ridges, the slopes of which are covered with snow. The distance between these ridges varies from 800 to 1500 meters.They are separated by a graben-like depression which is filled with glaciers. Both these ridges have several peaks whose heights exceed 3900 meters and are a paradise for mountaineers.

Geologically, Chaukhi massif represents a fragment of the Neotethys mid-oceanic ridge, which is predominantly built by gabbro-sheeted dykes, diabases, diabase porphyries and pillow lavas. In the western part of the southern ridge of this massif 10 gabbro-sheeted dykes are exposed, the thicknesses of which vary from 2.5 m to 40 m. Pillow lavas, with diameters from 30 to 120 cm, are mainly exposed in the eastern part of this massif. This ensemble of rocks is crossed by diabase porphyries. The primary minerals of these rocks are: pyroxene, basic plagioclase and olivine, and the secondary minerals are: chlorite, epidote, zoisite and prehnite. According to the chemical composition, they are basic rocks, in which the SiO2 content ranges within the 46.5-50,3%, Al2O3 - 15.5%-20.5%, MgO - 6.7-8.3%, Na2O - 2.1-2.6%, and KO2 - 0.14-0.22%.

Based on the analysis of Chaukhi massif data, we believe that it represents an impressive

geoheritage of international importance, with geotouristic and educational significance.

References

Lee, Y. H., Chung, S. L., Okrostsvaridze A., 2015. Cenozoic Mountain Building Process in the Greater Caucasus, from Subduction to Collision, AGU, Fall Meeting 2015, abstract #T21A-4565.
Okrostsvaridze A., Tormey D. R., 2011. Evolution of the Variscan Orogenic Plutonic Magmatism of the Greater Caucasus. Journal of Nepal Geological Society, Special Issue, vol. 403, pp. 45-52.

Keyword

Chaukhi Massif, the Greater Caucasus, Geoheritage, Potential Geopark

Geotourism Sites of the Outer Ukrainian Carpathians

Ihor BUBNIAK (BUBNYAK)[1]*, Lviv Polytechnic National University (ihor.m.bubniak@lpnu.ua)
Andrij Bubniak[2], Lviv Polytechnic National University
Lev Horodyskyj[3], Science Voices, USA; Blue Marble Space Institute of Science, USA; Universidade Estadual de Campinas, Brazil

Abstract

The Outer Ukrainian Carpathians, forming a part of Western Ukraine, are not only a testament to the region's varied topography but also a treasure trove of geological and ecological wonders. This region, bordering nations like Poland, Slovakia, Hungary, and Romania, encompasses several oblasts including Lviv, Ivano-Frankivsk, Zakarpattia, and others. The landscape here transitions beautifully from the northern plains to the majestic Carpathian Mountains in the south, comprising the Eastern Beskids and the Ukrainian Carpathians.

The Carpathian Mountains, a part of the grand Alpine mountain system, are geologically divided into the Outer and Inner Eastern Carpathians. This division brings out a rich tapestry of geological formations, including diverse sedimentary rocks, intriguing volcanic structures, and a wealth of mineral resources. The region's mineral wealth spans from salt to oil, gas, ozokerite, and various ores, making it historically significant for mining activities that date back centuries.

This geographical and geological diversity lends the Ukrainian Carpathians not just their natural beauty and ecological significance but also embeds them deeply into the cultural and historical fabric of the region, influenced by the diverse European cultures over the ages.

Geotourism, an essential aspect of sustainable tourism, plays a pivotal role in this region. It underscores the importance of preserving natural and cultural heritage while promoting responsible tourism. In the Carpathians, geotourism fosters environmental conservation and offers unique educational experiences, blending exploration with learning.

Our presentation delineates the most remarkable geotourism sites within the Outer Ukrainian Carpathians. These sites, numbering 32, are organized into four regional transects. Each site – be it a natural landmark, geological formation, park, protected area, or a unique landscape – has its own story. We delve into the geological features of these sites, discussing their ecological significance and historical or cultural importance.

The Carpathian region is renowned for its diverse ecosystems, home to an array of flora and fauna, making it a haven for biodiversity. The geological formations here offer insights into Earth's history, with rock structures and fossils that tell tales of the past. The protected areas and national parks, such as the Carpathian Biosphere Reserve, play a crucial role in conserving this biodiversity.

Visitors to these geotourism sites can engage in various activities, from hiking and rock climbing to more relaxed sightseeing tours. These activities are not just recreational but also educational, allowing visitors to gain a deeper understanding of the geological processes that shaped these landscapes.

Moreover, the presentation also touches upon the socio-economic impact of geotourism. It highlights how geotourism contributes to the local economy, supporting community livelihoods, and fostering a sense of pride and stewardship among the local population. We will detail a project we are working on with the US-based nonprofit organization Science Voices to improve the socio-economic impact of geotourism in Sukel' River communities in the Bolekhiv region, as well as how this collaboration provides students from Lviv Polytechnic experience in co-developing socio-economic and geoeducational projects with local communities.
In conclusion, the geotourism sites of the Outer Ukrainian Carpathians offer a unique blend of natural

Keyword

Carpathians, Geotourism, Geological Diversity, Outcrops, Bolekhiv

The Spatial-temporal evolution and determinants of homestays in the Dabie old-revolutionary-base-region, China.

Qiankun LIU[1]*, West Anhui University (lqk19890627@163.com)
Tongfei Li[2], West Anhui University

Abstract

The 20th National Congress of the CPC emphasized the imperative to comprehensively advance rural revitalization, that faces challenges in old revolutionary base regions (ORBR). Homestay is a major breakthrough in the process of revitalizing ORBR in China. However, existing academic attention on the temporal-spatial evolution and driving mechanism of homestays is lagging behind. In this study, with official statistics and field research data, the spatio-temporal pattern and contributing factors of homestays in Dabie ORBR were systematically analyzed using the spatial process analysis method with the aid of ArcGIS and Geodetector. The results show that: (1) homestays present a “one core and multiple centers” spatial pattern in Dabie ORBR. From 2019 to 2023, the total number and spatial distribution range of homestays in Dabie ORBR had been expanding, while homestay expansion remains comparatively sluggish in the low-density area. The center of spatial development changed steady, gradually moved northward. (2) Homestays in Dabie ORBR are characterized by high agglomeration in space, showing the multi-core cluster distribution. Spatio-temporal patterns of different grades of homestays are significantly different. The spatial agglomeration process is closely related to the natural environment, tourism resources, traffic trunks and market demand. (3) Geodetector revealed that 11 factors are all contributing factors of the spatial heterogeneity of homestays in Dabie ORBR. In terms of influence, tourism resources(0.532) > natural environment(0.419) > social factors(0.280) > geographic conditions(0.280). Significantly, traditional villages distribution is the decisive force. Further analyses suggested that the influence of the interaction between two determinants of dimensions appeared to be larger.

Keyword

Homestays, Old revolutionary base regions, Temporal-spatial evolution, Geodetector, Driving foctors

Tourism Intelligence in Cabo Ortegal Geopark. Case of San Andrés de Teixido (Spain)

Sergio MUINO FREIRE[1]*, University of Santiago de Compostela (sergio.muino@rai.usc.es)
Begoña Muíño Sar[2], University of A Coruña

Abstract

Tourism intelligence has become an ally in the management and planning of destinations, as well as in the sustainable development of the Cabo Ortegal Geopark (Spain) with the case study: San Andrés de Teixido, a consolidated tourist spot in the territory. This research highlights the advantages of having information and knowledge available for the governance and sustainability of the destination.

A mixed methodology was used. On the one hand, with a quantitative approach, surveys were carried out in the field to find out the profile of tourist demand and model forms were created for the collection of tourist data in the tourist offices, data that were dumped into the Business Intelligence tool. On the other hand, a qualitative approach was used to carry out in-depth interviews, participant observation in the territory and an analysis of social networks.

The research has been innovative and reflects the potential of smart management to support the development of geoparks. The main results have been, firstly, a socio-demoscopic study of visitors to San Andrés de Teixido, reflecting characteristics of their journey through the Cabo Ortegal Geopark. Secondly, the identification of San Andrés de Teixido residents needs for the sustainable development of the local communities in the geopark. Thirdly, an approach to the most photographed spots in the geopark on the social networks of those visitors who post with the tag San Andrés de Teixido.

In conclusion, after carrying out this study, it has been determined that scientific and tourism research in the territory can be a differentiating element for the planning and management of the Geopark. The replication and implementation of this methodology in other tourist sites would favour the creation of a network of useful, accurate and real-time information on tourist activity in the destination. This would be an advantage when carrying out actions for the conservation, promotion and sustainable use of the resources of scientific, educational and aesthetic value of the Cabo Ortegal Geopark.

Keyword

Tourism intelligence, Geopark management, Local development, Sustainable tourism, Heritage

Geological Characterization of the Geoparks within the Central Zone of the Limpopo Mobile Belt: Implication to the development of E - virtual geo-tourism, South Africa

Humbulani Rejune MUNDALAMO[1]*, University of Venda (humbulani.mundalamo@univen.ac.za)
Thangeni Mphanama[2], University of Venda
Jason Sammuel Ogola[3], University of Venda

Abstract

In the space of scientific studies, recently, the focus has been more on machine learning for developing scientific knowledge through E-learning. Therefore, this project aims to comprehensively assess the geological heritage sites within the Limpopo Mobile Belt, a region known for its significant geological and tectonic features. Primarily, the study focuses on the identification, characterization, documentation, and evaluation of various geo-heritage sites within the Central Zone of the Limpopo Mobile Belt and the development of the E-learning system for virtual access of the geological hot spots within the Limpopo Mobile Belt.

Geographical, cultural, aesthetic value, geology, structural, mineralogical, and chemical characterization were conducted in each of the identified geological heritage sites. Geographical and cultural aspects were used to unpark the historical beliefs and importance of the sites. Physical and landscape description was used to bring up the aesthetical value of the identified sites. Geological processes that evolved the occurrence of the geo-heritage sites as well as the description of the geological structures, mineral composition, and chemical constituents of materials from the sites were used to characterize the geological sites identified.

Integration of various geospatial analysis, data management systems, visualization, and machine learning techniques are a focus to interpolate the characteristics within the geo-heritage sites. At this stage, ArcGIS and QGIS were used for spatial analysis, mapping, and visualization of geological data. Remote sensing softwares (ENVI, ERDAS), Statistical tools, and visualization tools such as Python Matplotlib, and Seaborn will be used to develop an E - virtual geo-tourism system.

Keyword

Limpopo Mobile Belt, Geo-heritage sites, Virtual Geo-tourism, E-learning

The geoheritage and geodiversity framework of the newly listed Second 100 IUGS Geological Heritage Site, the Pleistocene Al Wahba dry maar of Saudi Arabia within the Kishb monogenetic volcanic field

Karoly NEMETH[1]*, Saudi Geological Survey (knemeth@geoconservation.org)
Rashad Mohammed Moufti[2], Afaaq Consulting, Jeddah
Turki Sehli[3], Saudi Geological Survey

Abstract

Al Wahbah is one of the largest dry maar crater on Earth with spectacular dimensions of around 250-m crater depth and 2.3 km rim-to-rim crater width. The volcano is a classic example of the hole-in-the-ground morphometry with textbook type flat crater floor and steep crater wall exposing the Neoproterozoic crystalline basement as well as pre-maar lava Quaternary basaltic lava flows all typify it as a maar crater. Al Wahbah is not only impressive by its geometry but also its sedimentary successions that showing clearly that the maar crater cut half an older scoria cone that was already suffered advanced erosional stage. The half-sectioned scoria cone forms a significant geosite as it exposes its proximal to distal pyroclastic facies as well as its conduit filling sub-volcanic body. Al Wahbah also unique in a sense to show clearly that the large maar crater was the likely product of complex collapse events due to repeated phreatomagmatic explosive eruptions in short time scale (days to weeks) creating a scalloped crater outline and overlapping complex base surge succession within its tuff ring. While Al Wahba is undoubtfully unique by its geometry, the Kishb Volcanic Filed where it belongs to have numerous explosion craters known mostly in its southern region where large intracontinental lake system operated and still recognizable. Within this region, however Holocene aeolian processes engulfed most of the larger craters hence they are difficult to recognize. In the northern region however, a remote and difficult to access volcano Aslaj stands another alternative, globally unique entity. At Aslaj, phreatomagmatic explosion(s) essentially excavated upper mantle sourced xenoliths and dispersed them over 10 km from its source. It is therefore suggested that at the Kishb Volcanic Field experienced at least two very similar violent explosive events from what Al Wahbah formed a perfect maar crater while Aslaj produced a more complex volcanic complex, both probably in a very short time scale in geological sense. In addition, the Kishb Volcanic field inferred to formed very young, potentially Holocene alkaline basaltic to phonolite lava flows engulfed the volcanic landscape filling morphological gaps between volcanic edifices. The volcanic geodiversity of the region is high and the natural aesthetic value of the location together justify to consider the region as an Aspiring UNESCO Global Geopark within geosite inventory, geoconservation strategy, geotourism goals and geoeducation aspects need to be developed. The Saudi Geological Survey new geoheritage initiative aims to serve this goal.

Keyword

geodiversity, maar volcano, phreatomagmatic, volcanic field, intracontinental

HEISEI SHINZAN LAVA DOME / THE SECOND 100 IUGS GEOLOGICAL HERITAGE SITES

Setsuya NAKADA[1]*, The University of Tokyo (nkd.sty@gmail.com)
Marekazu Ohno[2], Unzen Volcanic Area UNESCO Global Geopark (presently, Mt. Chokai & Tobishima Island National Geopark)

Abstract

Heisei Shinzan ("a new mountain in the Heisei era") is a dacite lava dome appeared in the "Heisei Eruption" (1990–1995) at Unzen Volcano, Japan. This is one of the best scientifically documented examples of dome growth during an eruption. Its formation was accompanied with thousands of pyroclastic density currents (flows and surges) due to its frequent partial collapses of the dome lava (Nakada and Fujii, 1993). In the June 3, 1991 eruption, 43 people were killed by a pyroclastic surge, including local residents, media, and volcanologists (Maurice Krafft, Katia Krafft and Harry Glicken). The 15 September 1991 pyroclastic flows burnt down the elementary school located on their way. Pyroclastic flows changed their directions, reflecting the moving of the growing dome. The dome growth changed its style from exogenous to endogenous, depending on the magma discharge rate (Nakada et al., 1999; Umakoshi et al., 2011). The foot of the dome was filled thickly with talus and pyroclastic-flow deposits, furthermore, mud flows repeated in rain seasons. This volcanic disaster, along with the June 1991 Mount Pinatubo eruption in the Philippines, triggered a reconsidering of volcanic disaster preparedness at that time. Agricultural lands and residential areas damaged by pyroclastic flows and mudflows were rebuilt through desilting and reclamation operations and the construction of safe infrastructure on top of them, providing a good example of building back better from severe natural disasters.

The dome growing and associated pyroclastic-flow generation were recorded in detail by geophysical, geochemical, and geological and visual data during the Heisei eruption, and timestamped erupted materials were used for petrological research. This eruption was in contrast to the explosive eruption of Mount Pinatubo, although the magma composition was similar. This question led to scientific drilling into the volcano immediately after eruption, carried out as part of the International Continental Scientific Drilling Project (1999-2004) (Sakuma et al., 2007; Yilmaz et al., 2021). The magma conduit of the Heisei eruption and the surrounding volcanic material were targeted for excavation, and research results regarding the eruption mechanism of the lava dome and the development of the volcano were obtained.

Heisei Shinzan was designated as a national natural monument, and access is permitted only for the purpose of scientific research and monitoring, it is currently the symbol of the Unzen Volcanic Area UNESCO Global Geopark.

Keyword

Unzen volcano, pyroclastic density currents, natural disaster, conduit drilling project, UNESCO

Global Geopark

Las Hoyas fossil site (Cuenca, Spain): an extraordinary Early Cretaceous faunal and floral wetland

Angela D. D. BUSCALIONI[1]*, Universidad Autónoma de Madrid (angela.delgado@uam.es)
Jesús Marugán Lobón[2], Universidad Autónoma de Madrid, Paleontology and Centre for the integration in Paleobiology
Hugo Martín Abad[3], Universidad Autónoma de Madrid, Paleontology and Centre for the integration in Paleobiology
Candela Blanco Moreno[4], Universidad Autónoma de Madrid, Paleontology and Centre for the integration in Paleobiology
José Luis Sanz García[5], Universidad Autónoma de Madrid, Centre for the integration in Paleobiology
Jerónimo López Martínez[6], Universidad Autónoma de Madrid, Centre for the integration in Paleobiology

Abstract

Las Hoyas stands out as an exceptional fossil site, renowned for preserving with remarkable fidelity, a Barremian wetland biota during the Cretaceous Terrestrial Revolution—a pivotal epoch in the evolution of the biosphere. Situated in a microbasin within the Cuenca sub-basin of the Iberian Domain, this locality forms part of a depositional system with lacustrine and palustrine facies within the La Huérguina Formation. The sediments, aged by charophyte and ostracod associations, consist of finely laminated limestones deposited in depressions formed by tectonic activity over pedogenic and karstified Jurassic marine limestones. The site represents a shallow lake within an extensive, perennial, carbonate wetland system devoid of marine influence. The lake's drainage, facilitated by carbonatic-rich water from karstic aquifers, was regulated by a seasonal subtropical climate controlling water-level oscillations. Microfacies with stromatolite appearance correspond to layers of microbial mats that grew during drier periods, while wetter periods exhibit finer carbonate particles, preserving fewer fossils but displaying higher diversity. The microbial mats played a crucial role in the exceptional fossilization of plants and animals, including the phosphatization of soft tissues, resulting in an impressive collection of over 20,000 curated fossils housed at the public Museum of Paleontology of Castilla - La Mancha. Trace fossils also abound, featuring invertebrate galleries, fish tracks, and dinosaur and crocodile trackways. Beyond the uniqueness of iconic organisms like multitoothed dinosaurs and dwarfed sharks, Las Hoyas has provided crucial evidence offering significant evolutionary insights into the early radiations of various organisms, along with remarkable novelties in the plant and animal realms. These include the initial stages of angiosperm flower origin, the development of maneuvering abilities in early birds, and the evolution of hair polymorphism in mammals. The systematic layer-by-layer excavation, spanning over three decades, is proving instrumental in retrieving detailed sedimentary and paleontological information, offering an even more realistic portrayal of the site's past. This systematic approach, indeed, reflects intricate ecological interactions in the wetland, serving as milestone data for the initial steps towards the ambitious quest of understanding the foundations of modern ecosystems during the Early Cretaceous.

Keyword

Barremian, Limestones, Lacustrine, Exceptional preservation, Microbial mats

Paricutin: The Volcano born in a Mexican cornfield

Lucero MORELOS-RODRIGUEZ[1]*, UNAM (lunalucerom@yahoo.com.mx)
Dante Jaime MORÁN-ZENTENO[2], UNAM

Abstract

Parícutin volcano is the first monogenetic volcano whose eruption was observed in detail by modern scientists since its birth in a cornfield in the state of Michoacán in central Mexico. It is the youngest edifice of the Michoacán-Guanajuato volcanic field, which is one of the most extensive monogenetic fields in the world, formed by more than 1,100 Quaternary volcanic centers. The historical record of the volcano is exceptional because its entire activity was documented in real-time by an international group. It is an emblematic volcanic feature due to its history, beauty and excellent state of preservation. It is in a region with a rich indigenous culture. The lava flows buried the indigenous village of San Juan Parangaricutiro but the church tower still stands in the middle of a lava flow.

Parícutin is an 81 years old volcano that consists of a pristine 424 m-high scoria cone and a 25 km2 lava flow field which formed during a 9 years-long eruption (1943-1952). The evolution of the volcano has been divided into four stages. The first two stages (1943-1945) are related to the main growth episodes when the cone almost reached its present-day height, and the lavas attained their maximum distance from the vent (4 km). These stages consisted of Violent Strombolian activity with high gas and ash columns, and the birth of a subsidiary vent that fed abundant lava. Parícutin emitted at least 23 distinct lava flows and a widespread ash blanket. The calc-alkaline composition of Parícutin´s rocks is related to the active subduction of the oceanic Cocos plate beneath the North American continent along the Middle America Trench. The volcanic products vary from olivine-bearing andesitic basalt to orthopyroxene-bearing andesite. Nonetheless, a recent geochemical study indicates that compositional variability can be explained by mantle source heterogeneity and fractional crystallization.

The population of the region interpreted the appearance of the volcano as a divine punishment in an attempt to understand something never seen before. The darkness caused by the ash rain, the losses of crops, forests, and livestock, the mudflows that destroyed rivers led to hunger and desolation, and the evacuation of two populations that were completely buried by lava and sand. This eruption changed the physical appearance of the region and the economic activity of the residents, who transitioned from farmers to tourist guides from around the world, fascinated by the unique volcanic eruption that represented a spectacle of nature.

Keyword

Parícutin, Monogenetic volcano, Heritage Geosite, Michoacán,Mexico, Michoacán-Guanajuato Volcanic Field

Outstanding geoheritage values of the Korean Getbol

Kyung-Sik WOO[1]*, IUCN WCPA Geoheritage Specialist Group (happyman369@naver.com)

Abstract

The Korean Archipelago Getbol (Island-type Tidal Flat) is located on the east side of the Yellow Sea on the western and southern coasts of the Korean Peninsula. Due to the highly dynamic and complex combination of geological, oceanographic, and climatic conditions, the area is characterized by extremely dynamic past and ongoing sedimentary processes, thus representing one of the most intricate and diverse sedimentary systems in the world. Korean Getbol is a natural, stable and sustainable region and encompasses all geological, geomorphic, and ecological characteristics and processes of archipelago tide flats, which are a rarity in the world.

Thousands of islands are scattered around a vast area adjacent to the land. Rapid macrotidal currents flow between these islands through tidal channels that are narrow or wide, short or long, shallow or deep, changing their direction every six hours. This creates one of nature's most spectacular phenomena along the coast with various coastal landforms. Tidal sedimentation is also greatly influenced by the seasonal changes of the Asian Monsoon climate regime, resulting in high geodiversity exposed to constant changes in hydrology and sediment supply. As a result the littoral environment includes tidal channels and gullies, intertidal and subtidal mudflats and all the related ecosystems to sustain highly dynamic yet stable mudflat sedimentation regimes. At the same time, the system has maintained a sustained sedimentation equilibrium, resulting in one of the world's thickest Holocene intertidal mud deposits as a result of sea-level rise since the Last Glacial Maximum. Typhoon deposits such as chenier and sand stringer are the unique sedimentary feature.

Korean Getbol also includes tidal flat habitats and ecosystems based on various tidal flat (muddy, sandy, mixed and rocky) substrates that have developed around rocky archipelago islands. Thus, it may well represent one of the best examples of a coastal ecosystem of high biodiversity with abundant threatened and endangered species as well as migratory birds. It can be noted that high biodiveristy is underpinned by geodiverity, and Korean Getbol display the outstanding relationship among geodiversity, biodiversity, and cultural diversity. The Korean tidal flat system therefore demonstrates unique and outstanding coastal landforms with ongoing dynamic and sustainable coastal processes, which may be the best in the world.

Keyword

Getbol, tidal flat, coastal system, geoheritage, Korea

Jurassic Coast: Lyme Regis

David A.T. HARPER[1]*, Durham University (david.harper@durham.ac.uk)
Jonathan Larwood[2], Natural England

Abstract

The Jurassic Coast exposes an outstanding sedimentary succession displaying 185 million years of the Earth's history - a near-continuous Mesozoic stratigraphical record. It is a globally unique near-continuous Mesozoic coastal succession exemplified by the classic Lower Jurassic of Lyme Regis. The succession encompasses the transition from terrestrial to marine Triassic (Gallois 2019; Proceedings of the Geologists' Association, 130) and Jurassic sediments, and culminates in the Upper Cretaceous Chalk (Mortimore 2019; Proceedings of the Geologists' Association, 130) exposed in the iconic Old Harry Rocks. This coastline provides "one of the finest sections of marine Jurassic rocks anywhere in the world" (Callomon and Cope 1995; Field Geology of the British Jurassic, Geological Society, London) - a statement exemplified by global reference sections in the marine Lower Jurassic at Lyme Regis. This area is noted for its prolific invertebrate (including a near complete Jurassic ammonite zonation) and marine reptile fossil fauna, first collected by Mary Anning (1799-1847). Today, housed in museums the world over, Mary Anning's discoveries included the world's first complete pleisosaur, many complete ichthyosaurs and fossil fish, and the first British pterosaur. She collaborated and corresponded with many contemporary scientists inspiring the world's first published palaeoecological reconstruction, De la Beche's Duria Antiquior. Fundamental to our modern biostratigraphy for the Lower Jurassic (Simms et al. 2004; Geological Conservation review Series, No. 30) Lyme Regis remains one of the most readily accessible and studied sources of Lower Jurassic marine fossils in the world (Jurassic Coast Trust 2021).

Keyword

Jurassic, Lyme Regis, ammonites, plesiosaur, Anning

The combined Esmark Moraine and Otto Tank's Moraine (Norway)

Ezio VACCARI[1]*, INHIGEO - IUGS Commission on the History of Geological Sciences / University of Insubria, Italy (ezio.vaccari@uninsubria.it)
Geir Hestmark[2], CEES, Department of Biosciences, University of Oslo (Norway) and INHIGEO

Abstract

The discovery of ice ages is one of the most revolutionary advances made in Earth sciences. In 1824 Danish-Norwegian geoscientist Jens Esmark (1762-1839) published a paper stating that there were indisputable evidence that Norway and other parts of Europe had previously been covered by enormous glaciers carving out valleys and fjords, in a cold climate caused by changes in the eccentricity of Earth’s orbit. Esmark and his travel companion Otto Tank arrived at this insight by analogous reasoning: enigmatic landscape features they observed close to sea level along the Norwegian coast strongly resembled features they observed in the front of a retreating glacier during a mountain traverse in the summer of 1823. Which glacier they observed up-close has however remained a mystery, and thus an essential piece of information in the story of this discovery has been missing. Based on previously unknown archive sources, supplemented by field study, the key locality has been identified as the glacier Rauddalsbreen. This is the northernmost outlet glacier from Jostedalsbreen, the largest glacier in mainland Europe. Here the foreland exposed by glacier retreat since the 'Little Ice Age' maximum around AD 1750 contains a rich collection of glacial deposits and erosional forms. The point of enlightenment is more precisely identified to be a specific moraine and its distal sandur at 61o43’26’’ N, 7o26’43’’ E. In memory of Esmark’s travel companion who possibly was the first to realize the analogy, it is proposed to name this moraine Otto Tank’s Moraine, a pendant to the already famous Esmark Moraine at Forsand by the sea. The two moraines are situated transversally in two valleys, and mainly differ in size. The Esmark Moraine, deposited at the end of the last ice age close to sea level, is about five times bigger than the Otto Tank Moraine. They both contain a mixture of rock sizes, from boulder to clay, a diamicton deposited by the northern tip of glacier Jostedalsbreen at the culmination of the 'Little Ice Age', at 1040 m. above sea level in Breheimen National Park.

Keyword

Esmark, moraine, ice ages, Norway

Mesoproterozoic Belt-Purcell Supergroup

Kylie CAESAR[1]*, National Park Service (kylie_caesar@nps.gov)
Stan Finney[2], California State University at Long Beach

Abstract

The Belt-Purcell Supergroup of western Montana, central and northern Idaho, and southwestern Canada recently earned the honor of being accepted into The Second 100 IUGS Geological Heritage Sites. The site is also part of Waterton-Glacier International Peace Park UNESCO World Heritage Site.

The Belt-Purcell Supergroup is one of the largest and best studied Mesoproterozoic sedimentary basins in the world. These ancient rocks are relatively undeformed by tectonic forces and undisturbed by plants and animals, resulting in the preservation of pure sedimentary processes, making them one of the world's finest examples of Precambrian sedimentary rock. Intensive glacial erosion of this strata has led to spectacular exposures that have fascinated geologists for over a century.

This immense package of sedimentary rocks resulting from passive rifting within supercontinent Nuna starting approximately 1.5 billion years ago. This event created a large, intracratonic basin that, during the mesoproterozoic, filled with up to 11 mi (18 km) of sand, silt, clay, and carbonate sediments resulting in the thickest sedimentary succession on earth. Concepts stemming from these rocks not only capture a unique stratigraphic setting, but have implications for other strata of pre-Cambrian age, and the entire Phanerozoic. Extensive quaternary glaciation throughout northwestern Montana, USA and southwestern Alberta, CA has resulted in incredible exposures of Precambrian age Belt-Purcell Supergroup in Waterton-Glacier International Peace Park, which, in tertiary time, were displaced eastward onto Cretaceous age rocks by the Lewis overthrust fault. The site contains seventeen stratotypes all within the Belt-Purcell Supergroup: two type sections, fourteen type localities, and one reference section. These stratotypes serve as world-class references for exceptionally preserved sedimentary features like ripples, mud cracks, and crossbedding as well as "molar-tooth" structures, and a variety of stromatolite fossils comprising one of the richest accumulations of Precambrian life in North America.

For decades, the Belt-Purcell Supergroup's incredible exposure of unique strata has drawn generations of geologists to study Earth's early geological processes. Researchers investigating the complexity within facies are challenging long-held interpretations, leading to continuously evolving conclusions and passionate debates on its origin and depositional environment.

Keyword

Sedimentology, Statigraphy, Geomorphology, Glaciers

Italian sites for the history of geosciences: Vesuvius and Agno Valley

Catherine (Kathleen) HISTON[1]*, IUGS INHIGEO (hiscat@interfree.it)
Ezio Vaccari[2], IUGS INHIGEO / University of Insubria, Varese (Italy)
Claudia Principe[3], Istituto di Geoscienze e Georisorse, CNR, Pisa (Italy) and INHIGEO

Abstract

During the 18th century, some significant geological research took place within some Italian sites and led to the definition of new interpretations and the establishment of new theories, particularly in the field of volcanology and stratigraphy. Two sites, Mt. Vesuvius and Agno Valley, are particularly relevant for the development of these scientific disciplines within the history of geosciences.

The science of volcanology was born at Vesuvius, with the first description of the phenomena which occurred during an explosive volcanic eruption. This account is included in two letters by Pliny the Younger to Tacitus about the 79AD eruption, that destroyed Herculaneum and Pompei. During the following centuries, the activity of Vesuvius, with its major eruptions (e.g. 472AD, 1631, 1906, and the last in 1944), was taken as a paradigm for the study of all possible volcanic activity by European scientists. From the 18th century to date, Vesuvius and its crater have been visited by several scholars and considered a natural laboratory for understanding the behavior of an active volcano. Positioned on the outskirts of Naples, Vesuvius has been studied by travellers, scholars, naturalists and scientists in particular after the devastating eruption of 1631. For centuries volcanologists described volcanoes by comparison with Vesuvius. Consequently, the available documental record on Vesuvius is one of the best of the world.

Within the new science of stratigraphy, Giovanni Arduino's 1758 study and representation of the lithostratigraphical sequence of the Agno Valley (in the Venetian Prealps, north-eastern Italy), led to the publication, in 1760 and in 1774, of a new theory of sub-division of rocks into four units according to the chronological order of their formation. This classification included mountains - defined as 'Primary' (with a basement of schists and mineral-bearing crystalline rocks; now Paleozoics) 'Secondary' (stratified limestones with fossils; now Mesozoics) and 'Tertiary' (clays, fossiliferous sandstones and some volcanic material; now Cenozoics) - as well as the most recent terrain of the plains, defined as the 'Fourth unit'. Arduino's system established the scientific notions of Primary, Secondary and Tertiary strata, and contributed to the later definition of Quaternary. This lithostratigraphical theory can be considered at the basis of modern stratigraphic chronology.

Keyword

Vesuvius, Agno Valley, volcanology, stratigraphy, history of geosciences

Wakulla Spring, Florida, USA: A preeminent example of karst hydrogeology

Guy MEANS[1], Florida Geological Survey
Jonathan ARTHUR[2]*, American Geosciences Institute (jarthur@americangeosciences.org)

Abstract

Wakulla Spring, located in northern Florida, is one of the largest artesian springs in the United States and perhaps the world. The spring is connected to a vast network of conduits that extend both to the north and south of the spring and are part of the longest mapped underwater cave system in the United States. As of January 2023, cave divers have explored and mapped approximately 72,153 meters of cave passage in what is called the Wakulla/Leon Sinks cave system. More than 30 entrances, through sinkholes and springs, to the Wakulla/Leon Sinks cave system are known and more than 35,405 meters of cave passage exceed a depth of 58 meters.

Wakulla Spring, the main source of water for the Wakulla River, discharges approximately 1,135,624 cubic meters/day from the upper Floridan aquifer. The watershed that supplies water to Wakulla Spring is estimated to be 2,525 square kilometers and encompasses parts of North Florida and South Georgia. Water that discharges from Wakulla Spring is a mix of older groundwater and younger shallow or surface water that recharges rapidly through multiple large swallets located throughout the watershed. Dye trace studies conducted in the Wakulla Spring watershed (or springshed) have verified that water flowing into four major swallets discharges at Wakulla Spring. Because of the complex interplay between surface water and groundwater within the Wakulla Spring watershed, Wakulla Spring has the largest observed range in discharge of any large magnitude spring in Florida.

Visitors to Wakulla Spring bring millions of dollars to the local economy. Wakulla Spring and the Wakulla River also provide recreational opportunities like fishing, boating, wildlife viewing and others. It is also one of the most studied spring systems in the United States. Early scientific work conducted at Wakulla Spring led to the discovery and excavation of mastodon remains by the Florida Geological Survey in the 1930's. Numerous skeletal remains from extinct Late Pleistocene megafaunal animals have since been discovered along with archaeological evidence of the first people that inhabited Florida. Today, ongoing research using cutting-edge SCUBA technology and autonomous underwater vehicles is revealing more information about this world-class artesian spring.

Like many springs around the world, Wakulla Spring and the Wakulla River have experienced ecological degradation due to anthropogenic impacts. Nitrate concentration in the spring water has increased over the last several decades along with increases in exotic invasive species. The State of Florida recognizes the significance of Wakulla Spring and has made some progress in enacting protection measures. Wakulla Spring is an Outstanding Florida Spring, a designation made by the

Florida Legislature to limit groundwater withdrawals deemed harmful to springs. Wakulla Spring is also a State Geologic Site designated by the State Geologist of Florida in 2018 as an outstanding example of a Florida spring. With its recognition by the IUGS as a Geological Heritage Site, Wakulla Spring will benefit from becoming an internationally recognized site of scientific and cultural importance.

Keyword

Karst, Florida, Caves, Sinkholes, Geoheritage

IUGS GEOLOGICAL HERITAGE SITES

Asier Hilario[1]*, IUGS International Commission on Geoheritage (flysch@gipuzkoa.eus)
Stanley Finney[2], IUGS
Juana Vegas[3], CSIC - IGME
Gonzalo Lozano[4], IGME - CSIC
Benjamin Van Wyk de Bries[5], Université Clermont Auvergne
Jianping Zhang[6], Chin University of Geosciences

Abstract

The announcement on October 28, 2022, of the “First 100” Geological Heritage Sites recognized by the International Union of Geological Sciences follows a 60-year tradition of the IUGS establishing globally recognized geostandards through international collaborations. The chronostratigraphic units and GSSPs, the IUGS Classification of Igneous Rocks and the Global Geochemical Reference Network represent good examples of these global standards.

IUGS ratified geostandards have authority. They are of the highest importance to the practice of geology and, thus, receive international recognition. Their legitimacy derives from the well established, transparent, deliberative process by which decisions are made and proposals are approved often by consensus or unanimously by the voting members of a subcommission, who are experts and internationally diverse. The proposals must then be analyzed and approved at the Commission level, and finally the IUGS EC must vote to approve the proposal. It is then ratified as an international geostandard.

For IUGS Geological Heritage Sites, a first group of 20 international experts on geoheritage from 13 different countries developed the high standards for recognition. More than 700 authors from 85 countries have participated in the Firts 100 and the Second 100 endeavor. 350 proposals have been received and were evaluated by a group of 92 experts. The result of this international collaboration between IUGS and 17 commissions and affiliated organization is the selection of the “First 100” and "Second 100".

IUGS recognition of Geological Heritage Sites gives visibility to those sites. It identifies them as being of the highest scientific value. They are sites that served to develop the science of geology, particularly its early history. They are the world’s best demonstrations of geologic features and processes. They are the sites of fabulous discoveries of the Earth and its history.
Their visibility is greatly enhanced by IUGS recognition. Some of the sites are classic and known to almost all geologists, but few geologists know most of the sites because of their diverse types and geographic settings. The announcement of the “First 100” and the attractive book and webpage will lead to many of the sites becoming known for the first time to large numbers of geologists and the public. Interest in individual sites will increase as will geo-visitors. Many of the

“First 100” are well protected in national parks, geoparks, and natural reserves, but many are not. Recognition and visibility of the “First 100” IUGS Geological Heritage Sites can lead to their further appreciation, to their use as educational resources, and, most importantly, to their preservation.

Keyword

Geological Heritage, Site, IUGS

Molassic sediments and pinacles of Meteora, Greece

Nikolaos ZOUROS[1]*, University of the Aegean (nzour@aegean.gr)

Abstract

Meteora landform is a complex of impressive rock pillar formations composed of molassic sediments belonging to the Mesohellenic trough. The spectacular pinnacles are 200 m high and up to 300 m wide. The Meteora rocks belong to the “Pentalophos Formation,” of Upper Oligocene - Lower Miocene age (Brunn 1956). The maximum thickness of the formation sediments is about 4.000 m. The sediments are essentially of marine origin however have been accepted as fluviatile and terrestrial material, and therefore there is a high turnover of sediments in this formation. The sediments of the formation change laterally to Meteora conglomerates. The stratigraphic succession of the Meteora conglomerates includes the Lower Meteora Conglomerates (LMC, composed of fan-deltas) and the Upper Meteora Conglomerates (UMC, composed of dominantly fluvial deposits in this area). The conglomerates were deposited in a Gilbert-type deltaic system, where large channels occurred, entrenched vertically to the progression axis of the delta. The formation of Meteora landforms is due to: (a) tectonic fracturing, (b) erosion due to flowing water and, (c) to a smaller extent, aeolic erosion. However, the tectonic activity had a significant impact on their formation and distribution, to form this unique morphology.

Meteora is one of the most iconic geological landscapes of the World. It is a complex of impressive rock pillar formations made by a huge accumulation of molassic sediments. The complex of Meteora is a perfect conjunction of tectonic, sedimentologic and geomorphologic processes which are very important for understanding the geology of the Hellenic orogen Byzantine monasteries were built on the top of many of these rocks pillars, creating a unique sacred lanscape declared as a mixed UNESCO World Heritage Site in 1988, including criteria viii for its geological value. Meteora is one of the most important touristic destination of Greece with over 2 million visitors every year. The most comprehensive sedimentary description of the formations comprising the Meteora rock spires is that of Brunn (1956). Since then several other national and international researchers studied the area from different geological disciplines. Meteora is a common destination for universities from all over Greece and surrounding countries.

Keyword

IUGS Geological Heritage Sites, Meteora-Pyli UNESCO Global Geopark, World Heritage Site

Iconic Colorful Navajo Sandstone of The Wave at Coyote Buttes, Vermilion Cliffs National Monument, Arizona, United States

Winston SEiler[1], KCSI Aerial Patrol, Inc.
Marjorie A CHAN[2]*, University of Utah (marjorie.chan@utah.edu)

Abstract

The Lower Jurassic Navajo Sandstone preserves the largest erg in Earth's history. Of all Navajo Sandstone outcrops in the desert southwest of the United States, the Coyote Buttes is globally renowned for stunning coloration and sculpted outcrop features including The Wave — where vivid colors accent aeolian cross strata to resemble a cresting ocean wave. The Wave is one of the most photographed and iconic sandstone outcrops worldwide.

Rich hues of red, orange, pink, purple, yellow, brown, and white colors document a complex history of chemical interactions between iron enriched fluids and ground water, resulting in concentration or removal of iron oxide grain coatings and cement within the sandstone. Coloration patterns are influenced by sedimentary textures and tectonic structures at laminae to outcrop to regional scales. The Wave's sculpted form initiated with water incision along a prominent joint; winds actively scour and smooth the sandstone walls to accentuate the aeolian bedding.

The larger Coyote Buttes area likewise displays unique and spectacular alcoves, bowls, faces, and bluffs shaped by wind and dramatically colored by past fluid flow. Large dune sets show cyclic cross bedding driven by paleoclimate. Dinosaur tracks document a rich paleontologic history. Extensive soft sediment deformation suggests seismic shaking and liquefaction during the Jurassic. Contemporary weathering crack patterns compose analogs to Mars.

Keyword

aeolian, erosion, sandstone, erg, paleoclimate

Kikaijima Island – the history of coral reefs over 100,000 years

Atsuko YAMAZAKI[1]*, Nagoya University (yamazaki.atsuko.x5@f.mail.nagoya-u.ac.jp)
Taro KOMAGOE[2], KIKAI Institute for Coral Reef Sciences
Rintaro SUZUKI[3], KIKAI Institute for Coral Reef Sciences
Yoshitaka UECHI[4], Kikai Town
Etsuo KUMASAKI[5], Kikai Town
Tsuyoshi WATANABE[6], Research Institute for Humanity and Nature

Abstract

The coral reef terraces of Kikaijima Island are unique worldwide and were formed by sea-level changes during the Late Pleistocene glacial cycle as the seafloor rose at an extremely high rate. The seafloor of Kikai Island has been uplifting at 2.1-2.3 m/ky over the past 100,000 years. The Ryukyu Formations form the basement of Kikai Island, where coral reefs have continuously developed and been repeatedly uplifted. The flat surface of the coral reef terraces represents prolonged periods of sea-level stasis followed by rapid uplift. The contrast between the flat terraces and cliffs, formed from the coral reefs during this cycle, creates a beautiful stepwise topography and represents one of the best records of late Pleistocene sea-level change, including marine isotope stage 3. The uplift rate on Kikaijima Island has been maintained from the late Pleistocene to the present, and the series of four terraces & cliffs provide a record of past seismic activity, repeated. In addition, well-preserved coral fossils from Holocene reefs surrounding the coast of Kikaijima Island have been used as continuous paleoclimatic indicators for the Northwest Pacific. The coral reef terraces in Kikaijima Island provide us with the history of the coral reef ecosystem with global environmental changes.

Keyword

coral reef terrace, Pleistocene, Holocene

Middle Jurassic dinosaur footprints from the Serras de Aire and Candeeiros

Luis LOPES[1]*, University of Évora and Earth Sciences Institute, Portugal (lopes@uevora.pt)
Artur A. SÁ[2], University of Trás-os-Montes e Alto Douro / CGeo - Geosciences Center
Jorge CARVALHO[3], LNEG - National Laboratory of Energy and Geology
Lia MERGULHÃO[4], ICNF - Institute of Nature and Forest Conservation
Mário CACHÃO[5], University of Lisbon / IDL - Dom Luiz Institute
António Marcos GALOPIM DE CARVALHO[6], University of Lisbon

Abstract

The Dinosaur Footprints Natural Monument of Ourém/Torres Novas, known as Galinha quarry, and the Vale de Meios quarry, are located in the Serras de Aire e Candeeiros Nature Park (Central Portugal). They are two geosites, duly geoconserved, of recognized international scientific value, due to its exceptionality regarding to the age, size, and quality of preservation of ichnites. Both quarries are located in limestones of the Serra de Aire Formation (Bathonian, Middle Jurassic) (Azerêdo 2007). The Galinha quarry preserves 20 trails with sauropod footprints, in an excellent state of conservation, and it is possible to observe finger marks and a ridge formed by the sediment that was removed under the weight of the animal. This deposit has some of the oldest and longest sauropod tracks known in the world (up to 147 m long) and allows to obtain a dynamic image of the locomotion of these sauropods (Santos et al 2009). The Vale de Meios quarry preserves more than 700 theropod tracks. They are organized in at least 80 unidirectional trackways, arranged in a bimodal orientation pattern (W/NW and E/SE). Paleoenvironmental studies in this quarry indicates an inter-tidal flat located at the margin of a coastal barrier (Razzolini et al 2016).

These quarries constitute a world-class Serial Site for understanding some of the oldest paleoenvironmental and paleoethological interactions involving sauropods and/or theropods. The ichnites of the Galinha quarry, with oval pes prints and speech-bubble–shaped manus prints (Castanera et al 2016), have provided an important contribution to the knowledge of sauropods at an early stage of their development. It was even possible to describe Polyonyx gomesi as a new sauropod ichnotaxon (Santos et al 2009). Vale de Meios quarry, is one of the most important sites with Middle Jurassic theropod tracks. The occurrence of Megalosauripus tracks represents the oldest occurrence of this ichnotaxon (Razzolini et al 2016).

Discovered and studied since the 1990s, multiple scientific studies have been carried out on these dinosaur track sites (Santos 2016), involving several international researchers. Similarly, since their discovery attracted educational and tourist visits, from nationals and foreigners, and they are currently duly protected and equipped for this purpose.

Keyword

Dinosaur footprints, Middle Jurassic, Bathonian, Serras de Aire e Candeeiros Natural Park, Portugal

A Dinosaur Quarry, the World's Wonder: The Dashanpu Middle Jurassic Dinosaur Fossils Site

Yi LI[1]*, Zigong Dinosaur Museum (hellen-lida@163.com)
YE YONG[2], Zigong Dinosaur Museum
JIANG SHAN[3], Zigong Dinosaur Museum
LI BIAO[4], Zigong Dinosaur Museum
WANG WENWEI[5], Administration Center for Zigong UNESCO Global Geopark
WANG LINGLING[6], Administration Center for Zigong UNESCO Global Geopark

Abstract

The presentation will introduce the site and its history, conservation, research and utilization, as well as share its sustainable development ways.

Dashanpu Middle Jurassic Dinosaur Fossils Site was found in 1972. It's valuable both in geology and paleontology. It is situated at the northeastern end of the Ziliujing Anticline of Sichuan Basin, a well-known red basin in the Upper Yangtze Platform of South China. There is a series of terrestrial strata during the Late Triassic to Early Cretaceous exposed on the surface of the basin. The dinosaur fossil-bearing Lower Shaximiao Formation (J2xs) of the Middle Jurassic is about 180 meters thick and comprises lacustrine and fluvial clastic deposits, mainly purplish red mudstones with several intercalations of yellowish grey or greyish green middle to fine-grained feldspathic quartz sandstone or feldspar lithic sandstone. The dinosaur fossils are concentrated in a layer of 3-5 meters thick of greyish green fine-grained feldspar lithic sandstone in the lower part of the formation.

The site is one of the most important dinosaur fossil sites in the world, and covers an area of about 70,000 square meters. Over 200 dinosaurs and other vertebrates uncovered in the Dashanpu Dinosaur Fossils Site and there are still numerous fossils preserved in the site. 29 species of 26 genera have been identified and described, including sauropods, theropods, basal ornithischians, stegosaurs, fishes, amphibians, turtles, crocodiles, plesiosaurs, pterosaurs and therapsids. Most of them are only and one globally, and are basal positions in the evolution of dinosaurs and other vertebrates; so as to fill the gap of dinosaurs research history. Such as Huayangosaurus taibaii(note: the words of Huayangosaurus taibaii should be in Italics) is the most primitive stegosaurs, providing important evidence for the origin of Stegosauria; Shunosaurus lii(note: the words of Shunosaurus lii should be in Italics) is the best example for the inheritance and evolution between the basal sauropods and eusauropods. They form a highly diversified vertebrate assemblage of the Middle Jurassic. 6 monographs, 2 special issues and more than 100 papers have been published so far.

The site has been well-preserved, well-protected and well-utilized. A site museum, Zigong Dinosaur Museum, had been built over it and officially opened in 1987, now is a core part of the

Zigong UGGp. The scientists of the museum coperated with the professors of local university developed successfully a protective nanomaterial for fossils and site, and which is now widely utilized on paleontology sites. Over 40 years, there are more than 50 million people, especially family visitors and children, benefited from Zigong Dashanpu Dinosaur Site, through dinosaur exhibitions, popular science events and activities, movies and books, community cooperation etc.. And the dinosaurs from the site toured over 30 cities abroad and more than 70 cities at home, attracted nearly 30 million visitors. Moreover, a new large dinosaur and tetrapod burrows have been found in the site, and a new exploring building has been built for protection and exhibition. The site created more and more value for the people, and earned more ways to be protected.

Keyword

Paleontology, Middle Jurassic, Ziong Dinosaurs, Sustainable Development, Protection and Utilization

Mackenzie Delta - coastal landforms created by giant sediment deposition of the fluvial system under Arctic permafrost conditions

Zbigniew Zwoliński[1]*, Institute of Geoecology and Geoinformation, Adam Mickiewicz University in Poznań (zbzw@amu.edu.pl)

Abstract

The presentation is about one of the proposed sites for the list of "The Second 100 IUGS Geological Heritage Sites" in the category "Geomorphology and active geological processes". This site is the Mackenzie River delta, which represents complex coastal landforms of diverse origin: glacial, permafrost, fluvial, and pseudokarst in the north-west Canadian Arctic.

The maximum extent of the Laurentide Ice Sheet in the Mackenzie Delta area was 30,000 years ago. The vast delta, with its branching channels, ponds and wetlands, covers more than 13,000 square kilometers of alluvial coastal plain. The delta stretches nearly 210 km from north to south and is 50 to 80 km wide. Below Fort McPherson, the Mackenzie River divides into several major channels and hundreds of smaller tributaries, the largest of which flows north-northeast and empties into the Beaufort Sea west of Tuktoyaktuk. The Mackenzie Delta is a labyrinth of shifting channels and pseudokarst lakes. Most of the land in the delta is permafrost, with great depths to bedrock and patches or taliks of unfrozen ground due to the influence of shifting channels. Retrogressive thaw slumps, up to 200m wide, are common where ground ice is exposed by bank erosion. Rivers and lakes are ice-covered for more than half the year. The Mackenzie River carries a large load of sediment, transporting about 128 million tonnes to its delta each year. A characteristic feature of the delta are the numerous pingos (1400, the largest population in the world). They are conical, ice-cored, 50m high, and >100m in diameter at the base.

The Mackenzie Delta (the second largest Arctic delta) is the best example of a complex landscape combining forms of different origins, from post-glacial rocky islands, through permafrost-related landforms such as polygons and pingos, to contemporary pseudokarst lakes, slumps and numerous migrating channels carrying huge bedloads and suspended sediment (Carson et al. 1998, Burn 2010, 2017). Sedimentation rates over much of the outer delta are less than the rate of subsidence associated with sea-level rise. Permafrost is ubiquitous and the surrounding landscape testifies to the enormous forces that can be unleashed by seasonal freezing and thawing of the ground.

The Mackenzie Delta is the best-studied of the polar regions. Especially the research and field experiments of J.R.Mackay (1998) have contributed to the understanding of permafrost phenomena. The Mackenzie Delta is the most spectacular geoecological landscape in the Arctic, which is nourished by the annual flooding of the Mackenzie River.

Keyword

Delta, Fluvial sediments, Permafrost, Pseudokarst lakes, Canadian Arctic

Vatnajökull - a complex interplay of rift, fire and ice

Zbigniew Zwoliński[1]*, Institute of Geoecology and Geoinformation, Adam Mickiewicz University in Poznań (zbzw@amu.edu.pl)
Małgorzata MAZUREK[2], Institute of Geoecology and Geoinformation, Adam Mickiewicz University in Poznań

Abstract

The presentation is about one of the proposed sites for the list of “The Second 100 IUGS Geological Heritage Sites” in the category “Geomorphology and active geological processes” and “Volcanology”. This site is the Vatnajökull Glacier, which represents a unique landscape forged by the constant conflict between fire and ice in the rift zone at the divergent plate tectonics.

The area of the Vatnajökull covers almost 10% of Iceland's territory and is characterised by the coexistence and ongoing interaction of an active oceanic rift on land, a mantle plume, and an ice cap that have varied in size and extent over the past 2.8 million years. Earth system interactions are constantly modifying this area, creating remarkably diverse landscapes and a wide variety of plate-tectonic, volcanic and glaciovolcanic features. There are eight subglacial volcanoes. Some of them are among the most active in Iceland (e.g. Grímsvötn, Bárðarbunga; Gudmundsson 2004). Particulary interesting and unique in this regard are the basaltic lava shields, volcanic fissures and cone rows, vast flood lavas, and features of ice-dominanted glacio-volcanism, such as tuyas and tindars. Geothermal heat and subglacial eruptions produce meltwater and jökulhlaups that maintain globally unique sandur plains, to the north and south of the Vatnajökull ice cap (~8000 km2), as well as rapidly evolving canyons. In addition, the area contains a dynamic set of glaciological and geomorphological features, created by 40 expanding or retreating outlet glaciers in response to climate change. These features can be easily accessed and explored at the snouts of Vatnajökull’s many glaciers and their forelands, especially in the southern lowlands (e.g., Skeiðarársandur).

Vatnajökull is an outstanding example representing interactions between volcanism and glaciation (Baldursson et al. 2018). The most spectacular are the jökulhlaups – sudden floods caused by glacier margin breaches during an eruption with a huge water discharges. This recurrent phenomenon has led to the formation of unique sandur plains, among the best of their kind in the world (Magilligan et al. 2002, Thórhallsdóttir, Svavarsdóttir 2022), braided channel systems and rapidly evolving canyons. Vatnajökull also illustrates different types of glaciation, from ice cap to outlet glaciers, while glacial landforms around the ice cap provide evidence of ice advance and retreat.

The pioneering descriptions of the Vatnajökull glacier were made by the Finnish geologist Jöns Svanberg in 1794. In the late 19th century, interest began to focus on the relationship between the geology and dynamics of the Vatnajökull glacier in an attempt to understand how the glacier responds to climate change.

Keyword

Glacier, Volcano, Rift, Sandur plain, Iceland

The Durbuy Anticline: a top geoheritage site in the UNESCO Global Geopark Famenne-Ardenne, Belgium

Boyeon JEON[1]*, IGC 2024 (bjeon789@gmail.com)

Abstract

The natural cross section of the Durbuy Anticline represents an archetype anticline and as such it is a classical site used for the education of geology and geoscience students from Belgium and neighboring countries. This geosite is situated in the medieval town of Durbuy within the UNESCO Global Geopark Famenne-Ardenne. It boasts a base of 90 meters, a height of 37 meters and is composed of about 25 layers of Mid-Frasnian (Upper Devonian) marine limestone of the Philippeville Formation. The slightly faulted disharmonic anticline is an excellent example of Late Carboniferous Variscan deformation in Europe. The structure was carved out by the Ourthe River, which originally meandered on a Cenozoic sandy cover, and subsequently eroded underlying folded Devonian formations irrespective of their resistance to erosion.

This wonderfully exposed outcrop is commonly referred to as the Anticlinal d'Omalius, in honor of Jean-Baptiste d'Omalius, widely recognized as the Father of Belgian Geology ((16 February 1783, Liège, Belgium - 15 January 1875, Brussels, Belgium) who described the Durbuy Anticline as early as in 1807. This description was part of a much larger endeavor: in 1813, d'Omalius completed the first geological map of France and bordering areas, which was published only in 1822 due to the political turmoil in western Europe. He subdivided the northern geological terrains into three parts, which subsequently through the works of Roderick Murchison and others, became well-established as the Silurian, Devonian and Carboniferous periods. Notably, d'Omalius is also the discoverer of the mineral halloysite formally described in 1826 by the French mine-engineer Pierre Berthier.

The Durbuy Anticline stands as an easily accessible and captivating geological feature, drawing in a diverse audience. Its significance is deeply rooted in the local culture and heritage, actively embraced and promoted by the town of Durbuy. The apex of the anticline is the highest point of the medieval town of Durbuy, serving as a popular destination for both residents and tourists seeking leisurely strolls and panoramic views. In 2023, the Durbuy Anticline was proposed as a candidate geosite to feature in the esteemed "Second 100 IUGS Geological Heritage Sites".

Keyword

Devonian, Jean-Baptiste d'Omalius, Geomorphology, History of Geology, Variscan deformation

Wuda Plant Fossil Site: Permian Vegetational Lagerstätte unveiling ancient coal forming plants and forest

boyeon JEON[1]*, test (coastal1803@naver.com)

Abstract

Coal, well known as fossil energy resources, about which a commonly queried mystery exists: what plants has formed coal? and what does an ancient coal-forming forest look like? As one of the Second 100 IUGS Geological Heritage Sites, the Wuda Plant Fossil Site may answer best.

A peat-forming forest was preserved in situ by a 298.34 ± 0.09 Ma volcanic ash fall in the Wuda Coalfield, Inner Mongolia, being called Wuda Tuff Flora, here termed as the Permian Vegetational Pompeii - Wuda Plant Fossil Site. With respect to the geologic and taphonomic similarities to the world-famous Italian UNESCO World Heritage Site of the Roman city of Pompeii, this flora has been also called Chinese “vegetational Pompeii”, well known as a plant lagerstätter, snapshooting a glimpse to the late Paleozoic peat-forming forest. Such a T0 deposit provides an unrivaled chance to reconstruct the taxonomic diversity, vegetation structure and density, and synecological associations.

Through the recent two decades, along with the open-cast mining of the Wuda Coalfield, extensive field research and quantitative investigation on some areas of over 10, 000 square meters have been conducted and yielded a larger collection of fossil material and data of forest community ecology. The completeness and the exquisiteness of plant remains facilitate a thorough systematic study of many taxa of this peat-forming forest. Nearly all the taxa of this forest show both gross morphology and anatomy, and both vegetative and fertile parts, and thus likely to facilitate restoration as whole plants and natural species, which is impossible in most other localities due to the small number and the limited size of specimens. There are seven plant groups forming this peat-forming forest: lycophytes, sphenohytes, progymnosperms, ferns, seed ferns, cycads and coniferophytes. In addition, forest structure and landscape heterogeneity, such as density of individuals, species-area curve and vegetational recovery are all detectable. In brief, long last geological and palaeobotanical investigation and research on the Wuda Plant Fossil Site significantly promote our understanding of the coal-forming plants and forest, providing so far the best answer to the above mentioned mystery of coal formation.

With respect to the high scientific significance and strong common interests, this fossil site has been proposed to be protected to build museum and geopark. Local government has organized meetings to discuss about the conservation, research and exploitation of this site.

Keyword

Plant Fossil, Wuda Coalfield, 100 IUGS Geological Heritage Sites, peat-forming forest, Permian

Tepuis and quartzite karst of Gran Sabana, Venezuela

boyeon JEON[1]*, test (coastal1803@naver.com)

Abstract

The Gran Sabana is a region in the south-eastern part of Venezuela, located in the humid tropics, just north of the Equator. It is renowned for the occurrence of striking plateaus and mesas, some rising to altitudes of more than 2000 m a.s.l., which host the most spectacular karst phenomena developed in silicate rocks. Geologically it is part of the Guyana Shield, where the basement of Precambrian magmatic and metamorphic rocks is overlain by a thick succession of clastic sedimentary rocks, mainly quartz sandstones and conglomerates, of also Precambrian age. This succession is a few kilometres thick and includes the most resistant quartz sandstones of the Matauí Formation, exposed in magnificent escarpments many hundreds of metres high. The most conspicuous landscape elements are tabular hills (tepuis, mesas), with flattish summit surfaces surrounded by sheer cliffs, rising above the regional planation surface. The tepuis have various dimensions and some form multi-tiered extensive plateaus, tens of kilometres long. Their top surfaces show extraordinary diversity of relief, described as ruiniform. It includes rock walls, towers and pinnacles, separated by narrow corridors and basins. Closed depressions, acting as sinkholes for surface streams, and deep shafts are common. Large, multi-level caves occur inside the mesas. The region hosts some of the longest caves in quartz sandstones globally, with the total lengths of galleries of the order of many kilometres, and several shafts exceed 300 m deep. Rivers originating on the plateaus descend in waterfalls, including the highest waterfall on Earth – Angel Falls (979 m). Part of the area is protected as the Canaima National Park, inscribed as World Heritage property of UNESCO in 1994, including criterion (viii).

Landforms similar to those in limestone karst, but in apparently non-soluble rocks, were long considered as a natural curiosity of little wider significance. Research in the Gran Sabana, initiated in the 1970s, demonstrated the critical role of quartz dissolution in the formation of surface and subsurface landforms, including ruiniform relief, dolines, karren, deep shafts, caves and speleothems. The mechanism of arenization, that is corrosion along grain contacts leading to loosening of the rock mass and making grains available for transport, was elaborated in detail and serves as a model for sandstone/quartzite disintegration. The Gran Sabana is therefore a benchmark locality and global reference site for silicate karst, which inspired many studies focused on sandstone landforms and surface-subsurface connectivity in sandstone terrains undertaken elsewhere.

Keyword

karst, Gran Sabana, Guyana Shield, Precambrian, arenization

Inverted landscape of a Plio–Pleistocene phreatomagmatic monogenetic volcanic field: Tapolca Basin, Hungary

Karoly NEMETH[1]*, Saudi Geological Survey (knemeth@geoconservation.org)
Barnabas Korbely[2], Bakony-Balaton Geopark Group, Balaton Uplands National Park Directorate

Abstract

Tapolca Basin is part of the Bakony–Balaton UNESCO Global Geopark and the Balaton Uplands National Park hence its geological landmarks enjoy high degree of conservations status. In the scientific literature it appears as part of the Bakony–Balaton Highland monogenetic volcanic field that is probably more correct to call as Bakony-Balaton Uplands referring its difference from being highland that is an area of land that is at elevation; mountainous land while upland is the area in the interior of a landmass with a generally higher elevation; often hilly, but not generally mountainous, just like the Tapolca Basin. In this area volcanic erosion remnants are closely spaced, and the significant erosion resulted a globally unique, breathtaking landscape that attracted scientific research since the 18th century. Relief inversion is a process where a negative landform becomes a positive one, e.g., a valley becomes a ridge. Relief inversion is particularly common in areas where rheologically contrasting rock types assembled. Relief inversion on volcanic terrains typically occurs when a valley filled by volcanic products that are either more erosion resistant since their emplacement (e.g., lava flow) or became harder than the surroundings through diagenesis (e.g., pyroclastic density currents). Over time, the valley shoulders diminish, and the resistant volcanic successions in the former fluvial networks become the new high ground. While relief inversion is mostly associated with linear valley networks, in volcanic environments craters (e.g., maar) and calderas can also act to capture volcanic products that are more erosion resistant. As a result of the relief inversion, the solidified rock (columnar jointed basalt) of lava lakes, especially those ponded within tuff rings/maars, can resist to erosion for much longer than the hosting pyroclastic edifices, generating inverted hills which are called “buttes” or “witness mountains” (the latter is a Hungarian term). The volcanic successions in the Tapolca Basin provide ample evidence that the volcanism was primarily driven by explosive magma and water interaction to form maar and tuff ring volcanoes. These volcanoes had broad and deep craters that operated as sediment traps or hosted scoria cones, lava flows and in some cases lava lakes. The differential erosion relatively quickly removed the tephra rings around the wide craters and carved into the pre-volcanic fluvio-lacustrine sedimentary layers leaving behind basalt lava and agglutinated scoria successions as hilltops. The volcanoes of Tapolca Basin represent a volcanic flare up between 4.5 and 3 Ma. Erosion made typical volcanic remnant hills marking a geomorphological level like the palaeosurface these volcanoes erupted on. World-class examples of columnar jointed basalt, peperite and diatreme-filling pyroclastic rocks complete the geological wonders of this region. As inverted relief is a unique type of differential erosion, Tapolca Basin is considered one of the best examples of complete geomorphic inversion of a high vent-density phreatomagmatic monogenetic volcanic field on Earth hence it has been selected to be one of the

Second 100 IUGS Geological Heritage Sites.

Keyword

erosion, monogenetic volcano, butte, lava lake, geopark

Suggestion of New Paradigm for UNESCO Global Geoparks

Daekyo CHEONG[1]*, Organizing Committee of IGC 2024 (dkcheong@kangwon.ac.kr)
Sujin HA[2], Pusan National University

Abstract

UNESCO Global Geoparks encourage international cooperation between areas with geological heritage of international value, through a bottom-up approach to conservation, local community support, promotion of heritage and sustainable development of the area. The original Geopark concept arose in the mid-1990s as a response to the need to conserve and enhance the values of geological significant sites in Earth history.

Global Geoparks consist of geological heritages, where science and local communities engage in a mutually beneficial way especially in remoted and low-developed areas. Education at all levels is also at the core of the Global Geopark concept. Geomorphic features and geological formations are key witnesses to the evolution of our planet Earth and are cornerstones for our future sustainable development. From the beginning, Geoparks adopted a “bottom-up” or community-led approach to ensure that an area’s geological significance could be conserved and promoted for science, education and culture, in addition to being used as a sustainable economic growth for indigenous people through the development of responsible ways such as geotourism.

From now on, UNESCO Global Geoparks should change their paradigms, and actively widen their scopes upto some large civilized areas to carry out new goals in addition to economic benefit for local inhabitants. In partnership with big city communities, metropolitan Geoparks will particularly provide wide ranges of chances for education to many visitors including young generations and can maximize popularization of geosciences to regional publics nearby mega cities.

Keyword

UNESCO Global Geoparks, geological heritages, geological significance, mega cities

The contribution of UNESCO Global Geoparks and Global Geoparks Network to Geosciences

Maria-Luise Luise FREY[1]*, Global Geoparks Network (frey@terra-outreach.de)
Nickolas ZOUROS[2], Global Geoparks Network

Abstract

As a result of the economic boom of the coal and steel industries after World War II, a structural change began to take place in Europe in the 1960s, led to their collapse in the western industrialised countries. The shift in economic priorities led to new industries with consumer goods and services. Formerly important know-how in the geosciences, for example, was pushed into the background in favour of new disciplines, such as cultural sciences, humanities or environmental sciences, or the establishment of new universities. The overall structure of geoscientific services etc. has undergone a change. Problems like unemployment on the one hand and the development of new fields of work as challenges of a structural change encouraged people to come up with new ideas. From 1998, four European partner regions started the EU-funded project: "Development of Geotourism in Europe" with the aim of developing a European Geoparks Network (EGN) under the auspieces of UNESCO. Haute Provence (F), Lesvos Petrified Forest (GR), Maestrazgo (E) and Gerolstein/ Vulkaneifel (DE) founded the EGN in 2000 and accepted new members (Martini, Zouros & Frey 2003). In 2004, together with eight Chinese national geoparks, they created the Global Geoparks Network (GGN) with the aim of promoting the sustainable development of rural regions on the basis of geoscientific heritage. New ideas are often not taken seriously in their own discipline, are often ridiculed and need time to become known. However, the demand for proof of success is established immediately and the GGN members pick it up. In 2015, UNESCO recognised the 120 members of the Global Geoparks Network and adopted them as the basis of the new UNESCO programme: "International UNESCO Geosciences and Geoparks Programme". It consists of the pillars "International Union for Geosciences" and "Global Geoparks Network association" and is the first "bottom up" programme of UNESCO. Through the regular quality assessment and assurance of the "UNESCO Global Geopark - UGGp" certification by UNESCO and the results of their activities, they impressively demonstrate the importance of geoscientific heritage and its use for sustainable development of rural areas. After 20 years of GGN, an impressive geodiversity is in the public awareness worldwide. Fields of action such as geotourism, geo-education and sustainable development in rural areas are image- and value-shaping components for modern geoscientific work. At universities worldwide, new sub-disciplines and chairs have emerged in geotourism as well as in sports sciences, exercise and health (Gabriel et al 2018) or mechanical engineering new fields of research have emerged through the geopark movement in social and linguistic sciences, didactics and pedagogy (Hlawatsch & Felzmann 2023), as well as in art and philosophy (Mehrpooya & Morovat 2021: 191-202).

By the end of 2024, there will be 215 UGGps with the "UNESCO Global Geopark" label. They

look back on an impressive track record of publicising and promoting the importance of geoscientific heritage in modern society and its new uses actual as well as for future generations. This paper focuses on the achievements of Global Geoparks for the geosciences. The latter

Keyword

Global Geoparks, UNESCO, Geosciences, Society, Sustainable Development

Samcheok Geopark: Promising and aspiring geopark in Korea

Kyung-Sik WOO[1]*, IUCN WCPA Geoheritage Specialist Group (happyman369@naver.com)
Kwang Choon Lee[2], Sangji University
Lyoun Kim[3], Cave Research Institute of Korea
Chong Chul Paek[4], The Korean Association of Natural Heritage Conservation
Junki Kim[5], Samcheokcityhall

Abstract

High geological diversity in Samcheok City is characterized by Precambrian metamorphic rocks of sedimentary and igneous origins, Cambrian to Ordovician marine sedimentary rocks (Joseon Supergroup), Carboniferous to Triassic, marine to nonmarine sedimentary rocks (Pyeongan Supergroup), Cretaceous volcanic rock (rhyolite), plutonic rock (granite) and pyroclastic rock (tuff), Cretaceous terrestrial clastic rocks of alluvial to fluvial origin, and Miocene marine sedimentary rocks of hemipelagic origin with plant and insect fossils. Also, Quaternary travertine formed by limestone karst spring and cave speleothems can be added. High mountain range in the west (Baekdudeagan), coastal erosional and/or depositional landforms along the eastern sea coast, various karst landforms and caves of different genetic processes, and specialized ecological habitats provided by karst springs provide high geomorphic diversity and ongoing processes. Among them, high national geoheritage values of some limestone caves and the lower Paleozoic sedimentary sequence in Seokgaejae area provide the justification to be endorsed as a Korean national geopark. This high geodiversity may well be enough to provide effective geotourism for public geo-education. Twelve geosites are selected based on geoheritage values and their high potential for educational tourism and local sustainable development; (1) Daetjae Baekdudaegan mountain range, (2) Jukseoru fluvial landform, (3) Deokbongsan coastal depositional landform, (4) Chogok coastal erosional landform, (5) Jangho coastal landform and its related ecosystem, (6) Chodanggul Cave and Sohan Valley, (7) Daeiri cave area, (8) Mugeonri moss waterfall, (9) Miin Waterfall and Tongri Gorge, 10) Gagok sulfur hotspring, 11) Deokpung Valley, and (12) Seokgaejae Lower Paleozoic sedimentary sequence and Seokgaejae Cave. Especially various and abundant, ecological, historical, cultural and archaeological features nearby every geosite, together with their close geographic proximity to each local village would make stronger potential candidate for an ideal geopark in Korea.

Keyword

Geopark, Geoheritage, Geodiversity, Samcheok, Korea

[Keynote] Global Geoparks Network: 20th anniversary Protecting and managing Earth heritage - Building Sustainable Communities

Nikolaos ZOUROS[1]*, University of the Aegean (nzour@aegean.gr)

Abstract

The Geopark concept was introduced at late 90's aiming to protect and promote Earth heritage sites through the sustainable local development of territories containing abiotic nature of significant value.

The Global Geoparks Network (GGN) was established in 2004, under the umbrella of UNESCO and operates as an international network, providing a platform of cooperation among Geoparks, bringing together government agencies, non-governmental organizations, scientists and experts from all countries around the world in a unique worldwide partnership.

In 2015, the 38th UNESCO General Conference ratified the statutes of the International Geoscience and Geoparks Programme and the UNESCO Global Geoparks Operational Guidelines, introducing the brand UNESCO Global Geopark as a label of excellence for areas that meet certain criteria. Since then the Global Geoparks Network was recognized as the official partner of UNESCO for the operation of the UNESCO Global Geoparks.

In 2024, the GGN includes 213 Geoparks in 48 countries working to protect Geological heritage and promote local sustainable development.

The GGN organizes co-operation and mutual assistance between Global Geoparks and between Global Geopark professionals.

The GGN initiates and co-ordinates Regional Geoparks Networks which will foster international co-operation and promotion of sustainable development.

The GGN represents, advances, and disseminates knowledge in Geodiversity management and other disciplines related to studies in Geo-conservation, Geo-tourism, Geo-education and/or the management and activities of Global Geoparks.

An important component of the Geopark management plan is the support of the local economy. Geoparks create links with local tourist enterprises, restaurants and small hotels in order to provide the necessary infrastructure to meet the needs of the increasing number of park visitors. As a result many new enterprises are connected with the activities of the Geopark.

The Geopark also supports the making of local handicrafts such as the production of fossil casts and souvenirs by local enterprises. These items are on sale in the Geopark shop along with a variety of other locally made products and the Geopark promotes these products to its visitors.

Geoparks also collaborates closely with women's agrotouristic cooperatives and local organic food producers to offer their visitors the opportunity to taste and buy local food products. The catering for all Geopark events (conferences, meetings etc.) is supplied using the local traditional food. The Geoparks organize Agro-touristic festivals, which promotes quality local products, food and drinks. The Women's agrotouristic cooperative found that this festival provided them with an excellent opportunity to promote their products and their success lead to the creation of similar

cooperatives in other villages

Geoparks contribute significantly to territorial development by directly and indirectly creating new jobs. But what is even more important for the employment in the area is the number of other job opportunities which are created in tourist enterprises, small hotels, guest houses, restaurants and other activities connected with the increase of tourist flow in the Geopark area.

Several other local artisans, such as makers of handicrafts and ceramic fossil casts, carpenters, and blacksmiths, are permanent collaborators with the Geopark.

Keyword

UNESCO Global Geoparks, Global Geoparks Network, Sustainable development

UNESCO Global Geoparks in Belgium - added value and perspectives.

Sophie Verheyden[1], Institute of Natural Sciences, Geological Survey of Belgium
Serge Delaby[2], UNESCO Global Geopark Famenne-Ardenne, Belgium
Jan Walstra[3], Institute of Natural Sciences, Geological Survey of Belgium
Xavier DEVLEESCHOUWER[4]*, Institute of Natural Sciences, Geological Survey of Belgium (xdevleeschouwer@naturalsciences.be)
Jonathan Jacops[5], Geopark Schelde-Delta, Belgium-Netherlands
Walter Jonkers[6], Geopark Schelde-Delta, Belgium-Netherlands
Vanessa M.A. Heyvaert[7], Institute of Natural Sciences, Geological Survey of Belgium

Abstract

Belgium has a rich history of managing its geological subsurface, dating back to the the beginning of the 19th century with the first geological maps covering France and the Netherlands also including the future territory of Belgium. Those geological maps were drawn at the request of Napoleon's government and printed in Paris. After a long period of exploration and industrial exploitations of the subsurface in Belgium, the decline of the coal mining led to a gradual fading for geology away of the forefront of societal concerns. Moreover, young people have limited exposure to geology in schools, despite the pressing contemporary challenges related to raw materials, clean energy, and natural hazards.

In 2014, research conducted in the caves of Southern Belgium, lead researchers from the Geological Survey, together with Mons and Namur Universities to the creation of the Geopark Famenne-Ardenne. This initiative earned the UNESCO Global Geopark designation in 2018. Building on this success, support was given during the creation of the cross-border Geopark Schelde-Delta in Northern Belgium and the Netherlands. It includes participation in the 3-years Interreg project (Be) Leefbare Schelde. This year, the Geopark also secured the UNESCO Global Geopark designation, marking a significant milestone with two such designations for Belgium.

The geoparks has had a profoundly positive impact by raising awareness among the public, including policymakers, about the significance of geology. While there is still progress to be made, these initiatives have fostered a greater appreciation for geoheritage and its role in enhancing our understanding of Earth processes through research. The public, whether residents or tourists, has shown keen interest and curiosity in exploring these territories in novel ways.

The geoparks facilitate the acquisition of resources necessary for improving the identification, characterization, digitalization, study, and management of geoheritage in Belgium. They also serve as platforms for initiating discussions with policymakers regarding specific legislation aimed at protecting this valuable heritage.

The Famenne-Ardenne Geopark offers a unique landscape associated with karstic features, developed on Devonian and Carboniferous folded and faulted limestone rocks. These rocks have undergone significant alterations during warm and humid climate periods with intense karstification. Caves were formed, subterranean meanders and hydrogeological systems such as "swallow-hole / resurgences" can be explained by the underground pathway of rivers sometimes

over 10 km.

On the contrary the Schelde Delta Geopark encompasses a distinctive transnational estuary where the tides of the North-Sea are impacting the course of the river Scheldt. This unique landscape is closely tied to the evolution of the Quaternary valley of the Scheldt river and its estuary. The environment undergoes significant changes influenced by climate change, fluctuating sea level, warming climate conditions, anthropic pollution, and pressure from the development of the nearby port of Antwerp. These dynamics shape this natural area, highlighting the importance of conservation and protection efforts.

A third geopark remains a viable option, as other regions in Belgium can showcase the connection between geology and human activities. UNESCO Global Geoparks play a crucial role in transitioning towards a more sustainable management of territories.

Keyword

Geopark, Famenne-Ardenne, Schelde Delta, Belgium, landscapes

UNESCO's Earth Sciences Activities in Africa: Impacts on sustainable development and capacity building

Asfawossen Asrat KASSAYE[1], Botswana International University of Science and Technology
Özlem ADIYAMAN LOPES[2], UNESCO Earth Sciences and Geoparks Section, Division of Earth and Ecological Sciences (EES), Natural Sciences Sector (SC), Paris, France
Kombada Mhopjeni[3], UNESCO, Natural Sciences Sector (SC), Windhoek, Namibia
Kombada Mhopjeni[4]*, Geological Survey of Namibia (k.mhopjeni@unesco.org)

Abstract

UNESCO, as the the only United Nations organization with a mandate to support research and capacity building in earth sciences, has been supporting the development of African geosciences through its two flagship programs – the IGCP (International Geoscience Program) and the UGGp (UNESCO Global Geparks), within the framework of its leading moto: Earth Sciences for a sustainable Earth and sustainable Societies. Though there is an increasingly impactful geosciences community in Africa, considering the deep-rooted and diverse challenges in the continent hindering the growth of the geosciences, thereby limiting their impact on the sustainable growth of the African society, UNESCO's support is not only crucial but instrumental in helping alleviate these limitations. This keynote will address the impacts of the major initiatives and activities UNESCO has been carrying out in Africa in collaboration with local geoscience institutions including professional societies, universities, geological surveys, and African geoscientists. Emphasis of the keynote will be on ongoing major initiatives and activities, but reference will also be made to past initiatives, such as the African Network of Earth Science Institutions (ANESI), which has been very impactful in creating a database of African Earth Science Institutions and researchers, which further helped in creating and supporting several early career researchers to establish research networks and collaborations among African Earth Science Institutions. One of the major ongoing activities of UNESCO in Africa is supporting the training of Earth scientists form many countries in Africa on geoheritage inventory and development of geoparks in collaboration with the Pan-African Support to Geological Sciences and Technology Africa-EU Partnership (PanAfGeo) and local institutions and geoscientists in Africa as well as supporting fledgling geoparks in Africa through expert missions, which helped to enhance existing aspiring geoparks and to initiate new geopark projects in the continent. UNESCO, through its IGCP-766 project – Fostering Researchers in the Geosciences (FoRGe), has recently conducted a survey of the African geoscience community to identify the needs of the community with the ultimate goal of building geoscience research capacity in Africa. All these and many other UENSCO initiated and supported projects in Africa have been impactful in building capacity of researchers, in creating knowledge networks and in helping establishments of sustainable institutions such as geoparks. In order for these impacts to take root and to ensure that African societies fully benefit from the geosciences, UNESCO will work with member states to own these initiatives and build upon them.

Keyword

UNESCO, Africa, Geoheritage, sustainable development, societal impact

Participatory inventory of geosites as a tool for geoheritage management in the Mixteca Alta UNESCO Global Geopark (Mexico)

Jose Luis SANCHEZ-CORTEZ[1]*, National Autonomous University of Mexico, Institute of Geography (jsanchez@geografia.unam.mx)
Norma López-Castañeda[2], National Autonomous University of Mexico
Xochitl Ramírez-Miguel[3], National Autonomous University of Mexico, Institute of Geography
José Luis Palacio-Prieto[4], National Autonomous University of Mexico, Institute of Geography

Abstract

Geosite inventories are important tools for determining the most important elements of the geodiversity of a territory, and also play a representative role when divulge an area of interest. Specialized literature has standardized the need for geosites to have a preponderant scientific value for their consideration.

However, in the context of geoparks, the efforts are made to ensure that geosites, in addition to their intrinsic interests, have a symbolic relationship with local communities. Geoparks seek to promote the relationship between the population and its environment.

In this sense, in Mixteca Alta UNESCO Global Geopark there is a valuable relationship between indigenous communities and their territory; this strong link unites the local cosmovision with geodiversity, evidencing it in their language, legends, orality, in the name of their communities. This sense of belonging must be encouraged and strengthened.

This particular panorama of the Mixteca Alta Oaxaqueña (Mexico) allowed us to generate a geosite inventory model that takes advantage of this strong social and geological link, for which a participatory inventory was developed that enhances this relationship, being a viable, appropriate and adapted option to the territorial reality.

Although this inventory was generated by local communities, represented by their municipal and communal authorities, the geosites listed and described effectively fulfilled the role of generating a panoramic vision of the main geological and geomorphological interests present in the territory of the geopark. A list of 48 sites was generated, of which 4.2% of the inventoried sites registered to have international importance, while 16.7% had national interest, 37% and 41% had regional and local values respectively.

Of the geosites inventoried through this method, 77.1% had some cultural, archaeological or anthropological value, linked directly or indirectly. But, on the other hand, 100% of the sites covered the geological and geomorphological interests previously prospected in this territory during the detailed geological mapping. 33.04% of the sites showed geomorphological interest, 19.79% petrological interests, 12.17% stratigraphic and sedimentological interests, 11.01% tectonic and structural interests, 9.28% mineralogical interests, 6.09% paleontological interests, 4.93% hydrogeological interests, and 3.77% pedological interests.

In general, this inventory covered a participatory need and also complemented geological-geomorphological information in the Mixteca Alta Geopark.

Keyword

Participatory inventory, Mixteca Alta UNESCO Global Geopark, Geoheritage, Geosites, Mexico

The Pollino UNESCO Global Geopark (southern Italy): a route in the Ancient Tethys Ocean

Roberto BUCCIONE[1], Department of Sciences, University of Basilicata, viale dell'Ateneo Lucano 10, 85100 Potenza, Italy
Giovanna RIZZO[2], Department of Sciences, University of Basilicata, viale dell'Ateneo Lucano 10, 85100 Potenza, Italy
Luigi BLOISE[3], Parco Nazionale del Pollino, 85048 Rotonda, Italy
Egidio CALABRESE[4], Parco Nazionale del Pollino, 85048 Rotonda, Italy
Giovanni MONGELLI[5]*, Department of Sciences, University of Basilicata, viale dell'Ateneo Lucano 10, 85100 Potenza, Italy (giovanni.mongelli@unibas.it)

Abstract

In the southern Apennines, rocks with distinctive characteristics, known as ophiolitic sequences, outcrop in the Pollino Massif near the border of the Basilicata and Calabria Regions. These rocks represent fragments of oceanic crust, with associated deep-sea sedimentary cover and record an ancient oceanic basin of Jurassic age known as Tethys Ocean. These rocks, which history began about 150-170 million years ago, were involved in the complex orogenic processes that led to the genesis of the southern Apennines. The southern Apennines is a fold and overthrust chain consisting of tectonic units resulting from deformation of the Mesozoic Apulian-African paleo margin. On a regional scale, the different tectonic units, which make up the southern Apennines in the Pollino Massif, are the result of compressional tectonics, which involved, at first, the rocks of the ophiolitic sequence and later, the Mesozoic-tertiary platform terrains consisting of calcareous-dolomitic successions. The geological features of the ophiolitic sequence constitute, therefore, fundamental elements that allow us to reconstruct the main evolutionary stages of this orogen. Pressure and temperature variations, to which ophiolitic rocks were subjected during the geodynamic evolution of the southern Apennines, induced both mineralogical and structural transformations in the original oceanic crust rocks. In the Pollino UNESCO Global Geopark trail, which is 720 m long, is possible to find the evidence of the opening of the ocean basin and its subsequent closure and to observe the origin and evolution of the rock outcrops and to understand the geological and environmental evolution of millions of years. The route is described through a series of stages with specific and detailed signage, where visitors can understand they are walking on the bottom of what was once an ocean. The geotouristic route deals with the rock outcropping at the "Timpa delle Murge" and "Timpa di Pietrasasso" sites, which represent the complete ophiolitic sequence of the southern Apennine area and characterize the landscape of the Pollino UNESCO Global Geopark. During the different stops, visitors will observe the different portions of the ancient Jurassic ocean and touch the different types of rocks of the Tethys oceanic crust which are: (I) the ultrabasic complex, whose dominant rocks are serpentinites; (II) the intrusive complex in which gabbros predominate; (III) the volcanic complex, with a spectacular outcrop of "pillow lavas"; and (IV) the cover of sedimentary rocks consisting of deep-sea deposits. The Pollino Massif ophiolitic sequence attracts visitors from all over the world since rocks that were

once part of an ancient ocean can be seen here and represents cultural patrimony that must be safeguarded, protected, and promoted.

Keyword

Pollino UNESCO Global Geopark, ophiolitic sequence, southern Apennines

Geopoetics as a new tool for the enhancement of the management of Natural and Cultural Heritage in UNESCO Global Geoparks

Georgius Dimitriadis[1], UNESCO Chair on Geoparks, Sustainable RegionalDevelopment and Healthy Lifestyles
Artur Abreu SÁ[2]*, Department of Geology, University of Trás-os-Montes e Alto Douro (asa@utad.pt)

Abstract

In recent times, there has been an increasing recognition of the significance of intangible assets, such as cultural heritage, on international platforms like UNESCO (UN Resolution 2199: 2015; UN Resolution 2347:2017) and various organizations (WB 22559:2000). This attention signifies a broader acknowledgment by scholars and policymakers of the crucial role played by cultural and geological heritage in driving regional socioeconomic progress. There is a concerted effort to incorporate contemporary discussions on geological culture and development, with a specific emphasis on comprehending prevailing patterns and practices across diverse geographical regions. This shift underscores the necessity of including both tangible and intangible aspects of heritage in endeavours to rejuvenate communities and economies.

Cultural and natural heritage are viewed as dynamic constructs that have been shaped by evolving value systems throughout history. Thus, the selection process for preserving certain objects, monuments, or natural environments is of utmost importance as it shapes cultural narratives and societal consensus about the past and present. In this sense, geological heritage sites hold symbolic importance as many times they represent cultural identities and foster a sense of community.

The management of cultural and natural heritage sites faces the challenge of striking a balance between the growth of tourism and the preservation of site authenticity and cultural significance. In this context, UNESCO emphasizes the significance of managing geoheritage to transmit cultural identity to future generations. In the same way, the Global Geoparks Network, which encompasses areas of geological and cultural heritage, is acknowledged for its potential contribution to human well-being. Within this framework, the concept of 'Geopoetics' highlights the dynamic relationship between humans and the Earth, providing a complementary approach to managing Natural and Cultural Heritage in UNESCO Global Geoparks. In effect, Geopoetics emphasizes geographical consciousness as a means to transcend limiting perceptions and enhance the management of heritage sites. Overall, there is a growing awareness of the interconnectedness between cultural, geological, and human dimensions of heritage, driving efforts to preserve and leverage these assets for sustainable development.

Keyword

Geopoetics, Global Geoparks Network, Geological heritage, UNESCO, Culture Resource Management

Geoheritage conservation and promotion on a small tropical island: first steps toward a UNESCO Geopark in Guadeloupe, Lesser Antilles

Yves MAZABRAUD[1]*, Université des Antilles (yves.mazabraud@univ-antilles.fr)

Abstract

Guadeloupe is located in the Eastern Caribbean (Lesser Antilles), a recognised biodiversity hotspot. It is an archipelago of six inhabited islands with a surface area of 1600 km2, 16% of which is protected, and a total population of over 400,000. This area is facing a rapid loss of biodiversity, which has led to several conservation measures in recent decades (creation of a National Park and a National Nature Reserve, protection of several forests, RAMSAR areas, Caribbean SPAW Protocol, Man and Biosphere Reserve). These efforts have led to a growing environmental awareness among the population, although much remains to be done. As an active subduction, tropical arc archipelago, Guadeloupe's geodiversity is particularly rich (carbonate platforms, living and fossil coral reefs, mangrove-rich mudflats, terrestrial and submarine thermal springs, various types of volcanic deposits, tropical karst and an active volcano, La Soufrière). Between the diminishing availability of resources (geomaterials and especially water), the multiple geohazards (volcanic, seismic, landslides, tsunamis, floods, hurricanes), the importance of soils for agriculture, and the growing income from ecotourism, the socio-economy of Guadeloupe is partly dependent on an effective geoconservation policy and strategy. Paradoxically, however, the geological heritage suffers from a lack of protection and is sometimes endangered or damaged.

We will present the strategy we have developed to prepare a geopark project and the results obtained so far. We will then present some of the questions and challenges we are facing in order to stimulate a constructive discussion.

Keyword

geological awareness, Caribbean, Lesser Antilles, Geoparks

University and Geopark: Fundamental Partnership for the Preservation and Promotion of Geological and Cultural Heritage.

Stela Mariana MORAIS[1]*, Universidade Federal do Triângulo Mineiro (stela.morais@uftm.edu.br)
Paula CUSINATO[2], Universidade Federal do Triângulo Mineiro
Thiago da Silva MARINHO[3], Universidade Federal do Triângulo Mineiro
Diogo Nobre SILVA[4], Universidade Federal do Triângulo Mineiro

Abstract

The role of universities in a Geopark, exemplified by the participation of the Federal University of Triângulo Mineiro (UFTM) in the Uberaba Geopark, is multifaceted and of paramount importance for the understanding, preservation, and promotion of the geological and cultural heritage of the region. UFTM offers scientific and academic expertise that is essential for understanding the geodiversity, natural, and cultural history of the Geopark. Collaborating with national and international research groups, the university develops projects and seeks to investigate and document the geological and cultural aspects of the region, contributing to the conservation and responsible management of resources. Additionally, UFTM actively participates in the development and execution of educational and scientific programs aimed at the Geopark. These programs not only inform but also raise awareness among the public about the importance of conserving geological and cultural heritage, promoting a sustainable relationship between the local community and its environment. The university's contribution also extends to the promotion of scientific and cultural dissemination activities for both the local community and visitors to the Geopark. This includes organizing events, exhibitions, lectures, and environmental education activities aimed at sensitizing the public about the importance of conserving geological and cultural heritage and engaging the community in its preservation. Specifically, UFTM plays a fundamental role in the management of Peirópolis Geosite, the main geosite of the Uberaba Geopark, coordinating a variety of activities that encompass teaching, research, tourism, local economic development, scientific dissemination, heritage, and cultural. Additionally, prominent events are regularly held at this location, contributing to the dissemination of knowledge and the promotion of the Geopark. In summary, the active participation of UFTM in the Uberaba Geopark exemplifies the essential role of universities in the conservation, research, education, and promotion of the geological and cultural heritage of a region. This collaboration is crucial to ensure the sustainability and responsible development of the Geopark, benefiting both the local community and visitors. By educating its students and contributing to the production of knowledge and documentation of geological and cultural heritage, the university plays a fundamental role in promoting research, education, and preservation within the scope of the Uberaba Geopark. Collaboration between the university, the local community, and other partners of the Geopark is essential to ensure the sustainability and responsible development of the territory, ensuring that its geological and cultural value is appreciated and protected for future generations.

Keyword

University, Geopark, Partnership, Scientific dissemination, Sustainable development

Strategic Management of Geoparks: Conservation, Development, and Challenges.

Stela Mariana MORAIS[1]*, Universidade Federal do Triângulo Mineiro (stela.morais@uftm.edu.br)
Daniela ROCHA[2], AGA - Associação Geoparque Arouca

Abstract

In the context of preserving geological, biotic, and cultural heritage, as well as promoting sustainable economic development through geotourism, a proposal for the strategic management of geoparks is presented. This work outlines the stages of an integrated and multidisciplinary process, aiming not only at conservation but also at the valorization and promotion of the territory, based on the model used by Geopark Uberaba (Brazil). The idea of creating Geopark Uberaba, particularly regarding its management structure, drew inspiration from the UNESCO Global Geopark Arouca. Both share the model of an Association as the managing entity with the participation of entities serving as anchors in the Geopark. The AGA - Arouca Geopark Association, founded in 2008, is an association formed by entities of both public and private nature, with the Municipality of Arouca serving as the President of the Board, employing a bottom-up participatory working methodology. In the case of Uberaba, the Geopark Uberaba Association comprises the four signatories: the Brazilian Association of Zebu Breeders (ABCZ), Uberaba City Hall (PMU), Brazilian Service of Support for Micro and Small Enterprises (SEBRAE), and the Federal University of Triângulo Mineiro (UFTM). The first step of the model used by Uberaba consisted of forming working groups, representing the diversity of areas of action within a Geopark, including management, geology and geoconservation, education, natural heritage, cultural heritage, economic development, tourism, and communication. Each group had to work on goals outlined based on the UNESCO Geoparks Self-Evaluation Form and develop a specific action plan to achieve them. Leadership, performed by the Management group, played a fundamental role in coordinating and monitoring the progress of all areas of action. It was essential to establish clear communication among the groups, ensuring that short, medium, and long-term priorities were aligned so that resources were allocated efficiently. Progress assessment was conducted using the "101 questions" form, allowing for a comprehensive and careful analysis of the Geopark's performance in relation to UNESCO criteria. This assessment served as a guide to identify strengths and areas that needed improvement, paving the way for the Geopark's candidacy. The main challenges were: 1. Establishing and maintaining a collaborative network from the early stages of the project, promoting an inclusive and participatory approach. 2. Making strategic decisions under conditions of uncertainty and risk, especially during the evaluation process for endorsement. 3. Balancing the technical and political dimensions of the team, recognizing and integrating different perspectives and skills necessary for project success. Conclusion: The strategic management of geoparks is a continuous mechanism of how the conservation of natural and cultural heritage can be integrated into the sustainable economic development of a community. The success of a Geopark is not limited only to obtaining UNESCO

endorsement but also to building local/regional/national/international partnerships and promoting sustainable and responsible tourism, highlighting the importance of participatory and integrated management in conservation and territorial development projects. This model can serve as a reference for other regions seeking to balance heritage conservation with socio-economic development.

Keyword

Strategic management, Geoparks, Collaborative network

Identifying the Relationship Between Geoparks and Local Government Policies

KEYUP KIM[1]*, GeoMecca Engineering (geokey@hanmail.net)

Abstract

UNESCO defines a global geopark as a geological site with special scientific importance, rarity, or beauty and has ecological, archaeological, historical, and cultural values, promoting regional economic development through conservation, education, and tourism. In this study, the consciousness, willingness to pay, regional policy evaluation, and the direction of future regional policy of Cheorwon residents for the geopark were proposed. 1,500 copies of the questionnaire were distributed and 1,011 copies of the recovered effective questionnaire were analyzed. The confidence level is 95% with a sampling error of 0.3% points.

Among the local residents of Cheorwon-gun, 83.9% know about the geological park and 77.3% have visited, but 16.1% do not know it and have low satisfaction. 87.1% of residents think that geoparks are helpful for regional development and improve economic development, cultural status, affection, and pride. Environmental management was cited as a good policy in relation to geoparks. On the other hand, it is worth paying attention to 31.1% of residents who think that there are no good policies. Regional policies that are not good are related to income growth and public relations. Among the residents, 60.2% said they would donate to geopark-related programs. Meanwhile, 51.5% of the residents said they would volunteer and 48.5% said they would not.

The participation and cooperation of residents are necessary for sustainable development. To know this, the willingness to donate or volunteer was determined. Willingness to donate and volunteer was greater, and this is related to more positive groups, more good policies, higher the education level, residing closer to geological attractions, and higherage groups. Geoparks are estimated to bring an average annual economic profit of 7,569 million won per household.

The regional policies related to geoparks obtained through this study are as follows. First, residents must deeply understand geoparks and change their perceptions. Second, promotion policies should be expanded and digitized. Third, there should be an effective economic policy promotion. Fourth, customized policies should be pursued. Fifth, efforts for sustainable development are needed. Sustainable development of ESG management concepts is also required. Sixth, efforts to popularize geological parks are needed.

Keyword

Hantangang UNESCO Global Geopark, Local Government Policies, Sustainable development, Willingness to pay

Geoheritage and Geodiversity in Yazd Province, the Potentials to Develop Shirkouh and Bahabad Geoparks, Iran

Alireza AMRIKAZEMI[1]*, National Iranian Geoparks Network (aamrikazemi@gmail.com)
Saeed Afsarifard[2], Nationa Iranian Oil Company
Soma Sayedyounesi[3], Geoscience Institute of New Age
Kimiya Ajayebi[4], Azad Islamic University of Karaj
Abolfazl Ezzatti[5], Azad Islamic University of Tehran

Abstract

Yazd Province in Central Iran is known for its remarkable geodiversity and diverse nature, complemented by a rich history and culture. From vast sand dunes and deserts to towering mountains and glaciers, this region offers a wide range of natural wonders. Additionally, Yazd Province is home to the rare and unique Zoroastrian community, as well as stunning examples of Islamic architecture from various eras. The local community takes great pride in their distinctive ceremonies and intangible heritage.

Shirkouh Mountain, with an elevation of 4075m, is the highest mountain in central Iran. This mountain is classified as one of the "Ultra Prominent Peaks". The presence of glaciers on this mountain is particularly unique, as they are situated at a latitude of 30 degrees in the middle of a desert. Another remarkable feature in this area is an underground conglomerate formation that functions as a natural dam, storing water. The Bahabad area is known for the best and rarest Liesegang patterns, which have a three-dimensional relief and are significantly larger than normal Liesegangs. Additionally, this area boasts the oldest exposed rocks in central Iran, dating back to the Pre-Cambrian era. Moreover, there are numerous structural, sedimentary, and geomorphological features in these areas.

Zoroastrians have been living in Iran and some neighboring countries for 2000 years. Currently, the largest community exists in Yazd Province, where they have their own temples and ceremonies. One notable temple is the fire temple in Yazd City, where a sacred fire has been burning for over 1500 years. It is known as the Eternal Flame. Each year, thousands of Zoroastrians, both from other cities within Iran and even from other countries, travel to this area as pilgrims.

The gastronomy of this area is unique and derived from desert living. There is a wide variety of natural herbs and vegetables that are used as food or traditional medicine. The indigenous people have a strong understanding of how to treat and remedy ailments using these natural products.

Qanat or Kariz was invented by Iranians to transfer water through underground channels to distant villages. The most famous and longest Qanats can be found in this area. It is a creative method to adapt to life in arid lands with limited access to fresh water.

After considering all the mentioned attractions and potentials, it is clear that there is a great opportunity to establish two geoparks in this province. These geoparks are intended to preserve and promote not only the geological heritage but also other types of heritage. The local community and authorities are highly enthusiastic about achieving sustainable development goals

through the geoparks. Extensive investigation and studies have already been conducted in these two potential areas, and the projects for establishing the geoparks are currently in progress.

Keyword

Shirkouh, Bahabad, Geoheritage, Geopark, Sustainable development

[Invited] The master plan of Hantangang transnational UNESCO Global Geopark between ROK and DPRK.

KIL YOUNGWOO[1]*, Chonnam National University (ykil@jnu.ac.kr)

Abstract

The Quaternary Hantangang River Volcanic Field (HRVF) in the central part of the Korean Peninsula hosts unique volcanic landforms associated with fluvial topography. The volcanic field consists of a series of basaltic lava flows, ca. 0.1 to 0.6 Ma old, which originated from two source vents in DPRK (Democratic People's Republic of Korea; North Korea) and flowed along a 110 km long stretch of paleo-river channels to the terminus in the northern part of ROK (Republic of Korea; South Korea). In 2020, UNESCO Global Geopark Secretariat recommended that Hantangang UNESCO Global Geopark of ROK (Republic of Korea) should be expanded into a border area of the DPRK (Democratic People's Republic of Korea) for an enlargement of outstanding geological heritage values. Around Cheorwon-Pyeonggang lava plateau area (ca. 1,530 km2) of Pyeonggang-gun, Sepho-gun, Cheorwon-gun, and Gimhwa-gun in DPRK is a reasonable area to make the Hantangang transnational UNESCO Global Geopark. The Marble Arch Caves transnational UNESCO Global Geopark, located on boundary between British Northern Ireland and Ireland, should be considered as the most suitable preceding model, because both are located in the troubled regions. There are many geological, archaeological, and ecological attractive sites in the Hantangang transnational UNESCO Global Geopark. There are four phases of 10 years for the nomination of the Hantangang transnational UNESCO Global Geopark: first phase, the establishment of preparatory committees and joint researches; second phase, the geosite designation and the visitor program development in the DPRK; third phase the establishment of management plans of two Koreas and geopark center in the DMZ (demilitarized zone); and fourth phase, submission of geopark application and on-the-spot evaluation. If the roadmap, suggested in this paper, is successfully carried out, the Hantangang transnational UNESCO Global Geopark will have the greatest impact on establishing a peace system between two Koreas.

Keyword

Transnational UNESCO Global Geopark, Hantangang, DPRK (Democratic People's Republic of Korea), ROK (Republic of Korea; South Korea)

Historical and cultural value of Mount Baekdu as seen through old Korean maps

Sangmyeoung MOON[1]*, Northeast Asian History Foundation (moon@nahf.or.kr)

Abstract

Old maps are works of art that have great pictorial value because they contain both style and artistic flavor, and they also convey information about spaces that we are not familiar with in three dimensions. In particular, the time period and social perceptions of the time when they were created are comprehensively shown through the images, implying the local characteristics and perceptions of the people who lived, observed, and felt at the time.

Baekdu Mountain has been a part of the Korean peninsula not only in history and geography, but also culturally. Our ancestors emphasized Baekdu Mountain on their ancient maps. And they expressed it with various names. Baekdu Mountain has been called by many names, including Bulhamsan, Taebaeksan, Gaemadaesan, Dotasan, Jangbaek, Baeksan, Baekdu, and Gaiminsangsangsan. As a large mountain in Northeast Asia, it's only natural that it has been called by many different names over the course of people's memories.

It has also long been considered a sacred and special place and recognized as Taebaeksan, the mountain where King Dan descended. On the other hand, Baekdu Mountain is not emphasized on the ancient maps of China.

It is often said that Westerners perceived Joseon as the land of ginseng, but this is not the case. Westerners remembered the marten that lived in Baekdu Mountain and remembered Joseon as the land of marten.

Keyword

Old maps, Baekdu Mountain, marten, Taebaeksan, Bulhamsan

[Keynote] Transnational UNESCO Global Geoparks

Patrick James MCKEEVER[1]*, Global Geoparks Network (patrickgsni@yahoo.ie)

Abstract

Since the creation of the Global Geoparks Network in 2004 and the subsequent adoption of the UNESCO Global Geopark designation in 2015, the number of Geoparks has reached 213 in 48 countries. Of these, currently only 5 are transnational, i.e. they are shared by one or more countries. All 5 however are in Europe and are part of the European Union. A similar geographical imbalance is also apparent in UNESCO's two other heritage-related designations, World Heritage Sites and Biosphere Reserves.

This could be due to the significance of funding schemes available for cross-border cooperation in Europe and a long history of such cooperation following the end of the Second World War. Transnational properties, whether UNESCO Global Geoparks, Biosphere Reserves and World Heritage Sites have a fundamental role to play in bringing countries together, furthering international cooperation and fulfilling the mission of UNESCO itself, "Since wars begin in the minds of women and men, it is in the minds of women and men that the defences of peace must be constructed."

Of course there is great potential for the creation of transnational UNESCO Global Geoparks in other areas of the world but in some areas, such as the Korean peninsula, huge challenges remain due to a hard, closed border which does not permit the kind of community cooperation so fundamental to UNESCO Global Geoparks.

Keyword

UNESCO, Geoparks, Transnational

Expected Effects and Key Strategic Approaches for Promoting a Transnational UNESCO Global Geopark Network in Northeast Asia, Including Baekdusan aUGGp and Hantangang UGGp.

Soo Jae LEE[1]*, Korea Environment Institute (sjlee@kei.re.kr)
Soo Jae LEE[2], Korea Environment Institute

Abstract

1. Overview
Although North Korea and China have been promoting the Baekdusan (Mt Paektu)/Changbaishan region as a UNESCO Global Geopark, China's prior designation as a UNESCO Global Geopark will have significant implications. This presentation explores strategies for promoting peace-based co-prosperity in Northeast Asia through the operation of transnational UNESCO Global Geoparks, in addition to addressing these implications. Furthermore, considering that UNESCO Global Geoparks are operated under international norms, we will examine an approach based on these norms.

2. The need for Baekdusan UNESCO Global Geopark and Transnational Global Geoparks
First, regarding the concern that the name "Changbaishan" will be used more frequently than "Baekdusan", it is desirable for North Korea to conduct a field evaluation of the UNESCO Global Geopark and be designated as soon as possible. It would be beneficial to actively promote the name "Baekdusan" through independent operation for a considerable period thereafter.

On the other hand, if North Korea pursues a Transnational UNESCO Global Geopark (TUGGp), it is necessary to strive for the selection of the name "Baekdusan-Changbaishan UNESCO Global Geopark." However, if this is not feasible due to various factors such as international norms and practices, efforts should be made to revise the UNESCO regulations regarding the use of names. In this case, it is necessary to establish regulations that allow North Korea to use the name "Baekdusan-Changbaishan UNESCO Global Geopark" and China to use the name "Changbaishan-Baekdusan UNESCO Global Geopark."

3. Necessity of Promoting Northeast Asian Transnational Global Geoparks
There are about four potential areas for TUGGps between North and South Korea. If conditions permit, it is necessary to promote these areas as TUGGps to seek peace-based co-prosperity between the two Koreas.

To effectively respond to the Northeast Asian TUGGps, it is necessary for South Korea to immediately start a dedicated organization and related activities. To this end, a "Northeast Asia Transnational UNESCO Global Geopark Forum" should be established to carry out its activities systematically and continuously.

4. Suggestions

The following considerations are necessary for the successful operation of Northeast Asian TUGGp.

- Preparation for Changes in Inter-Korean Political Situation
- Establishment of Sustainable Management Plan
- Securing International Support etc.

5. Conclusion

TNUGGps are essential for pursuing peace-based co-prosperity on the Korean Peninsula and in Northeast Asia. Even if the realistic conditions, such as the inter-Korean confrontation, are not sufficient, it is possible to prepare internally. Therefore, it is proposed to start with the "Northeast Asia Transnational UNESCO Global Geopark Forum." On the other hand, it is necessary to propose a revision of the operational guidelines for Transnational UNESCO Global Geoparks to UNESCO to minimize the side-effects of name usage.

Keyword

Transnational Geoparks, Baekdusan aUGGp, Changbaishan UGGp, Hantangang UGGp

The Designation and Denomination of Transnational Geoparks: A Case Study in East Asia

Jisung KIM[1]*, Hantangang River UGGp (intkim777@korea.kr)
Dongwon CHOI[2], Hantangang River UGGp

Abstract

To establish transnational geoparks, numerous obstacles must be overcome, encompassing not only political boundaries but also language, ethnicity, and historical perspectives.

Among these, language emerges as one of the predominant factors. Despite geographical congruence, many regions experience or have experienced conflicts over differing nomenclatures, even in areas physically identical. Such conflicts commonly arise in disputed territories with artificial boundaries, and they can occur within single political entities devoid of disputes.

The fact that three out of four existing transnational geoparks utilize bilingual naming highlights the challenge of achieving nomenclatural uniformity, surpassing the complexities of political integration.

Examining a prospective transnational geopark in East Asia, consider the case of the Hantangang River UNESCO Geopark in South Korea, where such impediments are non-existent. This region, comprised of a homogeneous ethnic group, remains separated into The Republic of Korea(ROK) and The Democratic People's Republic of Korea(DPRK) for political reasons of less than three-quarters of a century. Both sides utilize the same language and nomenclature, mitigating potential conflicts.

The other case is the Mount Changbaishan UNESCO Global Geopark in China designated recently. It is also a significant candidate for a transnational geopark. North Korea, which shares the identical geological area as Mount Changbaishan(in DPRK, it is called Paektusan), has requested UNESCO to designate its geological area as the "Mount Paektu Global Geopark." However, given the significant overlap in geological boundaries, it would be more appropriate for these areas to be designated as a single transnational geopark rather than separate national geoparks. Hence, the linguistic divergence between the two countries, each with distinct historical legacies, anticipates that consideration of the naming of transnational geoparks will be needed in the future.

Given these complexities, one alternative proposes leveraging geological terminology in geopark nomenclature. Geological terms offer neutrality compared to geographic names that originated from specific languages.

Keyword

Global Geopark, Transnational, Science and Policy, Political Geology, Political neutrality

Necessity of Transnational UNESCO Global Geopark in East Asia: Focusing on Baekdu Mountain Geopark and Gangwon Peace Geopark

Donwon CHOI[1]*, Jeju culture promotion foundation (cave4@hanmail.net)

Abstract

Currently, there are no transnational Geoparks in East Asia. However, with the designation of China's Changbaishan Geopark as a UNESCO Global Geopark in 2024, it will share a border with North Korea's Baekdusan Mountain Geopark (Mt Paektu Geopark). This has led to a growing interest in South Korea, particularly due to the historical symbolism of Baekdusan Mountain. This presentation discusses the considerations for the establishment of a transnational Geopark in South Korea's Gangwon Peace Geopark, which currently borders North Korea.

1. Introduction

The establishment of a transnational Gangwon Peace Geopark presents unique challenges and opportunities. While the shared geological heritage of the region provides a strong foundation for cooperation, the political divide between North and South Korea poses significant hurdles. This presentation explores the feasibility and potential benefits of establishing a transnational Geopark in this region, considering both the challenges and opportunities.

2. Background and Issues of the Gangwon Peace Geopark

The Gangwon Peace Geopark was designated as a national Geopark in 2014. Despite its potential, the Geopark faces several challenges, including limited accessibility, lack of public interest, and a shortage of readily accessible geological sites. Furthermore, the designation of the Hantangang River, a key geological feature within the Geopark, as a UNESCO Global Geopark has further reduced the number of internationally recognized geological sites within the Gangwon Peace Geopark.

3. Issues to Consider in Establishing the Gangwon Peace aUGGp

Distance from Neighboring Geoparks: UNESCO recommends a minimum distance of 100 km between existing Geoparks when establishing new ones. However, the Gangwon Peace Geopark is adjacent to the Hantangang River Global Geopark, necessitating a careful approach to address this issue.

4. Key Issues in Establishing a transnational Gangwon Peace Geopark

Naming: The name "Gangwon" is used by both North and South Korea as an administrative district name. Therefore, if the two Koreas operate a transnational Geopark along the current DMZ, the name "Gangwon Peace Geopark" could be used, minimizing naming-related disputes. However, if North Korea requests a different name, a process for renaming would be necessary.

5. Proposal for Establishing a transnational Gangwon Peace Global Geopark

Given the current political situation, the immediate demilitarization of the DMZ between North and South Korea is unlikely in the short term. Fortunately, North Korea has also expressed interest in establishing Geoparks in various regions, as evidenced by their application for Baekdu Mountain Geopark in 2019. Therefore, the following phased approach is proposed:

- Establishment of Individual Geoparks in North and South Korea
- Establishment of the Gangwon Peace Global Geopark by South Korea Alone
- Establishment of a transnational Global Geopark through Expansion

6. Necessity and Expected Effects of the transnational Gangwon Peace Global Geopark

The Gangwon Peace Geopark is a place that bears the scars and history of the Korean War and was the very site of ideological confrontation. Therefore, geo-tourism based on geological heritage can be a region that can attract great interest from both domestic and foreign visitors.

This region is an area where détente is absolutely necessary for sustainable

Keyword

Transnational Geopark, Gangwon Peace Geopark, Hantangang UGGp

Magnetic susceptibility measurement using simulated rock samples and application to the stone used in Himeji Castle, a World heritage site

Ayaha EMURA[1]*, University of Hyogo (fern.folium358@gmail.com)
Kyohei Sano[2], University of Hyogo
Norihito Kawamura[3], University of Hyogo

Abstract

As for the characteristics of rocks in Japan, volcanic rocks are commonly used as construction materials. Since ancient times, the technique of stone processing spread among the common people, and stones became ingrained in religious practices and daily life. In Geoparks, the relationship between geology and culture is an important theme. Stones have been carried and used for materials like accessories and buildings, so research on stone materials can tell us the relationship between people from different regions. It is the relationship between people and the earth, which is consistent with the Geopark ideal. In cultural geology in Japan, researchers observe the rock's texture and use magnetic susceptibility for the source identification of building materials and stone structures. However systematic studies have not been conducted on the stability of magnetic susceptibility measurements for rock samples, the relationship between the size of rock samples and magnetic susceptibility measurements, and the relationship between the crystallinity of volcanic rocks and magnetic susceptibility. In this presentation, we talk about the experiment of using simulated rock samples to propose a method for measuring the magnetic susceptibility and discuss the way and example applied to geopark.

Indoor experiments demonstrated changes in magnetic susceptibility when varying the magnetite content in the target object. The presentation also outlines correction methods for the thickness and area of the target object.

Considering these aspects, we think the magnetic susceptibility of the stone material used in Himeji Castle, a cultural heritage site, in Hyogo Prefecture can be compared with previous research findings.

Keyword

World heritage site, magnetic susceptibility, cultural geology

The Journey: IUGS Geological Heritage Sites of Namibia

Helke Brigitte MOCKE[1]*, Geological Survey of Namibia (helke.mocke@mme.gov.na)

Abstract

Namibia has had an interesting geological history starting from the Archaean and lasting until the Cenozoic, spanning 2600 million years of Earth's history. It is also synonymous with various beautiful minerals, gemstones, meteorites, and fossils. Given all this wealth in geoscientific resources, which has received much international scientific attention for more than 100 years many potential geoscientific heritage sites could therefore be nominated as IUGS Geological Heritage Sites. This led geoscientists from the Geological Survey to nominate several sites in collaboration with scientists who have worked here.

The Nama Group of southern Namibia has attracted much research on the first multicellular organisms known as Ediacara, especially answering questions about the evolution of complex life forms. Already in the 1920s Georg Gürich and Paul Range published on the Ediacara from southern Namibia and in the 1960s and 1970s Hans-D Pflug and Gerard Germs respectively added much needed information to the understanding of these enigmatic animals.

In the Cryogenian rare, special geo-historical events called Snowball Earths during which ice sheets covered most continents are recorded in rock formations in Namibia and have been of scientific interest for some time. The exposures at Fransfontein Ridge were critical in framing the Snowball Earth hypothesis and the acceptance of this hypothesis.

The Etosha Pan attracts many tourists annually, but geologically and geomorphologically it has always contributed to much interesting scientific debate. It can be considered one of the largest palaeolake salt pans in the world which supported a diverse Neogene to Pleistocene fossil fauna, of which southern mammoths were part of the wildlife.

In 1962, Dr Charles Koch established the Namib Desert Research Station at Gobabeb. From this time the Namib Sand Sea has received much scientific attention, especially on the formation and evolution of the various dune types. It is estimated that the Namib Sand Sea covers an area of about 34,000 km2.

One of the richest ore deposits of rare minerals in the world is the steeply dipping Tsumeb polymetallic ore deposit which is located in northern Namibia and takes on the shape of a pipe that extends to a depth of 1 700 m. Already in 1906, the first type mineral Otavite of the Tsumeb ore deposit was discovered by Otto Schneider of the Berlin Mining Academy. Not only aesthetic minerals were studied but also ore minerals. This led Dr Hans Schneiderhöhn of the University of Freiburg to develop his own microscope to study ore minerals.

The Fish River Canyon in southern Namibia is the largest canyon in Africa, as well as the second largest in the world. It cuts through rocks that formed over more than 2 billion years ago and exposes the geological history of three major Proterozoic orogenic cycles. The canyon's main geological interests include stratigraphy and sedimentology, igneous and metamorphic petrology, tectonics, geomorphology and active geological processes, and palaeontology.

These are just a few sites that have been nominated for Namibia, and there are many more that have contributed invaluable scientific knowledge to the geosciences.

Keyword

Namibia, Nama Group, Snowball Earth, Etosha Pan, Namib Sand Sea

Inventory and Revision of Paleobiodiversity in the Uberaba Geopark: Challenges and Perspectives

Isadora PIZZI[1]*, Uberaba UGGp (isadora.pizzi@hotmail.com)
Thiago da Silva Marinho[2], UFTM

Abstract

The territory of the Uberaba Geopark comprises the entire area of the homonymous municipality, where two highly fossiliferous units of the Upper Cretaceous (Bauru Basin) are exposed: the Uberaba Formation (Campanian) and the Serra da Galga Formation (Maastrichtian). However, data regarding the diversity of known species are scattered and with few revisions over eight decades of publications, making research in the area and the control of the real paleobiodiversity existing in the Geopark difficult. Therefore, a survey becomes necessary that, in addition to checking the previous data, adds the new discoveries made in the last ten years. Initially, an analysis of the two most recent compilation articles was made, which included fossils from the Serra da Galga and Uberaba Formations. From these two articles, the species were listed and placed in a table in order to undergo checking of their original sources and redescriptions, when available. For this, extensive bibliographic research was necessary to obtain the largest possible amount of available data for all known taxa for the Uberaba Geopark. The relevant information added to the table included: taxon, geographical locality, location coordinates, geological unit, age, accession number, original reference, and revision reference when available. During the analysis of the articles for the survey, various problems were encountered, with the most serious being in the articles of invertebrates, where the description is confusing or even erroneous, not corresponding to the species they claim to describe. There was also a mistake in cataloging the locations, which often did not correspond to reality, since some of the listed species were not found in Uberaba. When possible, the data were corrected based on other articles and consultations with the collection logbook deposited in the Dinosaur Museum of UFTM. Despite the attempt to add as much information as possible to the table, not all data were found. A revision of the descriptions of invertebrates is necessary, as many present errors and/or are incomplete. This work is important because it is the first to bring a complete inventory of the paleobiodiversity of the Uberaba Geopark, which can serve as reference material for researchers and visitors.

Keyword

Upper Cretaceous, geoconservation, paleobiota

Study on Environmental Characteristics of the Eundae-ri water spider(Argyroneta aquatica) habitat in Hantangang River Global Geopark

Jinah MOON[1]*, Kangwon National University (moon88@kangwon.ac.kr)
Heejung Kim[2], Kangwon National University

Abstract

Argyroneta aquatica, a rare species existing as a monotypic genus globally, spends most of its life underwater, creating air bubbles for habitation. This unique lifestyle is exemplified in South Korea solely by the Eundae-ri diving bell spider habitat within the Hantangang Global Geopark. Discovered in Eundae-ri, Yeoncheon County, in 1994, the necessity for conservation of this habitat was recognized, leading to its designation as Natural Monument No. 412. The habitat faces reduction in area due to extreme climate changes and drying conditions around the wetland. Efforts by the responsible local government include creation of artificial wetlands and groundwater extraction to control the water level, aiming to maintain the spider population. Based on monitoring surveys from 2019 to 2023, including data on spider population, pH, dissolved oxygen (DO), depth, geology, topography, and surrounding environmental changes, this study observes the environmental changes within the habitat, assesses its current state, and analyzes environmental factors affecting the spider population. Comparisons between breeding and non-breeding sites reveal lower average water temperatures and DO levels at breeding sites, while average depths and pH levels show similar trends. Given that Argyroneta aquatica typically hunts within a web at water depths of 5-10 cm, areas with depths of 15-20 cm are habitable, whereas those over 80 cm are unsuitable. This study proposes future research directions and management strategies for habitat preservation and maintenance to sustain the spider population.
This work was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (grant numbers 2019R1I1A2A01057002 and 2019R1A6A1A03033167)

Keyword

Argyroneta aquatica, Geopark, Environmental Characteristics, wetland, environmental changes

CoalHeritage project: Unlocking the potential of Europe's coal mining heritage

Nicolas CHARLES[1]*, French Geological Survey - BRGM (n.charles@brgm.fr)
Laurent BECCALETTO[2], French Geological Survey - BRGM
Gaël BELLENFANT[3], French Geological Survey - BRGM
Nikolaos KOUKOUZAS[4], Centre for Research and Technology Hellas - CERTH
Ioanna BADOUNA[5], Centre for Research and Technology Hellas - CERTH
Kamil SZEWERDA[6], Institute of Mining Technology - KOMAG
Dariusz MICHALAK[7], Institute of Mining Technology - KOMAG
Tadeja JEGRIŠNIK[8], Premogovnik Velenje - PV
Matjaž KAMENIK[9], Premogovnik Velenje - PV
Sylwia JAROSŁAWSKA-SOBÓR[10], National Research Institute - GIG
Piotr HETMANCZYK[11], National Research Institute - GIG
Hernan FLORES[12], Technische Hochschule Georg Agricola University - DMT-THGA
Tansel DOGAN[13], Technische Hochschule Georg Agricola University - DMT-THGA
Stratos GIOUVANIDIS[14], Centre for Research and Technology Hellas - CERTH
Eleftheria KARAMPETSOU[15], Centre for Research and Technology Hellas - CERTH
Pavlos KRASSAKIS[16], Centre for Research and Technology Hellas - CERTH
George MARIAS[17], Centre for Research and Technology Hellas - CERTH
Theodoros ZAROGIANNIS[18], Centre for Research and Technology Hellas - CERTH
Rania KARAMETOU[19], Centre for Research and Technology Hellas - CERTH
Evangelia ZYGOURI[20], Centre for Research and Technology Hellas - CERTH
Andreas KARAVIAS[21], Centre for Research and Technology Hellas - CERTH
George S. MARASLIDIS[22], Centre for Research and Technology Hellas - CERTH
Dimitris KARAPANOS[23], Centre for Research and Technology Hellas - CERTH
Eleonora MANOUKIAN[24], Centre for Research and Technology Hellas - CERTH

Abstract

CoalHeritage for "Conservation and promotion of the Coal Mining Heritage as Europe's cultural legacy" is an EU-cofunded project focusing on former coalmining regions and those that are currently in a transition. Its objectives are to (i) Identify the processes needed to declare coal sites as heritage; (ii) Enhance management in the coal regions in transition, improving health and safety of employees as well as minimizing the environmental impact; (iii) Design and develop a European Visual Map Journal; and (iv) Disseminate information and develop a European network. Thus, this project aims to develop an interregional network for the promotion and conservation of coalmining heritage in Europe and to support local communities in transition.

France experienced coalmining activity for three centuries, with a gradual decline in recent decades. The French State has supported as far as possible the reconversion of the mining regions, whose most famous are Nord-Pas-de-Calais and Lorraine. The reconversion was a necessity to ensure their economic survival, and a policy to preserve mining heritage has developed in both regions, especially at the Wendel Mine Complex (WMC) and the Lewarde Mining History Centre (LMHC).

The WMC (parc-explor.com), one of the largest and most complete complexes of coal mining buildings in Europe, offers leisure-time and cultural activities for visitors who can discover the

miner’s museum, cycle paths and walking trails, and enjoy a large number of activities such as visits to mining towns. The museum invites visitors to discover the history of coal mining in Lorraine while revealing the place occupied by miners. In a modern and attractive presentation, objects, models and multimedia resources immerse visitors in the history of coal, the daily life of the miner and his family, and the social policies of mining companies. The WMC also aims to conserve and highlight collections (nearly 2,000 objects and machines), publications and temporary exhibitions.

Nestled in the UNESCO World Heritage Nord-Pas de Calais Mining Basin, the LMHC (chm-lewarde.com/fr) comprises expansive industrial structures. Since 1984, the centre aims to preserve and display the mining culture ensuring that the forthcoming generations gain insights into this 300-years mining history. The LMHC holds a collection of 15,000 objects representing the mining techniques, ethnology with representations of the miners’ daily lives, and geology with significant petrographic and palaeontological collections. The Centre also aims to raise public awareness of energy issues and improve our understanding of the current challenges about future energy sources.

Keyword

Mining heritage, geoheritage, coal, Europe, France

The Italian Geosite Inventory: a useful tool for knowledge and geoconservation.

Elisa Brustia[1]*, ISPRA (elisa.brustia@isprambiente.it)
Paolo Primerano[2], ISPRA
Mauro Lucarini[3], ISPRA

Abstract

The importance of a Geosite Inventory is mainly linked to the growing need to know geoheritage within the national territory for scientific, educational and geotouristic purposes.
ISPRA, the Italian Institute for Environmental Protection and Research, collect information about "geosites" since the first 2000s when a collaboration project between Geological Survey of Italy and University of Genova started. It was driven from the common desire of the geological community to increase the knowledge of the Italian geoheritage. Presently, the Italian Geosite Inventory (ING) is a public geodatabase published on the ISPRA website, its consultation is open and all the information about each geosite is available. These concern, among other things, the classification of the degree of interest, information about divulgation and the state of conservation.

A map viewer is also available, where is possible to search geosites in a selected area. One of the most important activities carried on by ISPRA in collaboration with the Geological Regional Survey of Italy is the drafting of a document about "Criteria and Definition"; it's a necessary guideline to evaluate correctly every geosite. These guidelines are developed on the basis of the european ones (Wimbledon et al., 1995) and contain the definition of geosite, clarifying the terms "rare", "representative" and "exemplificative". On this basis, all the geosites that have been collected in the first phase of cataloguing of the Geosite Inventory are under a reviewing process, still in progress.
Although some italian regions are moving towards the introduction of regional laws, Italian geoheritage is not now protected by a national one. For this reason, the Geosite Inventory could be a useful tool for territorial planning and geoconservation.

Keyword

Geosite, Geoheritage, Inventory, website, guideline

Illuminating the cultural traces in the transition zones: Examples from the Mediterranean region

Nikos PAPADOPOULOS[1]*, Lab of Geophysical Satellite Remote Sensing and Archaeoenvironment, Institute for Mediterranean Studies, Foundation for Research and Technology Hellas (nikos@ims.forth.gr)

Abstract

Time, space and human intervention, are responsible for the conservation of archaeological remains and cultural heritage (CH) in general. The present and future survival of cultural remains is often compromised, particularly when the "space" in which these artifacts are today is hostile, rendering the documentation process a complex and expensive task. The accessibility to information regarding the current-state of now-submerged sites by minimizing the gap of available protocols and procedures for shallow-water CH investigations is nowadays quite important, considering the projected sea level rise due to climatic and geological factors. Thus it is very important to develop ways to explore and promote these under-studied submerged contexts improving at the same time the community awareness and involvement in protection practices.

Recently, geoinformation technologies integrating satellite/aerial remote sensing, photpgrammetry, geophysical prospection and risk assessment modeling have been extensively tested for the non-destructive documentation of littoral and shallow off-shore cultural material either visible or buried below the sea bottom. The complexity and constantly evolving environmental regime encountered in the transition zones posed limitations to implement efficiently such technological advancements in order to reconstruct the archaeoenvironment in these archaeological sites. The resolving capabilities, the spatial limitations, and the actual applicability of these technologies in mapping submerged cultural assets in shallow depth wetland environments was thoroughly investigated through laboratory numerical modelling approaches and extensive in situ implementation in coastal and submerged archaeological sites dating from prehistory to Byzantine times in Eastern Mediterranean.

The possibility to apply well-known methods to under-explored archaeological shallow-water contexts was very important from the methodological point of view and for the obtained results. Although the adaptation of commonly used tools to ultra-shallow depths presented some challenges and required the creation or customization of equipment, the final results support such efforts and provide useful information for the understanding of complex archaeological sites encountered in Eastern Mediterranean. Ultimately, the results of this work can integrated in the strategic framework of developing an effective interdisciplinary research model that could be applied to similar archaeological surveys in coastal or shallow-water environments thus contributing substantially towards the management and promotion of the concealed cultural resources.

Keyword

coastal archaeological sites, satellite remote sensing, geophysical prospection, underwater archaeology, risk assessment

Exploration of Characteristics of Pollen Assemblages in Soil Sampes of China

ping wang[1]*, Institute of Forensic Science,China (wp1029@cifs.gov.cn)
hongling guo[2], Institute of Forensic Science,China
hongcheng mei[3], Institute of Forensic Science,China
can hu[4], Institute of Forensic Science,China
jun zhu[5], Institute of Forensic Science,China

Abstract

The application of pollen analysis is in providing associative evidence, assisting to prove or disprove a link between cases, people and objects with places or with other people. The aerodynamic properties and the vast amounts of pollen grains released by many plants result in an airborne “pollen rain” which settles onto soil and other surfaces. In this paper, the pollen in soil was extracted by heavy liquid flotation method. Pollen assemblages were identified under optical microscope. Soil samples were collected from Beijing, Inner Mongolia, Shandong, Fujian and Xinjiang in China, including different regions, different climatic environments and different land use types in this paper.

The results showed that the pollen assemblages in soil samples from different regions were obviously different at a large spatial scale, and the content of the same pollen was different within a small scale. In soil samples with different climate environments and different land use patterns, there were remarkable pollen combination characteristics or marker types due to differences in vegetation cover types, like the pollen of Ephedra and Tamarix in Xinjiang. This study can provide the basis of inferring for geographic information and the environment. The analysis of pollen types as forensic samples can be used for comparison and geolocation purpose, such as to be confirmed or rejected by pollen types or to be identified pollen from diffrent carriers such as soil from soles to search dominant and/or marker pollen. However, the pollen results from the same soil vary across different sampling seasons. Moreover, when inferring information from the types and content of spore-pollen in soil samples, factors such as production, dissemination, sedimentation, and preservation of spore-pollen must also be considered.

Keyword

soil, pollen, region, climate, land use

Occurrence, Sources, Mechanisms of Enrichment and Possible Human Health Impacts of Fluoride-Bearing Groundwater in the Central Parts of the White Volta River Basin of Ghana

Moses Boakye OKYERE[1]*, University of Johannesburg, South Africa (mosesokyere5@gmail.com)
Hassina Mouri[2], University of Johannesburg
Carla Candeias[3], University of Aveiro

Abstract

Fluoride present in groundwater can affect its quality for domestic purposes, especially drinking and hence pose a risk to the health of the consumers. Therefore, the present study aims to determine the occurrence, sources and mechanisms of the high fluoride content in groundwater, in the central parts of the White Volta River Basin, Northern Ghana. Thirty-six (36) groundwater samples were collected and analysed to identify the hydrogeochemical processes responsible for variations in the groundwater chemistry. The Piper diagram, Gibbs plots, thermodynamic calculations, and multivariate statistical analysis, e.g., Spearman correlation matrix, and factor analysis, were conducted. Also, the study evaluated the human health risks associated with high groundwater F- consumption using the United States Environmental Protection Agency (USEPA, 1989) human health risk assessment model. The F- concentrations in groundwater samples varied from 0.2 to 19.5 mg/L, with a mean of 4.3 mg/L, with ~84% (n = 30) of the samples revealing levels above the threshold value of 1.5 mg/L, proposed by the World Health Organization (WHO, 2017). However, ~8% (n = 3) of the studied samples presented F- levels (0.20 to 0.25 mg/L) below the recommended value of 0.5 mg/L, considered needed for healthy human teeth and bone development. Meanwhile, ~8% of the samples had F- levels within the recommended standards of 0.5-1.5 mg/L (WHO, 2017). The predominant cation and anion in the studied samples were K+ and HCO3-, respectively and the dominant hydrochemical facies were K–HCO3 (33%); Mg – K – HCO3 (25%); K– Mg – HCO3 (11.1%), with other mixed water types. The Gibbs diagram and ionic bivariate plots suggested that groundwater chemistry, in the study area, was primarily controlled by water-rock interaction and ion exchange reactions. Furthermore, the R-mode factor analysis resulted in seven (7) principal components (PCs) having eigenvalues greater than 1 and accounted for a total variance of 82.86 %. The PCs confirmed that the major processes controlling the groundwater chemistry were mineral dissolution reactions, ion exchange processes and minor anthropogenic inputs, possibly from the use of sulfate and nitrate fertilisers. The spatial distribution of F- showed that the high concentrations were observed within the northeastern fringe of the study area, while the lowest levels were observed in the western fringe. The USEPA human health risk assessment revealed that the population including; infants, children, teenagers and adults had high hazard quotient (HQ) values ranging from 1.06 to 27.63. These values exceeded the safe limit of 1.00 recommended by the USEPA to prevent health risks associated with F-. However, children were found as the most hypersensitive population in the area, showing the highest HQ values of 1.56 to 27.63. This implies that most of the inhabitants, especially

children are prone to the health effects of elevated F- in water such as dental fluorosis. Therefore, preventive measures such as defluoridation techniques are suggested to be applied to reduce the high F- in the water content to make it safe for drinking.

Keyword

Groundwater, Hydrochemistry, Fluoride, White Volta River Basin, Northern Ghana

Assessment of potentially harmful elements on human health and agriculture of surface and groundwater sourced from the granito-gneissic phreatic aquiferous formations in Bertoua and its environs, east region Cameroon.

SHARON NTUBE NGWESE[1]*, University of Johannesburg, South Africa (ngwese.sharon2@gmail.com)
HASSINA MOURI[2], University of Johannesburg, South Africa
RICHARD AYUK II AKOACHERE[3], University of Buea, Cameroon
CARLA CANDEIAS[4], University of Aveiro, Portugal

Abstract

The purpose of the present study was to determine the potentially harmful elements and their concentrations in the surface and groundwater used for drinking and agricultural purpose in Bertoua and its environs, and to assess their possible health effects on the communities in the area. Ion chromatography (IC) and inductively coupled plasma mass spectrometry (ICPMS) were used to determine the major and trace elements as well as anion concentrations in the 30 surface and groundwater samples during the wet and dry seasons. The results revealed that Al concentrations vary between 0.017 and 1.79 mg/l and remain the same in both seasons, while NO3 is slightly higher during the dry season (2.0 to 705.4 mg/l) than during the wet season (0.0 to 643.5 mg/l). Such concentrations of Al and NO3 are far much higher than the World Health Organisation drinking water guidelines (0.1 mg/l for Al, and 50 mg/l for NO3). The average value for hazard quotient, for non-carcinogenic outcomes of Al was 6.6, with 96 % of the samples >1. The average value for hazard index of NO3- was 20.14 for males, 23.80 for females, and 9.61 for children, all >1, with 100 % for NO3, showing that human consumption of surface and groundwater, according to the United States Environmental Protection Agency guidelines can result in adverse health effects. Piper's diagram classified these waters as CaCl, Ca-Mg-Cl-SO4, CaHCO3, NaCl, and NaHCO3, suggesting the evolution of the water chemistry from ionic exchange. Gibb's diagram showed that rock weathering was the primary control of surface and groundwater geochemical characteristics, with minimal influence from precipitation. Surface and groundwater in the study area were assessed for irrigation suitability using various indices and showed that Na adsorption ratio <10 and Permeability Index >75 was excellent, while Kelly ratio <1 and Mg adsorption ratio <50 was suitable. Agriculture Food and Organisation and Wilcox diagrams showed that water can be used for irrigation. The possible sources of Al enrichment in the surface and groundwater might be geogenic caused by weathering of the granitic rocks, which are the main geological formation in the study area, while nitrate enrichment may be anthropogenic due to the use of fertilizer for agriculture in the area. Based on the results above, the consumption of surface and groundwater with high Al concentration might present a potential health risk to the population in the study area, that can induce serious common health issues such as Osteomalacia and Alzheimer, while high NO3 might trigger methemoglobinemia, colorectal, and thyroid cancer amongst others.

Keyword

Potentially harmful elements, Water quality, seasonal variations, Bertoua- Cameroon

Environmental and Health Risk Assessment of Coal Mining in Moatize, Tete, Mozambique

Micaela Arlete Jose CHAPO COSSA[1]*, University Of Johannesburg (mchapo906@gmail.com)
Kim Dowling[2], RMIT University, Melbourne, Australia
Vicente Albino Manjate[3], National Institute of Mines, Ministry of Mineral Resources and Energy, Maputo – Mozambique
Hassina Mouri[4], Department of Geology, University of Johannesburg, South Africa

Abstract

Tete Province, in the central part of Mozambique, has several natural resources, including extensive coal reserves in the Moatize Coal Basin. In this basin, coal is being exploited by mining companies such as Jendal, Nkondezi Mining and Vulcan Mozambique, with the latter controlling the largest mining concession area of approximately 25,000 ha.

Mining has the potential to release toxic trace elements into the environment through various vectors including dust. Without appropriate controls, the dust may degrade the environment with direct impacts on water, air and soil quality as well as indirect impact on food crops grown in affected soils and irrigated with contaminated water.

The coal field in Moatize is located close to the Zambezi River drainage system incorporating the Revúboè River and its tributaries. This drainage system crosses the district and presents an extensive rivers network that distributes contaminates. This rivers network provides drinking and agricultural water for local communities. Furthermore, the community of Moatize uses coal in homemade brick kilns. Ash resulting from coal burning is disposed of in the local environment without environmental controls, which enables this material to be transported by wind, and rain to riverbeds, resulting in further environmental contamination. It is therefore important to assess the impact of the coal mining in the study area on the environment quality and its possible health impacts on the local communities.

For Environmental Risk Assessment of Coal Mining, preliminary ten water sampling and field assessment revealed mean EC value of 3022 µs/cm, which is above the accepted limits by Mozambican legislation of 50 – 2000 µs/cm. Furthermore, all samples exceeded 5 NTU, the turbidity values set by Mozambican water quality legislation. pH and Total Dissolved Solids (TDS) parameters, were within the limits required by Mozambican water quality legislation (6.5 – 8.5) and 1000 mg/L, and by WHO (6.0 - 9.0), respectively. These preliminary results suggest that the population of Moatize might be consuming poor quality water. Therefore, a detailed, systematic and extensive sampling program (water samples as well as source material from the mining area including mine tailing, soil, ash and dust) is proposed. This will be accompanied by a human perception survey and health investigation program to assess public awareness of water quality issues and potential impacts. It is essential for the long term health of the region that we assess the level of contamination and determine impacts.

Keyword

Moatize, Coal mining, Environment, Human health risk

The occurrence of potentially harmful elements in gold mine tailings and their possible impacts on the environment and public health with reference to the Welkom goldfields in South Africa - A review

Rinae MAKHADI[1]*, University of Johannesburg (makhadir@ufs.ac.za)
Hassina Mouri[2], University of Johannesburg
Robert Hansen[3], University of the Free State
Kim Dowling[4], STEM college, RMIT university

Abstract

Gold mining activities in the Witwatersrand basin, South Africa have produced over 270 mine residue deposits such as tailings facilities and waste rock dumps that have covered a total area of about 400 km2. Tailings storage facilities may contain high levels of potentially harmful elements (PHEs) that can be released into the air, soil, and water. Such PHEs can be taken up by humans through drinking water, dermal contact, and ingestion of impacted food crops or geophagia resulting in serious adverse health effects.

Many communities live in the vicinity of the Witwatersrand goldfields and are potentially at risk of being affected by PHEs emanating from the tailing's repositories. Extensive research has been conducted in certain parts of the Witwatersrand goldfields to ascertain the environmental and health impacts associated with the tailings. However very limited studies were conducted in the Welkom goldfields, which forms the focus of this study under the form of a PhD research project.

A review of previous studies in the Witwatersrand and Welkom goldfields on the occurrence of PHEs in gold tailings dams, as well as their environmental and public health impacts in comparable parts the world was performed.

This review provided insight into the environmental effects associated with gold tailings dams on the quality of soil, surface, and groundwater resources, as well as food crops and air quality. For example, previous studies in different regions of the Witwatersrand goldfields showed that U, SO4, As, Mn, Cr, Cu and Pb are amongst some of the most common PHEs emanating from the gold tailings dams. These studies have also highlighted that communities near the tailing's dams are prone to adverse health effects possibly linked to the occurrence of PHEs in their environment. A study in Tudor shaft, in the west rand of Johannesburg, South Africa revealed that children were at cancer related risk associated to the exposure of metal and metalloid from gold tailings. Given the environmental similarities between parts of the
Witwatersrand basin and the Welkom goldfields (the study area), it is therefore necessary to conduct a multidisciplinary research investigation in this latter to ascertain and quantify the presence of PHEs in the tailings materials, their mobility to the surrounding environment, pathways, their bio accessibility and bioavailability, impacts on the quality of air, water, soil and

food crops, as well as health of the communities.

Keyword

Gold mining tailings, Potentially harmful elements, Public health

Identification of mercury in stream sediment in Yanomami Indigenous Land, Roraima, Brazil

Patricia DURINGER Jacques[1]*, cprm (patricia.jacques@sgb.gov.br)
Eduardo Paim VIGLIO[2], cprm
Daniel d`EL Rei[3], Habitat Geo Consultoria

Abstract

In October 2022, the Geological Survey of Brazil – CPRM carried out an environmental geochemistry campaign in the Yanomami Indigenous Land, located in the Alto Mucajaí Region, state of Roraima in Brazil. The work is part of the project “Impact of Mercury on Protected Areas and Forest Peoples in the Eastern Amazon: An Integrated Health-Environment Approach” (http://dgp.cnpq.br/dgp/espelhogrupo/532438#identificacao), under the led by researcher from the Oswaldo Cruz Foundation (Fiocruz), Paulo Cesar Basta. Geological materials (river water and stream sediment) were collected from 14 points, and the main objective of the Fiocruz project is to carry out a specific analysis of the element mercury to find out whether there is anthropic contamination of the element and whether it is affecting the health of the indigenous population. The project encompasses geological material (river water and stream sediment) and biological material (hair, saliva and fish), as well as clinical, neurological, pediatric and psychological evaluation of the indigenous population residing in the location. The data with the results of the geological material are presented in VIGLIO & JACQUES (2023) in the CPRM environmental geochemistry technical report (https://rigeo.cprm.gov.br/bitstream/doc/23869/3/levant_geoq_mucajai_final_ab.pdf) and in the scientific article JACQUES et al. (2023) (https://www.mdpi.com/2305-6304/11/10/861). In Brazil, the National Environmental Council - CONAMA, is responsible for implementing environmental standards and indicating indicator systems, so CONAMA Resolution 357 of March 17, 2005 was used as a reference for water samples and for the current sediments CONAMA Resolution 454 of 01/November/2012 was used. The river water results do not show mercury values above the maximum limit, however two of the stream sediment samples showed higher values, the limit being 0.17 mg/kg. These are samples PJS009, with a value of 0.344 mg/kg and PJS010 with a value of 1.386 mg/kg. Both were collected near the Fumaça waterfall, where researchers reported that there was an illegal mining dredger. It was not possible to carry out collections upstream, according to initial planning, as the researchers were alerted to the danger related to the presence of ilegal miners. The presence of mercury levels above the limits established by CONAMA resolution 454 in the stream sediments indicates that the region upstream of Cachoeira da Fumaça may also be contaminated. The project's biological analysis data has not yet been published and it is important to carry out a joint analysis of biological and geological data to prove whether or not the local population has been exposed to waste left by illegal mining, present in the region, mainly Mercury contamination in the Mucajaí River affects aquatic biota, more specifically fish, which are consumed by the local indigenous population.

Keyword

Medical Geology, Indigenous Land, Mercury

Geochemical and isotropic composition assessment of groundwater consumed by a vulnerable population with chronic kidney disease of unknown origin (CKDu) in the dry zone of Sri Lanka

Navodya Dhananjalee MAHALEKAM[1]*, University of Peradeniya, Sri Lanka (navodyadha@gmail.com)
Ishara Athauda[2], Department of Geology, Faculty of Science, University of Peradeniya, Sri Lanka
Rohana Chandrajith[3], Department of Geology, Faculty of Science, University of Peradeniya, Sri Lanka
Penny Vlahos[4], Department of Marine Sciences, University of Connecticut, Groton, Connecticut, USA
Santhushya Hewapathiranage[5], Centre for Research, National Hospital, Kandy, Sri Lanka
Chiran Weerakoon[6], Centre for Research, National Hospital, Kandy, Sri Lanka
Suchi Anand[7], Division of Nephrology, School of Medicine, Stanford University, Palo Alto, California, USA
Nishantha Nanayakkara[8], Nephrology and Kidney Transplant Unit, National Hospital Kandy, Sri Lanka

Abstract

In certain tropical and subtropical countries, including Sri Lanka, the problem of Chronic Kidney Disease with undetermined origin (CKDu) is widely recognized and mainly affects the agricultural communities in rural areas. Numerous case-control studies in Sri Lanka suggest CKDu is most likely an environmentally induced disease. Therefore, this study aims to determine the differences in groundwater quality consumed by the CKDu vulnerable community and non-vulnerable population in different climate zones in Sri Lanka. Water samples were collected from the dry zone with CKDu hotspots in Wilgamuwa (n=65), a dry zone with a low disease prevalence region of Hasalaka (n=28), and a CKDu non-prevalence wet zone of Kandy (n=20). In addition to basic field water quality parameters, samples were analyzed for their major anions, cations, and stable isotope compositions (δ2H and δ18O). The groundwater in the wet zone was slightly acidic (median pH= 4.89) and had a lower electrical conductivity (medium EC =172 µS/cm) compared to the locations in the dry zone. According to Na-normalized bivariate mixing diagrams, silicate weathering is pronounced in disease-free areas, while predominantly silicate and carbonate weathering processes occur in dry zone groundwater. Ca-Mg-HCO3 type groundwater is more common in CKDu and low-prevalence regions, while Na+ is predominant in the non-CKDu areas. Interestingly, the average silicon (Si4+) concentration was higher in the CKDu prevalence area (46.14 mg/L) while lower in the disease-free area (8.22 mg/L) and the low-prevalence area (20.5 mg/L) in the dry zone without any significant variation of the lithologies of the regions. Furthermore, 62% and 36% of wells used by CKDu-vulnerable and low-prevalence communities were in the “hard” and “very hard” water categories, respectively. However, only 10% of the wells from the wet zone can be classified as hard or very hard. The fluoride concentration is significantly higher (at $p < 0.05$) in the CKDu area (mean:0.62 mg/L) compared to wells in the low prevalent zone (mean:0.16 mg/L) and the wet zone (mean:0.03 mg/L), indicating the risk of

vulnerability of dental and skeletal fluorosis other than CKDu from the elected community. In addition, the δ18O and δ2H plot for groundwater in the regions with CKDu prevalence and low prevalence of the dry zone showed a slope of 5.4 (δ2H=5.4 δ18O – 3.47) and 6.39 (δ2H=6.39 δ18O + 2.39), respectively. Most groundwater samples were plotted below the LMWL with a slope of 7.71, indicating the modification of groundwater either by mixing with surface water or by evaporation before infiltration. The intersection points of the GWL and LMWL of the two regions of Wilgamuwa (δ2H- (-35.05‰), δ18O – (-5.84‰) and Hassalaka (δ2H- (-34.64‰), δ18O – (-5.795‰) showed the average isotopic composition of the nearest rainfall obtained for the regions - North East Monsoon. In summary, the frequency of CKDu prevalence varies depending on groundwater composition, and continuous monitoring of disease progression in individuals at risk of CKDu could be interesting.

Keyword

Chronic Kidney Diseasewith unknown origin (CKDu), Groundwater Quality, Stable water isotopes, Dry zone, Hydro-geochemistry

The Potential Traceability of Mineral Commodities using Artificial Taggant Particles

Laurance John DONNELLY[1]*, AHK and IUGS-IFG (laurance.donnelly@ahkgroup.com)
Quentin Dehaine[2], GTK
Ian Corfe[3], GTK

Abstract

Mineral resources have always played a crucial role in the development and advancement of civilisation. As we embark upon the so called 'battery revolution' and green revolution', minerals are likely to continue to remain fundamentally important. However, coinciding with this increasing demand for minerals are increases in crime in the mining, minerals and metals sectors. These include, but are not necessarily limited to illegal mining, illicit trading, theft, adulteration, substitution, fakery, smuggling. The beneficiaries are criminal cartels that legitimise huge profits via sophisticated money laundering schemes. Furthermore, the global flow of mineral commodities and associated regulatory frameworks are economic and political concerns. In Europe, these are driven by critical raw materials (CRMs) requirements, the European Union Battery Regulation and European Union Directive on Corporate Sustainability Due Diligence. A strategy is needed to trace minerals in order to 1) determine their legitimate provenance, to discourage illegal mining and trading, and 2) allow required data to follow minerals throughout their entire usage lifespan. The objective of this paper is to provide an overview of geological methods of traceability, using for example elemental analysis, geochemistry, mineralogy and isotopes. Additionally, this paper provides an overview of the three-year Horizon Europe funded MaDiTraCe (Material and Digital Traceability for the Certification of Critical Raw Materials) project, involving 14 partners and six countries. There will also be a focus on the potential use of artificial taggant particles (ATP) to track mineral commodities through global supply chains. ATPs were initially developed to track explosive additives but were later adapted for commercial and technology goods. Typically, these included clothing, pharmaceuticals, chemicals, drugs, explosives, vehicles and watches. The main taggants used include inks, dyes, spiked pollen and a variety of micron-sized particles or barcodes.

Keyword

Forensic, geology, mining, crime, traceability

Hazard and exposure assessment in contaminated land investigations and environmental management: The Lavrion case study, Hellenic Republic

ALECOS DEMETRIADES[1]*, IUGS Commission on Global Geochemical Baselines
(alecos.demetriades@gmail.com)

Abstract

The development of an integrated environmental management scheme should constitute the ultimate objective of contaminated land investigations. To develop such a scheme, it is necessary to carry out a systematic investigation, and to evaluate all spatial data and information generated, i.e., maps of (a) geochemical distribution of potentially toxic elements; (b) distribution of metallurgical processing wastes or other types of waste; (c) land use; (d) hazard and exposure assessment, and, of course, to propose effective rehabilitation techniques and their cost. In the decision-making phase, the results of cost/benefit analysis are important, because the cost in relation to the benefit index of recommended rehabilitation methods is evaluated, and remediation of land is accordingly prioritised. Since, in contaminated land investigations in urban areas the end aim is the development of better living conditions for the local population, it is important to communicate both the hazards of land contamination and the benefits of its rehabilitation to the people. The fundamental components of environmental risk assessment (hazard and exposure), the procedure of environmental management, as well as the problems of risk perception and communication, using the Lavrion (Hellas) case study results will be concisely described.

The large quantity and spread of mining and metallurgical processing wastes in the Lavreotiki peninsula and the Lavrion urban area (55 km SE of Athens) caused, together with other morphoclimatic factors (wind, streams, etc.), the contamination of the surface cover by Pb, As, Sb, Cd, Cu, Hg, Zn, etc. The rock geochemical survey determined the possible primaeval soil geochemistry in Lavrion before humans began contaminating it with their activities. Whereas, detailed mapping and chemical characterisation of metallurgical processing wastes, in combination with the geochemical survey of soil cover and house dust, have revealed the extent and intensity of the contamination problem. Despite the alkaline pH of the soil, high carbonate content of flotation tailings, carbonate rock substrate and Mediterranean climate (low rainfall during the winter months), their extreme contamination load is such that leaching of contaminants has been initiated and their downward movement towards groundwater has started.

Exposure effects on the population, due to the local severe environmental contamination, are verified by high levels of Pb in child blood and deciduous teeth. Child blood-lead concentrations, in combination with other variables, such as lithology, soil geochemistry with respect to lead, spatial distribution of metallurgical processing wastes and land use types, were used in the generation of a multi-criteria algorithm to assess the hazard and exposure of children to environmental contaminants.

It is concluded that the multi-element contamination of the ‘soil cover’ in the Lavrion urban area is very high, and presents a non-acceptable risk to the health of the local population, and is potentially hazardous to plants and animals. Consequently, rehabilitating the whole urban area with suitable cost-effective methodologies is considered extremely urgent.

Keyword

urban geochemistry, contamination, metallurgical wastes, soil, grounwater

Investigating the relationship between health and the environment using soil and air pollution data in a changing climate.

Jennifer M MCKINLEY[1]*, Queen's University Belfast (j.mckinley@qub.ac.uk)
Shay Mullineaux[2], Queen's University Belfast
Ruth Hunter[3], Centre for Public Health, Queen's University Belfast
Joanna Sara Valson[4], Centre for Public Health, Queen's University Belfast
Bernadette McGuinness[5], School of Medicine, Dentistry and Biomedical Sciences, QUB

Abstract

Soils can reveal the legacy of historical and modern pollution. Urbanisation will have an increasing impact on soils because of climate change. Therefore, soils can be used as 'urbanisation tracers' to determine geogenic and anthropogenic contamination. Research also shows that ultrafine particles (including lead (Pb), Molybdenum (Mo) and Sb) may become blood-borne and translocate to other tissues such as the liver, kidneys and brain. Therefore, urban soils combined with air pollution data may be used as a proxy for the availability of toxins for human intake from environmental pollution. The environment also plays an important role in promoting brain health and preventing dementia through access to green/blue space, and promoting walkability and cyclability. Exposure analysis undertaken as part of the UKRI ESRC SPACE (Supporting Environments for Physical and Social Activity Healthy Ageing and Cognitive Health) project explores how the local environment and pollutants synergistically affect our cognitive health outcomes. Studying long-term health outcomes in the NICOLA cohort, the "Northern Ireland Cohort for the Longitudinal Study of Ageing", comprising 8,000 older people, we can explore how different environmental factors relate to brain health. In this part of the study we use road buffer analysis (testing buffers of different sizes: 300m, 500m, 1000m and 2000m) for an elemental sub composition (comprising As, Cd, Co, Hg, Mo, Pb, Rb, Sb, Se, Sn, Th, U, Al, Ba, Cr, Cu, Fe, Mn, Ni, Sr, V, Zn) of an urban soil geochemistry database of total element concentrations of potentially toxic elements (PTEs). Combined with air pollution data: fine particulate matter (PM2.5), PM2.5 source fraction, PM10 and Nitrogen oxide (NOx), we examine the statistical relationship between cognitive Metrics provided in the NICOLA dataset with environmental toxins to assess how the participants' health outcomes are linked to proximity to transport networks. We also examine the decay rate function of different air pollution particles and the relationship to soils. A compositional balance and multivariate analysis approach is demonstrated to assess the association between the environmental toxins associated with proximity to road networks and the different cognitive health indicators.

Keyword

soil geochemistry, air pollution, cognitive health, compositional data analysis, road networks

Comprehensive assessment and multivariate statistical analysis of Transfer Factors soil-to-plante stimated from bioavailable concentrations: A Case Study in the Campania Region, Southern Italy

Lucia Rita PACIFICO[1]*, University of Naples Federico II (luciarita.pacifico@unina.it)
Annalise Guarino[2], University of Naples Federico II, Department of Earth Sciences, Environment and Resources
Antonio Iannone[3], University of Naples Federico II, Department of Earth Sciences, Environment and Resources
Antonio Pizzolante [4], Istituto Zooprofilattico Sperimentale del Mezzogiorno - Portici (Napoli)
Gianfranco Brambilla[5], Istituto Superiore di Sanità - Roma
Stefano Albanese[6], University of Naples Federico II, Department of Earth Sciences, Environment and Resources

Abstract

Understanding the transfer of contaminants from soil to plants, particularly in agricultural products, is crucial in environmental science, especially within the context of risk assessment and the development of sustainable agricultural practices. The estimation of transfer factors (TFs) (Singh et al., 2011), which quantify the adsorbption of elements or pollutants by plants from the surrounding soil, serves as a fundamental parameter in evaluating potential ecological and human health risks, as these elements may enter the food chain (Ozhovan and Kremenetskiy, 2018).

For this study, transfer factors from soil to plants were estimated using bioavailable concentrations (Guarino et al., 2022) of Potentially Toxic Elements (PTEs) identified by Italian law (D.lgs. 152/2006) in agricultural soils and the elemental concentration in primary agricultural products (PAP). These latter are freshly harvested fruits and vegetables, maintaining their integrity and freshness as they have not undergone significant processing and were collected across the entire region through the Campania Trasparente project (www.campaniatrasparente.it).

The study aimed to compare various transfer factors (TFs) among the most numerous vegetal species and potentially highlight different behaviors. A robust multivariate statistical approach, such as Robust Principal Component Analysis (RPCA) (Hubert et al.), was applied to the TFs, and multiple regression analyses were conducted using the stepwise method, with Principal Components (PCs) as dependent variables and soil physical parameters (grain size, organic matter, pH, cation exchange capacity, salinity, electrical conductivity) as independent variables.

Results revealed distinct patterns in the soil-to-plant transfer factors for various elements, emphasizing the role of soil properties, plant species, and environmental conditions. The results indicated that within the Campania region, the highest TFs for most vegetal species are associated with Zn and Cu. Specifically, RPCA indicates a positive correlation between Zn and Co TFs. Furthermore, multiple regression analysis applied to the PCs highlighted that certain soil physical

factors influence TFs across different plant species.

This integrated approach provides a comprehensive understanding of soil-plant transfer processes and the impact of soil physical parameters on TFs in regional cultivations. The study aids in better understanding the impact of soil physical parameters, such as cation exchange capacity (CEC), grain size, organic matter, etc., on vegetal species growth, leading to well-informed decisions regarding crop selection, fertilizer application, irrigation, and other factors.

Keyword

Environmental Geochemistry, Transfer Factor, Multivariate Statistical Analysis, Potentially Toxic Elements

The Development of Strontium and Oxygen Isoscapes to Determine a Geographical Origin of Human Remains in Korea

Seongshin GWAK[1]*, Mr. (ssgwak@korea.kr)
Yu Ran Lee[2], Dr.
Dongkye Lee[3], Dr.
Byeongyeol Song[4], Dr.

Abstract

Strontium (Sr) and oxygen (O) isotope analyses have been considered as a tool for human provenancing in the field of archaeology, ecology, and forensic science. As one of the alkaline earth metals in rocks, Sr has four naturally occurring stable isotopes: 84Sr, 86Sr, 87Sr, and 88Sr. The radioactive β-decay of rubidium-87(87Rb) produces radiogenic 87Sr with a half-life of 48.8 x 109 years. Bedrocks of different ages and Rb/Sr ratios have variable Sr isotope ratios (87Sr/86Sr) which can be transferred to a human body through food intake including groundwater and local food products. It is expected that 87Sr/86Sr of a human body correlate with environmental samples (groundwater, soil, rocks, plants, etc.) in a specific region. Oxygen is the most abundant element on Earth with three stable isotopes: 16O, 17O, and 18O. It is well known that the oxygen isotope ratio(δ18O) of human bone is related to the consumed sources of oxygen, including food intake and drinking water. In order to obtain useful geographical information of specimens, it is required to have a reference Sr and O isotope ratio map (isoscape) in the region of interest. This study was focused on the construction of Sr and O isoscapes using human tooth enamel taking account of environmental contribution. A total of 156 dental samples were collected from individuals with necessary information including a place of birth and address depending on age group classifications. Each dental sample was then prepared for the determination of Sr and O isotope ratios. Tooth samples were cleaned and ground for Sr and O isotope analyses. For the Sr isotope ratio analysis, the aliquoted ground dental samples were digested with a series of multiple steps for the quantification of Sr concentration using inductively coupled plasma mass spectrometry (Agilent Technologies). 87Sr/86Sr was then determined using multi-collector inductively coupled plasma mass spectrometry (Nu instruments). Another set of aliquoted ground dental sample was then prepared for the O isotope ratio analysis using a gas bench isotope ratio mass spectrometer (Thermo Fisher Scientific). Due to a limited number of dental samples for isoscapes, obtained data for 87Sr/86Sr and δ18O of dental samples were interpolated by inversed distance weighed (IDW), kriging, and spline (RBF-ST) methods using a coordinate-based Geographic Information System(GIS).

Keyword

isoscape, provenancing, isotope, strontium, oxygen

[Keynote] Community to Combat Crisis: Steps to engage with our environment and progress to better human and environmental health outcomes.

Kim DOWLING[1]*, RMIT University (kim.dowling@rmit.edu.au)
Philip Warner[2], Albatross Consulting
Macklin Leslie[3], RMIT University

Abstract

The UN Sustainable Development goals assert many principles and measures to attain sustainability and achieve a resilient human society that exists in harmony with our environment. However, humanity continues to address the major threats in a siloed and segmented manner. We make narrowly focused attempts to address the myriad of issues such as climate change, contaminated sites, human hunger, or population growth as individual items with scant regard to linking the components in a holistic systems-based approach. A partnership-centred approach that holistically addresses the significant issues and practices that threaten the survivability of humans is required and we need new ways to engage with our populations that demonstrate environmental connections. Medical Geology gives us a mechanism to consider a systems wide approach that maintains a focus on the human.

We suggest this siloed mentality is a social expression of physical distancing from the natural environmental. It is the result of increased urbanisation where exposure to nature is modified, limited, distorted, or remote. It is compounded by political messaging, expediency, short-term planning focusing on growth, and the ever-increasing demand for and acquisition of goods.

Complex holistic interventions are unlikely to appeal to populations and leaders in our current sociopolitical environment. To address this issue, we must establish new ways of Earth Systems engagement. Human and environmental health requires the reestablishment of the close and clearly defined links between environment and humans. We need to normalise that humans are part of the environment and not just differentiated users of the planet's products and functions. We explore the simple practice of supplementary foraging for food (fungi) and urban vegetable gardens as a way to reengage with environment, improve health outcomes, and establish a direct link between human and environmental health and thereby potentially drive change. The discipline of Medical Geology proved the scaffolding for this exploration.

Keyword

Medical Geology, contamination, health, community

Coupling of neurodegenerative diseases to element distribution through geospatial statistics

Katelyn Elisabeth Murphy[1], Department of Civil, Environmental and Natural Resources Engineering, Applied Geochemistry, Luleå University of Technology, Luleå, Sweden
Sarah CONRAD[2]*, Luleå University of Technology (sarah.conrad@ltu.se)
Lena Alakangas[3], Department of Civil, Environmental and Natural Resources Engineering, Applied Geochemistry, Luleå University of Technology, Luleå, Sweden

Abstract

Medical geology is a growing field in which elemental distribution from natural and anthropogenic sources are studied, and uptake by humans through exposure pathways such as ingestion, inhalation, and dermal contact are linked to disease development and/or progression (Selinus et al. 2010). This project aims to increase the knowledge of how we are affected by our environment and focuses on neurodegenerative diseases, including Multiple sclerosis and Parkinson's disease (MS and PD), and potential links to elemental distribution in bedrock, soil, sediment, and groundwater. Neurodegenerative diseases have been shown to be linked to an upset in the homeostasis of and interactions between metals in the brain, including Al, As, Cd, Pb, Mn, and Zn (Bredholt & Frederiksen, 2016; Karri et al., 2020; Schofield, 2017). To explore these linkages, soil and groundwater geochemical data from the last 35 years (SGU) will be used in collaboration with municipal level data on neurodegenerative disease rates to determine possible relationships. Geospatial statistics will be carried out using the geographical information software QGIS and statistical software. Statistical methods, including spatial weighting, factor analysis, and multiple regression, will be used to determine any statistically significant correlations between elemental concentrations and disease occurrence. Results from these analyses will be compared with relevant medical studies to assess validity and exposure pathways. These data will then be analyzed to locate areas for further environmental sampling. For example, acid sulfate soils, recently shown to overlap with MS prevalence in Finland, constitute a metal source directly linked to food production and drinking water resources (Åström & Roos, 2022). An environmental forensic approach using a multi-element and multi-isotope approach to pinpoint sources, transport, and exposure pathways to target elements will move medical geology forward. The compiled data will then be presented as a risk assessment mapping tool to ensure that the choice of residence will not jeopardise personal health and open the potential for increased monitoring of residents of potentially endangered areas.

References

Åström, M. E., & Roos, P. M. (2022). Geochemistry of multiple sclerosis in Finland. Science of The Total Environment, 841, 156672. https://doi.org/10.1016/j.scitotenv.2022.156672

Bredholt, M., & Frederiksen, J. L. (2016). Zinc in Multiple Sclerosis: A Systematic Review and Meta-Analysis. ASN Neuro, 8(3), 1759091416651511. https://doi.org/10.1177/1759091416651511

Karri, V., Schuhmacher, M., & Kumar, V. (2020). A systems toxicology approach to compare the heavy metal mixtures (Pb, As, MeHg) impact in neurodegenerative diseases. Food and Chemical Toxicology, 139, 111257. https://doi.org/10.1016/j.fct.2020.111257
Schofield, K. (2017). The Metal Neurotoxins: An Important Role in Current Human Neural Epidemics? International Journal of Environmental Research and Public Health, 14(12), 1511. https://doi.org/10.3390/ijerph14121511
Selinus, O., Finkelman, R. B., & Centeno, J. A. (2010). Medical Geology: A Regional Synthesis. Springer Science & Business Media.

Keyword

Environmental forensic, Exposure pathways, multiplie sclerosis, multi-isotope, multi-element

Potential risk of CO poisoning for casual workers exposed to emissions from clamp kiln: a South African perspective.

Lawrence DIKO MAKIA[1]*, University of Venda, South Africa (dikom73@gmail.com)

Abstract

The South African Clay Brick Industry (CBI) is a sector that contributes towards job creation in the country; accounting for about 16921 direct employment. It is unclear if this estimate includes casual workers (CW). The latter, also referred to as non-standard workers, comprises persons employed mostly on temporary, fixed-term, seasonal, casual or for piece-rate work, often associated with peak or comparatively busier work demand related periods. Literature contends that CW are usually paid for results rather than time and do not enjoy the full protection of the South African labour law. The South African CBI makes use of CW, especially during unloading of bricks after firing. In the production of bricks, the CBI mainly employs clamp kiln technology (accounting for 69% of total production). Despite their cost effectiveness, clamp kilns are associated with significant CO2 emissions. Exposure through incomplete combustion of scintle may lead to CO poisoning. Risk of exposure is exacerbated by the economic drivers of demand and supply owing to the housing challenge and associated backlog. The pressure on suppliers often interferes with recommended cooling periods of kilns, prior to unloading of bricks. This predisposes CW to incidental exposures of CO through inadvertent inhalation. This study ascertains the extent to which such exposures may pose health threats to the CW. It further interrogates the legal and policy framework and related ethical issues. The study concludes with recommendations for best practice.

Keyword

Casual workers, incomplete combustion, CO poisoning, clamp kiln, brick unloading

Determining the geographic origin of illegally imported Chinese dinosaur nests retrieved in Australia

Robert William FITZPATRICK[1]*, The University of Adelaide (robert.fitzpatrick@adelaide.edu.au)
Mark Raven[2], CSIRO Mineral Resources
Peter Self[3], CSIRO Mineral Resources
John Long[4], Flinders University
Robert Fitzpatrick Fitzpatrick[5], The University of Adelaide

Abstract

Dinosaur eggs and nests are highly sought after by collectors. China has some of the strictest regulations and laws in the world in protecting rare fossil remains. Despite the very best efforts of authorities there is a thriving black market in illegally acquired dinosaur fossils including teeth, bones and fossilised eggs with huge sums of money being exchanged. Under Chinese law, fossilized dinosaur nests are protected, and both their sale and purchase are banned in Australia. Between 2004 and 2005 the Chinese government asked for Australia's help through the Australian Federal Police (AFP) to stop the illegal trade in fossils. Approximately 6 million Australian dollars-worth of illegally imported fossils from China were seized by the AFP comprising 25 dinosaur eggs & nests and three dinosaur egg pieces. However, the Australian collectors claimed the nests were not Chinese, but rather from legal American fossils.

To prove that these fossils were illegally obtained, visual (e.g. soil Munsell colour) and mineralogical (X-ray diffraction – XRD and Diffuse Reflectance Infrared Fourier Transform Spectral DRIFTS) analyses were conducted on both the questioned fossils seized by AFP detectives and known reference nest fossil samples obtained from museums in Australia sourced from Henan Province, China.

Two questioned dinosaur nest materials from illegally imported samples were compared with four reference samples provided by the Victorian and South Australian museums sourced from Henan Province to determine if the samples have; no, limited, moderate, moderately strong, strong, very strong, extremely strong or conclusive “degree of comparability” of being from a single location.

One questioned sample from the illegally imported nests contained the following 9 out of 9 similar mineral components (semi-quantitative amounts) when compared with the four known reference materials provided by the Victorian and South Australian museums, sourced from Henan Province: quartz and calcite (co-dominant); smectite and albite (minor to sub-dominant); microcline, hematite (red colour), chlorite, mica and dolomite (trace). These samples were also remarkably similar as confirmed in the detail in the XRD patterns (i.e. line broadening).
The morphological descriptors of the samples (Munsell soil colour, consistency, shape of quartz particles, particle size, white coloured calcite-rich concentrations) and mineralogical data (XRD) indicate that the questioned sample has an extremely strong degree of comparability with the four

known reference materials provided by the Victorian and South Australian museums, sourced from Henan Province indicating the strong likelihood that these samples have a common origin and originate from a common geological source or region. In 2008 the collection seized by the AFP was handed back to China at a ceremony at the Chinese Embassy in Canberra. To show their gratitude to Australia's efforts, the Chinese government gave a gift of several important Chinese fossil specimens to two Australian museums.

However, one questioned sample of an illegally imported nest contained sufficiently different mineralogical properties (i.e. palygorskite and ankerite) to the materials provided by the Victorian and SA museums, indicating it was not sourced from Henan Province but likely the USA.

Keyword

Illegally imported Dinosaur eggs and nests, forensic geology, X-ray diffraction

“We Did not Notice This Demon in Our Backyard!”—Introducing a New Source of Geogenic Health Hazard

Kirtikumar Ramkrushna RANDIVE[1]*, Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University,Nagpur, Maharashtra, India (randive101@yahoo.co.in)

Abstract

Dust, an inevitable inhalation, cannot be avoided by any means in a day-to-day life except without applying preventive measures. The inhalation of certain minerals in fine particulates is a well-established respiratory health risk. It has been known that the occupational exposure to dust particles can result in lung diseases. The situation worsens when these dusts are mixed with high proportions of minerals; such as aluminum oxides, asbestos, coal, cement, limestone, magnesites, marbles, mica, man-made mineral fibers, silica, talc, titanium dioxide and zeolites, etc. The reaction of the lungs to mineral dust depends on the dosage and the nature of the dust inhaled. Most common mineral related disease is silicosis, which is caused due to long term inhalation of airborne particulate crystalline silica.The present study is subject of a peculiar condition in which contemporary soils are remarkably rich in silica fragments. This silica, which is a mixture of crystalline, cryptocrystalline and amorphous forms, also occur in various size fractions including clays, which are dispersed through dust and inhaled by men and animals alike.

In order to access the hazard potential of these silica pebble laden soils, we conducted systematic study which included (i) soil profiles from selected areas in order to understand the depth persistence and control of silica pebbles, (ii) Particle Size Distribution (PSD) analysis of silica pebbles using Image-J software, (iii) Granulometric analysis of soils, (iv) X-ray Diffraction studies of clay and silt fractions, and (v) chemical analyses of soils. It is commonly known that the atmospheric dust contains “environmental” level of mineral dust which is <50µg/m3; whereas in active mining areas this level is of the order of ~10 µg/m3. In the present study area we have recorded alarmingly high levels of mineralized silica which is in the order of ~2-7.5 µg/m3. Such high levels of mineralized silica were not reported earlier from the urban populated areas, and therefore needs immediate attention. We therefore present here a new source of geogenic health hazard.

Keyword

Geogenic health hazard, silica dust, crystalline silica, Medical Geology

Role of Critical Minerals in Medical Geology: Applications and Implications

PRATIK PRAVIN GODBOLE[1]*, Post Graduate Department of Geology, RTM Nagpur University, Nagpur, Maharashtra, India (prateek15godbole@gmail.com)
Kirtikumar Ramkrushna Randive[2], Post Graduate Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur, Maharashtra, India

Abstract

Medical geology, an interdisciplinary field merging geosciences and medicine, examines the intricate relationship between geological materials and human health. This abstract provides comprehensive insights of critical minerals and emphasizes the critical importance of harnessing these minerals for their diverse medical applications. Rare earth elements (REEs), prized for their unique magnetic properties, are essential for magnetic resonance imaging (MRI), enabling precise diagnostic imaging crucial for detecting and monitoring various medical conditions. Gadolinium, a specific REE, serves as a contrast agent in MRI scans, enhancing image clarity and diagnostic accuracy. Lithium, sourced predominantly from geologically distinct regions, is indispensable in psychiatric medications for managing mood disorders like bipolar disorder. Its mood-stabilizing properties make it a cornerstone in the treatment of these conditions, improving patients' quality of life and reducing the risk of relapse. Cobalt, commonly found alongside chromium, is vital for producing cobalt-chromium alloys used in orthopaedic implants. These implants, renowned for their biocompatibility and mechanical strength, are instrumental in joint replacement surgeries, restoring mobility and relieving pain for millions of patients worldwide. Gold nanoparticles hold promise in cancer therapy, serving as effective vehicles for targeted drug delivery and photothermal therapy. Their unique properties enable precise tumour targeting while minimizing systemic side effects, revolutionizing cancer treatment approaches. Silver nanoparticles exhibit potent antimicrobial properties, making them invaluable for medical applications such as wound dressings, catheters, and medical device coatings. Their ability to combat infections reduces healthcare-associated complications and promotes faster wound healing. Titanium, extracted from mineral deposits, finds widespread use in dental implants due to its biocompatibility and corrosion resistance, restoring oral function and aesthetics for patients with missing teeth. Zirconium, derived from zirconium minerals, enhances dental ceramics' durability and aesthetic appeal, ensuring long-lasting dental restorations. Hence, it is essential to explore secondary sources of these minerals to meet growing demand while minimizing environmental impact. Additionally, focusing on the environmental implications of mineral extraction and utilization is crucial for achieving sustainable development and ensuring the continued availability of critical minerals for medical applications. By integrating geological knowledge with environmental stewardship, we can optimize healthcare delivery while preserving our planet's health for future generations.

Keyword

Critical minerals, Medical geology, Geomedical applications, Sustainable mining, Healthcare technologies

Mineralogy and morphology of earth materials in vehicle wheel-rims as significant trace evidence in a double murder and arson investigation in Australia

Robert William FITZPATRICK[1]*, The University of Adelaide (robert.fitzpatrick@adelaide.edu.au)
Mark Raven[2], CSIRO Mineral Resources
Peter Self[3], CSIRO Mineral Resources
Robert William Fitzpatrick[4], The University of Adelaide

Abstract

Through two diverse cases involving a double murder and arson investigation, this paper will demonstrate how combined pedological, mineralogical and chemical investigations involving earth materials recovered in vehicle wheel-rims, have been critical in developing reliable information on earth materials, from landscape to microscopic scales, to help in forensic investigations, which were used as evidence in Australia.

Sufficient descriptive (Munsell colour) and mineralogical (X-ray diffraction: XRD) data was acquired on all questioned earth material samples collected from vehicle wheel-rims and control samples collected from materials sampled from surfacing aggregate on road surfaces associated with the crime scenes. This information was used in both a double murder and arson investigation to determine the major similarities and differences between the questioned samples and control samples using no, limited, moderate, moderately strong, strong, very strong or extremely strong "Categories of Comparability" of being from a single location.

Double murder case: A suspect was trying to cover up a murder, whose body was found in a shallow bush grave in the Dandenong Ranges, Victoria in 2011, when he killed a second victim (cyclist) in a hit-run and then torched his car to cover up the crime. The suspect denied ever traveling on the unsealed roads leading to where the body was found. Two questioned earth material samples were recovered from the inside back rim of the suspects vehicle. Control samples were collected at 9 sites that cover road surfaces leading to the bush grave. Based on morphological and mineralogical examination the two questioned samples recovered from the back rim of the suspect's vehicle have an extremely strong degree of comparability to the control sites that cover the road surfaces leading to the crime scene. A jury found the suspect guilty of murder and manslaughter.

Arson case: The Cherry gardens bushfires occurred on in 2021 during a 37 degree centigrade day with a total fire ban declared. The bushfire destroyed 2 homes and blackened 1,700 hectares. A suspect was arrested, and his vehicle ceased and transported to the South Australian Police storage depot. Questioned earth material adhering to the rear inner wheel-rims was recovered from both

wheel-rims on the passenger and drivers sides of the vehicle. The 2 questioned calcareous soil materials from the inside rear wheel-rims of the suspect's motor vehicle had an extremely strong degree of comparability with the 4 control calcareous earth materials sampled from the calcrete surfacing aggregate on road surfaces adjacent to where 4 fires were lit along sections of four different roads. The calcrete road surfacing aggregate material placed on sections of the roads where the 4 fires were lit were also proven to be sourced from a known nearby Quarry. The morphological and mineralogical examination of the 2 questioned materials from the back rims of suspect's vehicle and 4 control samples of calcareous earth materials that cover the road surfaces where 4 fires were lit provided compelling evidence that these samples have virtually identical origins. A jury found the suspect guilty of starting 7 bush fires.

Keyword

Forensic geology, X-ray diffraction, bushfire and arson, murder

Forensic application of traceability technology in illegal marine sand mining crimes

Ping YIN[1]*, Qingdao Institute of Marine Geology,China Geological Survey
(yinping@mail.cgs.gov.cn)

Abstract

Marine sand is a precious marine mineral resource and an important raw material for construction. With the development of urbanization and the decrease in the supply of sand and gravel resources on land, especially under the influence of strict environmental protection, marine sand has become an important supplement to sand and gravel resources, while the illegal exploitation of marine sand has gradually increased around the world, causing disruption to the legal development and utilization of marine mineral resources. Marine sand is an important part of Marine ecological environment, and illegal mining brings serious harm to marine ecological environment.

Modern Marine geological survey, monitoring, experimental analysis and data processing technology have been widely used in the forensic identification of illegal marien sand mining. Sonar mapping can compare the changes of seabed landform before and after sand mining in detail, and assess the seabed damages. Through the investigation of Marine biodiversity, the influence of sand mining on the change of biological population was detected. By means of mineral composition, particle size analysis, heavy mineral and element analysis and foraminifera analysis, the source information of marine sand can be traced. By combining the results of all physical and chemical analyses with ecological models, it is possible to fully assess the overall impact of illegal sand mining activities on marine ecosystems.

This report introduces the application cases of forensic geological in judicial protection of marine sand resources in China.

Keyword

Forensic Geology, marine sand mining, traceability technology

Dimensionality reduction for visualizing gold trace element geochemistry through the chain of production in Brazil using UMAP

Angel VERBEL[1]*, Universidade de Brasilia (aaverbelo@unal.edu.co)
Daniel Gregory[2], University of Toronto
Maria Emilia Schutesky[3], Universidade de Brasilia
Liland McInnes[4], Tutte Institute for Mathematics and Computing
Jay Thompson[5], United States Geological Survey
Eric Moreira[6], National Institute of Criminalistic, Brazilian Federal Police

Abstract

The process of producing and selling artisanal gold in Brazil can be broken down into four steps: refining the ore locally, selling it to a trading house, then to an international refinery, and finally using it for various applications. However, irregularities in this chain can result in gold entering at various points. Surprisingly, from 1995 to 2007, artisanal gold introduced irregularly amounted to six times the declared amount produced regularly. Hence, having tools to understand how gold behaves throughout the chain of production would help develop mechanisms to prevent gold trafficking and all the problems it brings with it.

This study was carried out using natural gold samples and gold bars, seized at the deposit and declared to be from it (these bars were produced with that gold ore using amalgamation) and were analyzed via LA-ICP-MS/MS providing trace elemental and Pb isotopic composition. The results were compared by mass balance, taking the average composition of the natural samples as our fresh material. Later, the trace element concentrations were compared using Uniform Manifold Approximation Projection (UMAP), using the compositional data of gold as vectors of probabilities to compare their similarities with Hellinger distance.

Lead Isotopes from the ore showed a wide range ratio (206Pb/204Pb 12.1 to 22.7) which agrees with the analysis of the bars that were seized at the deposit (206Pb/204Pb 12.9 to 19.5). However, gold bars declared to come from there showed a narrower Pb isotopic signature (206Pb/204Pb 15.9 to 18.7). In addition, the UMAP projection of the multinomial probabilities of gold in the compositional space reveals that one of the samples seized at the deposit has a different chemical signature which suggests that it came from a different source.

These findings show that high-resolution in-situ analyses via LA-ICP-MS/MS on gold can track Pb isotopic signature of gold allowing to differentiate gold with a markedly different origin. In addition, the use of UMAP on the results gives us a detailed differentiation of the samples based on their trace element composition unveiling what can be interpreted as smuggled gold in the mine.

Keyword

Gold, Mining, UMAP

Anthropogenic gadolinium in surface and groundwaters of Poland

Irena Agnieszka WYSOCKA[1]*, Polish Geological Institute National Research Institute (irena.wysocka@pgi.gov.pl)
Dorota Kaczor-Kurzawa[2], Polish Geological Institute National Research Institute
Adam Porowski[3], Institute of Geological Sciences Polish Academy of Sciences
Agnieszka Konon[4], Polish Geological Institute National Research Institute
Angelika Szczypczyk[5], Polish Geological Institute National Research Institute

Abstract

Since the first publication on an anthropogenic gadolinium (Gd) in rivers in Germany (1996) detecting a positive gadolinium anomaly in surface waters has been reported in various regions of the developed countries. The gadolinium anomaly is linked, most of all, to the widespread usage of Gd-complexes for enhancement contrast in magnetic resonance imaging. With an increasing tendency in the application of stable Gd-based contrast agents in medical tests all over the world, it can be expected that the contribution of anthropogenic gadolinium to the total Gd concentration in water can reach up to 100%. This phenomenon has been observed mainly in waste and surface water, but due to limitations of analytical methods it is much less recognised for groundwater. Furthermore, there is no regular monitoring of Gd concentration in surface waters that receive the significant load of treated wastewater and no gadolinium threshold value for drinking water has been set in any country.

In this presentation we provide the information on gadolinium microcontamination in different types of Polish waters, including groundwater which is an important source of drinking water. The presented data are the compilation of the 10-year study on rare earth elements in Polish waters. For the data comparison, we apply the estimated background values for gadolinium in European natural waters based on the analysis of datasets produced within two European projects: (1) ‘FOREGS – Geochemical Atlas of Europe’ and (2) ‘Geochemistry of European Bottled water’. We discuss some implications of the anthropogenic gadolinium emission to the environment, such as (1) emerging new Gd species and its prevalence in total Gd pool in natural waters, and (2) the significant change of total Gd concentrations and disturbance on distribution patterns of rare earth elements in natural waters, especially surface waters.

Our long-term study has shown that the anthropogenic Gd fraction in groundwater is generally negligible (below 10%) but it already reaches up to 90% in tap water samples collected in big Polish cities (e.g. Kraków and Warszawa) and up to 95% in the Vistula river samples collected near to the places of treated wastewater discharge.

Keyword

gadolinium, water, emerging contaminant, anthropogenic, rare earth elements

"RASASHASTRA": AN ANCINET INDIAN MEDICINAL SYSTEM PROMOTING MEDICAL GEOLOGY

Kirtikumar Ramkrushna RANDIVE[1]*, Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University,Nagpur, Maharashtra, India (randive101@yahoo.co.in)
Pratik Godbole[2], Department of Geology, Rashtrasant Tukadoji Maharaj Nagpur University,Nagpur, Maharashtra, India

Abstract

The Rasashastra uses minerals and metals for cure of diseases. Development of Rasashastra as a separate discipline simultaneously developed with the science of mining and metallurgy in ancient India. Among the inorganic substances used in Indian medicine, the most important is mercury. Pure mercury is consumed in different forms for getting long and disease-free healthy life. Other substances are classified into three categories namely, the Maharasa (means the substance of great importance), which includes mica, tourmaline, pyrite, black bitumen, blue vitriol, selenite and zink ore, the Uparasa, means the substance of secondary importance viz., sulfur, melanterite, hematite, alum, orpiment, realgar and the Sadharana Rasa, means an ordinary or a common substance e.g arsenolite, sal-ammoniac, montroydite, cinnabar, etc. However, the basis of this classification is not clearly known. Reference has been made of seven metals (dhatus), namely Suvarna (gold), Rajat (silver), Aara (brass), Tamra (copper), Vanga (tin), Naga (lead), and Tikshna (steel) in the Rashshashtra. Similarly, use of gemstones for medicinal purpose also finds a mention. The stones are classified in Ayurveda based on their preciousness as, Ratna, means precious, Uparatna, means semi-precious, and Kshudra Ratna, means non-precious stones. The calcium compounds also find special mention in Rasashastra, they are called as Sudha varga in Rasashastra. Their inorganic sources include chalk, selenite, gypsum, talk, quicklime, whereas animal sources include fossils encrinite, norinite, gastropod oyster shells and corals. Mercury is the base of all medicinal formulations of Ayurveda, although considered toxic in the modern medicines. These medicines are prepared in the form of their incineration, pastes and pulps, tablets and syrup. The traditional knowledge has been serving for last 5000 years in India and still used by a large number of populations. However, there are several areas where modern knowledge cannot concur with the traditional knowledge. This could largely be due to poor documentation of the traditional knowledge and other missing links such as selection of particular materials, which almost have no use in the modern medical practices. It is therefore imperative that systematic studies be carried out to bridge the gap between traditional and modern medicinal practices through medical geology.

Keyword

Ayurveda, Mineral Medicine, Geopharmacy, Medical Geology

Olle Selinus (1943-2023): The Founder of Modern Medical Geology

Robert B. FINKELMAN[1], University of Texas at Dallas, United States
Jose A. CENTENO[2], University of Puerto Rico at Mayaguez, Puerto Rico
Hassina MOURI[3], Department of Geology, University of Johannesburg, South Africa
Chaosheng ZHANG[4], International Network for Environment and Health, School of Geography, Archaeology and Irish Studies, University of Galway, Ireland
Anna LADENBERGER[5]*, Geological Survey of Sweden (anna.ladenberger@sgu.se)

Abstract

Few people have had the opportunity to establish a globally recognize discipline. Olle Selinus (1943-2023) is one of those selected few for having established the modern discipline of Medical Geology. Medical Geology is defined as the impacts of geological materials and geologic processes on animal and human health had is modern beginnings with the initiatives of Olle Selinus two decades ago. However, awareness that the natural environment can have both positive and negative impacts on health stretches back to the dawn of time. Early humanoids were aware of the benefits and dangers of geologic materials and they undoubtedly learned this by observing the behavior of various animal species. The earliest writing of virtually all of the ancient civilizations contained detailed recommendations for using a wide range of minerals and rocks to treat various health issues. The term ‘medical geology’ was used as far back as 1849 and during the past 50 years there had been several efforts to develop a discipline along the lines of medical geology but none were successful until Olle Selinus turned his attention to this issue. In 1996 Olle led a Working Group under the auspices of the International Union of Geological Sciences. The name ‘Medical Geology’ was adopted by the Working Group in 1997. Thanks to Olle’s foresight and leadership the discipline of Medical Geology is now firmly established with the formation of the International Medical Geology Association as well as several other regional and national medical geology organizations, More than 40 books on Medical Geology have been produced since Olle’s groundbreaking 2005 Essentials of Medical Geology. Perhaps most importantly, Olle Senius’s efforts have led to countless medical geology studies designed to better understand the health impacts of the natural environment resulting in improved health outcomes globally.

Keyword

Medical Geology, Olle Selinus, health

Mineralogical and elemental information for soil geolocation tracing

hongling guo[1]*, Institute of Forensic Science, China (guohongling1234@163.com)
Jun Zhu[2], Institute of Forensic Science, China
Hongcheng Mei[3], Institute of Forensic Science, China
Ping Wang[4], Institute of Forensic Science, China
Can Hu[5], Institute of Forensic Science, China

Abstract

One of the key tasks of soil analysis in forensic sciences is to provide information about its diversities for comparison and geolocation provenance. The evidence value of soil depends on the variation of its characteristics. A research project about soil multivariable examination and geolocation tracing was carried out in China from 2018-2021. A combination of comprehensive techniques was established. These techniques concern the physicochemical information (elemental, mineral and isotope information) in bulk soil, trace pollutants (pesticide residues) in soil, soil spore and pollen features, plant debris fingerprint (microscopic fingerprints of plant species analyzed by scanning electron microscope and optical microscope) analysis in soil, soil microbial DNA test, plant barcoding inspection for soil samples. The combination of these different techniques can improve the accuracy of source tracing of soil evidence. However, in China, soil examination is the duty of trace evidence division. The inspectors prefer to use physiochemical methods first to analyze soil samples. In addition, soil botany and microbial community analysis are time consuming, expensive and require complex statistical analyses. Soil botany analysis, highly skilled inspectors are needed to perform pollen examination. And source tracing analyses of microorganisms and pollen in soil samples are difficult to perform at a large scale. In this study, a total of 80 soil samples were collected from eight Chinese cities (*Fuzhou*, *Guangzhou*, *Wuhan*, *Hohhot*, *Lanzhou*, *Xian*, *Changchun*, *and Beijing*, covering most areas of China). Minerals and elemental analysis were carried out by XRD and XRF. Principal component analysis (PCA) and hierarchical clustering analysis (HCA) methods were performed for dimensionality reduction, elemental marker identification and soils classification to the city they came from purposes. The eighty soils analyzed in this study could be tracked correctly to their city of origin. The K-Nearest Neighbors (KNN) model was done to evaluate the prediction ability based on the soil elemental composition. The results demonstrated that mineralogical and elemental composition can provide powerful information for soil discrimination and source tracing. Till now the comprehensive geological examination methods were applied in 103 cases and promoted in forensic labs in 20 provinces and cities around China.

Keyword

soil, forensic, geolocation tracing, minerals, elemental analysis

Forensic Geology in Chile: Foundations of a scientific basis for Justice and Environmental Sciences.

Kristian AGURTO VELASQUEZ[1]*, University of Chile (kmagurtov@gmail.com)
Katja DECKART[2], University of Chile

Abstract

Forensic geology, or geoforensics, is the application of the tools available in geology to the resolution of police cases associated with crime and homicide. It is here that soil analysis plays a fundamental role in providing information that can be useful in narrowing down crime areas, or associating an environmental crime to a group of people.

Given the total absence of professional geologists dedicated to Forensic Geology in Chile, and the lack of a specific scientific method for geoforensic cases and environmental crimes, it is proposed to develop a methodology based on compositional geochemical analysis and isotopy of carbon, oxygen, strontium and lead in soils characteristic of some geographic and geomorphological areas of Chile, considering general physicochemical parameters of the soil such as pH, electrical conductivity and granulometry, together with variables such as climate, humidity and rainfall of the environment. Potentially useful instruments for isotopic measurements will be ICP-MS, IRMS, QEMSCAN and TIMS. Currently, this is the first doctoral research work of its kind in Chile.

The specific objectives are directly related to the 5 variables to be included in the baseline, which are defined as: sampling methodology, standard geochemical data, physicochemical parameter maps and error/confidence ranges. The methodology is expected to be based on the protocol, survey and measurement of different soils of the Metropolitan Region of Santiago, and of geographic and geomorphological zones representative of Chile in urban, peri-urban and rural sectors, for its application in police investigations related to crimes against persons, and in cases of environmental crimes typified in the law.

The hypothesis of this research establishes that the physicochemical parameters of the soil (pH, EC and SOC) allow differentiating two completely equal or different soils, without the need to know whether they are intervened by natural or anthropic factors. In addition, the isotopic concentrations of δ12C and δ13C together with those of δ16O and δ18O contribute significantly to the characterisation of anthropogenic or organic interventions in soils, as well as the concentrations of δ87Sr/ δ86Sr and δ206Pb/ δ204Pb, and δ208Pb/ δ207Pb allow the identification of various sources of anthropogenic and geogenic contamination such as fuels, fertilisers, natural leaching processes and inputs of atmospheric pollutants.

This also connects directly with the environmental crime line, where it is expected to typify particulate matter contamination or non-standard emissions in volcanic, urban (analysing fuels),

agricultural (fertilisers and wildlife input) and large-scale industrial (mining, manufacturing, among others) soils.

The products of this thesis are expected to be: an unpublished database of physicochemical and isotopic parameters of Chilean soils; chemical maps of elemental concentration by geographical area; isotopic maps of C, O, Sr and Pb by: climatic zone, land use and potentially contaminated areas of Chile.

Keyword

Forensic Geology, Geochemistry, Stable isotopy, Chile

The impact of ashes produced during a fire event on the soil: a comparative study between anthropogenic and natural sources in the Campania region (Southern Italy).

Lucia Rita PACIFICO[1]*, University of Naples Federico II (luciarita.pacifico@unina.it)
Annalise Guarino[2], University of Naples Federico II - Department of Earth Sciences, Environment and Resources
Antonio Iannone[3], University of Naples Federico II - Department of Earth Sciences, Environment and Resources
Antonio Pizzolante[4], Istituto Zooprofilattico Sperimentale del Mezzogiorno - Portici (Napoli)
Mauro Esposito[5], Centro di Referenza Nazionale per l'Analisi e Studio di Correlazione tra Ambiente, Animale e Uomo, IZS Mezzogiorno - Portici (Napoli)
Stefano Albanese[6], University of Naples Federico II - Department of Earth Sciences, Environment and Resources

Abstract

In recent years, intentional illegal burnings have escalated in frequency, emerging as a globally significant issue. Consequently, humans and animals are exposed to potentially toxic elements (PTEs) released during combustion, dispersed by wind, and accumulated in fire ashes (Dimitrios, 2020).

Various studies have indicated that the PTE content in deposited ashes can modify the chemical and physical properties of soil, thereby affecting the development and growth of local microorganisms and vegetation (Raison, 1979). The geochemical characteristics of ashes are contingent upon the nature of the burned material (Dermibas et al., 2003), as well as factors such as combustion intensity, underlying soil composition, and bedrock type.

This study aimed to assess the environmental impact of two fire events that occurred in the Campania region (Southern Italy) during the 2017 summer season at two distinct sites. One fire involved a forest on the slopes of Mt. Somma-Vesuvius, while the other affected a waste disposal site known as Ilside near the city of Caserta. Changes in PTE concentrations in the topsoil were examined.

Specifically, 30 topsoil samples were collected before and immediately after the fire events at both locations, resulting in a total of 60 samples each from the Mt. Somma-Vesuvius slopes and Ilside surroundings. Post-fire samples were collected at pre-existing sampling sites along the main wind directions recorded during the fires.

To investigate potential elemental soil contamination resulting from the fires, the Enrichment Factor (EFs) of selected PTEs was determined and mapped for individual samples. Predominant enrichment of Hg was observed in both areas.

Furthermore, a combined application of multivariate statistics and geospatial analysis was conducted on the calculated EFs.

For the Ilside site, where special waste and e-waste were burned, the association of Hg, Tl, Cu, and Co was identified as the main contributor to data variability. In the Vesuvian area, the association of Hg, Cu, and Cr was found to be significant, likely linked to forest biomass burning.

This study highlights the varying chemical evidence left by fires depending on the nature of the burnt materials. Additionally, it demonstrates that even burning biomass from natural areas can introduce PTEs into the environment, potentially increasing the existing level of environmental hazard.

Keyword

Environmental Geochemistry, Enrichment Factor, Multivariate Statistical Analysis, Potentially Toxic Elements

A Study on Discrimination Capability of Soil for Forensic Comparison based on Statistical Approach in South Korea

Yu Ran LEE[1]*, National Forensic Service (urain94@korea.kr)
Seongshin Gwak[2], National Forensic Service
Siwon Kim[3], National Forensic Service

Abstract

Forensic soil analysis can play an important role in various crimes including thefts of agricultural products, homicides, and illegal disposal of waste. The comparison and differentiation of soil samples between suspects or objects to a crime scene is crucial in crime investigation. Soil exhibits various elemental compositions based on its location and depth due to the different weathering process of rocks and geological formation periods. Since the formation of soil is largely affected by surrounding environmental factors including climate, topography, and biology, it is important to understand characteristic elemental compositions of soil in different region for forensic soil analysis. In this study, 5 distinct regions in South Korea were selected for soil sample collection because its varied topography, climate, and geological history. Soil samples were collected in plastic bags (approximately 500 g) from the surface(topsoil) and the depth of 0.3 meter at 9 points with 1-meter interval in each region. The collected soil samples were then dried at room temperature for 3 days and then sieved to separate them into particle size of between 200 and 63 μm, and below 63 μm for analysis. Colorimeters, x-ray diffraction (XRD), and x-ray fluorescence (XRF) were employed to differentiate and characterize each soil sample. In order to provide objective discrimination value in forensic soil analysis, various statistical approaches were applied.

Keyword

Forensic Science, Soil, XRD, XRF, Colorimeters

Tracing the geographical origin of bottled water collected in South Korea via isotopic and elemental analyses

Byeong-Yeol SONG[1]*, National Forensic Service (songby10@korea.kr)
Dong-kye Lee[2], National Forensic Service
Yu-Ran Lee[3], National Forensic Service

Abstract

The production of bottled water requires a forensic discriminant technique that enables the identification of the brands or accidents caused by intended contaminants. The bottled water poisoning crimes have drawn much attention, and such crimes may recur in the future. The water is colorless and odorless, and thus it is difficult to detect contaminated water through visual observation. Thus, bottled water can be easily exploited for poisoning, and a method for tracing their origin is currently required. In this study, a total of 27 brands of bottled water samples were analyzed to determine stable oxygen isotopes, strontium isotopes, major and trace elements. The geographical origin of the water was traced based on the climatic and geographical characteristics of the location from where water was sourced, which was assumed to be reflected in the bottled water. Furthermore, we investigated whether this method can be applied to identify bottled water products. The results demonstrated that the characteristics of the bottled water, including the oxygen stable isotope ratios, reflect the latitude and altitude of bottled water source in South Korea, from the high-latitude region to the coastal regions. In addition, the results indicated that excellent discrimination was achieved using strontium isotopes to identify source areas with different types of bedrock, complex underlying lithologies, and ocean areas in South Korea. A statistical method based on discriminant analysis was applied to measure trace elements, and the results effectively reflected the characteristics of water–rock interactions (cross-validated classification probability: ≥92%).

Keyword

bottled water, stable isotope, strontium isotope, trace element, product identification

Medical and environmental aspects of multipurpose geochemical mapping

Iosif Faitelevich VOLFSON[1]*, Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements (rosgeo@yandex.ru)
Roman Alexeievich Bobkov[2], Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements
Viktor Alexeievich Kilipko[3], Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements
Elena Nickolaievna Levchenko[4], Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements
Igor Gennadievich Spiridonov[5], Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements
Yurii Alexandrovich Sharoijko[6], Institute of Mineralogy, Geochemistry and Crystal Chemistry of Rare Elements

Abstract

GIS used in the practice of multi-purpose geochemical work significantly increase the reliability of research results that require visualization of their content. The cadastres, thematic databases and banks of primary geochemical information accompanying cartographic data make it possible to clarify the Clarke concentration of chemical elements in bedrock, evaluate the natural regional and local geochemical backgrounds of all studied components of the geological environment and solve a complex set of geological and environmental problems. In particular, ecological and geochemical maps display the areas and territories with abnormally high concentrations of chemical elements with an assessment of the degree of environmental contamination in relation to the functional zoning of the study area according to the nature of its economic use.

The achieved high level of reliability of multi-purpose geochemical research allows today, using medical statistics data and multi-scale cartographic materials, to replenish databases on regions that are problematic in terms of the presence of environmental problems, and to reliably delineate the administrative boundaries of areas where endemic and environmentally-related diseases occur.

In combination with situational design using GIS, it becomes possible to determine the landscape and geological-geochemical parameters of the areas of hotbeds of endemic and environmentally-related diseases associated with the problems of pollution of environmental components with toxic chemical elements, to establish the possible causes of their occurrence, to assess the risk and forecast their further spread, create scientific and methodological foundations for medical and environmental monitoring of territories.

Based on the analysis and synthesis of geochemical mapping data, including the results of reprocessing materials from past years using modern procedures, the possibilities of delineating areas of environmental and medical risk with substantiation of the causes of occurrence and forecast for the spread of disease foci caused by geological factors of natural and technologic origin have been demonstrated.

Keyword

multi-purpose geochemical research, endemic diseases, environmentally-related diseases, environmental risk, medical risk

Occurrences of potentially toxic elements such as uranium (U) and molybdenum (Mo) in the Karoo ground-and-surface waters near Beaufort West, Western Cape, South Africa: a possible health threat to the local population?

Okuhle POTO[1]*, University of Johannesburg, South Africa (okuhlepoto@gmail.com)
Bastien Linol[2], Nelson Mandela University, South Africa
Hassina Mouri[3], University of Johannesburg, South Africa
Gaathier Mahed[4], Nelson Mandela University, South Africa
Thomas Muedi[5], Council for Geoscience, South Africa

Abstract

This study investigates the degree of ground-and-surface water contamination from uranium (U) and molybdenum (Mo) in the Rietkuil river catchment (114 km2) and Leeugamka Dam near Beaufort West and associated health risks to the local communities. Twenty water samples were collected in the study area from the mine pit and surface water sources in September 2018 during the wet season and July 2019 during the dry season, respectively. Hydro-chemical analysis revealed abnormally high concentrations, up to 6760 g/l for U and 266 g/l for Mo, in the mine pit compared to other sampled localities, suggesting active leaching of these chemical elements, most likely by rainfall from the rocks exposed by previous mining activity in the pit. Conversely, the concentrations of these elements in surface water upstream and downstream of this mine pit and exposed stockpiles during both sampling seasons are generally low and within acceptable limits (U ≤ 30 µg/l; Mo ≤ 70 µg/l) determined by World Health Organization (WHO) and South Africa National Standards. However, spatial analysis shows a progressive increase in U and Mo concentrations downstream from the mine water sample, most likely due to transportation nearly 10 km from the defined source in the mine pit. While concentrations of these elements in all groundwater locations were also within acceptable limits, comparing U against standard limits of 20 g/l suggested by Health Canada, two groundwater samples surpassed this limit with concentrations reaching up to 27 g/l. Moreover, the chemical form of U in groundwater samples occurring as uranyl hydroxide can have serious health implications. These results indicates that drinking from groundwater sources close to the mine pit in the Riekuil drainage is not safe for drinking purpose for both humans and animals. However, a detailed health investigation is necessary in order to assess the current health issues associated with the revealed high concentration of such elements in the study area as well as their possible short and long terms implications.

Keyword

Uranium, Molybdenum, Ground-and-surface water, Contamination, Beaufort Group

New insights into the geological occurrence, morphology and toxicology of New Zealand erionite minerals

Janki Prakash Patel[1], University of Auckland
Martin Brook[2]*, University of Auckland (m.brook@auckland.ac.nz)
Alessandro Francesco Gualtieri[3], University of Modena and Reggio Emilia
Sonia Scarfi[4], University of Genoa
Melanie Kah[5], University of Auckland
Ayrton Hamilton[6], University of Auckland
Serena Mirata[7], University of Genoa
Vanessa Almonti[8], University of Genoa

Abstract

The presence of volcanic processes in New Zealand has led to the formation of diverse minerals that originate from volcanic activity, including a category of aluminosilicates referred to as zeolites. One such notable zeolite is erionite, which typically crystallizes through hydrothermal alteration or diagenesis of volcanic rocks, forming mainly in tuffs and basalts. Erionite possesses a fibrous crystal habit, similar to asbestos. And as with asbestos, erionite exposure has also been linked to cases of malignant mesothelioma- A significant epidemic was discovered in the Cappadocia region of Turkey in the 1970s. While undisturbed erionite fibers are not considered harmful to human health, the International Agency for Research on Cancer (IARC) has designated erionite as a Group 1 carcinogen due to its hazardous potential when disturbed or inhaled. Consequently, research is ongoing in New Zealand, employing various experimental and analytical techniques to detect and identify the occurrence of erionite. Some of the methods being utilized include Electron Microscopy, X-Ray Fluorescence, Electron Microprobe Analysis, micro-Raman spectroscopy, and X-ray powder diffraction with the Rietveld Method. These techniques aid in the characterization and identification of erionite in different regions of New Zealand. Notable findings so far include woolly erionite discovered in vesicles of rhyolitic rock at Mount Somers in the Canterbury region of the South Island, asbestiform erionite found in the Waitakere Group Volcanics in the Auckland region of the North Island and acicular bundles of erionite fibers found in tuff from the Timber Bay Formation in Kaipara. Toxicity tests have also been conducted on two of the erionite samples (Mount Somers and Kaipara) with results indicating that NZ erionite signifies an acute toxic potential especially in relation to non-carcinogenic fibers such as wollastonite. Due to the potential adverse health effects linked to erionite exposure, this research aims to develop an understanding of erionite occurrence, towards mitigating any environmental hazards exhibited this mineral.

Keyword

erionite, fiber, carcinogen, New Zealand

WATER QUALITY FOR HUMAN CONSUMPTION IN THE CONTEXT OF ABANDONED ARTISANAL GOLD MINING

Marina THIMOTHEO[1]*, University of Campinas - UNICAMP (marina.thimotheo@gmail.com)
Ricardo Perobelli BORBA[2], University of Campinas - UNICAMP
Francisco Wohnrath TOGNOLI[3], Federal University of Rio de Janeiro - UFRJ

Abstract

Artisanal mining of metallic elements in gold mines is still carried out today without adequate environmental regulation, frequently causing hard impacts and irreversible damage to human life and associated ecosystems. The study area is located in southern Brazil, in the Lavras do Sul municipality, where gold prospects occur in quartz veins derived from hydrothermal fluids percolating in volcanogenic crystalline terrains. In this region, there was artisanal extraction of Au-Cu-Ag mines for almost three centuries, until the beginning of the 1980s, without decommissioning and environmental remediation. Nowadays, some of these areas are contaminated, but they are used for agricultural activities and pastures. This study evaluated the water quality produced in homemade and groundwater wells used for human consumption, verifying the possible relationship with byproducts of abandoned mining. Two field campaigns were carried out, totaling 34 water and 10 soil sampled points. Quantification included alkalinity, Cl-, NO3- and SO4-2 and potentially toxic metals (Al, Ba, Cu, Cr, Fe, Mn, Ni, Zn, Hg, As, Cd and Pb), determined by an Inductively-Coupled Plasma Optical Emission Spectrometry (ICP OES). The soils were mineralologically characterized by X-ray Diffraction (XRD). The water analytical results were compared with the standard references to evaluate their portability by Brazilian environmental legislation. The assessment of the chemical composition is based on the interactions between the aqueous and minerogenic phases through hydrogeochemical modeling using the PhreeqC program, version 3.7.3, llnl.dat database. Considering the two campaigns, the results show that 64% of the samples present at least one element with values above the maximum determined by the legislation. However, most elements that make samples inappropriate for human consumption are Al and Fe, essentially contained in the particulate phase. Among the potentially toxic elements, Cd, As and NO3- are detected above the maximum of 0.003 mg/L, 0.01 mg/L and 10 mg/L, respectively, in 27% of the total samples. The hydrogeochemical modeling indicates that the minerals are in equilibrium in the aquifer, except arsenopyrite, which may be a potential source of As for the waters. Primary minerals contribute to chemical composition. However, exogenous factors prevail. It is concluded that the NPK-based fertilizers used for many years influenced the dynamics of toxic metals, both in the sorption of these elements and in their desorption, much more than the interactions of water with ores or mining waste. Therefore, the control of the chemical composition of water is strongly influenced by current human activity, which is agriculture. The byproducts of mining activities 40 years after their completion do not significantly influence the quality of these waters and, therefore, the impacts on public health today.

Keyword

secular mining, hydrogeochemical modeling, heavy metals, medical geology

Frequency dependence of internal mechanical losses in rocks in the low-frequency range

Aleksandr Sergeevich VOZNESENSKII[1]*, NITU MISIS (al48@mail.ru)
Vladislav Sergeevich Salyukov[2], NUST MISIS
Yaroslav Olegovich Kutkin[3], NUST MISIS

Abstract

The study of internal mechanical losses in rocks and the patterns of their changes under cyclic deformations and loadings of varying duration, frequency and intensity are considered. Internal mechanical losses are estimated either by the quality factor Q, or by the inverse value - the mechanical loss coefficient Q-1. In rocks, they manifest themselves under cyclic loads resulting from earthquakes, blasting or the effects of various machines, leading to fatigue phenomena and subsequent destruction. The fatigue properties of rock materials are usually studied using cyclic load–unload tests, and the evolution of deformation and damage reflects their weakening characteristics. Studying the fatigue properties and failure mechanism of rocks, which is characterized by the Q-1 coefficient, is crucial for predicting the long-term stability of mining engineering structures. This study involves determining losses depending on the frequency of mechanical impacts. One of the models for describing such a dependence is the Rayleigh model, which takes into account two components. One of them characterizes the increase in losses with increasing frequency of exposure. The second component characterizes their increase with decreasing frequency. Mechanical losses in rocks under low-frequency periodic impacts have not been sufficiently studied. The purpose of the study was to experimentally establish the patterns of change in the loss coefficient Q-1 in the low-frequency region of periodic impacts for various rocks. The experiments used samples of gabbro and dolerite in the form of a rectangular parallelepiped with dimensions of 120x40x40 mm. The samples were cyclically loaded during bending according to a three-point scheme on a press in a deformation mode. The tests were carried out using a specially designed device for cyclic loading according to ISRM recommendations, which allows minimizing friction in the supports, as well as measuring deflection directly on the samples. The load was measured with a strain gauge dynamometer, and the beam deflection was measured with LVDT transducers. The sample was loaded at a given speed to a value of 0.2 MPa, after which a cyclic load occurred in the range from 0.2 MPa to 0.3 MPa (8 cycles), then the sample was loaded to a value of 0.4 MPa, after which a cyclic load occurred in the range from 0.4 MPa to 0.5 MPa (8 cycles). The sample loading rates were: 0.05, 0.075, 0.1, 0.25, 0.5, 0.75, 1 mm/min. Frequencies were defined as the reciprocal of cycle durations. As a result, hysteresis loops were obtained for each sample at each loading rate. The loss coefficient was estimated through hysteresis loops. To plan the experiments, as well as to interpret their results, modeling of the entire process of sample deformation was carried out using the finite experiment method in the COMSOL Multiphysics environment. As a result, it was found that in the frequency range under consideration there is a minimum Q-1, with a frequency

deviation in both directions from which the loss coefficient increased. The work was carried out with financial support from the Russian Science Foundation, grant No. 24-27-00103.

Keyword

Frequency, internal, mechanical, losses, rocks

The engineering geology of London's raised reservoirs with a summary of ground investigation risks and recommendations, citing techniques used at three sites

Hollie Elizabeth FISHER[1]*, AtkinsRealis (hollie.fisher@atkinsrealis.com)

Abstract

In London and the immediate Thames Valley area, there are thirty raw water reservoirs supplying water services to nine million customers in the capital. The majority of these reservoirs are retained by a soil embankment dam with a traditional puddle clay core that extends down to the underlying London Clay Formation bedrock. These reservoirs were built without filters or drains downstream of the puddle clay core which together with the age (up to or over a century old) make them more prone to internal erosion problems. Non-intrusive geophysical surveys are regularly carried out to identify areas of excess leakage or seepage, with remediation works being carried out afterwards.

London is situated within the London Basin formed during the Alpine Orogeny and comprises a faulted succession of Paleogene sediments. Locally derived soils were typically used for constructing the embankments, including London Clay Formation derived Puddle Clay, and embankment shoulder material largely comprising a combination of granular River Terrace Deposits and cohesive London Clay Formation.

Ground investigation through puddle clay cores is notoriously challenging with a number of key risks; this presentation uses three projects as case studies to provide a summary of the ground conditions and associated risks which may be expected at the various reservoir sites around the capital. This presentation also summarises the various techniques used for investigating the dams to mitigate these risks and support the construction and remediation of the structures, with a particular focus on the requirements of British Standards and best practice, and the practicality of using these techniques in the field.

Keyword

London, Reservoir, Dam, Embankment, Soil

The Engineering Geology of Havant Thicket Reservoir – The first to be built in the United Kingdom in over three decades

Hollie Elizabeth FISHER[1]*, AtkinsRealis (hollie.fisher@atkinsrealis.com)

Abstract

Havant Thicket Reservoir shall comprise a 160hectare, naturally flooded reservoir bounded by a 3km long, 20m high soil dam and the natural bowl-like topography of the site. Havant Thicket Reservoir is the first reservoir to be built in the UK in over three decades and will be constructed in Hampshire, England; currently the project is in its pre-construction phase with earthworks due to commence in 2025. This reservoir is a nationally strategic asset securing reliable drinking water for the water-stressed Southeast England. In addition, the scheme will maximise the community and environmental benefits of a new reservoir - creating a vibrant new wetland habitat and leisure facilities for local communities.

The site of the reservoir is directly underlain by a classic succession of Hampshire Basin geology, formed during the Alpine Orogeny, and comprising a faulted succession of Paleogene and Cretaceous sediments. Due to the southerly dip of the topography and strata associated with the Bere Forest/Chichester syncline, the bedrock strata form a rough geological ‘feather-edge’ meaning the site is home to range of daylighting strata.

Overlying the site are superficial peri-glacial ‘Head’ deposits containing relic shear surfaces. The investigation into the presence and condition of these features are key for the design of the soil dam as these could present potential significant risks to the project, including embankment failure and the loss of water and flooding of adjacent land. As well as significant geohazards being present at the site, there are also a number of opportunities due to the favourable ground conditions; these include use of the bedrock (primarily London Clay Formation) for the construction of the embankment dam itself.

This presentation aims to provide a summary of the regional and local geology of the site (a major factor for the selection of the site for this nationally important scheme), and a review of the identified geohazards and their investigation.

Keyword

Per-Glacial, Reservoir, Dam, Embankment, Head

Crack Propagation Analysis Through Digital Image Correlation in Volcanic and Plutonic Specimens Under Brazilian Tensile Tests

Chamran KAZEMI[1]*, Universitat Politècnica de València (ckazemi@upv.es)
Akbar CHESHOMI[2], University of Tehran
Víctor MARTÍNEZ-IBÁÑEZ[3], Universitat Politècnica de València
María Elvira GARRIDO[4], Universitat Politècnica de València
Carlos HIDALGO SIGNES[5], Universitat Politècnica de València
Álvaro RABAT[6], Universidad de Alicante

Abstract

The mechanical characteristics of rocks stand as pivotal parameters across multiple engineering domains, including petroleum, mining, civil, and environmental engineering. Among these attributes, the phenomenon of crack propagation holds paramount importance. This intricate process encompasses the initiation point, trajectory of extension, and morphological features within rock specimens. The Brazilian test emerges as a widely employed technique to induce cracking. In this method, compressive stress is applied diametrically to disc-shaped samples, inducing a tensile stress regime, perpendicular to the compression according to ISRM and ASTM standards. Consequently, the samples experience failure in the diametrical direction towards the loading jaws .. Diverse methodologies exist for evaluating crack extension in rock samples subjected to the Brazilian test. This study aims to leverage Digital Image Correlation (DIC), to discern the initiation and evolution of strain fields and cracks sans physical contact with the samples. A comprehensive dataset comprising 10 rock samples representing two main lithological groups of volcanic and plutonic rocks was utilized to assess the influence of varied parameters such as grain size, presence of pre-existing cracks, matrix composition, indirect tensile strength, and ultrasonic pulse velocity on crack trajectory. The outcomes of the investigation unveil intriguing patterns. Specifically, samples with grain sizes akin to sand tend to exhibit indentation influencing the crack propagation pattern. Conversely, irrespective of grain size, samples lacking a matrix predominantly display curvature patterns. Moreover, a decrement in indirect tensile strength correlates with cracks adhering more closely to standard trajectories (straight and diametral connecting loading jaws). Notably, the primary crack trajectory is highly influenced by the surrounding pre-existing cracks, unless the tensile strength of the lithology is substantially low. The Digital Image Correlation is a powerful mean to measure the full-field strain development in objects, and this study intends to focus on its applications within crack detection in igneous rocks.

Keyword

Digital Image Correlation (DIC), Crack Propagation, Brazilian Tensile Test, Rock Mechanics, Igneous Rocks

Shear behavior and deformation mechanisms of reactivated ancient landslides soil in the Nepal Himalaya

Bharat Prasad BHANDARI[1]*, Tribhuvan University (bharat@bharat.com)

Abstract

The reactivation of old landslides has emerged as a major problem in the Nepal Himalayas in recent years. A significant number of individuals have resided atop the historical accumulation of landslide debris for a long time and are currently confronted with the threat of reactivation. This study examines the shear behavior and deformation mechanism of fourteen reactivated landslides in the Sidhupalchwok District, Nepal. Between 2020 and 2021, fourteen distinct ancient landslide deposits were reactivated in the study region during the monsoon season. The remolded soil samples from all fourteen reactivated landslides were obtained from the field. The multistage direct shear test of unsaturated soil was conducted by enabling separate regulation of matric suction. The curve depicting the relationship between shear stress and horizontal displacement was derived for each soil sample. The shear strength parameters of all soil samples were evaluated. The samples exhibit cohesion values that span from 5 to 10, whereas the angle of internal friction varies between 21 and 27. The soils exhibited a plasticity index ranging from 3 to 7. Out of all the samples, eleven are loose and non-compact, while three samples are in a dense state. The findings of the gradation study indicate that the soils are characterized as Clayey sands (SC) with a relatively low plasticity index and a low cohesion. The average rainfall amount in the monsoon period from 2015 to 2023 ranged from 1400 mm to 2200 mm. The rainfall amount in the early monsoon period increased dramatically from 2019. The unconsolidated soils with low cohesion and a low plasticity index deformed due to the 7.8 magnitude Gorkha earthquake and subsequent aftershocks, causing the landslide reactivation during the early monsoon season.

Keyword

Landslide reactivation, cohesion, soil deformation, direct shear test

Engineering-geological characteristics of pyroclastic deposits from paroxysmal eruption of Shiveluch volcano in 2023 (Kamchatka Peninsula)

Mariya NIKULINA[1]*, Lomonosov Moscow State University, Faculty of Geology, Department of Engineering and Ecological Geology (mariya.nikulina.2002@mail.ru)
Julia Frolova[2], Lomonosov Moscow State University, Faculty of Geology, Department of Engineering and Ecological Geology
Olga Girina[3], Institute Of Volcanology And Seismology FEB RAS

Abstract

Pyroclastic deposits are the most common volcanic products. They cover large territories in areas with high volcanic activity (e.g., the Kamchatka Peninsula in Russia, Indonesia, and the Philippines). The significance of their engineering-geological study relates to the planning and development of engineering projects and economic infrastructure on these territories, as well as the growth of tourism in volcanic areas. It is well known, that pyroclastic deposits (especially the finest-grained fractions, such as ashes) have a number of undesirable properties that complicate construction. These include settling, shrinking, swelling, and in the case of freezing, extreme heaving of soils. Additionally, dangerous geological processes such as mudflows, landslides, and dust storms may also be associated with pyroclastic deposits.

The paroxysmal explosive eruption of Shiveluch volcano (Kamchatka peninsula, Russia) in April 2023 led to the formation of pyroclastic flows. Their length reached 10-15 km. During the field work in August 2023 we studied pyroclastic deposits and collected six samples over the area of pyroclastic flow. The samples were studied both at the micro and macro levels. Dispersion of soils varies from fine and very fine sands with a significant amount of coarse grain material (15-20%) to clayey soils with a small number of inclusions. The finest fractions, even with low moisture, are capable of grains aggregation. The aggregates are generally spherical in shape, but irregularly shaped aggregates are also present. Point and coagulation types of contacts are formed between the grains. According to X-ray analysis, plagioclase (up to 75%) and cristobalite (up to 23%) predominate in the composition of pyroclastic deposits. Quartz, pyroxene, and hornblende are present in smaller amount.

The bulk density varies from 1.44 to 1.57 g/cm^3 in undisturbed deposits. The grain density ranges from 2.64 to 2.74 g/cm^3. The porosity of the soils varies between 42 and 47%, with a porosity coefficient between 0.73 and 0.9.

The plasticity for fine-grained soils varies, with a plastic limit (PL, %) in the range of 20 to 21%. The liquid limit (LL, %) is 26 to 29% and the plasticity index (PI, %) varies from 6 to 8%. According to plasticity chart in ASTM D2487-17, some samples are classified as silty clays (CL-ML), while others as lean clays (CL). In terms of consistency index (Ic, %) fine-grained samples can be classified as very stiff and very soft-stiff (ISO 14688-2—2017). The strength and deformation characteristics of the samples are also different, and depend not only by soil dispersion, but also by grain habitus. The presence of thin material as a filler for the pyroclastic flow increases the strength of deposits (all other things being equal).

Keyword

volcanicash, pyroclastics, pyroclasticproperties, Kamchatka, Shiveluch

Influence of anthropogenic factors on landslide activity in the Moskva river valley (Moscow, Russia)

Pavel Novikov[1]*, Lomonosov Moscow State University (pasha-nov@mail.ru)
Oleg Zerkal[2], Moscow State University, Moscow, Russia
Olga Barykina[3], Moscow State University, Moscow, Russia
Igor Averin[4], "Engineering Geology" LLC, Moscow, Russia

Abstract

Moskva River valley is located in the European part of Russia, in the central part of East European Platform. It is one of the most densely populated areas of the country, and a large part of Moscow agglomeration is situated within the Moskva River valley. The territory is characterized by subhorizontal bedding of terrigenous-carbonate strata of the Carboniferous deposits and sandy-clayey deposits of the Jurassic, Cretaceous and Quaternary ages.

The first settlements in the valley of the Moskva River date back to the 1st millennium B.C., but until the 20th century the main anthropogenic impact on landslide masses consisted in planning and terracing of certain areas (e.g. Vorobyovy Gory, Khoroshevo-I). Since the 20s of the XX century, large-scale measures on economic development of territories, including landslide areas, have started to be implement.

Despite the fact that landslide processes in the Moskva river basin have been studying since XX century influence of some of anthropogenic factors were being underestimated for a long time. Among the anthropogenic factors of landslides, both those related to the purposeful impact on the landslide masses and those related to the indirect impact of human activity have been identified.

There are 2 two main types of landslides 1). Shallow slides associated with Quaternary glacial, glaciofluvial, alluvial and deluvial deposits, 2). Rotation slides associated with Jurassic clayey sediments.

For the first type of landslides such methods as forest planting, surface drainage, flattering and benching significantly reduce activity of shallow slides. On the site “Vorobyovy Gory” after mitigation measures only several landslide events are known. In contrast, human-induced river and gully erosion lead to intensification of such processes. An example is the site "Rublevo-Arkhangelskoye” the coastline of which is characterized by the impact of small landslides of about 30%.

For rotational slides the greatest impact on stability reduction is caused by slope loading and undercutting, as well as leakage from water-bearing utilities. Activities, which increase factor of safety are: building counterforces and anti-erosion measures (e.g. concrete embankments). Erosion control measures reduce water flow influence on slopes with no respect to volume and shape of landslides. At the same time efficacy of counterforces, is not so obvious. There are well-known cases when loading of toe part of the slopes had only temporary effect (“Vorobyovy Gory”, “Khoroshyovo-II”, “Kolomenskoye”).

For human activity analysis of spatial-temporal aspects is crucial. Immediate effect of landslide

control measures was significant up to complete cessation of deformations. However, after 20-30 years signs of movements on some sites were identified. It could be explained by complex inner structure of such large landslides and rapid changes in anthropogenic impact over time.
In comparison with shallow slides, anthropogenic influence assessment for rotational slides is a complex task. In the end, types and rate of technogenic impact drastically change in space and time, combination of multiple factors could have both positive and negative effect on slope stability.

Keyword

shallow slides, rotation slides, Moscow

Effects of heating-LN2 cooling on the Brazilian tensile strength of rock materials

BIKASH KUMAR KUMAR RAM[1]*, INDIAN INSTITUTE OF PETROLEUM AND ENERGY VISAKHAPATNAM INDIA (bikashramgeo@gmail.com)
DEEPAK AMBAN MISHRA[2], INDIAN INSTITUTE OF PETROLEUM AND ENERGY VISAKHAPATNAM INDIA
Rajeswar Das[3], INDIAN INSTITUTE OF PETROLEUM AND ENERGY VISAKHAPATNAM INDIA

Abstract

Evaluation of the effects of temperature on physical and mechanical properties of rock has key implication towards safe and sustainable development of various rock engineering projects such as extraction of geothermal energy and coal/shale gas, nuclear waste repositories, drilling and blasting etc. The rocks, which have experienced very high temperatures in such engineering sites, very often undergo rapid cooling treatments either to increase the permeability of the hot dry rock masses or cool the vicinity of the high temperature rock formations. In the recent past, liquid nitrogen (LN2) cooling has gained considerable attention as a substitute for conventional water-based cooling techniques. LN2 has also become common as a potential fracturing agent to construct enhanced geothermal system. However, this cryogenic cooling process significantly deteriorate the strength of the rock. Therefore, a comprehensive understanding on physical and mechanical properties due to heating and LN2 cooling is required to build sustainable and economical design of deep underground engineering projects and optimize the drilling parameters. In this investigation, the effects of LN2, and air-cooling methods were used in order to study the influence of different heating-cooling treatments on the physical properties and Brazilian tensile strength of the sandstone and basalt. The prepared specimens were heated in a muffle furnace at 100°C, 200°C, 300°C, 400°C, 500°C, 600°C and subsequently cooled in two different cooling conditions i.e. under normal room temperature and in LN2. It has been found that the sandstone possesses a general decline in Brazilian strength with a slight increase in strength between 300°C and 500°C. The Brazilian strength further decreases and becomes ~45-46% with the induced quenching after heating above 600oC. However, in case of basalt it is observed that the Brazilian strength increases ~11-21% with reference to untreated specimens at thermal treatments of 100°C in both the cooling methods. In thermal treatments above 200°C the Brazilian tensile strength of the basalt gradually decreases with higher drop in

case of LN2 cooling. This study infers that the mineral content and inherent texture plays a vital role in the development of thermal induce stress and pertaining its effects on the physical properties of different rock materials which influence the strength of the rocks.

Keyword

Thermal treatment, LN2 cooling, Basalt, Sandstone, Air cooling

Sensibility analysis of the parameters "Factor of Safety" and "Probability of Failure" in Slope Stability

Rubén Eduardo ROMERO MAYMA[1]*, IAEG Peru (rromerom@uni.pe)

Abstract

In many projects of roads and surface mining, an important challenge to solve is the assurance of the stability of the designed slopes. However, the common analysis is principally focused on the realization of a deterministic approach with the calculus of the Factor of Safety (FoS). In this job, was considered the estimation of the Probability of Failure (FoS) that uses the variability (Media and Standard Deviation) of several variables involved in the deterministic approach, as the cohesion or friction angle. It was realized taking in account data of slopes in Peru. The zones considered was a road (Ica), and two open pits (Moquegua and Lima). With the data, the FoS and PoF were calculated rigorously comparing diverse calculus methods like limit equilibrium (analytical) or shear strength reduction (numerical). The softwares Dips, Slide, Rocplane, Swedge, FlacSlope, Phase2 and SBlock were used. It is to obtain the most representative values of FoS and PoF. So, having these two parameters, was conducted a sensibility analysis via statistical correlations. The relationship varies with the change degree of confidence of the standard deviation, the statistical distributions used and the function analyzed. Taking in account all the possible analysis and comparisons, the better distributions to analyze these variables are the normal and, in less grade, the exponential distribution. And between all the functions the most adequate is the "Function error" because it stablishes a great determination coefficient in comparison with another functions. The established relationship is consistent and is useful to know better about these methods. In general, it is a good idea to foster the use of probabilistic approaches in future slope stability projects to avoid the uncertainty that a deterministic approach can generate.

Keyword

Deterministic approach, Probabilistic approach, Slope stability, Correlations, Error function

INTERPLAY OF COHESIVE-ORGANIC SOILS AND DISPERSIVE BEHAVIOR: SHAH ALAM'S SUSCEPTIBILITY TO WATER PONDING

NOR SHAHIDAH MOHD NAZER[1]*, UNIVERSITI KEBANGSAAN MALAYSIA
(shahidahnazer@ukm.edu.my)

Abstract

Flash floods, especially in urban areas like Shah Alam, may result from a combination of factors including heavy rainfall and inadequate drainage. The localized nature of these floods and their impact on infrastructure, including roads and vehicles, underscores the importance of flood preparedness and the need for comprehensive flood mitigation strategies. However, one often overlooked factor is the presence of cohesive-organic and potentially dispersive soils, which complicate water absorption and runoff management. This research explores the intricate relationship between the physical properties of cohesive soils, their dispersive characteristics, and the resulting impact on water ponding. Cohesive-organic soils in Shah Alam, peat primarily composed of fine clay particles, exhibit high water retention capacities due to their small size and surface charges, leading to inherently low permeability. This characteristic slows water infiltration during heavy rainfall, contributing to increased surface runoff. Additionally, when these soils display dispersive behavior—where clay particles are prone to separation and suspension in water due to high sodium concentrations—the risks are compounded. Soil dispersion can lead to erosion, sedimentation in drainage channels, and reduced structural integrity of slopes, further obstructing effective water management and exacerbating flood conditions. Therefore, effective management and mitigation efforts incorporating the aspect of water ponding from dispersive behavior of cohesive-organic soil are essential to reduce the vulnerability of these areas to flooding and its associated impacts.

Keyword

cohesive-organic soil, dispersive, water ponding, flood, peat

Damage Evolution Mechanisms of Granite Rock under Cyclic Loading: X-Ray Computed Tomography and Digital Volume Correlation Technique Analysis

Shangtong YANG[1]*, China University of Mining and Technology / University of Strathclyde, UK (6538@cumt.edu.cn)
Qinxin HU[2], University of Strathclyde
Xiaozhao Li[3], China University of Mining and Technology, Xuzhou, China

Abstract

Understanding the damage evolution mechanisms under cyclic loading, leading to brittle failure of rocks, can shed light on estimating and predicting the life-cycle reliability of rock structures and rock engineering. In particular, microscale fracture evolution is a key to understanding and elucidating the macroscopic engineering properties of rocks, especially the fracture propagation and damage behavior. In this study, cyclic uniaxial compression tests were performed on granite rocks together with X-Ray Computed Tomography (XCT) and Digital Volume Correlation Technique (DVC) analysis. The quantitative statistics of cracks reveals the dynamic closing, opening, nucleation and self-propagation of micro-cracks. Evidence of micro-cracks coalescence and crack clustering to achieve failure has also been demonstrated. The strain fields reveal the relationship between the strain localization and crack behavior and reflect stress concentration zones under different damage level. Damage evolution is dominated by nucleation at initial cycles and transit to self-propagation and coalescence as the cycles increased. DVC results show that distortion has the highest correlation to cracking. Apart from the strain localization, damage evolution process tends to cause larger deformation in the undamaged zones, which is completely different to the monotonic loading scenario. The results implicate that the stress transfer is the main mechanism for fatigue damage.

Keyword

rock fatigue, in-situ XCT, DVC analysis, microstructural changes, damage evolution

Comprehensive studies of the engineering geological behavior of red clay soils in Bangladesh

Md Shohel RANA[1]*, Institute of Mining, Mineralogy and Metallurgy (IMMM); Bangladesh Council of Scientific and Industrial Research (BCSIR), Joypurhat 5900, Bangladesh (shohelrana@bcsir.gov.bd)
Tamanna Tasnim[2], Department of Geological Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh
Hossain Md. Sayem[3], Department of Geological Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh
Md. Emdadul Haque[4], Department of Geological Sciences, Jahangirnagar University, Dhaka 1342, Bangladesh

Abstract

Red clay soils are widely distributed over the Madhupur Tract, Barind Tract, and Lalmai Hills areas of Bangladesh, covering an area of 12800 km2 (8.67% of the total area of the country). These tracts are comparatively more populated than neighboring areas due to their stable landscape. The growing cities, e.g., Dhaka, Gazipur, Narayanganj, Tangail, Bogura, Naogaon, Joypurhat, Dinajpur, and Lalmai area of Cumilla, are located over this unique variety of residual soil. These areas are urbanized rapidly, which expands laterally as well as vertically. The red clay soils serve as a shallow foundation layer in these areas for low to moderately load-bearing superstructures. Therefore, the aim of this research is to evaluate the engineering geological properties of red clay soils that were collected from the Barind Tract (the largest Pleistocene Terrace) in two boreholes by combining the light cable percussion drilling method and the standard penetration test (SPT) method. The lithology of the investigated soil reveals that it is reddish brown to yellowish in color, mottled, and occasionally contains manganese tints and iron concretions. The field SPT values indicate that the ground condition of the soil is mainly stiff to hard. The red clay soils are fine-grained, composed predominantly clay-sized particles (42% to 59%), with lower amounts of silt (26.31% to 36%) and sand (14.5% to 30%). Mineralogically, the soils mainly composed of illite (77% to 89%) over kaolinite (11% to 23%) with a small amount of smectite. The liquid limit values range from 33.75% to 52.7%, plastic limit values from 13.88% to 21.27%, and plasticity index from 16.36% to 32.26%. According to the British soil classification system, clay soils are characterized as low- to high-plasticity inorganic clay and classified as CL to CH. The activity (0.42 to 0.73) value suggests the soil is inactive. However, the high linear (11.07% to 16.64%) and volumetric shrinkage (24.34 to 36.19%) values reveal that these soils are critical in nature, with a shrinkage ratio of 1.82 to 2.03. The soils exhibit medium to high swell potential based on the plasticity index and clay content plot. The 3D swelling test results indicate that the rate of swelling strain normal to the bedding plane is greater than the rate of swelling strain parallel to the bedding. In terms of consolidation, the soils are overconsolidated with an overall lower settlement, stiff to hard consistency, medium to very low compressibility, medium to low plasticity, and low permeability. Despite having a poor index and swell-shrink characteristics,

the consolidation behavior suggests that this soil is suitable for low- to moderately load-bearing superstructures. This engineering geological information is valuable for stakeholders, including land developers, urban planners, policymakers, geotechnical engineers, and the local population, aiding in informed decision-making for construction and development in these areas.

Keyword

Red clay soils, standard penetration test, clay mineralogy, shrinkage and swelling, soil consolidation

Successful Replacement for Slope Stability Enhancement in Group-housing Site

BYUNG DON RO[1]*, Architecture Safety Center, Gangseo-Gu, Seoul, Korea (engeo@naver.com)

Abstract

In the case of a cut slope, when exposed for a long period of time in the air, weathering progresses rapidly, and rock mass or shallow sliding on the surface layer often occurs. In particular, slopes with frequent joint or crack are likely to gradually be destroyed because sliding may occur between each nail or rock bolt installation point when reinforced only with nails or rock bolts.
As a common countermeasure to this, cover with shotcrete while installation of rock bolt or soil nail. However, due to the nature of the material, rigid surface-reinforcing such as shotcrete cause cracks easily, ductile deformation within the slope surface cannot be allowed, and there is a possibility of falling out due to seepage in the back surface. It also has the disadvantage that greening is difficult and the landscape is poor. In the case of ductile surface-reinforcing, it is difficult to apply to steep slopes, and there are restrictions due to the strength of the material itself (geotextile or geo-membrane), so it is particularly difficult to apply it to rock slopes. A flexible surface-reinforcing, which combines the advantages of rigid and plastic method, while allowing a certain amount of displacement within the slope supports, so it has excellent applicability on soil and rock slopes, and can be applied in combination with nailing. Furthermore, in terms of environmental friendliness, it is possible to plant planting and greening slopes, and also minimizes maintenance costs. Currently, the development trend of slope stabilization methods around the world is an environmentally friendly construction method and can be restored to a natural state, and research and development is being carried out in the direction of minimizing future maintenance costs.

Keyword

slope stability, flexible surface-reinforcing, BYUNGDON RO

Paleostress from healed microcracks and fluid inclusions in granites in the northeastern and southwestern areas of the Ogcheon folded belt, South Korea

Seong-Seung KANG[1]*, Chosun University (kangss@chosun.ac.kr)
Bo-An Jang[2], Kangwon National University
Taeyoo Na[3], Korea Institute of Geoscience and Mineral Resources
Jeongdu Noh[4], Jeonnam Research Institute

Abstract

In the northeastern and southwestern areas of the Ogcheon folded belt, where Mesozoic granites are distributed, measurements were taken of healed microcracks and fluid inclusions within the granite bodies to elucidate the paleostress field that acted upon these areas. The predominant orientations of healed microcracks in the northeastern and southwestern areas of the Ogcheon folded belt are as follows: N50°W for the Inje granite, N30°W for the Jecheon granite, N55°W for the Wolaksan granite, N5°W for the Sobaeksan granite, N30°W for the Daebo granite, and N70°W for the foliated granite. The homogenization and trapping temperatures of fluid inclusions, along with the estimated formation periods of healed microcracks, are 170-290°C, 260-390°C, and 209-149 Ma for the Jecheon granite; 165-290°C, 250-400°C, and 176-160 Ma for the Inje granite; 165-375°C, 230-570°C, and 116-88 Ma for the Wolaksan granite; 155-280°C, 210-410°C, and 92-84 Ma for the Sobaeksan granite; 150-310°C, 380-550°C, and 120-166 Ma for the foliated granite; and 150-320°C, 380-440°C, and 183-166 Ma for the Daebo granite, respectively. Consequently, during the Mesozoic era, the predominant maximum horizontal stress direction in the Korean Peninsula was NW-SE, with secondary influences from N-S and E-W directions. Moreover, it is thought that the direction of these maximum horizontal stresses rotated from NW-SE to N-S around the mid-Cretaceous period. The directions and formation periods of healed microcracks in the study area align well with the Mesozoic orogenies of the Korean Peninsula. The Daebo orogeny, occurring from the Jurassic to early Cretaceous, primarily influenced the Jecheon granite, Inje granite, Wolaksan granite, foliated granite, and Daebo granite in a NW-SE direction, while the Bulguksa orogeny, from the mid to late Cretaceous, mainly influenced the Sobaeksan granite in a N-S direction.

Acknowledgement: This study was supported by research fund from Chosun University (K205769013-1-1).

Keyword

paleostress, healed microcrack, fluid inclusion, homogenization temperature, Ogcheon folded belt

Comparative analysis of slope stability assessment using LightGBM and CatBoost

Jeongdu Noh[1], Jeonnam Research Institute
Dahye Kim[2], Chosun University
Youngshin Park[3], Chosun University
Seong-Seung KANG[4]*, Chosun University (kangss@chosun.ac.kr)

Abstract

Machine learning prediction models, LightGBM and CatBoost, were utilized to assess the stability of slopes. The slope prediction models were classified into three types: Case-1 composed of 9 numerical data, Case-2 composed of 22 categorical data, and Case-3 composed of 31 mixed numerical and categorical data. Model results for each analysis stage were evaluated and analyzed based on training performance, prediction performance, and variable importance. Analysis using the LightGBM model for slope stability prediction showed that the AUC values were 0.681 for Case-1, 0.766 for Case-2, and 0.783 for Case-3. While training and test data showed similar learning performances in Case-1 and Case-2, overfitting was observed in Case-2. In terms of prediction performance, the precision, recall, F1-Score, and accuracy for training and test data were 73% and 68% for Case-1, 79% and 77% for Case-2, and 84% and 78% for Case-3, respectively. Variable importance was in the order of slope length, upper slope gradient, and slope gradient for Case-1; rock type, surrounding terrain for Case-2; and soil layer depth, upper slope gradient, slope gradient, slope length, slope height for Case-3. In the analysis using CatBoost, AUC values were 0.672 for Case-1, 0.777 for Case-2, and 0.794 for Case-3. Similar to LightGBM, Case-1 showed similar learning performance between training and test data, but overfitting was evident in Cases 2 and 3. Prediction performance metrics such as precision, recall, F1-Score, and accuracy for training and test data were 70% and 67% for Case-1, 86% and 78% for Case-2, and 90% and 79% for Case-3, respectively. Variable importance was in the order of soil layer depth, upper slope gradient, slope height for Case-1; discontinuity orientation, side shape, surrounding terrain for Case-2; and soil layer depth, discontinuity orientation, side shape, discontinuity type for Case-3. LightGBM did not show prediction imbalance across the three interpretation methods and exhibited similar training performances between training and test data. Numerical data showed relatively higher importance, with rock type and surrounding terrain being significant among categorical variables. CatBoost, except for Case-1, showed more significant overfitting in training data compared to LightGBM. Categorical data showed relatively higher importance in variable significance, with soil layer depth being the most significant, followed by discontinuity orientation, side shape, and discontinuity type among categorical variables. Consequently, LightGBM could be considered the most stable model for predicting slope stability, while CatBoost could be considered the most accurate model for this purpose.

Acknowledgement: This research was supported by “Regional Innovation Strategy (RIS)” through

the National Research Foundation of Korea (NRF) funded by the Ministry of Education (MOE) (2021RIS-002).

Keyword

machine learning, LightGBM, CatBoost, slope stability, prediction model

A comparative study of cation exchanges in 'extreme types of clay minerals' to modify the swelling index of the foundation soil underlying the civil engineering structures

Sudipta SARKAR[1]*, Retired Deputy Director General from Geological Survey of India (sudiptaashish@yahoo.co.in)
Ashish Sarkar[2], Retired Associate Professor from Pandit Deendayal Petroleum University, Gandhinagar, India

Abstract

Essential components of the soils are phyllosilicates in the form of clay minerals, a product of chemical weathering of other silicates. While weathering of basic and ultrabasic rocks produce smectite group of clay minerals, feldspar rich rocks produce kaolinite. The geotechnical properties of smectites and kaolinite are vastly different. Presence of various groups of clay minerals in the soils are responsible for wide variation in the foundation property of the soil, which in turn control the stability of the civil engineering structures (CES) erected on it. Among the other geotechnical properties, swelling index is a very important and a very significant geotechnical parameter determining the stability of the CES. While, under the influence of water, kaolinites do not swell much; montmorillonite, a significant member of smectites, swells 'infinitely' causing instability to the CES.

The swelling index of the soil containing clay minerals can be effectively modified by treating it with the chlorides of different cations resulting in the 'cation exchange' in the structures of the clay minerals. But the process of cation exchange in the soils containing both smectite and kaolinite becomes tricky as these clay minerals respond differently to the different cations. To address this problem, a series of experiments were carried out in the present study. In order to determine and understand the amount of cation exchange vis-a-vis modification in the geotechnical properties of soil samples, a total of 36 aliquots of each montmorillonitic and kaolinitic soil were treated with CaCl2, MgCl2, NaCl, and KCl with 0.5N, N, and 2N concentrations and were cured for periods of 7, 15, and 21 days following standard procedures. Swelling Index of the untreated (soaked in double distilled water) montmorillonitic and kaolinitic soils, and each of the total 72 treated samples were determined following the standard procedures. Ammonium Acetate and double distilled water extracts of each of the treated montmorillonitic and kaolinitic soil samples have been analysed in the ICP-ES system following the standard procedures to understand the cation (Ca++, Mg++, Na+, and K+) exchange behaviour in each of the treated montmorillonitic and kaolinitic soil samples.

The experimental data reveal that while treatment with different cations in treated montmorillonitic soil results in lowering in swelling index at the combination of 2N concentration and lower curing period in general with all the cations, the best reduction in swelling index

(~15%) is obtained at the concentration of 2N with a curing period of 15 days. Interestingly, barring only one sample (at 2N MgCl2 with 7 days curing period), all other (35 samples) treated kaolinitic soil samples show enhancement of swelling index from 11 to 53%. The results depict that if the foundation soil of the CES contains substantial amount of kaolinite along with montmorillonite, cation treatment should be avoided, even though the cation exchange proves to be an effective method of lowering the swelling index of montmorillonite.

Keyword

Montmorillonite, Kaolinite, Swelling Index, Geotechnical Property, Cation Exchange

Rockslides and Rock Avalanches in the Upper Part of Mzymta River Valley (Caucasus, Russia)

Oleg V. ZERKAL[1]*, Moscow St. University, Geological Department (igzov@mail.ru)
Alexander A. PONOMAREV[2], "EngZashita" Ltd., Sochi, Russia
Andrey A. PONOMAREV[3], "EngZashita" Ltd., Sochi, Russia
Olga S. BARYKINA[4], Moscow St. University, Geological Department

Abstract

The valley of the Mzymta River, which flows into the Black Sea, is located in the southwestern part of the Caucasus (Russia). The Caucasus mountain system is a collisional orogen that was formed on the southern border of the East European Platform as a result of the interaction of the Eurasian and Arabian lithospheric plates. The geological section of the Mzymta River valley is composed of Lower Jurassic terrigenous flysch (right side, lower part of the left side) overlain by Middle Jurassic volcanogenic-terrigenous strata (middle and upper parts of the left side). The regional tectonic suture (the Main Caucasus thrust) is located slightly to the north (~4 km).

The present-day valley of the Mzymta River in this area has a complex character. Its left side is formed by the Aibga Ridge with a relative height of up to 1.5-1.7 km. The right side of the valley is formed by a series of lower ridges (Achishkho, Pseakhako and others) with a relative height of less than 1.0 km. The valley of the Mzymta River is an alternation of narrow linear sections, where the channel has a V-shaped form with sharp drops in elevation, and relatively wide sections of the trog type, with the presence of several floodplain terraces. The studies have shown that the present-day appearance of the Mzymta valley is associated with the wide development of large-scale rockslides and rock avalanches, the frontal parts of which reached the valley bottom or overlapped it.

Based on the results of mapping (aerial photographs and satellite image analysis, field investigations), six rock avalanches with volumes ranging from 145 million m3 to more than 310 million m3, 31 rockslides and rock avalanches with volumes ranging from 10 million m3 to 95 million m3, and several hundred smaller landslides have been described in the Mzymta River valley. The rockslides, typically formed in terrigenous flysch, are located in the middle and lower parts of the valley sides. The source areas of rock avalanches are located in the tributary part of the Aibga Ridge, within the area of distribution of Middle Jurassic volcanogenic deposits. The frontal parts of rock avalanches reach the Mzymta River channel and often extend to the opposite side of the valley. Due to the insignificant width of the channel part of the valley, the dynamic impact of rock avalanches provoked displacement of "counter" rockslides from the opposite side of the valley. This is one of the peculiarities of the development of rockslides and rock avalanches in the upper part of Mzymta river valley.

Keyword

rockslide, rock avalanche, Caucasus

A Basic Study on the Development of Trenchless Excavation Technology and Construction Method

YONG BAEK[1]*, KICT (baek44@kict.re.kr)
JIN HWAN KIM[2], KICT
JONG HYUN LEE[3], KICT

Abstract

Hydrogen is essential as a future energy industry, and it is expected that the supply of hydrogen energy will be activated. In order to secure localization of hydrogen pipe network construction technology in consideration of the characteristics of demand and production sites such as hydrogen cities, the current status of excavation technology is re-examined according to the characteristics of the ground field. It is necessary to develop construction technology roughly into an excavation method and a trenchless excavation method in accordance with the characteristics of the domestic ground. Therefore, the current status of the excavation technology used in Korea was investigated and analyzed, and the applicable method was suggested according to the characteristics of the domestic ground. Develop a trenchless excavation method for domestic hydrogen pipe network construction by deriving improvement plans or suitable technologies for the applied technology in accordance with the strengths and weaknesses of each ground characteristic. It is to localize the trenchless excavation method by improving the localization and the inefficient operation plan. In the case of weathered rock or abnormal ground, there is a possibility of excavation work, but in the case of hard rock, there may be a problem with the construction speed, so the ground characteristics may be a problem. It is necessary to develop management technology for the stability of construction during the construction process. For maintenance, this study introduces maintenance technology and sensing technology in a visible and intuitive manner using a contactless sensor. The collected data can be acquired and analyzed through a transmission system. By incorporating customized communication equipment and technology into regional characteristics, the focus was on safety during construction. In addition, the data of the construction process can be used from the beginning of the work to the operation by leading to maintenance and operation. The utility of this study is to safely construct the hydrogen pipeline and secure highly efficient equipment design and construction technology for safe hydrogen transfer in the city. In addition, it is intended to lead to localization and practical use of development technology, thereby reducing the cost of building the hydrogen pipeline.

Keyword

Hydrogen pipe network, Bedrock, Ground environment, Trenchless excavation technology, hydrogen energy

Investigating physico-chemical and mechanical properties of Cretaceous sandstones within Khorat Cuesta, Northeastern, Thailand

Prachya Tepnarong[1]*, School of Geotechnology, Institute of Engineering, Suranaree University of Technology (prachya@sut.ac.th)
Anisong Chitnarin[2], School of Geotechnology, Institute of Engineering, Suranaree University of Technology

Abstract

Clastic sedimentary rocks within the UNESCO Khorat Geopark in Nakhon Ratchasima Province, northeastern Thailand are examined for physical, chemical and mechanical properties. The natural exposures on the western border of the Geopark area including Phra Wihan (PW), Phu Phan (PP) and Sao Khua (SK) Formations were investigated. At each locality, primary and secondary structures were inspected, rock types were initially identified, then the representative samples were collected. The polished sections were prepared to classify the rocks, physical characteristic such as grain size, texture, type of gravels, cementing materials were also defined. Sets of rock samples were prepared to determine their mechanical property following ASTM. Rock samples belonged to the Phra Wihan and Phu Phan Formations which exposed naturally as a double cuesta were classified as fine- to coarse-grained sandstones and conglomeratic sandstones. Rock samples of the Sao Khua Formation represented a valley between the double cuesta are consisted of very fine-grained sandstones, conglomerates, and calcrete. PW and PP samples tend to have lower density but higher porosity than SK samples, and range between weak to strong rock types. SK samples have high density, low porosity, and are assigned to strong to very strong rock types. It is found that Point Load Strength Index and Slake Durability Index of the rocks correlate well with the density, therefore; SK samples are stronger and more durable than PW and PP samples. Rock strength does not pertain with silica and clay mineral contents but refers to percentage of calcite. Calcite cementation and deposition in SK samples should play important role in weathering and development of the Khorat Cuesta.

Keyword

Khorat Group, Khorat Geopark, Point Load Strength Index, Slake Durability Index, Sandstone

Evaluation of operating cost and economic feasibility of a limestone open pit mine in Korea

Dong-Kil LEE[1]*, Korea Institute of Geoscience and Mineral Resources (ldk@kigam.re.kr)
Jae-Ho Lee[2], Korea Institute of Geoscience and Mineral Resources
Ji-Whan Kim[3], Korea Institute of Geoscience and Mineral Resources
Yong-chan Cho[4], Korea Institute of Geoscience and Mineral Resources

Abstract

As difficulties in securing ore production are expected due to a decrease in the ore reserves in the mining area under development, a preliminary feasibility assessment was conducted for a mine planning to develop a new ore body in adjacent mining area under development. For this purpose, a final pit was designed based on a grade block model of the ore body, and a production schedule planning for 11 million tons per year was established. Based on the established production plan and engineering mine design, a preliminary feasibility assessment over the entire life of the mine was assessed as of 2020. As a result of comparing the cost of Korea's limestone open pit mines investigated after the evaluation point and the cost evaluated in 2020, the unit operating cost of this study was found to have an error of -1.9% compared to the domestic average cost, and an error of -8.8% compared to the cost of the mine. In this study, it was evaluated that the mine mines limestone itself, but in reality, the mine mines limestone by outsourcing it to other companies. It is considered that this error occurred for this reason. The development of a new mining area in this mine showed good economic feasibility with a discount rate of 4.5%, an net present value (NPV) of KRW 174.2 billion, a internal rate of return (IRR) of 59.2%, and a B/C ratio of 1.30 based on present value. As a result of a sensitivity analysis, it was found that the main factor affecting economic feasibility was the price of ore.

Keyword

open pit mine, limestone, preliminary feasibility study, operating cost

Case of Rockmass Classification in the Submarine Ground Where Marine Investigation is Difficult Due to Rapid Current

Seong-Woo MOON[1]*, Chungbuk National University (msw2080@naver.com)
Jeong-Eum Lee[2], Chungbuk National University
Se-Jeong Ju[3], Chungbuk National University
Yu-Jin Ha[4], Chungbuk National University
Yong-Seok Seo[5], Chungbuk National University

Abstract

This study carried out to conduct rock mass classification in sections that have been drilled without cores, connecting the mainland and an island in the southwestern part of the Korean Peninsula. The sea of the study area has the fastest current (up to 6.5m/s) in the Korean Peninsula, making marine drilling surveys using barge difficult. Additionally, the inclined drilling for the submarine pipeline installation is kind of a drilling type, not a boring type that can recover samples, and only the fractured rock fragments can be recovered as slimes. For these reasons, it is difficult to conduct directly rock mass classification.

Therefore, the types of rock masses distributed around the study area were first identified using geological surveys of land outcrops and the results of drilling surveys conducted near land and the coast. After mechanical properties of rocks were then acquired through core observations, ultrasonic tests, and unconfined compressive tests, and rock classification was performed on the sections of rock cores that could be observed. After that, gamma-ray logging was conducted at regular intervals in the submarine pipeline (inclined drilling) section, and the gamma-ray results were compared to the results of rock classification. For the submarine ground where it was difficult to carry out rock classification through visual observation, the rock classification of the submarine ground was performed by matching the gamma-ray values and the distribution of rock masses (inferred from the results of drilling surveys on land and the coast).

Keyword

submarine rockmass, rockmass classification, geological investigation, laboratory test, gamma-ray logging

Experimental study on mechanical properties of pore-filling and fracture-filling clayey silt hydrate-bearing sediments

Yiming LI[1]*, jilin university (1192718979@qq.com)
Wei Guo[2], Jilin university
Yuan Wang[3], Jilin university
Rui Jia[4], Jilin university

Abstract

The filling characteristics of hydrate have significant influences on the mechanical properties and failure mechanisms of sediments. In this study, two typical filling characteristics of hydrate were selected, which were pore-filling and fracture-filling (layered) in clayey silt sediments, the mechanical response characteristics of pore-filling hydrate-bearing sediments (PFHBS) and fracture-filling hydrate-bearing sediments (FFHBS) were compared and analyzed through a series of triaxial tests. The results show that PFHBS and FFHBS exhibit significant differences in mechanical properties under identical conditions. The stress-strain relationships of clayey silt sediments with varying hydrate saturation are influenced by the filling characteristics of the hydrate. The enhancement effect of hydrate on the strength parameters of the sample at the same saturation increment is influenced by the filling characteristics. The failure strength, Young's modulus, and shear strength indexes of FFHBS surpass those of PFHBS under identical hydrate saturation conditions, while FFHBS exhibits a greater volume expansion than PFHBS. The number of fracture layers in FFHBS exhibits a positive correlation with the strength parameters of the sample, yet intensifies the phenomenon of volume expansion. In addition, the filling characteristics of pore hydrate and fracture hydrate determine that the sediments exhibit different strength enhancement and shear mechanisms. The results provide valuable references for the selection of target hydrate reservoir sites and the design of safe exploitation in various target areas.

Keyword

Hydrate filling characteristics, Pore-filling hydrate, Fracture-filling hydrate, Hydrate-bearing sediments, Strength and deformation

Engineering geological studies and expected support design during the construction of diversion tunnels, Renukaji Dam Project, District Sirmaur, Himachal Pradesh, India

TRIPTI BABA[1]*, Geological Survey Of India (tripti.baba@gsi.gov.in)
Prashant Ilamkar[2], Geological Survey Of India

Abstract

Renukaji Dam Project envisages construction of a 178m high rock fill dam across Giri River, near Dadhau town, Sirmaur district, Himachal Pradesh, India. The main components of the projects are three circular (10.50m finished diameter) diversion tunnels of 1355.46 m, 1549.76 m and 1448.90 m lengths, a surface power house of 40 MW capacity located on the right bank and a 550m long chute spillway on left bank of the Giri River.

The proposed diversion tunnel would pass through the repetitive sequence of rocks of pink shale followed by pitted, crumbly, cavernous limestone and bedded limestone of Krol Group and carbonaceous slates and bleached shales of Infra Krol Formation due to folding in nature. These are expected to behave as weak tunnelling media & would offer little stand up time. However, drill hole data drilled along the alignment of the diversion tunnel have established the presence of adequate rock cover above the tunnel grade having very poor to poor RQD. The project area also bounded by two major thrusts viz., Main Boundary Fault (MBF) exposed in the d/s and Renukaji Thrust in the u/s of the propose dam axis due to which rocks can be seen as folded, highly jointed, sheared and fractured at many places along the DTs.

Rock mass rating (RMR), Rock mass quality (Q), Geological Strength Index (GSI) systems, Weathering Grade and UCS as per IS Code were used for empirical rock mass quality determination, site characterization and expected support design.

According to the field based studies, tunnel stability problem expected in the carbonaceous shale/siltstone/phyllite and limestone bands observed in bedded form forming synclinal closure near to the proposed dam axis. The expected support system, suggested by empirical methods, was given but the performance of suggested support system must be evaluated by means of numerical modelling during the construction of the diversion tunnels. Reducing the width of the tunnel should also to be considered depending on the discharge and storage capacity of the river/reservoir.

This paper presents the results of surface engineering geological investigations along proposed DTs and recommendations rendered accordingly during the field studies. These include engineering geological mapping, intensive discontinuity surveying, drill hole logging and empirical field tests.

Keyword

Rock Mass Rating, Engineering Geology, Q, GSI, Tunnel support design, RQD, IS Code,

diversion tunnel, drill hole logging

Review on geological and engineering aspects of gypsum solubility and dissolution in the Arabian Gulf coast

Sungbin YIM[1]*, KEPCO E&C (sbyim@kepco-enc.com)
Joohyeon YI[2], KEPCO E&C
Hyunseok YUN[3], KEPCO E&C
Yongwoo NOH[4], KEPCO E&C
Jihwan SHIN[5], KEPCO E&C

Abstract

Evaporitic geology, hot and arid climate, fluctuating relative humidity, and alkaline environment governs the evolution of gypsiferous rock formation in the Arabian Gulf coast. In this area, gypsum beds are interspersed within the Miocene and Eocene sediementary formations. Unusually, small opening and network of small-diameter passages with cavities are developed within gypsiferous rock formation.

Calcium sulphate generally occurs naturally as two different forms of anhydrite (CaSO4) and gypsum (CaSO4·2H2O) in the local formation. Hydration of anhydrite and dehydration in gypsum lead to alternating volume changes, thereby posting serious engineering problems.

The engineering properties of gypsum and anhydrite change as a consequence of groundwater pressure and heat. The two basic problems cause the subsidence due to the solubility characteristics of gypsum and heave due to the hydration of anhydrite. Generally, gypsification of anhydrite is associated with up to 63% swelling and dehydration of gypsum to form anhydrite results in a maximum volume reduction of 39 % (Zanbak and Arthur, 1986).

Especially, gypsum is susceptible to rapid dissolution wherever there is active circulation of water that is unsaturated with respect to calcium sulfate.

CaSO4·2H2O+H2O → Ca+SO4-2+3H2O

In underground system, chemical solution trends to occur along existing discontinuities, e.g. joints and faults. Thus, until a late stage of development, karstic gypsum terrains usually have cavity patterns related to the discontinuity geometry. Karst features in the gypsum usually consist of a network of small-diameter passages (Culshaw and Waltham, 1987). If gypsiferous rock is massive and jointed, large openings are created along preferential flow paths (Karacan and Yilmaz, 1987).

Many studies have been undertaken on the solubility and dissolution of gypsum in the context of construction engineering and karst processes. In this study, the dissolution characteristics of gypsum are reviewed through both field observations and literature studies.

Keyword

gypsum, anhydrite, hydration, dehydration, dissolution

Mainstreaming urban geoheritage as a tool for environmental education and geotourism in local administrations

Juana VEGAS[1]*, Geological Survey of Spain (IGME-CSIC). Spain (j.vegas@igme.es)
Andrés Díez-Herrero[2], Geological Survey of Spain (IGME-CSIC). Spain

Abstract

In 2022 there will be more than 8 billion people on our planet and currently around 56% of the world's population lives in cities. For millions of people the little 'nature' in urban environments, together with gardens, zoos and parks are the only option for real contact with biodiversity and geodiversity. Geoheritage and geodiversity are also present in many cities and form part of their skyline, with rock outcrops in streets and squares, which may contain fossils in the case of sedimentary rocks. The wide variety of ornamental rocks on building walls and interiors are also a resource at our disposal. The movable geological heritage in collections and museums allows us to enjoy elements that are accessible to all audiences (including people with disabilities). Not forgetting the rock gardens in some cities. The relationship between the geology and the historical-artistic buildings is highly remarkable, through the location of the quarries from which the raw materials were extracted, the traditional trades, the foundations of monumental buildings, and even legends, children's stories and miraculous with a geological background. This social reality shows the great potential of urban geoheritage as an asset for the promotion of environmental education, geotourism and the health of people living in or visiting cities.

A paradigmatic case in the integration of geoheritage in land-use planning, environmental education programmes and urban geotourism is the city of Segovia (Spain). Due to its position on the Iberian Peninsula (SW Europe), Segovia's geological record covers the last 600 Ma of Earth's history. A detailed inventory of the municipal district was compiled that containing 94 geosites, where four of them are collections of minerals, rocks and fossils (movable geoheritage). An assessment method of the geoheritage for environmental education and geotourism in the urban areas was designed, including six main criteria that specifically assess aspects of environmental education, geohazards, global change and geotourism. The potential users of environmental education in the city have also been considered: students of primary, secondary and university education, families in their leisure time, visitors and people with disabilities. This assessment of the geoheritage is a novel design worldwide, and this is the first time that it has been implemented and applied to a city. This model can be replicated in any other urban area. Understanding Segovia's geological past and present through environmental education and geotourism generates more resilience among people when tackling important issues in our society such as climate change and its effects on the urban ecosystem and people.

Keyword

local government, environmental education, geotourism, urban geoheritage, Segovia

The monitoring of land subsidence and groundwater level in the southeast Kanto groundwater basin, Japan

Atsushi KAGAWA[1]*, Research Institute of Environmental Geology, Chiba
(kagawaa2016@gmail.com)
Kunio FURUNO[2], Former Institute of Environmental Geology, Chiba

Abstract

The Kanto groundwater basin is composed of Pleistocene marine sediments, Kazusa group and Shimosa group. The number of observation wells for monitoring groundwater level condition in the basin was 375 in total as of 1982 and 471 as of 2020. Chiba Prefecture is located in southeast part of the basin; and as of 2020 land subsidence has been monitored by 159 wells and 1075 benchmarks. Based on continuous monitoring, the mechanism of land subsidence is now reasonably well understood.

Kazusa group contains brine groundwater including natural gas and iodine. Heavy land subsidence occurred in 1970s and was due to gas production. Since that time, groundwater-pumping regulations have been strictly enforced in the Tokyo Bay area. Therefore, the pumping is now limited to the marginal area of the basin. Shimosa group has been extensively pumped, mainly for public water supply, agricultural and industrial use. Groundwater in the aquifer fell to its lowest level at the coastal industrial zone of Tokyo metropolis in the 1960s to early 1970s. National government and local governments then regulated groundwater using. Annual pumped volume of the southern Kanto groundwater basin was 4.0 million m3/day in 1973 and 1.6 million m3/day in 2020. After that, the recovery of the groundwater level was monitored according to the pumping up control. Recently, the lowest groundwater level in the lower aquifer has been around 10 m below sea level.

Our general hydrogeologic investigations now show that we can reasonably pump groundwater in the Kanto Basin without causing undue land subsidence. Nevertheless, groundwater pumping requires constant monitoring for sustained use.

Keyword

Kanto groundwater basin, groundwater level, land subsidence, monitoring well

Characterizing Groundwater Drought-Induced Land Subsidence Dynamics in Economic Hub of State of Gujarat, India

Anuradha Karunakalage[1]*, Indian Institute of Technology Roorkee (anuradha_s@es.iitr.ac.in)
Mohammad Taqi Daqiq[2], Indian Institute of Technology Roorkee
Marc-Henri Derron[3], University of Lausanne
Ravi Sharma[4], Indian Institute of Technology Roorkee
Michel Jaboyedoff[5], University of Lausanne

Abstract

The economic capital of the state of Gujarat, Ahmedabad, exhibits a semi-arid climate prone to droughts, with a variable surface water supply. The city experienced significant municipal and industrial expansion, alongside meeting the demand from the neighbouring agricultural areas reliant on groundwater irrigation. Groundwater in this region is stored within a complex aquifer system characterized by alternating layers of coarse and fine-grained sediments, with the latter acting as aquitards. Hence, fluctuations in groundwater levels can possibly be associated with the deformations of the land surface to both the elastic and the inelastic deformations in the underlying strata. State-of-the-art remote sensing techniques highlighted land subsidence as a prevalent occurrence in cities across the northwestern region of India, and the land surface deformation in Ahmedabad was first unveiled in 2021. However, the influence of groundwater drought on land subsidence in Ahmedabad and the relative compaction and its nature among the subsurface strata have not been discussed in any previous scientific work. The present study observed maximum vertical subsidence rates of 9.1 cm/year in the southeast and 7.2 cm/year in the western parts of the city between October 2017 and March 2020, utilizing the Small Baseline Subset (SBAS) technique in Interferometric Synthetic Aperture Radar (InSAR). Building upon these findings, the study aims to identify the period of initial compaction occurrence and its nature and estimate the spatial distribution of deformation type in the city. Additionally, it seeks to establish correlations between land subsidence and groundwater drought events to understand the dominant spells of drought-induced compaction. The anticipated information and findings of this study hold potential benefits for simulating long-term compaction processes within fine-grained layers, its interplay with the coarse-grained sediments, and offer comprehensive insights for water management and urban development authorities to mitigate the risk of infrastructure damage.

Keyword

InSAR, Land subsidence, Nature of compaction, Groundwater drought

Bridging the Data Gap with 3D Geoscientific City Models (GeoCIM): A case study of the Liberec municipality, Czech Republic

Jan JELENEK[1]*, Czech Geological Survey (jan.jelenek@geology.cz)
Zita Bukovská[2], Czech Geological Survey
Ondřej Švagera[3], Czech Geological Survey
Lucie Koucká[4], Czech Geological Survey
Martin Paleček[5], Czech Geological Survey
Jan Jelínek[6], Czech Geological Survey
Jan Malík[7], Czech Geological Survey
Tomáš Hroch[8], Czech Geological Survey
Jaroslav Řihošek[9], Czech Geological Survey
Josef Klomínský[10], Czech Geological Survey

Abstract

With cities growing, the pressure on the urban subsurface has become a significant challenge in urban development. Limited understanding of subsurface conditions can lead to costly conflicts and damages during construction. The data Exchange between geological surveys, municipalities and urban planners may help to mitigate these risks and potentially prevent spending large amounts of funds on remediation works.

Geological surveys often possess extensive amount of archival data on the urban subsurface, encompassing various geoscientific domains. However, these data are not usually used during the urban planning or the decision-making processes by the municipalities. The absence of direct data links and user-friendly visualization tools hinders effective communication between geoscientists and urban stakeholders. The Geoscientific City Model (GeoCIM), conceptualized by European Urban Geology experts within EuroGeoSurveys (EGS), offers a promising solution to this challenge. It envisions a 3D subsurface model that facilitates seamless data exchange, bridging the knowledge gap between disciplines.

This study presents a pilot 3D GeoCIM for the city of Liberec, Czech Republic. The core objective was to create a user-friendly platform for the Liberec municipality to access and utilize pre-processed and visualized subsurface data held by the Czech Geological Survey. The 3D model integrates newly interpreted archival data with existing sub- and on-surface information from the city (engineering networks, technical objects) and historical underground structures (shafts, tunnels, bunkers, cellars) documented by the Museum of North Bohemia. Such comprehensive data integration helps uncover potential conflicts that could arise during urban planning projects.

The model was built using MOVE software with emphasis on the shallow subsurface providing detailed insights into crucial features like underground water level, tectonic faults or artificial deposits. To ensure convenient access for the municipality, a free, open-source 3D viewer was built on QGIS and Python platforms. This tool allows the municipality to directly query subsurface data at any point on the surface, thanks to a condensed grid-based layer.

This pilot project demonstrates the potential of GeoCIM as an effective tool for integrating

valuable subsurface data into the urban planning process. By bridging the gap between geoscientific knowledge and practical urban development, GeoCIM can foster informed decision-making, minimize conflicts, and contribute to resilient and sustainable city growth.

Keyword

Urban geology, Subsurface 3D modelling, GeoCIM, Urban geoscience, Shallow subsurface

Locations that are prone to liquefy and locations that are difficult to liquefy by strong earthquakes in the Tokyo bay reclaimed land: Knowledge for urban planning that is unlikely to cause earthquake damage

Osamu KAZAOKA[1]*, Reserch Institute of Environmental Geology, Chiba (osamu.kazaoka@gmail.com)
Shoichi Shiozaki[2], Disaster Prevention Equipment Management Department, Chiba Prefecture government
Takahiro Kojima[3], Reserch Institute of Environmental Geology, Chiba
Atsushi Kagawa[4], Reserch Institute of Environmental Geology, Chiba
Takeshi Yoshida[5], Reserch Institute of Environmental Geology, Chiba
Hisashi Yabusaki[6], Reserch Institute of Environmental Geology, Chiba
Shun Kameyama[7], Environmental Living Department, Chiba Prefecture Government
Itaru Ogitsu[8], Environmental Living Department, Chiba Prefecture Government
Naoto Ito[9], Environmental Living Department, Chiba Prefecture Government
Mitsuo Sato[10], Shinko Engineering Co., Ltd.

Abstract

Damage caused by liquefaction and fluidization was seen at the Tokyo bay reclaimed land on the 1987 east off Chiba Prefecture Earthquake and the 2011 off the Pacific Coast of Tohoku Earthquake. The damage was concentrated in multiple bands about 500m wide extending northeastward. Elucidating the cause of this problem geologically can contribute to planning cities that are resilient to disasters. For this reason, we have investigated by continuous borings and dynamic cone penetration tests in more than a dozen sites where liquefaction and fluidization have occurred. Here, we will summarize the results of these surveys and examine the distribution of damage based on the base distribution of the Holocene formation and the seismic amplification status of the Holocene formation measured by underground seismometers.

Almost of the Tokyo bay reclaimed land were filled by the sand pump system from the mid-1960s to the mid-1980sThe reclamation material was supplied by dredging alluvial and shallow-marine late Pleistocene strata on the sea bottom of adjacent the Tokyo bay.

The results of geological surveys in and around areas where liquefaction-fluidization phenomena were observed are summarized as follows regarding liquefaction-fluidization.

1. Most of the liquefied strata are sand layers.
2. No liquefaction was observed in most of the shell layer, shelly sand layer, and mud layer.
3. Liquefaction-fluidization is observed when the shelly sand layer is overlain by a well-continuous mud layer laterally.
4. Beneath the reclaimed layer, thick alluvial layers are distributed in a belt-like manner in some areas, and liquefaction-fluidization phenomena are observed in such places, whereas this phenomenon is rarely seen in areas where the alluvial layers are thin.
5. On the 2015 West off Ogasawara Irands Earthquake (Mg: 8.1), we compared the accelerations of a seismometer installed in a reclaimed land where the Holocene formation is thick and a seismometer installed in an adjacent reclaimed land where the Holocene formation is thin. The

acceleration at the base of the Holocene formation is the same. However, the acceleration at the ground surface where the Holocene formation is thick was about 1.5 times that where the Holocene formation is thin.

From the above, it is estimated that in the Tokyo Bay reclaimed land, the shaking during an earthquake was amplified in the thick band-like Holocene formation, the sand layer in the reclaimed layer liquefied and fluidized, and the damage was concentrated within that band. In this way, when planning urban development in coastal reclaimed areas, it is important to consider the facies distribution of the reclaimed layer, the thickness of the Holocene formation, and the amplification of seismic motion caused by this.

Keyword

liquefaction-fluidization, the 2011 off the Pacific Coast of Tohoku Earthquake, Tokyo bay reclaimed land, human made strata, Holocene formation

[Keynote] Safe Urbanization in an Alluvial Terrain (Bangladesh): In the Reality of Seismic Risk and Climate Change

A K M Khorshed ALAM[1]*, Formerly Geological Survey of Bangladesh
(khorshed2024@gmail.com)

Abstract

Bangladesh, a Holocene fluvio-deltaic sedimentary terrain in South-Asia and located in one of the active tectonic regions of the world with a rich archaeological heritage, is the home of nearly 170 million people and a density of 1150 per sq km. Due to the complex regional tectonics and geology the country experiences frequent seismic shaking, and it also faces other natural hazards and impacts of man-made climate change owed to its low elevations. With rapid economic development and population growth in Bangladesh rapid urbanization is going on, occasionally unplanned. At present the urban population is 31.66% which is expected to rise to 80% by 2050. Moreover, the situation would be aggravated and challenging because of the climate migrants imposing pressure on scanty land resources. Hence safe urbanization and planned development activities are essential in the reality of seismicity, land resource and climate change.

During the last about two hundred and fifty years nine >7.0 magnitude earthquakes occurred in this region which changed landforms in many instances, although casualty and damage to infrastructure within the country were low because of low population and weak infrastructures. The country is shaken occasionally by medium to strong earthquakes originated in and around it. However, based on the available earthquake data seismic zoning map of the country was prepared, updated and included to building code. A number of activities such as comprehensive investigations for safe urbanization, geo-information for urban development, and geo-information for urban planning and climate change adaptations have been implemented. Still, investigations for identification of potential seismic sources, characterization of geodynamics and related researches are carried on by different organizations and academic institutions.

Although, people of the country is greatly dependent on its scarce land resources for food and shelter. But, geoscientific data plays pivotal role not only for safe urbanization but also for optimum utilization of land resources. Anyway, for effective seismic risk reduction actions, a better understanding of the complex interplay of regional tectonics and geology is essential. Through this judicious and sustainable use of land and other natural resources, food security, safe and resilient infrastructure and sustainable human settlements, combat climate change and its impact, social justice and gender equality, peace and global partnership can be achieved, vital for the population living in this region. Here the tectono-geologic characteristics and geotechnical properties and their roles in urban safety, combat climate change impacts, needs of its inhabitants and sustainability of resources, and challenges to reach the goals will be discussed.

Keyword

Earthquakes, Safe Urbanization, Bangladesh, Fluvio-deltaic Terrain, Climate Change

Assessment of tunnel stability in active fault zone: Integrating A multidisciplinary approach

Kiwoong PARK[1]*, Pukyong National University (pko8108@naver.com)
Seong-Woo Moon[2], Chungbuk National University
Jeongdu Noh[3], Jeonnam Research Institute
Sambit Prasanajit Naik[4], Pukyong National University
Yong-Seok Seo[5], Chungbuk National University
Seong-Seung Kang[6], Chosun University
Young-Seog Kim[7], Pukyong National University

Abstract

We conducted a tunnel stability analysis utilizing data acquired from the paleoseismological survey to assess the impact of the fault on the tunnel. Through a trench survey conducted in the central part of the Ulsan fault zone, we confirmed the Quaternary faults and obtained paleoseismological data, including displacement and the timing of the most recent earthquake event. To evaluate the seismic safety of the tunnel within the construction area under dynamic loading conditions, we performed dynamic analysis using Midas IT's GTS-NX program. Analysis of ground displacement and stress over time using nodes and elements surrounding the tunnel revealed significant ground stress occurring around the 3.8-second mark, corresponding to the peak ground acceleration. Ground displacement exhibited noticeable differences in both left and right directions based on the fault zone in both static and dynamic analyses. The maximum tunnel displacement induced by dynamic loading was approximately 2.86 cm. Regarding stress distribution, the greatest stress along the X-axis was observed in the lower tunnel, while the smallest was in the upper tunnel. Along the Y-axis, the highest stress occurred in the left tunnel, with the lowest in the upper tunnel. Additionally, the maximum shear stress was highest in the left tunnel and lowest in the lower tunnel. The maximum axial force (member force) of the rock bolt was approximately 74 kN, occurring at the intersection point of faults, which was lower than the allowable tensile axial force (load capacity) of 88.6 kN. Similarly, the bending compression stress (member force) of the shotcrete followed the order of side (approximately 5.7 MPa) > bottom (approximately 5.5 MPa) > ceiling (approximately 2.7 MPa), with a maximum of about 5.8 MPa on the side part. This was below the allowable bending-compressive stress (load capacity) of 8.4 MPa. Upon assessing the seismic safety of the tunnel concerning dynamic loading, it was determined that the load capacity of the tunnel's rock bolt and shotcrete members exceeded the force generated by the earthquake. These results are deemed valuable as fundamental data for analyzing the impacts of faults on tunnels in future studies.

Keyword

active fault, tunnel stability, trench survey

August 2022 monsoon thunderstorm impact on the sedimentation in a tectonically active small catchment; case study of Saydoon dam reservoir, Southern Iran

Arash Barjasteh[1]*, Khuzestan Water & Power Authority (KWPA) (barjasteh@hotmail.com)

Abstract

Saydoon dam site in the eastern part of Khuzestan Province, Iran is located in Izeh Fault Zone of of the active Zagros Fold-Thrust Belt. The present-day configuration of the drainage system in this zone is mainly controlled by transverse faults including formation of linear valleys, landslides, rupturing of rocks and changing water tables in the area. The dam will be constructed over the Saydoon River with a 13.3 km length and a catchment area of about 78.8 km^2. Although the Province is classified as an arid-semi arid region, the dam site region has an average annual rainfall of 790mm. The intense rainfall from the August 2022 monsoon thunderstorm striped away the surficial weathered argillaceous rocks causing significant increase of the bed load sediment within the reservoir area. It also triggered a rock fall near the end of the reservoir mainly composed of calcareous blocks. The exposed rocks are mostly composed of marly and shaly layers of Pabdeh Formation of Eocene Age. It is mostly composed of Marlstones (71%) and marly Limestones (18%) and petrographic analysis indicated that its clay content is about 35 to 45 percent. Most of the bed rock along the river banks is covered by quaternary alluvium deposits that are soft, uncemented and erodible. A paleo-landslide is seen nearly in the middle of the reservoir with a surface area of about 12km^2. Regarding to the August 2022 monsoon event, a re-assessment and calculation of sediment load within the reservoir area is necessary for the project.

Keyword

Saydoon dam site, Izeh Fault zone, monsoon, erosion

[Keynote] Near-fault earthquake multi-hazards

Timothy Austin STAHL[1]*, University of Canterbury (timothy.stahl@canterbury.ac.nz)
Colin Bloom[2], Swiss Federal Research Institute WSL
Erin McEwan[3], University of Canterbury
Corinne Singeisen[4], University of Canterbury
Chris Massey[5], GNS Science
Andrea Wolter[6], GNS Science
Andrew Howell[7], University of Canterbury
Thomas Robinson[8], University of Canterbury
Brendon Bradley[9], University of Canterbury
Robert Langridge[10], GNS Science
Clare Wilkinson[11], NIWA
Tim Davies[12], University of Canterbury

Abstract

The risks posed by surface fault rupture to buildings and infrastructure have been recognised for decades, but Fault Displacement Hazard Analysis (FDHA) is a relatively new field. Other earthquake hazards often spatially coincide with zones of permanent, coseismic ground deformation near surface rupturing faults. Recent case studies have highlighted that coseismic landslides and floods may be exacerbated by tectonic and seismological factors associated with faulting. The 2016 Kaikoura earthquake in New Zealand is an important case study for investigating near-fault multi-hazards. Off-fault deformation zones spanned hundreds of metres and discrete fault displacements were in some places distributed on traces >2 km across strike, highlighting the complex kinematics of faulting and its hazard implications. Coseismic landslides clustered near surface rupturing faults and there is evidence that rock mass damage and/or uncharacterised seismic site effects within fault damage zones influenced the distribution of slope failures. Landslide susceptibility models may be improved by including a fault deformation zone width variable, where possible. Both fault rupture and landslides affected rivers draining some of the highest ranges outside the Southern Alps. In several places, fault rupture caused instantaneous avulsion of streams and in one instance diverted a major braided river. The avulsion event and attendant flooding could have been anticipated using simple hydrodynamic models and pre-event paleoseismic data, lidar, and hydraulic constraints. The results of these studies demonstrate linkages between traditional seismic source characterization and multi-hazard models that reduce the consequences of earthquakes on people and property.

Keyword

Fault Displacement Hazard, Earthquake Multi-hazard, Coseismic Landslides, Coseismic Floods

Landslide susceptibility assessment based on multi-sources data in the Three Gorges Project reservoir area

Ningtao WANG[1]*, Wuhan Center,China Geological Survey (wnt113@126.com)
Runqing Ye[2], 13469992966

Abstract

Landslides result in enormous property damages human casualties, congested river valley and causing shipping disruptions in the Three Gorges Project reservoir area. Landslides are controlled and influenced by many temporal and spatial factors, is a difficult point to landslide susceptibility mapping. Comprehensive understanding of landslides should be based on multi-source data acquisition, information extraction and system analysis. This paper selects landslide-prone area which is from Zigui to Badong as the study area, explores landslide information extraction and hazard analysis based on multi-source data accumulated systematically, focused on the research topic of integration between remote sensing and non-RS information, such as geological map and DEM, for landslide investigation and hazard analysis. Ten thematic maps for landslide susceptibility mapping, including controlling factors and influence factors, were created from the multi-source data, namely geotechnical map, slope map, slope structure map generated from geological map and DEM, and land cover and its changes map, NDVI, NDWI and object-oriented images features extracted from remote sensing images. The Support Vector Machine (SVM) is employed to create landslide prediction map (landslide or no-landslide area with a value of 0 and 1 respectively) and landslide susceptibility map (with a value range 0 to 1), which are useful for landslide hazard control and protection.

Keyword

Multi-source data, Remote sensing, Landslide, Susceptibility mapping, Three Gorges Project reservoir area

Analysing the dynamics of rockfall at Koto Panjang, Indonesia : A Multi-Temporal Approach Through Street View Images and UAV

Tiggi Choanji[1]*, Risk Group, Institute of Earth Sciences, University of Lausanne (tiggi.choanji@unil.ch)
Li Fei[2], Risk Group, Institute of Earth Sciences, University of Lausanne
Antonin Chale[3], Risk Group, Institute of Earth Sciences, University of Lausanne
Yuniarti Yuskar[4], Institute of Earth Surface Dynamics, University of Lausanne
Marc-Henri Derron[5], Risk Group, Institute of Earth Sciences, University of Lausanne
Michel Jaboyedoff[6], Risk Group, Institute of Earth Sciences, University of Lausanne

Abstract

Areas affected by rockfalls require an in-depth understanding of the evolutionary processes that govern these events. This study investigates the case of Koto Panjang, a local quarry located beside a cross-provincial road. Geologically, the area consists of the Bohorok Formation, which is characterised by pebbly mudstone. Three different rockfall events in 2015, 2016, and 2017 severely disrupted vehicular traffic, highlighting the inherent risks of collapse.

To estimate rockfall volume, a multi-temporal approach was employed, leveraging historical and primary data. A comprehensive dataset of images from 360° street view panoramas (2015-2021) was processed using the "decompose equirectangular panorama" method and Agisoft software to generate detailed point clouds. Comparative analysis with recent UAV data revealed significant volume changes, reaching a 5.27×10^3 m^3 at specific locations between 2015 and 2021. Furthermore, kinematic structural analysis, incorporating direct measurements and 3D point cloud data, identified prevalent direct toppling and wedge failure mechanisms as the primary drivers of rockfall events.

This study demonstrates the effectiveness of combining historical data with cutting-edge technology in reconstructing landscapes affected by rockfall. By elucidating the temporal evolution of rockfall retreat, this approach has the potential to significantly improve risk prediction and mitigation strategies, ultimately protecting public safety and ensuring uninterrupted transport in vulnerable areas.

Keyword

Rockfalls, Hazard, Road, UAV, Street view

The role of brittle rock mass fracturing in alpine slope instabilities

Reinhard GERSTNER[1]*, Insitute of Applied Geology, Department of Civil Engineering and Natural Hazards, University of Natural Resources and Life Sciences, Vienna (reinhard.gerstner@boku.ac.at)
Christian ZANGERL[2], Insitute of Applied Geology, Department of Civil Engineering and Natural Hazards, University of Natural Resources and Life Sciences, Vienna

Abstract

Tectonic structures such as faults, joints, or shear bands are a decisive factor influencing rock slope stability, as their reactivation can provide kinematic feasibility for specific failure mechanisms. However, natural rock slope failures can also involve the formation of new, brittle, landslide-induced fractures. Combining both the reactivation of structures and the formation of new fractures in numerical investigations is challenging and remains a topic of ongoing research. To this end, we present a synthetic rock mass approach to model the initiation of four active rock slope instabilities in the European Alps. The landslides addressed in our study are located in similar geological settings characterized by highly schistose, anisotropic, fractured metamorphic rock masses. However, the landslides differ regarding their failure mechanisms and volumes, ranging from 30,000 to several million m3.

Using the 2D distinct element code UDEC, we applied a synthetic rock mass approach that we refer to as 'asymmetric Voronoi logic'. In the approach, we consider the schistose metamorphic rock mass as a matrix of small polygons characterized by an elongated axis, i.e. asymmetric Voronoi elements. By aligning the elongated axes according to the orientation of the schistosity planes, we represent the rock mass anisotropy related to schistosity. Finally, we implemented field-related discontinuities into the matrix of small Voronoi elements. Assigning a Mohr-Coulomb contact law to the discontinuities and the contacts bounding the Voronoi elements allowed us to model the development of any failure geometry.

We derived the model input from comprehensive investigations comprising geological mapping, lithological analysis, discontinuity characterization, and rock mechanic testing. Data from several remote sensing techniques, such as synthetic aperture radar, multitemporal terrestrial laser-scanning, and unmanned aerial vehicle photogrammetry surveys, enabled us to identify the rock slope failure mechanisms and validate the UDEC model results.

By the asymmetric Voronoi approach, we successfully modelled the initiation of all four landslides on rock slopes ranging from 200 m to 1,500 m in height. The models accurately reproduced complex detachment surfaces involving reactivated geological structures and newly formed fractures along the Voronoi contacts. The resulting failure geometries, e.g. step-path or complex toppling failures, were consistent with our field observations. These results confirmed that pre-existing geological structures and brittle rock mass fracturing processes control the

mechanics of the investigated rock slope failures. In accordance with our geological landslide models, the numerical model also reproduced characteristic landslide features, e.g. minor scarps, uphill-facing scarps and retrogressive tensile fractures. Thus, our asymmetric Voronoi approach proved to be a feasible method to model the initiation of landslides in complex geological settings and further contributes to our understanding of landslide mechanics.

Keyword

rock slope failure, asymmetric Voronoi logic, rock mass fracturing, structural control

Paleoseismology and capable faults in the Rieti intermountain basin (Central Italy)

Alessandro Maria Michetti[1]*, Università degli Studi dell'Insubria, Como, Italy (alessandro.michetti@uninsubria.it)
Valerio Comerci[2], ISPRA, Geological Survey of Italy, Roma, Italy
Gilberto Binda[3], Norwegian Institute for Water Research, Oslo, Norway
Anna Maria Blumetti[4], ISPRA, Geological Survey of Italy, Roma, Italy
Marco Caciagli[5], INGV, Bologna, Italy
Pio Di Manna[6], ISPRA, Geological Survey of Italy, Roma, Italy
Maria Francesca Ferrario[7], Università degli Studi dell'Insubria, Como, Italy
Fiorenzo Fumanti[8], ISPRA, Geological Survey of Italy, Roma, Italy
Roberto Gambillara[9], Università degli Studi dell'Insubria, Como, Italy
Luca Guerrieri[10], ISPRA, Geological Survey of Italy, Roma, Italy
Franz Livio[11], Università degli Studi dell'Insubria, Como, Italy
Paolo Lorenzoni[12], Professional Soil Science Consultant, Rieti, Italy
Valerio Materni[13], INGV, Roma, Italy
Miscione Francesco[14], ISPRA, Geological Survey of Italy, Roma, Italy
Rosa Nappi[15], Istituto Nazionale di Geofisica e Vulcanologia, sezione di Napoli Osservatorio Vesuviano
Rosella Nave[16], Istituto Nazionale di Geofisica e Vulcanologia, sezione di Napoli Osservatorio Vesuviano
Kathleen Nicoll[17], University of Utah, Salt Lake City, Utah USA
Alba Peiro[18], University of Zaragoza, Spain
Marco Pizza[19], Università degli Studi dell'Insubria, Como, Italy
Roberto Pompili[20], ISPRA, Geological Survey of Italy, Roma, Italy
Luca Maria Puzzilli[21], ISPRA, Geological Survey of Italy, Roma, Italy
Mauro Roma[22], ISPRA, Geological Survey of Italy, Roma, Italy
Aurora Rossi[23], Università degli Studi dell'Insubria, Como, Italy
Valerio Ruscito[24], ISPRA, Geological Survey of Italy, Roma, Italy
Vincenzo Sapia[25], INGV, Roma, Italy
Argelia Silva Fragoso[26], Università degli Studi dell'Insubria, Como, Italy
Emanuele Scaramuzzo[27], Università degli Studi dell'Insubria, Como, Italy
Frank Thomas[28], Università degli Studi dell'Insubria, Como, Italy
Giorgio Tringali[29], Università degli Studi dell'Insubria, Como, Italy
Stefano Urbini[30], 3INGV, Bologna, Italy
Andrea Zerboni[31], Università degli Studi di Milano

Abstract

Damage induced by the 2016-2017 seismic sequence to building and infrastructural heritage in Central Italy was locally associated with the major evidence of surface faulting. This confirmed the relevant impact that surface faulting processes can have in urbanized areas and amplified the need to consider them in reconstruction planning, promoting Seismic Microzonation studies focused on capable faults. The presence of capable faults that produced dislocation of the ground surface at least once over the past 40.000 years (cf. Italian Civil Protection guidelines), is, in fact, one of the exclusion criteria for post-earthquake reconstruction.

In 2020-2022, the Italian Government Extraordinary Commissioner for post-earthquake reconstruction funded a program of studies to better characterize known and suspected capable faults affecting urbanized zones in the epicentre area, including several villages located along the NE, E and SE borders of the Rieti Quaternary intermountain basin.
Extensional tectonics that affected the western flank of the eastward migrating Apennine chain during the Quaternary, combined with regional uplifting, have controlled the formation and evolution of the box-shaped Rieti basin. During the Early Pleistocene, the NNW-trending normal fault located along the eastern edge acted as a master-fault, controlling progressive deepening of the half-graben, and the deposition of thick sequences of fluvial deposits, from early alluvial fan (Fosso Canalicchio Synthem) to late alluvial plain (Monteleone Sabino Synthem) facies. The E-W oriented structures along the northern and southern margins of the basin acted as transfer structures linked to the eastern border fault. Early Pleistocene deposits were displaced a few hundred meters, with a further deepening of the Rieti basin and northward diversion of the Velino River hydrographic network, also affecting the evolution of the Marmore Falls system.
Field observations and extensive geophysical prospections along the E master fault and the N and S transfer faults driven the opening of 17 new paleoseismological trenches that yielded 52 radiometric dates. We recognized evidence for Late Pleistocene and Holocene paleoearthquakes along the investigated faults. We identified five time windows, each ranging from 500 yr to more than 5 kyr, during which surface faulting events occurred along the NNE-trending master fault and the transfer faults of Rieti basin. We discuss whether the events recognized in the various trenches located along the three different faults correspond to a single ca. M6.5 earthquake, or multiple M6.0 earthquakes that occurred in succession in the different segments of the local tectonic architecture. In fact, the threshold for coseismic surface faulting in the Rieti Basin is ca. M6; no significant surface rupture occurred during both the June 28, 1898, Santa Rufina (M5.5), and December 31st, 1949, Rivodutri (M5.4) earthquakes along the S and N transfer faults, respectively. We argue that these new results allow us to better constrain the tectonic evolutionary style of the Rieti Basin, recognize the possible presence of seismic cycles and define the current seismic hazard.

Keyword

Capable fault, Rieti basin, paleoseismology, seismic hazard, microzoning

Updating empirical regressions for Probabilistic Fault Displacement Hazard Analysis of distributed ruptures for dip-slip faults

Paolo BONCIO[1]*, University of Chieti - Pescara, Department of Engineering and Geology (paolo.boncio@unich.it)
Francesco Visini[2], Istituto Nazionale di Geofisica e Vulcanologia, Pisa, Italy
Alessandro Valentini[3], Istituto Nazionale di Geofisica e Vulcanologia, Pisa, Italy
Oona Scotti[4], Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-Aux-Roses, France
Fiia Nurminen[5], RINA Consulting, Rozzano, Italy
Stéphane Baize[6], Institut de Radioprotection et de Sûreté Nucléaire, Fontenay-Aux-Roses, France
Bruno Pace[7], University of Chieti - Pescara, Department of Engineering and Geology, Italy

Abstract

The Probabilistic Fault Displacement Hazard Analysis (PFDHA) plays a crucial role in evaluating the likelihood of surface fault displacement during seismic events, which has significant implications for infrastructure systems such as pipelines and lifelines. Recent seismic activities have underscored the importance of fault displacement as a major contributor to damage. This research expands upon existing PFDHA models by introducing innovative approaches and widening the dataset to include various seismic events, thereby offering a more comprehensive assessment of distributed ruptures (DRs) associated with both reverse and normal faulting. Leveraging the SURE 2.0 database, which categorizes DRs into primary (Rank 1), simple (Rank 2), and triggered (Rank 3), logistic regression models are utilized to evaluate the likelihood of DR occurrence. Factors such as earthquake magnitude, proximity to the principal fault, faulting style, and DR location are considered as predictive variables. Furthermore, a fault displacement model is developed to estimate the median throw on DRs based on these parameters. The findings provide valuable insights into the characteristics and probability of DRs, with implications for PFDHA applications. The study introduces a decision-tree algorithm aimed at aiding PFDHA practitioners in selecting the most appropriate models based on their geological expertise. This research contributes to an enhanced understanding of fault displacement hazard analysis and presents a flexible framework for its implementation across diverse geological settings.

Keyword

Earthquake surface rupture, Probabilistic Fault Displacement Hazard Analysis, distributed faulting, dip-slip fault

Evaluating the Relationship between Catchment Area Capacity and Constructed Slope Failure Probability in South Korea

alain LUMOO bindu[1]*, International NGO Safety Organization (INSO) (alaindebin1@gmail.com)
Hwang Sang-Gi Hwang [2], Pai Chai University, South Korea
tomple mayange Byamungu[3], Institute of Green Bio Science and Technology, Seoul National University
Rocky Kubuya Kiro[4], Mines WESTWOOD and research director at the Center of Expertise and Geological Surve

Abstract

Evaluating the Relationship between Catchment Area Capacity and Constructed Slope Failure Probability in South Korea

Bindu Lumoo Alain1, Hwang Sang-Gi2 and Byamungu Mayange Tomple3

1GIS & IT/Database Officer at International NGO Safety Organization
(Email: alaindebin1@gmail.com, gis.officer@drc.ngosafety.org)
2Professor, Pai Chai University, South Korea
(Email: sghmap@pcu.ac.kr)
3Senior Researcher, Institute of Green Bio Science and Technology, Seoul National University
(Email: tomple07@snu.ac.kr)

ABSTRACT
Slope stability challenges persisted throughout South Korea's history, driven by the rising demand for engineered cut and fill slopes in construction projects. To address these issues, a deep understanding of analytical methods, investigative tools, and effective stabilization techniques was crucial. Notably, South Korea's rapid infrastructure expansion since the 1960s, driven by a growing population, necessitated the development of a robust transportation network, especially highways. As mountains covered approximately 70% of the country's land, highway construction resulted in substantial slope excavations on either side of these roadways. This study aimed to "Evaluate the Relationship between Catchment Area Capacity and Constructed Slope Failure Probability," specifically focusing on the connection between catchment area size and slope failure probability. It investigated how the intensity and duration of precipitation data in South Korea related to the moment of slope failure. The study findings revealed that during the rainy season from June to September, slopes with larger catchment areas were more prone to failure due to continuous and heavy rainfall. Consequently, areas with larger catchment regions experienced a higher concentration of slope failures as precipitation events increased.
However, when examining the moment of failure, the study considered 188 slopes with known failure dates. Three distinct groups of slope failures were identified based on the rainfall pattern leading to the failure. The majority, 66.3% (124 failed slopes), experienced failures as rainfall

intensity decreased during the rainy period. These slopes were characterized by higher elevation, larger catchment areas, intense weathering, and elongated catchments. The analysis suggested that while precipitation played a role in slope failures, it interacted with other factors like elevation, catchment size, catchment shape, and weathering, leading to varying patterns of failure.
Therefore, the distinctive characteristics of these three groups of failed slopes demonstrated that precipitation was not the sole cause of slope failure; rather, it influenced slope failure by interacting with other factors such as elevation, catchment area size, catchment shape, and weathering.

Bibliography

MSc. BINDU LUMOO ALAIN, Congolese and a master's degree holder in environmental and railway engineering, specializing in slope stabilization and GIS at PAI CHAI University in South Korea. I am currently working as GIS & IT/Database Officer at the International NGO Safety Organization which is a humanitarian organization and I am also a cartography consultant within the Center of Expertise and Geological Survey (CEEG) - North Kivu in the Democratic Republic of the Congo.

Keyword

Evaluating the Relationship, Catchment Area, Slope Failure Probability, Constructed, South Korea

Suggestions for safety distance based on surface rupture characteristics and its importance to active fault Investigations

Yeoeun SEO[1]*, Pukyong National University (oehxx@pukyong.ac.kr)
Jinhyeon SO[2], Pukyong National University
Young-Seog KIM[3], Pukyong National University

Abstract

Most damaging earthquakes are caused by the reactivation of pre-existing faults. Large earthquakes, typically those with magnitudes of MW 6.5 or higher, can lead to surface rupture. Surface ruptures associated with large earthquakes pose a significant risk to structures, infrastructure, and lifelines (such as roads, bridges, and pipelines), crossing or locating near active faults. For this reason, understanding the location and behavior of active faults is critical for seismic hazard assessment and for land use planning and engineering design for earthquake damage mitigation. The damages from surface rupture can be reduced or minimized by enforcement of regulatory building codes based on the safe distances or buffer zones from the surface ruptures. Regarding the issue of setback distance from active faults, although some countries have successively formulated relevant laws and regulations, accurate quantification of near-field deformation along earthquake surface ruptures is difficult due to the inherent complexity of the local geological and structural conditions as well as different building types. Detailed surface rupture data from several previous earthquakes were analyzed using fracPaQ (MATLAB toolbox). The analysis of surface ruptures from recent earthquakes showed that 98.1~88.1% of the total length of the surface rupture were not included in the minimum regulatory distance of the 15 m safety distance (safe distance keeping zone 1) defined by most countries, and 71.1~31.6% was not covered by the 200 m of zone 3 proposed by Hong (2021). These results indicate that the proposed safety distances by previous researchers do not adequately accommodate the surface ruptures generated by recent earthquakes. Because these distances are based on the traces of mapped active faults, the loss of life and property can increase exponentially if active faults are not properly surveyed. Therefore, detailed active fault survey and setting correct safety distance are the best way to effectively reduce the risk to the public from surface rupture damages during earthquakes.

This research was supported by a grant(2022-MOIS62-001(RS-2022-ND640011)) of National Disaster Risk Analysis and Management Technology in Earthquake funded by Ministry of Interior and Safety(MOIS, Korea).

Keyword

Surface rupture, Active fault, Safety distance, Earthquake hazard

The advantages of using a combination of ground, air, and space technologies for mitigating large landslides in Uzbekistan.

Rustam Aminovich Niyazov[1], Institute Hydroengeo, University of geological sciences
Abdulla Khasanovich Baratov[2]*, Institute Hydroengeo, University of geological sciences (abdulla0486@gmail.com)
Vali Khalikulovich Khidirov[3], State survey for monitoring hazardous geological processes

Abstract

The purpose of using a combination of ground, air, and space technologies to monitor landslides is to study trends in their distribution and collect data for early warning systems.

Various geodetic methods have been widely used for 35-45 years in Uzbekistan to measure surface crack development during ground observations in local stationary areas, totaling 150-160 cycles.

The process of landslides can be studied by analyzing satellite images. The boundaries of the affected area can be identified and recorded, providing a clear understanding of the extent of the landslide. By analyzing satellite images from past years, we can also map the history of the formation and development of the landslide process, including any repeated secondary landslides that have occurred over time.

Aerial surveillance using drones has become widely used in the past three years. This technology allows us to determine the main geometric parameters of landslides, such as their shape, area, main scarp zone in plan and depth, and lateral boundaries. By analyzing this information, we can determine whether the landslide was a one-time or multiple displacement, especially for larger landslides with a graben-shaped detachment zone. Furthermore, this technology can help us predict the further areal development of landslides due to vertical or horizontal movements.

Show the location, direction, and orientation of tension, compression, shear cracks, and extrusion zones on liquefaction landslides with massive development of multidirectional cracks.

When it comes to mudflows, it is important to record the boundary of the height of the flow, as well as whether there is a mass of soil inside. This information helps to determine the type of flow, whether it is laminar or turbulent. Additionally, it is necessary to map the formation features, location, height, shape of landslide blockages, and the presence of a dam lake.

In areas with historical landslides, new cracks and gullies are well documented to determine future landslide activity.

Keyword

observations, measure, satellite image, drone, movement

Generating plausible multifault ruptures with empirical rupture simulation

Timothy Austin STAHL[1]*, University of Canterbury (timothy.stahl@canterbury.ac.nz)
Ethan Walsh[2], PDP Nelson
Andy Howell[3], University of Canterbury
Thomas Robinson[4], University of Canterbury

Abstract

Multi-fault earthquakes present a challenge in seismic source models. Physics-based rules and simulations are invaluable for defining the various configurations of fault patches that may rupture together in single events. Historical surface rupturing earthquakes can also provide empirical constraints on plausible multi-segment and multi-fault earthquakes. We developed a numerical simulation that uses relationships derived from maps of historical surface ruptures to characterize different rupture pathways initiating on a seed fault. This 2D simulation uses step distance, number of steps, angular change, and kinematic change variables to compute a combined passing 'likelihood' for all considered fault section connections and subsequent active ends of the propagating rupture. Ruptures end when all possible active ends fail to pass to the next section and the next iteration begins. We applied this approach to a few seed faults and compared the results to independent constraints on paleoseismic magnitude, segmentation, and global estimates of rupture complexity. Rupture set characteristics change dramatically based on seed fault location and indicate that kilometer-scale structural discontinuities serve as barriers to rupture. Our preferred model reproduces total trace complexity of historical earthquake catalogues. This approach may be useful for filtering or weighting on-fault maximum magnitudes in earthquake rupture forecasts. Alternatively, it could be used a straightforward tool for estimating maximum magnitude scenarios.

Keyword

Seismic hazard, Multifault earthquakes, Surface rupture

Geo-engineering characteristics and performance analysis of the landslide mitigation measures implemented in the Rohingya camps in Bangladesh

Farhad HOSSAIN[1]*, University of Dhaka (farhad.geo@du.ac.bd)
A S M Maksud Kamal[2], University of Dhaka
Md. Zillur Rahman[3], University of Dhaka
Bayes Ahmed[4], University College London

Abstract

Landslides occur every year in the Chittagong Hill Tracts of Bangladesh and cause life and property damage, especially during the monsoon. Due to the ethnic and social cleansing in Myanmar, nearly a million Rohingya populations have fled to Bangladesh since 2017. They took shelter in an undulated topography and fragile lithological region – the Kutupalong Rohingya Camps (KRC). They raze forests and cut slopes for their shelters and food. Which immediately resulted in numerous landslides and killed many peoples in the monsoon. The KRC area is stratigraphically composed of upper cohesive soil and lower non-cohesive sandstone. They belong to the Pliocene to Pleistocene age DupiTila, Girujan clay, and Tipam Formations. The exposed slopes were relatively high (>15 m) and steep ranging from 40° - 70° which have numerous polygonal tension cracks and fissures. The landslides are mostly of slide and slump type and have multiple heads like stair-step morphology and have retrogressive failure modes. The upper residual soils have a bulk density of 1.49 - 1.97 g/cm3, liquid limit of 25 - 48%, plasticity index of 5 - 16%, and undrained shear strength of 23 – 46 kPa and show strain-softening behavior under stress. Whereas the lower sandstone unit has a bulk density of 1.44 - 1.94 g/cm3, an internal friction angle of 34° - 40°, and cohesion of 0.5 - 13 kPa. The mineralogical composition determined by the X-ray diffraction shows low clay mineral content, which does not seem to affect slope failure. The low shear strength of materials and strain-softening of upper soil facilitates landslides in the KRC area. The presence of a high permeable layer underlying the residual soil and tension cracks allows preferential water infiltration during rainfall which may also contribute to the landslide occurrence. The state of equilibrium determines by LEM and FEM simulations using the field shear strength parameters shows that under natural conditions i.e., without any overburden loads, slopes are stable. But slopes get unstable or critically stable when extra overburden loads are applied. Before the Rohingya settlement, there was no relict of landslides in the KRC area which in addition to the above-mentioned factors demonstrate that the large-scale anthropogenic interventions by the Rohingyas are the major cause of landslide occurrence. Numerous landslide mitigation measures (both structural and non-structural/nature-based solutions) were implemented in the KRC area to reduce landslide risk. The safety factor analysis of the slopes with mitigation measures shows that they give protection only to a marginal level and in some cases structural mitigation measures failure cause fatalities. Among the different mitigation measures based on LEM and FEM simulations and field observations, it is evident that concrete retaining walls are more effective in reducing landslides and slope reforestation controls

soil erosion. It is also observed that the cohesion and friction angle of lower sandstone and the cohesion of upper soil layers are crucial factors to be considered during designing any landslide mitigation measures in the KRC area.

Keyword

Landslide, Geology, Slope stability, Rohingya, Bangladesh

Probabilistic Fault Displacement Hazard Analysis of a strategic dam in the Sansepolcro graben (Northern Apennines, Italy): methodologic implications for distributed faulting

Paolo BONCIO[1]*, University of Chieti - Pescara, Department of Engineering and Geology (paolo.boncio@unich.it)
Alessio Testa[2], University of Chieti - Pescara, Department of Engineering and Geology, Italy
Bruno Pace[3], University of Chieti - Pescara, Department of Engineering and Geology, Italy
Francesco Mirabella[4], University of Perugia, Department of Physics and Geology, Italy
Cristina Pauselli[5], University of Perugia, Department of Physics and Geology, Italy
Maurizio Ercoli[6], University of Perugia, Department of Physics and Geology, Italy
Francesco Visini[7], Istituto Nazionale di Geofisica e Vulcanologia, Sezione di Pisa, Italy
Stéphane Baize[8], Institut de Radioprotection et de Sûretè Nuclèaire, BERSSIN/SCAN/PSE-ENV, France

Abstract

Earthquake surface faulting can be the source of hazard for critical infrastructure located close to the trace of a capable fault (near-fault conditions). Zonation and avoidance strategies are common practices during the design of new infrastructure, but this option can be not feasible for existing facilities. This issue can be addressed by Probabilistic Fault Displacement Hazard Analysis (PFDHA), assessing the likelihood of exceeding a certain level of displacement at the site of the infrastructure. The resulting hazard curves can help to choose the most appropriate mitigation strategies.

Since the early 2000s, several authors proposed different methodologies for different kinematic contexts. Particularly, empirical regressions have been proposed to assess the probability of occurrence and the probability of exceedance of certain values of displacement (for both Principal and Distributed faulting) starting from databases of coseismic ruptures of past earthquakes. Since the probability of exceeding a certain value of displacement at the site of interest also depends on the probability of occurrence of a surface faulting earthquake on a certain fault, the fault parameters and earthquake rates are needed to perform PFDHA.

We present the PFDHA of the Montedoglio dam located in the Sansepolcro graben (Northern Apennines of Italy), located 1.5 km off the trace of the principal active normal fault of the area, in the hanging wall: the Anghiari normal fault. After having verified the absence of surface faulting hazard due to a principal fault beneath the dam, we focused on the assessment of the distributed faulting hazard due to the Anghiari fault. To account for the epistemic uncertainties related to the high segmentation of the Anghiari fault, we considered different rupture scenarios, with fault parameters obtained from a paleoseisologic study. We obtained several hazard curves for the Montedoglio dam site, integrating different rupture scenarios and several empirical regressions available in the literature. The analysis has shown that the distributed faulting hazard at the site of the dam is very low. However, methodological issues raised from the application of the existing PFDHA models, such as the general poor constrain of empirical regressions for distributed faulting, for both the probability of occurrence and the expected displacement.

Keyword

Earthquake surface faulting, normal fault, seismic hazard, Probabilistic Fault Displacement Hazard, Distributed faulting

Landslide Prediction in Nepal Himalaya with a National-Scale Rainfall-Triggered Nowcast System

Ananta Man Singh Pradhan[1]*, Water Resources Research and Development Centre, Government of Nepal (anantageo@hotmail.com)
Hyuck-Jin Park[2], Department of Energy Resources and Geosystems Engineering, Sejong University
Suchita Shrestha[3], Department of Mines and Geology, Ministry of Industries and Supplies, Government of Nepal

Abstract

Landslides are becoming increasingly common in Nepal, and their incidence is expected to grow as precipitation patterns become more severe and road-building increases. This poses a significant threat to the lives and livelihoods of people in the region. In this study, we developed an integrated approach combining two modeling methods to predict the likelihood of landslide occurrences and develop a near-real-time warning system.

The first method involved using a probabilistic explainable artificial intelligence (XAi) approach that combines– random forest (RF) and extreme gradient boosting (XGB) - to predict the likelihood of landslide occurrences. The models incorporate multiple causative factors (CFs) and utilize data on geo-environmental factors related to landslide occurrence.

The second method involved developing a near-real-time landslide warning system by integrating the results of the landslide susceptibility modeling with decision tree-based selection criteria. To support the modeling procedures in this research, independent variables obtained from terrain analysis were included. Additionally, a global Landslide Hazard Assessment model for Situational Awareness (LHASA) was utilized to indicate where and when landslides may be likely in the study area.

The results showed that the ensemble model was more accurate than any individual model in predicting landslide occurrences. The accuracy of the model was 87%. The ensemble landslide susceptibility maps were classified using the natural break algorithm in the GIS platform.

A total of 69.72% of the area was categorized as having a very low susceptibility, 16.01% as low susceptible, 6.84% as moderate, 4.07% as high and the remaining 3.36% was considered to have very high susceptibility. About 81.51% of landslide data were located in the very-high-susceptibility class, demonstrating the reliability of the map.

The findings of this study could be used to improve landslide risk management in Nepal and other mountainous regions. The landslide warning system could help to save lives and livelihoods by providing early warnings of potential landslides.

Keyword

Landslide, Explainable artificial intelligence, Nowcast, Machine learning

Analysis of Landslide Hazard and Geoenvironmental Condition in Rangamati and adjoining areas of Chittagong-Rangamati National Highway Road, the South-Eastern Hilly Districts of Bangladesh

Lubna Yesmin KHONDAKAR[1]*, Geological Survey of Bangladesh (lubnayk@gmail.com)
Michel Jaboyedoff[2], University of Lausanne
Ivanna Penna[3], Ramboll Norway
Zillur Rahman[4], University of Dhaka

Abstract

Landslide hazards along the Chittagong-Rangamati National Highway Road and adjoining areas of the Rangamati district pose the highest challenges to development in the southeastern part of Bangladesh. On 13 June 2017, the area encountered extensive and dangerous landslides which caused 120 people to die and a huge loss of economy. The road was disconnected for one week so immediately after landslides and full damage at Sapchhari point in Chittagong-Rangamati National Highway Road. Hence it is crucial to identify the areas prone to landslides for appropriate risk management strategies. This study aims to investigate landslide location, mechanism, and geoenvironmental condition with experimental analysis of slope soils to map landslide hazard, vulnerability, and elements at risk assessment. 40 landslide locations are selected for fieldwork-based landslide inventory, collection of soil samples, and secondary data analysis. Google Earth images and the Geological Map of Bangladesh, GPS, and clinometers are used in the field to identify the landslide's location, geology, and slope angle. The displaced slope materials are mainly sand, silt, and clay. The elevation of the study area ranges from 0 to 483 m. Landslide susceptibility mapping is carried out by overlying the landslide inventory with factor maps such as geology, topographic wetness index, NDVI, land cover, road, drainage pattern, and aspect and slope using the weights of evidence (WoE) technique. The landslide susceptibility map is categorized into very low (6-37), low (37-59), moderate (59-86), and high (86-141). The landslide risk map is categorized into very low (6-50), low (50-120), moderate (120-220), and high (220-503). The assessment of the vulnerability (road and houses, element at risk) and risk map revealed that the Chittagong-Rangamati National Highway Road and surrounding areas represent low vulnerability and high risk for landslide hazards. Field observations revealed that most slope failures occurred in the residual soil and weathered silty sandstone. A total of 7 soil samples are tested using direct shear equipment. The laboratory determined that the moisture content of soil samples varies from 2.21 to 14.19%, with an average of 6.45%, respectively. The percentage of sand, silt, and clay-grained particles are 12-32%, 60-70%, and 6-21% respectively. The cohesion and friction angle results from the direct shear test range from 4.5 to 24 kPa and 31-39 degrees, respectively. Friction angles are found higher for sandy soils, but clayey soils represent higher cohesion values. The analysis shows that in addition to geotechnical factors, extreme rainfall in a short period and human interference are the main causes of landslide hazards, therefore it can be mitigated by proper geologic investigations and effective enforcement of land

use management regulations.

Keyword

Landslide, Rainfall, Soil, Rangamati, Bangladesh

InSAR techniques and multi-risk assessment approach for monitoring Cultural heritage

Federica Ferrigno[1], ISPRA Geological Survey of Italy
Paolo Iannelli[2], Ministry of Culture
Gabriele Leoni[3], ISPRA Geological Survey of Italy
Francesco Menniti[4], ISPRA Geological Survey of Italy
Daniele SPIZZICHINO[5]*, ISPRA Geological Survey of Italy (daniele.spizzichino@isprambiente.it)

Abstract

The present work shows the results obtained in the framework of the first "National Plan for Monitoring and conservation of Italian Cultural Heritage" (NPMCH), it's aimed at the monitoring, conservation, and proactive protection of cultural heritage, threaten by different hazards, both anthropogenic and natural, including climate-induced extreme events.

The main target of this work was to develop a multi-risk assessment approach for the areas of interest, starting from a screening of the existing data and considering the peculiarities of the elements at risk, in terms of value of vulnerability, exposure, state of conservation, then the identification of all the possible relationships between the different geo-hazards and their interaction with the archaeological structures, has been carried out. The following phase predicted the use of Earth Observation data, and in specific the application of multi-temporal InSAR techniques, to detect the potential interaction between ground displacements and archaeological structures and to define potential unstable areas over the time, calculating anomalies and accelerations. Additionally, field surveys and integrated monitoring systems have been also planned and implemented.

Starting from this purpose, eight case studies have been selected among the national CH, from the north to the south of the Italian regions: the Port of Classe (Emilia Romagna) the Archaeological area of the Phlegrean Fields and the Archaeological Park of Paestum and Velia (Campania); Volterra and Pienza historical centres (Tuscany); Orvieto and Civita di Bagnoregio (Lazio) and the Villa Romana del Casale, Piazza Armerina (Sicily).

Depending on the sensor characteristics (e.g. spatial resolution, band, repeat cycles) SAR images acquired from different constellations (Cosmo-SkyMed and Sentinel-1A and 1B) have been processed using a D-InSAR approaches to obtain the spatial and temporal evolution of deformation induced by subsidence and slope instability phenomena. Based on ground and site conditions the existing algorithms built for the Permanent Scatterer (PS) and the Small Baseline (SB) approaches, have been exploited. As a result, we obtained: i) maps of the measurement points identified in the images and their spatial coordinates; ii) the average displacement velocity of each measurement points along the sensors Line Of Sight (LOS) (mm/year); iii) time series for each measurement points over the analysed interval time.

Focusing roughly on the period between 2016 and 2022, data processing has been performed using the Interferometric synthetic aperture radar Scientific Computing Environment (ISCE), the Stanford Method of Persistent Scatterers (StaMPS) and SARscape software. In the interferometric

processing has been used the SRTM 1 arc-second DEM, acquired with X and C-band radar system (resolution of 30m). Where available, local GNSS network data has been used to calibrate real rate of subsidence and displacement anomalies.
The main results of this study have highlighted the importance of the InSAR analysis providing very useful information to detect and monitor ground displacements and geo-hazards, thus offering to archaeological site managers a powerful tool for the prevention of ground related damage of cultural heritage. The anomalies shown up must be detailed in both spatial and temporal resolution to be correctly interpreted, validated and calibrated directly in situ

Keyword

InSAR, geohazards, heritage, risk

Chronological constraints of a fault scarp in a glaciated high mountain environment: the Coronas fault scarp

MARÍA ORTUÑO [1]*, Dept. Earth and Ocean Dynamics, University of Barcelona (maria.ortuno@ub.edu)
Tamara Briceño-Sarmiento[2], Universidad Técnica Particular de Loja (Ecuador)
Matthew Tompkins[3], Department of Geography, Univ. of Manchester, UK
Angel Rodés[4], Universidad de Santiago de Compostela, Dep. Xeografia (Spain)
Paula Figueiredo[5], Marine, Earth and Atmospheric Sciences, North Carolina State University, Raleigh, USA
Marisol Monterrubio-Velasco[6], Barcelona Supercomputer Center (Spain)
Pierre Lacan[7], Centro de Geociencias CGEO (UNAM), México
Marta Guinau[8], Dept. Earth and Ocean Dynamics, University of Barcelona
Raimon Pallàs[9], Dept. Earth and Ocean Dynamics, University of Barcelona
Eulàlia Masana[10], Dept. Earth and Ocean Dynamics, University of Barcelona

Abstract

Normal faults are common features in high mountain environments, and are often interpreted as the result of different process associated to deglaciation (upper crust-bottom valley uplift, glacial isostatic rebound, ..), isostatic recovery after long term-large scale erosion and adjustment to deep crustal and mantle changes. The Coronas normal fault (more than 11 km) is a prominent feature displacing the southern side of the Maladeta granitic massif (Central Pyrenees). It shows an accumulated vertical displacement reaching 155 ± 1 m. It's location fits with the epicentral area of the 1373 Ribagorçana earthquake (M ~ 6.2), one of the largest seismic events of the Iberian Peninsula historical record. Recently, the area has undergone a series of earthquakes starting in August 2023 with a maximum event of M 4.1. The driving forces of this seismic activity are now under discussion. Previous works interpreted the fault movement as part of a gravitational collapse of the massif towards the north. After two sampling campaigns in a mountain pass (Brecha de Llosás, 2850 m), we obtained the first chronological constrains of its exhumation history in a 50 m high scarp profile and using two different techniques to determine the exposure ages: the Schmidt Hammer (SH) technique, with three ages obtained from regional calibrated curves and SH onsite measurements, and 10Be cosmogenic technique, collecting and analyzing six samples taken along the scarp to obtain ages measured from quartz. We discuss the exposure history of the fault scarp in relation with the regional glacial chronology and possible driving faulting mechanisms.

Keyword

Schmidt Hammer ages, 10Be ages, paleoseismology, bedrock scarp, Pyrenees

Landslide Hazards and Forecast under Changing Climatic Patterns

Devesh WALIA[1]*, North-Eastern Hill University (deveshwalia.17@gmail.com)

Abstract

The study area is in the northern part of Ribhoi District, Meghalaya. Most of the area exhibits a rugged topography with high mountains and intermittent linear valleys. The area of study is selected on the basis of landslide zone close to road (NH 40) and the digging for the road has already undertaken decreasing the load from the toe area, which may increase the landslide incidences along NH 40, and disrupting the communication and supplies to Mizoram, Tripura and Lower Assam along with Meghalaya.

The study area is seismically active and displays high seismic activity, tilting and settlement of the river channel demarcated by trellis to sub- trellis drainage patterns, with low drainage density, low frequency and high bifurcation ratio. The circulatory ratio and form factor depict diversified slope, low discharge of runoff, high permeability of the subsoil and structurally controlled drainage system. The asymmetry factor also proves that watershed is under tilting and hence vulnerable to geohazard.

The FoS, maximum velocity vectors and respective contours of shear strain rate have been calculated for the vulnerable slopes by FLAC/Slope software.

The study indicates that landslides in the region would occur when the daily rainfall crosses 150 mm and three days antecedent rainfall (R3ad) exceeding 84 mm. These thresholds can be used as a predictive tool, but due care needs to be taken when used as an early warning system.

Keyword

Landslide hazard, Landslide forecast, linear and areal aspects, Asymmetry factor, Rainfall Threshold

Citizen science in response to the climate crisis : focus on old building retrofit for low-income people

Jong-Won Lee[1]*, Korea Institute of Civil Engineering and Building Technology
(jongwonlee@kict.re.kr)

Abstract

In Korea, the issue of energy-poor households has gained urgency and prominence in recent years due to climate change and social problem-solving R&D issues such as heat waves and cold waves. Energy-poor households are vulnerable groups that are more exposed to natural disasters and suffer increased damages due to energy inequality but have less political influence, and the government is taking comprehensive measures. However, despite various welfare programs and policies related to energy-poor households, the lack of accurate survey statistics and systematic management remains the biggest policy and technical difficulty. Therefore, this study aims to propose a data accumulation plan that can provide fundamental and mid- to long-term solutions in terms of improving the living environment of energy-poor households. To this end, we interviewed stakeholders in energy poverty policy and business, investigated the necessary technologies, and prioritized the construction of a digital database and map of paper surveys. This was done with the participation of local citizens. We designed a survey questionnaire on the living conditions of energy-poor households and developed a data collection tool to digitize and collect paper surveys. In addition, we developed a start-up map platform that shows information on energy-poor households intuitively by linking survey responses to map data. The most challenging aspect of collecting this data was access to vulnerable populations. In general, it is difficult to know the location of vulnerable households' addresses, and the information on occupants is not known due to privacy issues. Therefore, this study devised a citizen science model based on the concept of crowdsourced data that allows citizens to directly participate in data collection related to energy and housing welfare. The photos of old windows collected through citizens are the dataset for AI training. By learning the collected window photos and extracting the insulation performance attribute information of the windows, supports a preliminary simple diagnosis to know the condition of the windows of the building displayed on the map. The aging building data platform developed through this research is a new approach that realizes the aging degree of buildings (especially windows) as online-based visual data, which is highly efficient in terms of time, cost, and manpower. It can be used to help prioritize the retrofitting of old buildings in energy-vulnerable neighborhoods across the country. In conclusion, this study presents a meaningful model and framework for engaging citizens in science to address the climate crisis.

Keyword

Cimate crisis, Energy poverty, Citizen science, Crowdsourced data, GIS map

Current Research and Education Efforts for Proactive Landslide Disaster Management in the Context of Climate Change in Korea

Joon-Young PARK[1]*, Korea Institute of Geoscience and Mineral Resources (jypark@kigam.re.kr)
Seung-Rae Lee[2], Korea Advanced Institute of Science and Technology
Graham Gilbert[3], Norwegian Geotechnical Institute
Young-Suk Song[4], Korea Institute of Geoscience and Mineral Resources
Enok Cheon[5], Korea Advanced Institute of Science and Technology
Minseok Kim[6], Korea Institute of Geoscience and Mineral Resources
Luca Piciullo[7], Norwegian Geotechnical Institute
Hwan-Hui Lim[8], Korea Advanced Institute of Science and Technology

Abstract

The magnitude and frequency of landslide disasters in Korea have escalated due to extreme rainfall patterns associated with climate change trends. Since 2000, the area damaged by landslides has doubled, and the annual average cost of recovery has surged to approximately 80 billion won. The records of lives lost to landslide disasters remain at a catastrophic level of severity. Notably, in 2023, human casualties from landslides exceeded 50, surpassing the toll of the historic and symbolic Umyeon mountain landslides in 2011. Against this backdrop, research aimed at developing advanced technologies for the prediction and mitigation of landslides is of critical importance. This paper introduces an initiative to develop and pilot a landslide early warning system in the city of Busan, in collaboration with local government officials. Furthermore, it discusses the installation and operation of a landslide monitoring system across 12 natural hillslopes within 8 national parks. Our strategies for mitigating landslides through the optimal design of debris barriers, based on numerical simulations, will be briefly addressed. Concurrently, the need for education on understanding, preparing for, and responding to landslide disasters is growing among students, officials responsible for landslide management, and the general public. In response to this need, three research institutes and universities from Norway, Korea, and Japan have embarked on an international collaborative project, known by the acronym GEOMME, supported financially by the Research Council of Norway. This paper will also highlight our ongoing experiences as participants in educating students and early-career researchers, as well as in engaging with public officials under the GEOMME project.

Keyword

Landslides, climate change, early warning, monitoring, education

[Keynote] Geological risk assessment in Mexico City: The Interactive Observatory of Land Subsidence and Fracturing, OIHFRA

Dora Celia CARREON-FREYRE[1]*, UNAM (freyre@geociencias.unam.mx)
Raul Ivan Gutierrez-Calderon[2], Municipality of Iztapalapa
Mariano Cerca[3], UNAM
Carlos Felipe Alcantara-Duran[4], Municipality of Iztapalapa
Raul Basulto-Luviano[5], Municipality of Iztapalapa

Abstract

Land subsidence is a long-term studied phenomenon in Mexico City; however, the geological conditions, effects, and risks for urban infrastructure and inhabitants have been neglected. Damages in the short, medium, and long term imply maintenance and important mitigation costs. Over-exploitation of the aquifer has caused a continuous piezometric water level decline reaching about 80 m and up to 13 m of land subsidence in the central part of Mexico City during the last five decades. Consequently, the increasing intensity of the deformation has caused numerous problems to urban infrastructure, and estimations of damage are in the order of several thousands of millions of dollars. This represents a challenge for land and groundwater management in Mexico. Nowadays, there are no systematic studies that address methodologies for the estimation of the physical vulnerability of the geological media to deformation in Mexico City, one of the most populated cities in the world. Land subsidence in this fluvial-lacustrine basin and differential compaction of sediments and, volcanic materials associated with groundwater depletion have caused earth fissures, ground fracturing, and reactivation of regional faults. During more than 15 years of a collaborative work with the municipality of Iztapalapa, one of the most affected areas by ground ruptures in Mexico City, we integrated a multicriteria analysis to identify factors related with the generation of fractures using methods of characterization of geological materials and monitoring changes in their mechanical properties in time and space. The susceptibility to fracturing was analyzed using a deterministic approach. Fractures mapped and physical variables were integrated in a database for a proper correlation of the parameters that condition the spatial distribution of fractures. With the results the design of adequate monitoring systems were proposed aiming to the optimization of mitigation measures in the damaged sites. In 2022, with the support of a special call of the Mexican Council of Research (CONAHCYT) for the “Establishment of a network of universal access to scientific, technological and humanistic knowledge through art” was launched the Interactive Observatory of Land Subsidence and Fracturing, OIHFRA (Observatorio Interactivo de hundimiento y Fracturamiento) (https://oihfra.org/). The OIHFRA was created for the analysis of information and dissemination of the research results to the local and national communities of Mexico. Artistic and cultural activities are also encouraged as an outreach tool for water management, geological risk awareness and, for the improvement of local construction techniques. The spaces are advocated to: knowledge expansion through info-graphics; an interactive area with scale models for workshops addressed for primary and secondary students; scientific monitoring of deformation for the

generation of new data, to continue the research work and, an artistic gallery for temporary exhibitions of urban artistic expression related to geohazards. With the OIHFRA we seek to create a culture of adaptation to land subsidence and sustainable management of water and land use, to improve the resilience of the inhabitants of Iztapalapa and other affected areas in Mexico City.

Keyword

Land subsidence, ground fracturing, water management, land use, Mexico City

[Keynote] The UNESCO Land Subsidence International Initiative (LaSII)

Dora Celia CARREON-FREYRE[1]*, UNAM (freyre@geociencias.unam.mx)
Pietro Teatini[2], University of Padua
Shujun Ye[3], University of Nanjing
Devin Galloway[4], USGS

Abstract

Society is facing many challenges related to the sustainable use of land and water resources that have been increasing in the last decades. The effects of climate change in terms of sea-level rise and variation in the distribution and timing of precipitation, runoff and recharge, are compounded by the increasing concentration of population in megacities. The UNESCO working group on Land Subsidence (LS) was created during the International Hydrological Decade, 1965-1974 when LS was first recognized as a globally prevalent phenomenon. The First International Symposium on Land Subsidence was organized in Tokio in 1969; since then, ten more international symposia have been convened through cooperation of UNESCO with the International Association of Hydrological Sciences (IAHS), and several other agencies and organizations. In the VIII Phase Strategic Plan (2014-2021) of the UNESCO Intergovernmental Hydrological Programme (IHP) that addressed Water Security, LS was considered as a major threat. Because of the strong anthropogenic component of the prevalent subsidence processes and significant local and regional impacts, the proposal to transform the working group in a UNESCO Initiative has been accepted during the IHP Intergovernmental Council of 2018. The LaSII is one of the IHP flagship initiatives in the IHP-IX Strategic Plan “Science for a Water Secure World in a Changing Environment” (Phase 2022-2029). LaSII enhances the scientific understanding and technical knowledge required to identify and characterize hazards related to natural and anthropogenic land-level lowering, and facilitates the international exchange of information regarding the design, implementation, and evaluation of risk assessments and mitigation measures. The main goals are to publish guidelines for the identification, investigation, development, and management of LS-related phenomena; to support capacity building in member countries to gain and advocate better understanding and handling of hazards, vulnerabilities and benefits involving LS; to raise awareness of decision makers and the general public of the importance of groundwater as a store of freshwater in order to encourage improved protection and sustainable exploitation of groundwater and, to strengthen capacity building and educational capabilities in urban water management aimed at relevant target groups, including decision makers, planners, and practitioners, with a special emphasis on developing countries and, to propose methodologies for establishing an inventory of subsiding areas in the world. Nowadays, over 150 areas of subsidence are known, some with as much subsidence as 10 m in countries such as Mexico, China, Indonesia and the United States. Many more areas of subsidence are likely to develop in the next few decades because of accelerated exploitation of natural resources to meet the demands of increasing population and industrial development in many developed countries of the world.

LaSII activities focus primarily on four main aspects: (1) LS due to groundwater resources overexploitation, (2) LS in coastal areas, related with sea-level rise, (3) LS related with earth fissures, ground fractures and fault reactivation and, (4) LS related with water security in urban areas (https://www.landsubsidence-unesco.org/).

Keyword

Land Subsidence, Geohazards, Groundwater management, sea level rise

Experience and challenges of popularizing sciences related to earthquake disasters in S. Korea

Jin-Hyuck CHOI[1]*, Korea Institute of Geoscience and Mineral Resources (cjh9521@kigam.re.kr)

Abstract

Korea is tectonically a slow-deforming yet active region and large earthquakes have a very long recurrence period as evidenced by no report of surface faulting earthquakes in historical periods. Geologic records of pre-historical earthquake surface ruptures are only evidence of large earthquakes in the past. In modern society, therefore, large earthquakes have been perceived not as a scientific phenomenon but as a terrifying disaster that cannot be prepared for. In 2016, an earthquake with a magnitude of Mw 5.5 (the largest event among the instrumental seismicity) occurred near the Yangsan Fault, one of the active faults in S. Korea, and earthquakes became a vague fear among the general public. Meanwhile, the possibility of a large earthquake in Korea was highlighted by the 2016 earthquake, and efforts were made to increase public understanding of earthquakes. In this presentation, I introduce the activities to popularize large earthquakes conducted by the Active Tectonics Research Center in KIGAM (Korea Institute of Geoscience and Mineral Resources) over the past years. Popularization activities are mainly classified into broadcasting (news, science talk shows, YouTube), article writings (newspapers, science magazines, newsletters), lectures (public/citizen lectures, college/high school student lectures), and exhibition and public relation (videos, exhibitions). Each research fields of our multidisciplinary investigation was used as an item for popularization, and we focus on communicate the case studies rather than simply conveying knowledge about earthquakes. Before the excavation investigation trench was restored, video of the investigation site was obtained, and exhibits were secured using epoxy from the trench wall and displayed in the lobby of the main building of the KIGAM and the Geological Museum. Kiosks were used for the exhibits so that the public could easily access explanations about the exhibits. As a result of these activities, it is felt that the public's perception of large earthquakes is gradually changing, but interest in large earthquakes is still not high in Korean society. Korea has a clear trend of ‘low frequency yet high risk’ of large earthquakes due to its lack of experience with large earthquakes in modern society and its industrialized cities and high population density. Therefore, earthquake preparedness and awareness training through systematic earthquake popularization activities are necessary.

Keyword

Korea, Large earthquake, Popularizing sciences

Presenting the Outcome of Earthquake Prediction Spatial Probability Mapping Utilizing Explainable Artificial Intelligence in the Nepal Himalayas

Suchita SHRESTHA[1]*, Department of Mines and Geology, Government of Nepal (suchitashrestha@gmail.com)
Tae-Seob Kang[2], Division of Earth Environmental System Science, Pukyong National University, Busan 48513, Republic of Korea
Ananta Man Singh Pradhan[3], Water Resources Research and Development Centre, Government of Nepal
Hyun Jae Yoo[4], dInstitute of Environmental Geoscience, Pukyong National University, Busan 48513, Republic of Korea

Abstract

Earthquakes present significant risks to urban areas due to their destructive potential. Recent research suggests that integrating specific variables, such as elevation, topographic position index, magnitude density, depth, fault densities, fault proximity, and tectonic zones, into artificial intelligence (AI) models can notably improve the accuracy of earthquake probability mapping. However, the opaque nature of AI models raises concerns about their interpretability. This study investigates the application of explainable AI models in earthquake probability mapping to address this issue. Utilizing Shapley additive explanation (SHAP), the study predicts earthquake probabilities using two distinct machine-learning techniques: random forest (RF) and extreme gradient boosting (XGB). This approach facilitates a hierarchical understanding of the model's predictions, elucidating the influence of each predictor on the final outcomes. A comparative analysis of RF and XGB algorithms is conducted to evaluate the significance and impact of driving factors. Subsequently, SHAP is employed to interpret the results of earthquake probability models. In the context of earthquake probability assessment for Nepal, seven factors are considered for SHAP analysis. The resulting models achieve overall accuracies of 79% for RF and 76% for XGB, demonstrating the effectiveness of SHAP in refining earthquake probability mapping for Nepal. This study contributes to the advancement of earthquake risk assessment by enhancing model interpretability and providing insights into the factors influencing earthquake probabilities. Moreover, it underscores the importance of transparent AI methodologies in improving decision-making processes related to natural hazard mitigation and urban planning.

Keyword

Earthquake probability mapping, explainable artificial intelligence, Shapley additive explanation, machine learning

SINKHOLES AND UNDERGROUND WATER FLOW AS A RESULT OF PROLONGED RAINFAL; THE CASE OF SAKATA, CHOWE, AND ZOMBA IN SOUTHERN MALAWI

Joseph Martin CHIRWA[1]*, Department of Mines (chirwajoseph5@gmail.com)
Steve Gondwe[2], Malawi University of Science and Technology (MUST)

Abstract

Malawi, located in Southern Africa, has experienced above-average rainfall multiple times, leading to geohazards such as sinkholes, ground noise, floods, and mudslides. Geologically, Malawi is situated within the seismically active East African Rift System (EARS). The heavy rainfall from tropical Cyclone Idai in 2019 *and Cyclone Freddy in* 2023 *caused significant flooding and other geohazards in southern Africa, including Malawi, resulting in extensive damage and loss of lives. The country has seen above-average rainfall in* 2015, 2019, *and* 2023, *triggering geohazards like underground water flow, especially after the rainy season. Reports of unusual ground noise have surfaced across Malawi, particularly between March and May, with sinkholes posing a significant geohazard and generating peculiar noises, leading to public discomfort and infrastructure damage. This study utilized existing literature, case studies of geohazards in the Zomba and Machinga areas, field visits and random interviews with community members in the affected areas. Understanding the geological context and identifying potential causes of underground noise are crucial in addressing sinkhole occurrences. In areas like Sakata, where clay soil impedes water flow, sinkholes form through pore spaces in ant-hills. In Zomba central, continuous rainfall resulted in erosion and the formation of a sinkhole with vigorous water flow and noise. The geological settings vary in different regions, with Zomba characterized by basement rocks of Charnokitic gneiss and granulite, while Chowe is underlain by Precambrian gneisses intruded by alkaline rocks. Investigations into underground water flow and associated sounds in Chowe indicated that the high-pressure water belt was a result of prolonged heavy rainfall caused by a low-pressure air belt over Mozambique for approximately four days. Unlike sinkholes reported in parts of South Africa, where they are associated with dolomitic rocks and karst weathering, preliminary investigations linked sinkholes not to carbonate rocks but to certain clayey soils.*

Keyword

Sink hole, Heavy rains, Groundwaterflow, Clay soils, granulite

Recent landslides of liquefaction in Uzbekistan triggered by resonant frequency oscillations during deep strong Pamir-Hindu Kush earthquakes

Rustam Niyazov[1], Institute of hydrogeology and engineering geology
Bakhtier Nurtaev[2], Institute of geology and geophysics
Mansurjon Makhmudjanovich TASHPULATOV[3]*, Uzbekhydrogeology (mansur.uzbek@mail.ru)

Abstract

Between 2009 and 2023, a total of 93 cases of liquefaction landslides were recorded in Uzbekistan, with an annual frequency ranging from 1 to 22. The Pamir-Hindu Kush zone of deep earthquakes is a permanent seismic source. Here in the central part of the continent, within a fairly small area (about 60-70 km2), there is an extremely high level of seismicity at depths ranging from 70-300 km. The frequency of occurrence of deep strong low frequency Pamir-Hindu Kush earthquakes with M > 4 in the spring season is approximately 35-45 events. Years with increased snowfall and rain, particularly in February and March, are associated with the highest number of landslides caused by these earthquakes (ranging from 22 to 10 cases per year). Landslides can occur simultaneously in multiple locations hundreds of kilometers apart. In average and low-water years, the frequency of landslides ranges from 4-6 to 1-2 cases. At the same time, during strong earthquakes that occurred in dry summer and autumn, the liquefaction landslides were not recorded at all. So the moisture content of loess and sandy-clay rocks is the key factor in the formation of mass movements caused by seismic vibrations.

Using digital seismic station CMG-6TD we determined frequency fluctuations, the horizontal to vertical spectra ratio (HVSR), and the dynamic liquefaction coefficient (Kg). As a result, the dominant oscillation frequency at many landslide points was from 1.5 to 2.5 Hz, the ratio of horizontal to vertical spectra was from 5.2 to 6.8, and the dynamic liquefaction coefficient Kg was from 15 to 35.

Depending on the geological structure, depth, scale, and development mechanism, liquefaction landslides are divided into quicksand and thixotropic liquefaction landslides, where the shape of the sliding surface is different. Quicksand liquefaction landslides happen when seismic waves cause compression in the slope due to the resonance effect, leading to groundwater movement acceleration. As a result, tension occurs in the upper zone of the slope, forming a graben-like main scarp. A wider distribution characterized thixotropic liquefaction landslides. Loess-sandy formations on flat watershed surfaces are often distributed and repeated as secondary landslides. Strong fragmentation, a system of different orientations of tension, shear, compression, and extrusion cracks characterizes them. Horizontal movement of the landslide occurs over the entire area of the landslide at a uniform distance of up to 20-25 m, and vertical movement up to 2-3 m. The main scarp zone does not have a clear circus shape. The key feature of this type of landslide is to repeat and expand. These findings may contribute to a more comprehensive understanding of the earthquake-triggering landslide mechanism and are significant for long-term landslide risk assessment in seismically active areas.

Keyword

Landslide, earthquake, liquefaction, Pamir-Hindu Kush, risk assessment

Geohazards and Risk Reduction Framework in India

VINOD KUMAR SHARMA[1]*, Geological Survey of India (vksharma_gsi@yahoo.co.in)

Abstract

Geohazards present threats to life and livelihood throughout the world ranging from minor disruptions to catastrophes. These are censorious geological conditions that can cause significant harm to life, property, and infrastructure and inflict colossal loss on the economy. Geohazards may be the result of slow and continuous geological and geodynamic processes or sudden or quickly developing phenomena viz. avalanches, landslides, earthquakes, and earthquake-triggered phenomena such as tsunamis, glacial lake outburst floods, and liquefaction, etc.

The geological, physiographic, geographical, seismotectonic, and population density in India is conducive to multitudes of hazards of varying dimensions. India has the highest mountain chain on earth, the Himalayas, which are formed due to the collision of Indian and Eurasian plates which causes continuous stress building in rock resulting in landslides and earthquakes of varying proportions. The Himalayan collision zone, which has the potential for massive earthquakes, is particularly vulnerable to seismic hazards, the other regions are the Kutch, the Andaman and Nicobar Islands, and the northeastern region together covering over 59% of India's land mass to moderate to severe seismic hazard.

Landslides and avalanches are among the major hydro-geological hazards that affect large parts of India that cover the Himalayas, the Northeastern hill ranges, the Western Ghats, the Nilgiris, the Eastern Ghats, and the plateau region, covering about 15 % of the landmass. Glacial Lake Outburst Floods (GLOFs) events, recognized as climatological disasters in the Himalayan are increasing due to global warming phenomena causing rapid deglaciation.

The risk reduction strategies of geohazards involve understanding the causative factors, and repercussions of these hazards, and implementing mitigation and prevention strategies. Geohazards are often unpredictable and have potentially damaging consequences. Climate change due to the global warming scenario has also been found to have a link with some geo-hazards. A spatial and temporal analysis of the threat of geohazards is difficult to determine accurately because of variable factors responsible for their occurrences and areas exposed to their risk. However, by employing strategies such as the development of policy framework, guidelines, preparedness, and mitigation of the hazards in specific geological domains, their impacts can be substantially reduced. Improving environmental, structural, and community resilience at the local, regional, and national scale calls for a novel risk reduction strategy.

India, being a signatory to the Sendai Framework for Disaster Risk Reduction 2015-2030, has a comprehensive framework for geohazards risk reduction. The policy framework (Disaster

Management Act,2005) and national policy on disaster management (2009) focus on promoting a culture of disaster prevention, mitigation, and preparedness in continuous mode. Geohazard preparedness includes spatial mapping of hazard-prone zones on a progressively larger scale. The temporal prediction for critical hazards includes an Early Warning System (EWS), which incorporates continuous observation of potential hazards.

Identifying and mapping high-risk areas, quantifying the hazard and the risk, and implementing structural, non-structural, and nature-based solutions for risk mitigation measures, including early warning systems, community preparedness, public awareness campaigns, etc. may address the impact of geohazards.

Keyword

Geohazards, Himalaya, Disaster risk, risk mitigation

Man-Induced Landslides in Uzbekistan: Overview and Case Studies

Gany BIMURZAEV[1]*, Uzbekhydrogeology, Ministry of Mining Industry and Geology of the Republic of Uzbekistan (gany82@mail.ru)
Bakhtier Nurtaev[2], Institute of geology and geophysics
Azam Kadirhodjaev[3], Ministry of Mining industry and Geology of Uzbekistan

Abstract

Landslides are considered one of the most dangerous geological processes. In Uzbekistan, they cover an area of 17-21 thousand km^2, which is approximately 22% of the mountainous regions. More than 2,000 landslide areas identified in Uzbekistan, where over 12,000 displacements have occurred in the past 60 years.

An analysis of landslide processes since 1990 has shown that approximately 7,900 cases occurred in Uzbekistan. The number of landslides varies depending on various factors, with the highest number of occurrences ranging from 103 (in 2022) to 630 (in 2005) per year. The most active landslide processes occur in the mountainous regions of Tashkent (3,640 or 45.6%), Kashkadarya (1,604 or 20%), and Surkhandarya (1,438 or 18%) regions of the country.

This study aims to identify the triggers of landslide formation and assess the impact of man-induced factors on mitigating the risks of landslides on human activities. The effect of human activities on landslides is varied and widespread, mainly observed in mining areas, construction and operation of reservoirs, and intensive use of linear structures such as roads and railways. As a result of extensive construction in the foothill zones, landslides have been activated in these areas.

In the mountainous and foothill regions of Uzbekistan, there are mountain reservoirs for energy and irrigation purposes with a capacity of 150 million m3 to 2 billion m3.

Based on the results of long-term observations of the Verkhne-Turksky landslide, a pattern in the mechanism of landslide development was revealed. This landslide has a volume of 20.0 million m3 and is located on the left bank of the Akhangaran reservoir. The dynamics of the landslide process show a certain cyclicity, which corresponds to the level regime of the reservoir. It is associated with the fragmentation of the landslide mass at a generation where, due to a decrease in volume, the displacement rate increases. This type of landslide movement reaches critical movement speeds of 18-24 mm/day. The recommended approach for studying similar landslides during the operation of hydraulic structures is to use the mechanism of long-term development influenced by a reservoir.

Linear structures are often built by cutting slopes and this is usually done along ancient landslide areas. This can lead to the exposure of groundwater movement (unloading) or flooding of areas. Research over the years has shown that the proportion of landslides caused by the construction and operation of linear structures has been increasing annually. Between 1990-2000, their share was 17% of the total volume of landslides, while in 2001-2010 it increased to 32.1%. In the period between 2011-2020, it rose even further to 44.4%. At present, manifestations account for 50% of the total volume.

The intensive use of highways facilitates the formation and activation of landslide processes. On the Tashkent-Osh highway, where the daily traffic flow is 35,000 vehicles (including heavy vehicles) and the railway runs parallel, the vibration effect coincides with frequency fluctuations, leading to thixotropic processes in moistened rocks. Additionally, landslides occur most commonly in areas where linear structures intersect with tectonic disturbances.

Keyword

landslide, trigger, displacement, man-induced, factor

Characters of Landslides Development in Arid Areas, Assessment and Trends

Azam Kadirhodjaev[1], Ministry of Mining industry and Geology of Uzbekistan
Gany BIMURZAEV[2]*, Uzbekhydrogeology, Ministry of Mining Industry and Geology of the Republic of Uzbekistan (gany82@mail.ru)
Bahodirjon Tulyaganov[3], Institute of hydrogeology and engineering geology

Abstract

The study of landslides in the aspects of geological-engineering service in Uzbekistan take place one of the key subjects, since exogenous geological processes are widely developed and observed in the mountain and foothill areas in the country. Every year, on average, more than 200 landslides occur, that resulted significant damage to various economic and social impacts.

This work analyzes the character of landslide occurrence for the period 1990-2023, and also examines the main factors influencing the activation of landslide processes. It was noted that in Uzbekistan about 7,989 landslide processes have been occurred since 1990.

Based on the results of the analysis (1990-2023), it was shown that the degree of landslide activity is distributed as follows: Low degree of landslide activity 15% (5 years); Medium degree of landslide activity 58% (20 years); High degree of landslide activity 15% (5 years); Catastrophic degree of landslide activity 12% (4 years).

The activity of the year is primarily associated with abnormal changes in climatic conditions (rain fall, precipitation, temperature, etc.) and man-made impacts.

In contrast, analysis for the period 1990-2000 years showed that there is a large change in the amount of precipitation between years - annual precipitation varied from 371-419 to 831-859 mm during this period and the 2,809 landslides have been occurred.

The next decade (period 2001-2010) is characterized by stabilization of precipitation, but an increase in the number of days with heavy precipitation - annual precipitation varied from 445 to 736 mm and during this decade the occurrence of landslides increased to 3,148.

Since 2011-up to 2023, precipitation has been recorded from 627 up to 501 mm, respectively, the number of landslides during this period is 1,496 manifestations.

Based on the analysis and assessment of the results of long-term monitoring of landslide processes, the authors developed a classification for the quantitative assessment of landslide activity of the year.

A coefficient of the degree of landslide activity has been established, where it is noted that at low degree (at Kak ≤ 1.0), medium degree (Kak from 1.1 to 3.0) and high degree of activity of landslide processes (Kak from 3.1 to 5.0) The State Tracking Service operates in high alert mode (around the clock), when there is a deterioration in the hydrometeorological situation, the onset of sharp fluctuations in temperature, precipitation, and rising groundwater levels. During this period, the main tasks are to strengthen observations and multi-stage monitoring of the condition of landslide-dangerous areas.

In case of catastrophic activity of processes (over 5.0), the State Tracking Service operates in emergency mode (around the clock). During this period (the occurrence and elimination of emergencies due to landslides, resulting in the death of people, the destructing /disturbing of economic facilities and communications), the main tasks are to issue recommendations to prevent additional casualties, new destruction of residential buildings and engineering structures.

Keyword

landslide, damage, classification, coefficient, emergencies

The Kumalu catchment area, Bulolo District, Morobe Province, Papua New Guinea: Some findings and conclusions about the floods and landslides since 1950s

Shekinah Pilamp[1]*, Mineral Resources Authority (spilamp@mra.gov.pg)
Joseph Onglo Espi[2], University of Papua New Guinea

Abstract

Kumalu, in Morobe Province of Papua New Guinea, has been a region of flooding-and-landslide for more than 70 years that has impacted government infrastructure and human lives. A comprehensive study was undertaken to understand the history of the flooding-and-landslide and their social impacts. Data was collected through geological field mapping, use of remote sensing data, and slope analysis using DEM.

Through interpretation of these datasets, it was observed that the initial flow direction of Kumalu River was towards the north from its present location closer to the boundary with the northern ridgeline. The flow direction started to change when the landslides and floods started in the 1950's. There was evidence that an older similar event likely occurred based on field observations of older Quaternary sediments that were consolidated, and chaotically deposited, with absence of gradational deposition comparable to the recent flood deposits.

Landsat images showed that the river course migrated from the north to the south within the floodplain from 2000 to 2005. This movement was influenced by overbank deposits. As the river flowed near the northern ridge, sediment build-up began to increase. Perennial floods-and-landslides within these years also deposited large volumes of overbank sediments that built a levee on the northern side of the riverbank which created a natural buffer that pushed the water back south. This may have repeated several times diverting the river channel until the new south river channel formed. This process was repeated between 2005 to 2008, but this time, the overbank flood sediments created a levee on the south riverbank which pushed back the channel to the center of the floodplain. From 2008 to the present, the river course has been widening and thinning with minor changes in the course of the river within the center of the floodplain.

In 2005, the Mumeng government station was destroyed by a major flooding-and-landslide event. Statistics of infrastructure destroyed indicated that two villages were completely wiped out, three villages were partially affected, fifty-six houses, both local and government buildings were washed away, two bridges, one aid post, one primary school, two coffee plantations were washed away, and four lives lost that were recorded of. This data does not account for houses built after 1978 and up to 2005. The more recent events of flooding and landslides occurred in 2010, 2012, 2016, and 2019 with more sediment added to the flood plains.

Structural mapping indicated active fault shears are grinding into the metasedimentary rocks creating regions of areas prone to mass wasting along the steep slopes of the river upstream. Satellite imagery confirms cracks and scarp in the headwaters of Kumalu. The dynamic brittle deformation within the metasedimentary rocks with pre-existing planes of weakness along

foliations coupled with steep slope angles of over 70°, steep gradient of the river, and rainfall average of 2529 mm in wet seasons of November to March are highly in favor of mass wasting. This study has concluded that there is a possibility of another major destructive event in the near future.

Keyword

landslide, flooding, floodplain, field mapping, remote sensing

Geological Survey Ireland, managing geohazards in a safe country, landslides, groundwater flooding and coastal change.

Koen M VERBRUGGEN[1]*, GEOLOGICAL SURVEY IRELAND (koen.verbruggen@gsi.ie)
Ted McCormack[2], GEOLOGICAL SURVEY IRELAND
Charise McKeon[3], GEOLOGICAL SURVEY IRELAND
Xavier Monteys[4], GEOLOGICAL SURVEY IRELAND
Silvia Caloca-Casado[5], GEOLOGICAL SURVEY IRELAND
Sophie O'Connor[6], GEOLOGICAL SURVEY IRELAND

Abstract

Geological Survey Ireland is a division of the Irish government Department of Environment, Climate and Communications, and has typical origins as a geological survey founded to map the nation's natural resources, in the 19th century. In recent years it has changed focus from more traditional geological mapping activities and methods to carrying out major projects of national societal value, supporting and developing policy initiatives, many of which also support the management of geohazards. While there are no major geohazards such as earthquakes or volcanoes, Ireland's geohazards include landslides, flooding, and coastal erosion. Landslides in upland areas have caused considerable damage to property and loss of life in historical times and are mainly related to failures of peat-rich water logged soils in upland areas. After two particularly damaging landslides in 2003, Geological Survey Ireland set up a Landslides Programme which has completed a National Landslide Database and subsequently developed National Landslide Susceptibility Mapping. This is now a dataset that must be consulted in all planning of upland Windfarms under national regulations. Groundwater Flooding after particularly wet winters in 2015/16 resulted in extensive groundwater flooding of seasonal lakes, called turloughs, that are common in Irelands lowlands that are underlain by Missisipian age karstified limestones. In response to this Geological Survey Ireland set up a Groundwater Flood/Climate Programme to better understand the issue and provide baseline data for the Local and National Authorities responsible for flood relief and safety. A methodology was developed to map the turloughs using satellite radar data, from the EU Copernicus Programme, in collaboration with third level researchers. This data was then validated through the development of a groundwater monitoring network which provides real time water levels which are then available online to relevant authorities. The combination of flood extent mapping with water levels and rainfall data allowed stage models to be developed both measuring and predicting the behaviour of individual turloughs. More recent work is focussed on modelling future groundwater availability and levels related to climate change models of rainfall changes. Coastal change, in particular coastal erosion, is a particular problem on much of Ireland's coastline, particularly where soft and/or low lying coastlines combine with strong coastal storms. Geological Survey Ireland have developed a Coastal Change Programme to develop data on the issue and in particular, to map coastal change from remotely sensed data and combine this with modelled Coastal Vulnerability Index (CVI). The CVI methodology has been refined in-house in collaboration with third level researchers and

draws on a range of inputs to provide guidance on the susceptibility of different sections of the coastline to erosion in particular. In all cases in relation to these geohazards there was a lack of the fundamental geoscience data required to understand occurrence and behaviour, which hampered the ability of authorities to deal with the issues. Geological Survey Ireland has therefore developed programmes to gather relevant geoscience data and develop models to help understand these issues and ultimately inform decision making and support

Keyword

landslide, groundwater, flooding, coastal erosion, Ireland

Development of Classification and Grading Approach for Potential Large-scale Landslides and its Application

TING-YU WU[1]*, Sinotech Engineering Consultants Inc. (r123867575@gmail.com)
TE-WEI CHEN[2], Sinotech Engineering Consultants Inc.
LUN-WEI WEI[3], Sinotech Engineering Consultants Inc.
CHE-MING YANG[4], Department of Civil and Disaster Prevention Engineering, National United University
CHIA-HAN TSENG[5], Department of Geology, Chinese Culture University
CHUEN-MING HUANG[6], Sinotech Engineering Consultants Inc.
LIU-XUAN JIAN[7], Sinotech Engineering Consultants Inc.
YU-CHUNG HSIEH[8], Geological Survey and Mining Management Agency, MOEA
HSI-HUNG LIN[9], Geological Survey and Mining Management Agency, MOEA
CHIN-SHIUNG HOU[10], Geological Survey and Mining Management Agency, MOEA
SHIH-TING LU[11], Geological Survey and Mining Management Agency, MOEA

Abstract

Heavy rainfall events due to typhoons during Taiwan's monsoon season frequently trigger large-scale landslides, causing significant loss of life and property damage. Following the devastating Typhoon Morakot in 2009, the Geological Survey and Mining Management Agency (GSMMA) identified over 2,500 potential large-scale landslides across the island. However, existing classification methods lacked practical application due to limitations in standardization.

To address this challenge, this study presented a novel two-level classification and grading system for large-scale landslides in Taiwan. It leveraged methods from both the Japan Landslide Society and the Geological Survey of Norway (NGU). The Level 1 Landslide Topographic Feature Grading Form (LTFGF) incorporated the Analytic Hierarchy Process Theory (AHP) from Japan, assigning quantitative scores based on a landslide's location, developmental stage, and activity level. The Level 2 Potential Large-Scale Landslide Hazard Assessment Form (PLHAF) built upon the Norwegian approach, further classifying landslides by their mechanism (gravitational slope deformation, rotational slide, planar slide, or thick colluvium) based on specific characteristics and on-site monitoring data.

This new system was successfully applied to approximately 650 potential landslide sites using the LTFGF form. The combined LTFGF and PLHAF system was expected to provide a more comprehensive and nuanced understanding of potential large-scale landslide hazards, ultimately aiding in improved risk assessment and mitigation strategies.

Keyword

potential large-scale landslides, classification and grading, analytic hierarchy process theory (AHP)

Assessing the influence of geological structures and lineaments on the landslides in KwaZulu-Natal Province, South Africa: A case study on the Sangwana Mountain landslide

MAWANDE NCUME[1]*, COUNCIL FOR GEOSCIENCE (deyimawa@gmail.com)

Abstract

Landslides are devastating natural hazards which can cause damage to infrastructure and may lead to human fatalities. Intense rainfall events that triggered landslide phenomena, occurred early–mid December 2019 and in April 2022, in the Ndwedwe and eThekwini municipal regions, KwaZulu-Natal Province, respectively. The December 2019 Sangwana Mountain landslide, which is the largest (~15414 m2) in the Ndwedwe municipal region, produced debris flow runout that extended ~215 m downslope and endangered dwellings and a primary school. This terrifying event alarmed the surrounding communities and the Provincial Disaster Management authorities. In addition to this, the April 2022 landslide events in the eThekwini municipal region, which led to ~448 fatalities and ~1.9 billion worth of damage to infrastructure, alarmed the entire country. The Council for Geoscience (CGS), South Africa, commenced investigative research on the predisposing factors and their influence on these landslide events. This ongoing, regional multidisciplinary research on landslides forms part of the CGS National Geohazards Mapping Programme. This study aimed at assessing the influence of geological structures and lineaments on landslide occurrences within the eThekwini municipal region and to conduct kinematic analysis on the Sangwana landslide.

The methodologies employed included the utilisation of available geological and structural data including fracture and bedding plane measurements, field observations, kinematic analysis using the Dips 8.0 software, visual interpretation and digitisation of lineaments based on remote sensing and medium-resolution aeromagnetic data. Lineament density and Euclidean distance maps were created using ArcGIS 10.4.1 software, and the landslide site localities were overlain on the created map for ease of interpretation.

The Natal-Metamorphic Province gneisses and granites and Natal Group sandstones characterise the study region. Geological fractures and discontinuities, representing zones of weakness in which the strength and stability of the rock masses have reduced, are identified as factors inducing rock slope failures and deep-seated landslides. These geological features are more susceptible to weathering and contribute to rock mass strength reduction due to preferred stress accumulation. The weakened rock mass and residual soils from increased degree of bedrock weathering are prone to landsliding. The Sangwana landslide and slope failure occurrences in the eThekwini municipal region appear to be influenced by geological fractures, bedding planes and lineaments. Field mapping suggests that the Sangwana landslide is most-likely structural-controlled. Kinematic analysis using the Dips software suggests that the Sangwana landslide classifies as a

block-flexure topple failure, which agrees with our field observations. The findings of this study suggest that geological fractures, lineaments and bedding planes play a major role in landslide initiation. Comparisons between landslide distribution (1554) and lineament density and distance maps, for the eThekwini municipal region, reveal that 95% of landslides occurred in high and moderate density areas and are in proximity to fractures and lineaments (0–200 m range). The kinematic analysis method for the Sangwana landslide can be applied to other structural-controlled landslides in the province, especially to better understand stress dynamics. These data may be utilised to identify landslide-prone areas, which will aid infrastructure development and disaster management planning at local and national levels.

Keyword

: Geological structures, landslides, kinematic analysis

Geological characteristics of the area where land subsidence has continued for more than 12 years with in liquified-fluidized part on the Tokyo bay reclaimed land at the 2011 off the Pacific Coast of Tohoku Earthquake

Osamu KAZAOKA[1]*, Reserch Institute of Environmental Geology, Chiba (osamu.kazaoka@gmail.com)
Mitsuo Sato[2], Shinko Engineering Co., Ltd.
Shoichi Shiozaki[3], Disaster Prevention Equipment Management Department, Chiba Prefecture government
Atsushi Kagawa[4], Research Institute of Environmental Geology, Chiba
Takeshi Yoshida[5], Research Institute of Environmental Geology, Chiba
Itaru Ogitsu[6], Environmental Living Department, Chiba Prefecture Government
Hisashi yabusaki[7], Research Institute of Environmental Geology, Chiba
Naoto Ito[8], Environmental Living Department, Chiba Prefecture Government
Takahiro Kojima[9], Research Institute of Environmental Geology, Chiba

Abstract

On the 2011 off the Pacific Coast of Tohoku Earthquake, liquefaction-fluidization damage with land subsidence was observed in patches on the northern part of the Tokyo bay reclaimed land. In some of the damaged areas, the land continues to subside even though more than 12 years have passed. In order to clarify the cause of these, we investigated the geological characteristics by continuous borings and dynamic corn penetration tests.

Almost of the Tokyo bay reclaimed land were filled by the sand pump system from the mid-1960s to the mid-1980sThe reclamation material was supplied by dredging alluvial and shallow-marine late Pleistocene strata on the sea bottom of adjacent the Tokyo bay. As a result of observation of continuous boring core samples, the reclaimed layers, where are human made strata, are composed of shell fragment layer, shelly sand layer, sand layer and mud layer. And most of the parts that were liquefied and fluidized by the earthquake were the sand layer. In addition, the following common hydrogeological structures were observed in areas where the land continues to subside.

1. The thickness of the reclaimed layer is over 8m.
2. Thick impermerble mud layers, where are well continuous laterally, are interbedded in the upper part of the reclaimed layer. And the lower part of the reclaimed layer is composed of extremely loose liquefaction-fluidization massive sand layers.

Due to these characteristics, during an earthquake, the sand layer in the lower half of this reclaimed layer liquefied and fluidized, but it was unable to break through the mud layer in the upper half of the reclaimed layer and erupt to the surface. The liquefied-fluidized sand layer did not rapidly dehydrates and compact and remains extremely loose. It is assumed that the water in the liquefied loose sand layer continues to sink over a long period of time because dehydration progresses slowly through the overlying impermeable mud layer. When using reclaimed land, it is important to consider these hydrogeological characteristics and perform ground improvement in advance.

Keyword

liquefaction-fluidization, the 2011 off the Pacific Coast of Tohoku Earthquake, land subsidence, the Tokyo bay reclaimed land

How do overpressure-driven hydrofractures grow in sedimentary basins?

Qing WANG[1]*, China University of Geosciences (qingwang@cug.edu.cn)
Qiliang Sun[2], China University of Geosciences
Kehua You[3], University of Texas at Austin
Martino Foschi[4], University of Oxford

Abstract

Overpressure-driven hydrofracture zones are pipe-like structures and widespreadly develop in sedimentary basins worldwide. They have the ability to penetrate vertically for multiple kilometers, acting as pathways for fluid on the basin scale. When the hydrofracture zone penetrates the near-seafloor, it can infuse the upper strata (transition layer) with a substantial quantity of overpressured fluid, leading to seabed liquefaction potentially. Similarly, if the hydrofracture zone breaches the seabed, it has the potential to destabilize the sediment, triggering the shallow gas eruptions. All these geological processes could cause submarine landslides potentially. Despite extensive research on hydrofracture zones, the mechanisms of their formation and evolution are still poorly understood. In this study, the hydrofracture zones are explored by numerical models constrained by well log data and seismic data in the South China Sea. Drawing upon the stress condition and the fracture pattern within the study area, we've deduced the critical pore fluid pressure and developed the coupled fluid-geomechanical fracture model. Then the multiple linear regression is used to analyse the factors influencing hydrofracture zone growth. We find that the formation of hydrofracture zone is mainly controlled by rock density, bottom overpressure, Poisson's ratio, and radius of hydrofracture zone at its origin. Moreover, there is always a pressure transition layer between the hydrofracture zone and the overlying hydrostatic pressure zone. The thickness of this layer depends on strata permeability, strata thickness, and pressure within the hydrofracture zone. What's more, hydrofracture zones can continuously act as fluid pathways for a long time after their formation. Our study quantitatively explores the development and evolution of overpressure-driven hydrofracture zone for the first time. This research has broad implications for marine engineering and geohazard assessment.

Keyword

Overpressure, Hydrofracture, Gas chimney, Transition layer, Numerical modelling

Submarine geohazards and renewable energy

Kiichiro KAWAMURA[1]*, Yamaguchi University (kiichiro@yamaguchi-u.ac.jp)

Abstract

In recent years, coastal facilities such as offshore wind power generation and nuclear power generation have attracted attention as carbon-free energy and renewable energy. In addition, the safe installation and maintenance of various structures from the coast to the deep seabed, such as optical cables, pipelines, and power cables related to offshore wind power generation, is also attracting attention. These structures are under continuous threat from submarine geological hazards. Submarine geological disasters are diverse, including earthquakes, volcanoes, tsunamis, liquefaction, submarine landslides, large-scale movement of sediments such as dunes, scours, and shallow gas. Their location, scale, and frequency are important items in assessing their risks. However, despite these threats, their importance remains unknown and bothers us. Here, we will introduce information on submarine disasters around the world shared by the International Union of Geological Sciences (IUGS) Seabed Disasters Task Group (TGSG), which we established in February 2023, as well as our company's response to submarine disasters. We will also introduce our efforts. Japan's offshore wind power project discussed at the Science Council of Japan. We would like to discuss how to respond to submarine geological disasters caused by active faults, submarine landslides, and volcanoes, including in Japan, where renewable energy development is expected to accelerate rapidly in the future. I demonstrate the recent activities associated with submarine geohzard studies, and discuss the future activities.

Keyword

Submarine landslide, Liquefaction, Seabed unstability, Active fault, Volcanoe

Key Technologies and Equipment of Geological Environment Observation in Deep-Sea Development

Yonggang Jia[1]*, Ocean University of China (yonggang@ouc.edu.cn)
Cong HU[2], Ocean University of China
Hongxian SHAN[3], Ocean University of China

Abstract

The deep sea holds abundant resources, and research on the geological environment of deep-sea is of great significance for achieving the goal of carbon emission and assessment around the world. To address the challenges of in-situ observation of the geological environment of deep-sea development projects, a deep-sea in-situ testing device for soil mechanics properties has been developed, with a maximum working depth of 11,000 meters. This device has successfully obtained accurate soil mechanics characteristics in the Philippine Sea and the rare earth deposit area in the ocean, making China the first country with the capability of in-situ testing of soil mechanics properties at full ocean depth. Furthermore, the first set of internationally advanced long-term monitoring equipment for complex deep-sea engineering geological environments has been developed. This equipment has achieved continuous in-situ observation of marine engineering geological parameters at a depth of 1,500 meters in the gas hydrate production test area in South China Sea for 12 months, filling the gap in long-term real-time monitoring of deep-sea engineering geological environments. In addition, an in-situ monitoring device for the impact of plumes during deep-sea polymetallic nodule mining has been developed. Over a period of three years, in-situ observation work has been carried out in the Western Pacific polymetallic nodule and rare earth areas, achieving synchronous in-situ observation of plume concentration and re-deposition thickness during deep-sea mining. Based on the above-mentioned in-situ observation devices, first-hand data on the geological environment of deep-sea development projects have been obtained, providing essential support for the geological safety of deep-sea development and environmental engineering.

Keyword

In-situ Observation, Geological Environment, Long-term Monitoring, Deep Sea

Spatial time series variation of contourite drifts on active margins: Examples from the Kuril Trench in the NW Pacific

Hisashi IKEDA[1]*, Yamaguchi University (Hisashi.0906@outlook.jp)
Kichiro KAWAMURA[2], Yamaguchi University

Abstract

Contourite drifts that shaped by the persistent influence of bottom currents, represent a key focus in marine geology (e.g., Stow et al., 2002). In particular, contourite drifts have been extensively studied in the North Atlantic and Antarctic Oceans, and the geometry and depositional processes associated with deep water formation are well known (e.g., Rebesco et al., 2014). However, our understanding of contourite drifts is less advanced on the active margin due to differences in features during their identification (Bailey et al., 2021). Consequently, exploring contourite drifts and depositional processes in active margins has emerged as a significant issue in marine geology.
This study focuses on the active margin of the Kuril Trench in the northwestern Pacific, where the northward flow of the Lower Circumpolar Deep Water (LCDW) from the Antarctic Ocean occurs (Ando et al., 2013). Despite previous seismic studies suggesting the influence of bottom currents on erosional features, the identification of contourite drifts in this region remains elusive (Nakamura et al., 2023). To address this gap, we employed four sets of Multichannel Seismic Reflection (MCS) data (KT093, KT150, A2, R1) from the JAMSTEC Seismic Survey Database, aiming to: 1) identify and map the spatiotemporal distribution of contourite drifts and 2) elucidate changes in ancient oceanic environments, revealing the impact of bottom currents on deep-sea sedimentation.
Our methodology involved mapping seismic units and their horizons based on changes in sedimentary structure. Four criteria—onlap, downlap, apparent truncation, and vertical seismic facies change—were used to define horizons. Integration with the DSDP Site 436 stratigraphic package (Langseth et al., 1977) allowed us to assign depositional ages to these horizons. Stratigraphic interpretation revealed five seismic units (U1-U5) with estimated depositional ages ranging from 113 to 0 Ma. Notably, U4 and U5 displayed distinct contourite drifts, including a mound drift, a patch drift, and a sheet drift with sediment waves, each associated with specific erosional discontinuities.
The evolution of the deep-sea environment, as interpreted from the sedimentary structure, suggests three distinct stages: 1) a period dominated by pelagic sedimentation (U1 to U3), 2) a period characterized by weak bottom currents (U4), and 3) a period dominated by LCDW influenced by active orogeny and trench development (U5). In addition, our conclusion emphasizes that the sedimentary structure of contourite drifts deposited during the LCDW-dominated period (U5) reflects water mass relationships and their global-scale evolution.
References: Stow, DAV, et al. (2002). Geol. Soc. Lond. Mem.; Rebesco, M., et al. (2014). Mar. Geol.; Bailey, WS., et al. (2021). Sed.; Ando, K., et al. (2013). J. Oceanogr.; Nakamura, Y., (2023). PEPS; JAMSTEC Seismic Survey Database (2004) Japan Agency for Marine-Earth

Science and Technology, https://doi.org/doi:10.17596/0002069. Accessed 12. 7, 2023.; Langseth et al. (1977). Initial rep. Deep Sea Drill. Proj.

Keyword

Contourite drift, LCDW, Active margin, Kuril Trench

Depositional process of contourite on active margins: Examples from the Kuril Trench and the Japan Trench in the NW Pacific

Hisashi IKEDA[1]*, Yamaguchi University (Hisashi.0906@outlook.jp)
Kichiro KAWAMURA[2], Yamaguchi University

Abstract

Contourites represent sediments shaped by the continuous influence of bottom currents, and their characteristics vary across deep-sea environments (e.g., Rebesco et al., 2014). While considerable knowledge has been amassed about these deposits in passive margins, their understanding in active margins is less comprehensive (Bailey et al., 2021). This disparity arises from distinct identification features, including diminished sediment supply from continental slopes and sporadic deposition of volcaniclastic debris challenging to transport via bottom currents. Consequently, delineating contourite facies and depositional processes in active margins has become a crucial focus in marine geology.

The Japan Trench and Kuril Trench in the northwestern Pacific, forming part of an active margin, channel the northward flow of the Lower Circumpolar Deep Water (LCDW) from the Antarctic Ocean (Ando et al., 2013). Despite this dynamic setting, no contourites formed by bottom currents have been identified in this region. Thus, our study focuses on piston core samples from the outer slope-outer rise of the Kuril Trench and the Japan Trench in the northwestern Pacific Ocean, aiming to discern contourite facies and the current depositional processes.

Piston core samples (KH-18-5 PC01, PC04, KH-20-8 PC01) from the cruises KH-18-5 and KH-20-8, conducted by the "R/V Hakuho-Maru", were utilized in our investigation within the outer slope to outer rise areas of the Kuril Trench and the Japan Trench.

When bottom currents are active, particles undergo selective deposition due to upward shear stress from turbulence interacting with the seafloor (McCave, 1995). Consequently, contourites typically exhibit upward coarsening structures during increased flow velocity and upward fining structures during decreased flow velocity along the bottom current axis. The Sortable Silt range is particularly indicative of these grain size changes. Analyzing core samples using laser diffraction at 2 or 4 cm intervals, we interpreted the grain size changes as indicators of varying depositional processes in the deep-sea environment.

Our study involved the classification of nine sedimentary facies based on mode diameter (small, medium, large) and sand particle content (small, medium, large). Mode diameters within the sortable silt range displayed a consistent trend: decreasing skewness with increasing strain and increasing skewness with decreasing strain, aligning with previous observations in contour sedimentology (e.g., Brackenridge et al., 2018). This implies that mode diameter categories correspond to the sieving action of the bottom flow. In contrast, sand content exhibited a shift from unimodal to bimodal grain size distribution. Smear slides indicated that the sand fraction comprised mainly volcaniclastic debris, unaffected by bottom current transport. Therefore, the nine sedimentary facies categories reflect contourite facies (siliciclastic or volcaniclastic) and the

intensity of bottom currents influencing these facies. Additionally, sortable silt mean grain size exhibited significant changes corresponding to both upward coarse-grained and upward fine-grained structures.

References: Rebesco, M., et al. (2014) Mar. Geol.; Bailey, WS., et al. (2021) Sed.; Ando, K., et al. (2013) J. Oceanogr.; McCave, I. N., (1995) Paleoceanography.; Brackenridge, RE., et al. (2018) Sed.

Keyword

Contourite facies, LCDW, Active margin, Depositional process

Imaging offshore deformation features in western Luzon using integrated geophysical analyses

Carla Besa DIMALANTA[1]*, University of the Philippines - National Institute of Geological Sciences (cbdimalanta@up.edu.ph)
Leo Armada[2], University of the Philippines - National Institute of Geological Sciences
Elisha Jane Maglalang[3], University of the Philippines - National Institute of Geological Sciences
Nathaniel Parcutela[4], Energy Development Corporation
Rurik Austria[5], Philippine Geothermal Production Company, Inc.
Karla May Sayen[6], Department of Physical Sciences and Mathematics, University of the Philippines Manila
Berlyn Eleazar[7], University of the Philippines - National Institute of Geological Sciences
Graciano Yumul Jr.[8], School of Environmental Science and Management, University of the Philippines, Los Baños

Abstract

Understanding the tectonic complexities and deformation in the Manila Trench forearc region is crucial for seismic hazard assessment. This study integrates gravity data, seismic reflection, and sub-bottom profiles to delineate faults in the area. A Bouguer anomaly map of the region was generated by combining ground gravity data with the Earth Gravitational Model 2008. Power spectrum analysis was employed to distinguish residual and regional effects, enhancing the resolution of the anomalies. Through this analysis, a prominent belt of high gravity anomalies was identified, notably west of Zambales and extending towards the northwestern tip of Luzon. This belt has previously been reported to be the offshore extension of the Zambales Ophiolite Complex. The occurrence of a tectonic mélange in the northwestern tip of Luzon indicates the sheared character of this ophiolite belt. We hereby identify this zone as the West Luzon Shear Zone, a relict tectonic boundary attributed to the northward translation of Luzon since the Neogene. Furthermore, the calculation of the first vertical and tilt derivatives of the gravity anomalies revealed displacements in the gravity belt indicative of the presence of younger strike-slip faults. These features are identified to be offshore extensions of the Philippine Fault Zone. These findings were corroborated by seismic reflection profiles, which showed the subsurface configuration of the offshore splays of the Philippine Fault Zone. Additionally, recent normal faults were documented by analyzing sub-bottom profiles, providing further insights into the tectonic evolution of the Manila Trench forearc region. The integration of gravity data, seismic reflection, and sub-bottom profiles has enabled a characterization of deformation structures, highlighting the complex interplay of tectonic processes in the area. The multidisciplinary approach employed in this work demonstrates the efficacy of integrating various geophysical techniques to unravel the subsurface dynamics of tectonically active regions.

Keyword

deformation features, seismic hazard assessment, gravity anomalies, seismic reflection data,

offshore faults

Tectonic structure and deformation along the Manila Trench subduction zone: Implications on submarine geohazards in the South China Sea eastern margin

Leo ARMADA[1]*, University of the Philippines Diliman (ltarmada@up.ed.uph)
Armando Bambao[2], University of the Philippines Diliman
Carla Dimalanta[3], University of the Philippines Diliman
Elisha Jane Maglalang[4], University of the Philippines Diliman
Karla Sayen[5], University of the Philippines Manila
Rurik Austria[6], Philippine Geothermal Production Company
Nathaniel Parcutela[7], Energy Development Corporation
Shu-Kun Hsu[8], National Central University
Yi-Ching Yeh[9], National Central University
Graciano Yumul[10], University of the Philippines Los Baños

Abstract

The eastern margin of the South China Sea faces significant risks from submarine geohazards, such as earthquakes, mass movements, and tsunamis resulting from tectonic activity. This research examines the tectonic structure and current deformation along the Manila Trench. Previous studies on the western Luzon offshore region have highlighted the diverse nature of the subducting slab beneath Luzon, leading to distinct deformation patterns in the subduction zone. The present investigation delves into strain rates in the overriding plate and their correlation with the mechanical structure of the subducting slab. Spectral analyses of bathymetry and gravity data are employed to investigate the complex characteristics of the subducting slab, aiming to understand the role of bathymetric highs (i.e., subducting seamounts and extinct spreading ridges) in the segmentation of the mega-thrust and the overlying forearc crust. Additionally, 2D gravity modeling of trench-arc transects contributes to developing a mechanical model for the subducting slab, incorporating factors like elastic thickness and buoyancy effects relevant to seismic coupling at the subduction interface. Integrating strain rate calculations from earthquake and geodetic datasets, the study assesses the mechanical behavior of the slab concerning its seismogenic potential along the mega-thrust fault. Potential seismic gaps in the forearc region are identified as likely locations for triggering cascading submarine geohazards in the eastern South China Sea basin.

Keyword

subduction, geohazard, South China Sea, geophysics, earthquakes

In-situ Observation and Machine Learning Prediction of Marine Shallow Gas Emission

Cong HU[1]*, Ocean University of China (hucong@ouc.edu.cn)
Ting ZHANG[2], Ocean University of China
Yanyun XING[3], Ocean University of China
Yonggang JIA[4], Ocean University of China

Abstract

Marine shallow gas emission not only influences the marine environment and ecosystems but also can induce marine geohazards. However, our knowledge about the mechanism of marine shallow gas emission is still limited. In this study, a comprehensive investigation into the mechanism of marine shallow gas emission was conducted near the coast of Zhoushan Island in the East China Sea. A lander was deployed to study the correlation between hydrodynamics and marine shallow gas emission. The lander was equipped with an upward-looking 2M ADCP, a 6M ADV, a wave and tide gauge, and a dissolved methane sensor. Initial analysis of the in-situ observation results showed that pressure changes caused by tides was highly correlated with marine shallow gas emission. Methane concentration varies greatly when tidal pressure is at its lowest. Sediment resuspension induced by wave and current interaction often accompanies significant changes in methane concentration. Two different machine learning methods, Long Short-Term Memory (LSTM) and Random Forest (RF), were used to predict the influence of different hydrodynamics on marine shallow gas emission. Compared with the LSTM method, the RF method demonstrated a higher accuracy in predicting methane concentration changes and showed a better model performance. Its coefficient of determination (R^2) was 0.887, and the root mean square error (RMSE) was 2.618 nmol/L. The feature importance assessment of RF also indicated that tidal pressure and sediment resuspension were the key factors affecting marine shallow gas emission, followed by wave and current velocity. This study provides new insights into the mechanism of marine shallow gas emission and contributes to a better understanding of the controlling factors of seafloor fluid systems.

Keyword

Marine Shallow Gas, In-situ Observation, Machine Learning, East China Sea

In-Situ Observation on the Interaction of Deep-Sea Internal Solitary Waves with the Seabed

Yong Gang JIA[1]*, Ocean University of China (404806030@qq.com)

Abstract

The benthic boundary layer instability caused by internal solitary waves can result in sediment resuspension and transport, leading to reshaping of continental margin topography and significantly impacting the transport of sediment solutes and biogeochemical cycles. However, there is currently very little research that combines the sediment resuspension and transport caused by internal solitary waves with direct measurements of bottom pressure or pore pressure, and little is known about how the driven pore fluid circulation and seepage processes affect the bottom environment.

This study is focuses on the Dongsha Slope in the South China Sea, and conducts IWBBLE (Internal Wave - Benthic Boundary Layer Experiment). For the first time, long-term high-frequency in-situ pore pressure observations are carried out in the South China Sea. The aim is to reveal the characteristics of seabed response under the large-amplitude internal solitary waves, and to explore the physical mechanisms of seabed response affecting sediment suspension and transport based on scientific discoveries.

The combined results of this study and previous observations indicate that the seabed pressure disturbance in the deep-sea has been underestimated. Deep-sea internal solitary waves exhibit distinct and sharp pressure signal characteristics. The maximum seabed pressure disturbance caused by internal solitary wave at a depth of 740 m on the Dongsha Slope is approximately 1.5 kPa, which is one order of magnitude larger than typical results observed in shallow seas. Using parameter R, the estimated maximum pressure disturbance of the internal solitary wave with a maximum amplitude of 173 m on the Dongsha Slope is predicted to be between 3.94 and 5.91 kPa. Using the DJL equation, it is estimated to be 5.68 kPa, which is roughly equivalent to the estimate of 5.91 kPa obtained using parameter R=0.4.

Pore fluid seepage caused by internal solitary waves results in pore fluid circulation across the sediment-water interface. The results confirm the lag of pore pressure response under the internal solitary waves. The maximum pore pressure response is approximately 0.69 kPa, with pore pressure changes concentrated in the surface sediment. The high pore pressure response core is observed beneath the peak of seafloor pressure disturbance. The depth of pore pressure response during IWBBLE is approximately 0.5 m below the seafloor.

Throughout the observation period, sediment resuspension induced by internal solitary waves was more significant compared to that caused by contour currents and internal tides, suggesting that internal solitary waves control the development of the bottom nepheloid layer at a depth of 740 m on the Dongsha Slope in the northern South China Sea. Deep-sea cameras have captured for the first time the transport of sediment particles, including bedload, saltation, and suspension, under the influence of internal solitary waves, with particles rapidly transported downslope after entering

the water column along the direction of bottom current. The global instability and vortex shedding of internal solitary waves dominate the intense vertical sediment transport at the rear of the waves, with suspended sediment heights far exceeding those caused by tidal currents and internal tides.

Keyword

Internal solitary waves, Seabed response, Erosion and resuspension, Material transport

Submarine geohazards and educational materials

Kiichiro KAWAMURA[1]*, Yamaguchi University (kiichiro@yamaguchi-u.ac.jp)

Abstract

In order to develop human resources for submarine geohazards, it is important to develop teaching materials using various approaches. Here, I would like to introduce teaching material development from a multifaceted perspective, and share and exchange information at this international conference.

1) Observation of outdoor survey (https://www.youtube.com/channel/UCAG1N7HZbWVBh9NT4vIBE4g)

For on-site observations, it would be best to observe sedimentation processes along the coast. This allows us to understand the sedimentation and erosion effects caused by water flow. It is also desirable to distribute these using YouTube and use them as repeated teaching materials for students.

2) Observation of indoor experiments

For the sedimentation and erosion effects caused by water flow, it is often appropriate to observe sand particles in a laboratory using a water tank or channel. Experimental approaches are important for simplifying complex processes and understanding mechanisms in nature. Without experimental equipment, it would be impossible to teach many students at the same time, so classes could be conducted by making the experimental equipment cheap and simple, or by streaming videos. However, video streaming does not allow detailed observations, so it is desirable to create experimental equipment suitable for the number of students taking the course.

3) Utilization of open data (https://www.kyoumu.jimu.yamaguchi-u.ac.jp/portal/Public/SyllabusV2/DetailMain.aspx?lct_year=2024&lct_cd=1043600031&je_cd=2)

In recent years, ocean floor topography data has become open data and is being uploaded by various organizations. In order to promote the utilization of these data, I am working with TGSG to create an online program for universities. Every year, I invite famous teachers from around the world to teach us how to utilize data.

4) Development of tools necessary for observation (https://ds0n.cc.yamaguchi-u.ac.jp/~kawaken/index.html)

When conducting observations in the field or in the laboratory, it is necessary to develop teaching materials related to various observations, descriptions, and measurements. Here, I would like to introduce three that I have recently developed. The first is a simple clinometer made of plastic. This is an inexpensive and durable clinometer. A clinometer is used to measure the strike and dip of bedding planes and to measure the orientation. Many smartphone apps have been developed in recent years, but we developed this based on the idea that teaching materials that can get dirty are needed when used outdoors. The second is the particle size table. Equipment is required to measure the size of sand particles on-site. In recent years, only expensive ones are on the market, so I have been making inexpensive ones myself. The third is a safety aid when creating rock

slices. You can understand this by creating rock flakes, but it's easy to injure your fingers. They cut their hands on glass and grinders. To prevent this, the aids used to press the glass into the grinder are made of plastic. This can also be produced inexpensively.
Thus, I would like to do capacity development for submarine geohazards by devising various teaching materials.

Keyword

Geocompass, Grain size scale, Open data, Capacity development, Experiments

An optimal geological method to decipher active faults and related lineaments at Yamaguchi, SW Japan

Momoko TSUTSUMI[1]*, Yamaguchi University (c018dgw@yamaguchi-u.ac.jp)
Kiichiro Kawamura[2], Yamaguchi University

Abstract

In active marginal areas like Japan, disasters related to tsunamis, earthquakes, and volcanic eruptions occur frequently, and these disasters are often recorded in the topography. However, the topography is made up not only of the topographical features at the time of the disaster, but also of natural changes over time, such as weathering and erosion. Therefore, in order to decipher the topographical features that serve as records of disasters, topographical and geological analysis methods are required. In this paper, we use the 10 m grid digital elevation model provided by the Geospatial Information Authority of Japan, the map drawing software GMT, and the image analysis freeware ImageJ to explore the optimal method for quantifying changing topography. The study area was located in the Tokusa area of SW Japan. We extract the lineament structure by the optimal method.

In general geological features, the SW Japan Inner Belt is located in the northern part of the median tectonic line being a dextral strike-slip fault with a total length of over 1,000 km, and the southern part is called the SW Japan Outer Belt, which is mainly composed of accretionary prisms dating from the Cretaceous to the present, and E-W faults related to accretionary processes can be seen.

On the other hand, lineament structures originating from the NE-SW faults are often seen in the inner belt. Most of them are thought to be closely related to the formation of the Sea of Japan from ~19 Ma to ~14.5 Ma during the Miocene period. The Japanese archipelago as a land arc being an onshore volcanic arc on the edge of the Eurasian continent, separated from the continent as forming a V-shape open while the Sea of Japan expanded, and became an island arc. These faults being "old scars" formed by large-scale events in the past are probably closely related to the current lineament structure of the Japanese archipelago and the active faults as well. These lineament structures characterize the topography of the Japanese archipelago, and in particular regulate the distribution and extension of river systems. In this study area, major rivers flow along the NE-SW lineament structure. However, many lineament structures are associated with the expansion of the Sea of Japan, and are often overwritten by subsequent crustal deformation. Such overwriting occurs due to igneous activity of the Aonoyama volcanic group of several hundreds thousands of years ago. This igneous activity caused major deformation of the topography, resulting in numerous river captures and complex changes in flow paths.

We discussed the optimal geological method to decipher active faults and related lineament structures based on digital elevation models, ground surveys, and prior data. As a result, the weighting parameter of the lineament length is important. In the future, we plan to apply this type of analysis method to research on submarine geohazards using bathymetry data.

Keyword

Active fault, GMT, DEM, Lineament, River caputure

Microplastics: diffusion into ocean floors by tsunamis and typhoons and application for age determination

Kiichiro KAWAMURA[1]*, Yamaguchi University (kiichiro@yamaguchi-u.ac.jp)

Abstract

Marine plastic pollution is a serious social problem. The sight of many plastic bottles washed ashore on the coast is a symbol of our current situation. These plastic materials typically degrade and shatter into microplastics, which are dispersed into the ocean. Pollutants (such as PCBs) attached to these microplastics accumulate in marine life. Such marine plastic pollution has been investigated at shallow depths, but unknown at depths deeper than a few thousand meters.

According to the Vinyl Environmental Council, plastic products have rapidly increased from 100 million tons per year in the 1960s to 200 million tons per year in 1991. But more recently, since 2008, it has been 180 million tons per year. These products and their particles are similar to microplastics. It accumulates continuously without decay, but is unknown. Most of them may have settled to the deep sea floor, been retransported by bottom currents, and accumulated somewhere on the deep sea floor. I believe that such missing sinks will become a future research topic in earth science.

Additionally, microplastics can be used in geoscientific research as reference fossils in a sense. Radionuclides are one famous example of age determination using artifacts. For example, we use cesium-134 and cesium-137 to determine age. 134Cs, which has a half-life of about two years, is an indicator of nuclear tests and nuclear power plant accidents. It plays an important role in the Fukushima Daiichi nuclear power plant accident (e.g. Oguri et al., 2013; Sci. Rep.). Cesium-137 has a half-life of approximately 30 years, and the age of the accident can be detected from sediments over a relatively long period of time. The famous peak of cesium-137 is a deposit from nuclear tests in the 1960s and the Chernobyl disaster in 1987. Microplastics are similar artifacts, and it may be possible to estimate the age of sediments by using them in the same way as radionuclides.

I have studied mainly a relationship between marine microplastics and geohazards. Nakajima et al. (2021; Frontiers in Marine Science) disclosed the effects of typhoon and related flood disasters, and Tsuchida et al. (2023; Mar. Poll. Bull.) discussed the effects of deep-sea sedimentary processes including turbidity currents and bottom currents. Kawamura et al. (2019; GS LondonSP) has reported a relationship between microplastic distribution and tsunami events. In this paper, I introduce the relationship between marine microplatics and submarine geohazards, and the implication of microplastic studies on submarine geohazards.

Keyword

Japan Trench, Microplastics, Tsunami, Marine pollution, 137C

A harmonized database on geological events occurrence as a tool to support geohazard assessment in European seas

Andrea FIORENTINO[1]*, Geological Survey of Italy - ISPRA (andrea.fiorentino@isprambiente.it)
Loredana Battaglini[2], Geological Survey of Italy - ISPRA
Simone Orefice[3], Geological Survey of Italy - ISPRA
Alessandra Pensa[4], Geological Survey of Italy - ISPRA

Abstract

A database of information concerning submarine landslides, earthquakes, volcanic centres, tsunamis, fluid emissions and Quaternary tectonics has been gathered in the frame of the EMODnet Geology Project. EMODnet (European Marine Observation and Data Network) is a long-term marine data initiative funded by the European Union. It provides easy and free access through a Central Portal (https://emodnet.ec.europa.eu/en) to marine data, metadata and data products and services spanning seven broad disciplinary themes (lots): bathymetry, geology, physics, chemistry, biology, seabed habitats and human activities.

EMODnet Geology provides full areal coverage of all European regional seas delivering maps at multiple scales on sea-bed substrate, sediment accumulation and erosion rates, Quaternary and pre-Quaternary lithology and age, geomorphological features, coastal behaviour, geological events and probabilities, minerals and submerged landscapes.

The Geological Survey of Italy – ISPRA coordinates the “Geological events and probabilities” work package which consists of digital maps of landslides, earthquakes, volcanoes, tsunamis and fluid emissions. Quaternary tectonics has also been considered since most of the events are connected to the underlying geological and structural setting.

Data, deriving from national and international Projects held by Partners or by third parties, were collated, validated and standardized. Each type of geological event occurrence is represented by features organized according to their geometries (polygons, lines and points) and complemented by a comprehensive pattern of attributes.

Besides the collection of events occurrences, events probabilities were also considered, although not easy to assess. Based on data gathered by WP6 and on parameters obtained from EMODnet Bathymetry (such as depth, slope, curvature, etc.), it was possible to elaborate a “Landslides susceptibility map” by applying the MaxEnt model.

Data, metadata and complementary information are displayed on the EMODnet Central Portal subdivided into layers at 1:250.000 scale, which include data at lower resolutions, and layers at 1:100.000 scale, which include also data more detailed than 1:100.000.

They provide a reliable and complete interoperable database which can be downloaded and may represent a baseline to support further research or to elaborate additional thematic maps.

Keyword

geological events, database, EMODnet, geohazard

Possible development and implication of subsurface fault structures offshore northeast Taiwan

Chien-Wei HSU[1]*, Institute of Oceanography, National Taiwan University
(r11241313@ntu.edu.tw)
Jih-Hsin Chang[2], Institute of Oceanography, National Taiwan University

Abstract

The geological structures of the North and Northeast Coast Taiwan are considered significant due to nuclear power infrastructures. As far as we know, northern Taiwan had experienced late Cenozoic uplifted mountain building and is now in the state of mountain collapse. As the northern extension of the collapsed mountain, northern offshore Taiwan is now dominated by a series of normal fault structures and regional extension. Historical records suggest that the activities of the major normal fault likely played a significant role in triggering tsunamis in northern Taiwan. The detailed geometries and possible activities of these fault structures are thus important. To derive detailed fault structures and to propose extension of the faults, we take advantage of new and reprocessed offshore marine multi-channel seismic reflection surveys data northeast offshore Taiwan. In our seismic dataset, a series of normal faults separating fault blocks, and two seismic sequence boundaries representing top-of-fault blocks and top-of-filled sediments are recognized, collectively showing several half grabens. The depths of the seismic sequence boundaries are mapped and interpreted to represent the offset of the normal faults. The offsets of these normal faults seem to gradually decrease towards the onshore region, where the sense of the fault is mainly reverse. Toward the offshore, however, we found that the offsets of these faults appear to gradually decreases as well and seem to disappears. Besides, it seems that the variations in depths of both seismic sequence boundaries seem not consistent, probably indicating that the formation of these fault blocks and activities of these faults are not in sequence. Detailed fault development in this study combined with historical depositional records of tsunami event can help us better understand the possible mechanism of tsunami, providing useful implications for future geohazard assessments in northern Taiwan.

Keyword

Offshore Northeastern Taiwan, Post-collisional collapse, Multi-channel seismic, Seismic Stratigraphy, Tsunami

Active Fault and fold structures in northern Taiwan Strait

YI-PING CHEN[1]*, Ocean Center, National Taiwan University (yiping@ntu.edu.tw)
Ho-Han Hsu[2], Ocean Center, National Taiwan University
Sung-Ping Chang[3], Department of Earth Sciences, National Cheng Kung University
Yu-Xuan Lin[4], Ocean Center, National Taiwan University
Arif Mirza[5], Ocean Center, National Taiwan University
Cheng-Chun Chung[6], Institute of Oceanography, National Taiwan University
Char-Shine Liu [7], Ocean Center, National Taiwan University
Song-Chuen Chen[8], Geological Survey and Mining Management Agency, Ministry of Economic Affairs
Yi-Jung Lin[9], Geological Survey and Mining Management Agency, Ministry of Economic Affairs

Abstract

Northern Taiwan Strait is located in a geological environment of the transition zone from a compressional regime to an extensional regime. In this area, there are complex fault and anticline structures, including normal fault structures formed during the syn-rift stage, and reverse faults formed during the orogenic stage. Some of the reverse faults were reactivated along the Pliocene normal faults due to the westward advancement of the Taiwan orogeny. The active faults may cause shallow strata displacement and potentially impact the construction of offshore wind turbines. This study utilized advanced seismic data processing techniques to reprocess previously collected seismic reflection profile data and to improve the accuracy of profile location effectively enhancing the quality of the seismic image. From seismic stratigraphic analysis, we have identified two unconformities, the foreland basal unconformity and the last glacial maximum unconformity (LGMU), to build age models of geological formations. There are many normal faults present in the northern Taiwan Strait, with most of them being buried at depths. Several fold structures are identified, some of the crests were truncated by the LGMU, and the post-LGMU strata there have been uplifted by the folding. One of the active fold structures with a NE-SW trending fold axis has been mapped extending southwestward from near shore to off shore for 10 kilometers, and its strike is similar to the Chingtsaohu anticline on land. One of the reverse faults is the Hsinchu offshore fault, its strike is east-west and is a high-angle south-dipping reverse fault. It may be a reactivated fault, with a length larger than 6 kilometers, and its strike and dip angle are similar to the onshore Hsinchu fault. In this study, we have identified the distribution of faults and folds in the area where the deformation front may have extended from onshore to offshore, and provide valuable information for geohazard risk assessment of wind turbine generator locations and submarine cable deployment.

Keyword

fold structures, Taiwan Strait, seismic profile

Shallow Subsurface 3D Velocity Structure Identification in Turkey Antakya based on Microtremor Horizontal-to-Vertical Spectral Ratio

Jikai SUN[1]*, Disaster Prevention Research Institute Kyoto University (sunjikai01@outlook.com)
Ziqian Wang[2], Disaster Prevention Research Institute Kyoto University
Eri Ito[3], Disaster Prevention Research Institute Kyoto University
Hiroshi Kawase[4], Disaster Prevention Research Institute Kyoto University

Abstract

Heavy building damages were caused by the 2023 Turkey Kahramanmaras Mw7.8 earthquake. According to statistics (Rapor, 2023), 22.39% of the houses in Hatay province suffered heavy or collapsed earthquake damage. In Antakya city, the capital of Hatay province, six strong-motion stations set up by the Turkey Disaster and Emergency Management Authority (AFAD) have observed seismic strong ground motions with high PGAs. Although the distance between each station is only 2-4km, the waveforms observed at the northeast, northwest and southern stations are very different from each other. We initially consider that there is strong site effect affecting the observed seismic strong-ground motions in the urban area of Antakya. Our team conducted site microtremor (surface background noise) observations in the urban area of Antakya in October 2023. We set up a 600m*600m staggered grid in the direction parallel to and orthogonal to the East Anatolia Fault. Considering the observation efficiency and the ease of field work, we observed 90 points. We then analyzed the Microtremor Horizontal to Vertical Spectral Ratio (MHVR) at each point and obtained the fundamental frequency of the site in Antakya urban area. We found that in the northwest and southwest corner areas, the fundamental frequency of the sites are very high, reaching 10Hz, while in the northeastern area of the city, the fundamental frequencies are around 4Hz, and the fundamental frequencies of areas close to the Asi River are about 2Hz. These results illustrate that thickness of the sediment layer varies greatly in different areas of Antakaya urban area. We next need to convert the MHVR of each point into the pseudo Earthquake Horizontal to Vertical Spectral Ratio (pEHVR), and then identify detailed three-dimensional velocity structure of Vs ≦ 3km/s based on the diffused field theory for EHVR (Kawase et al., 2011). We will analyze and simulate the seismic strong-ground motions in Antakaya urban area when the Mw7.8 earthquake occurs.

Keyword

2023 Turkey Mw7.8 Earthquake, Seismic strong-ground motion, Microtremor Horizontal to Vertical Spectral Ratio, Fundamental frequency, Site effect

Framework for prioritization strategies for slope reinforcements under heavy rainfall based on probabilistic connectivity of road networks

Zhengying He[1]*, Tongji University (zhyhe@tongji.edu.cn)
Yu Huang[2], Tongji University
Zhen Guo[3], Tongji University

Abstract

Rainfall-induced landslides are common global phenomena, leading to significant traffic disruptions and compromised road network connectivity. To mitigate these impacts, it is crucial to quantify road network connectivity, facilitating the development of effective slope reinforcement strategies. However, current research on prioritization strategies for slope reinforcements predominantly focuses on the reliability assessment of individual slopes without adequately addressing road network connectivity enhancement. This study presents a novel framework for prioritizing strategies for slope reinforcements under heavy rainfall based on probabilistic connectivity of road networks. Rainfall hazard intensities are assessed by Generalized Pareto Distribution (GPD). Vulnerable slope locations are identified by field investigation and spatially correlated states of these slopes are estimated by fragility assessment and spatial correlation of landslides. The probabilistic connectivity of road networks is estimated considering spatially correlated states of multiple slopes, leveraging both geographical information systems (GIS) and graph theory. With the proposed framework, improved road network performance can be achieved by optimal strategy in slope reinforcement prioritization. As an illustrative example, the proposed method is applied to the road network in Lishui City, China, susceptible to rainfall-triggered landslides. The probabilistic connectivity of road networks is substantially enhanced with the pile-reinforcement strategy for slopes. This study not only offers a new perspective on addressing the prioritization strategies for slope reinforcements but also contributes to the broader field of disaster-resilient infrastructure planning.

Keyword

slope failure, reinforcement, rainfall hazard, road network, connectivity

Energy evolution of subaqueous gravity flows composed of viscous liquids and particles

Chen PENG[1]*, Tongji University (chenpenghn@tongji.edu.cn)
Xingyue Li[2], Department of Geotechnical Engineering, College of Civil Engineering, Tongji University
Yu Huang[3], Department of Geotechnical Engineering, College of Civil Engineering, Tongji University

Abstract

Subaqueous gravity flow is a geological process in which sediments consisting of gravel, sand, mud and water move underwater. The column collapse in water has been extensively used to investigate subaqueous gravity flows in previous studies, where the column is composed of either particles or non-Newtonian fluids like slurry. However, the real composition of the gravity flow can be much complex, and the simplified consideration of subaqueous gravity flows as viscous flows or particle flows makes it difficult to fully understand the flow dynamics controlled by interactions between different flow compositions. In this work, the collapse of a particle-slurry mixture underwater was simulated using the coupled computational fluid dynamics (CFD) and discrete element method (DEM), where the particles were simulated as rigid particles with DEM and the slurry was simulated as a Herschel-Bulkley fluid with CFD. As a reference case, the collapse of particles in water was also simulated. The adopted approach can reasonably recover the flow of mixtures rich in clay and coarse particles. In particular, the influence of Herschel-Bulkley fluids with different properties on the run-out distance and the energy evolution is explored. The results show two trends in the distance travelled by the particles in the mixtures. When the clay content of the slurry is high, the final runout distance can be larger than the reference case. On the contrary, a smaller runout distance can be obtained if the clay content is low. The opposite trends depend on the competing effect of the viscous force and the buoyancy on the particles. From the perspective of energy evolution, more energy is dissipated by particle collision, friction, and fluid viscosity at the early stage of the column collapse, and less is dissipated at the later stage. The efficiency of the conversion of kinetic energy from vertical to horizontal direction is critical in controlling the final runout distance of the particles. The numerical results in this study help understand the behaviour of mixtures composed by Herschel-Bulkley fluids and particles flowing under water, and explain the possible mechanisms of the promoting or inhibiting effect of viscous fluids on particle motion.

Keyword

Subaqueous gravity flow, energy evolution, runout distance, coupled CFD-DEM

DEM modeling of undrained cyclic triaxial behavior in submarine loose sediments under wave loading: the influence of fine contents

Yandong Bi[1]*, Tongji University (2110056@tongji.edu.cn)
Yu Huang[2], Tongji University
Shu Zhou[3], Tongji University
Chongqiang Zhu[4], Tongji University

Abstract

The accumulation of pore water pressure in submarine loose sediments subjected to cyclic wave loading gradually compromises the stability of submarine slopes and poses a threat to offshore engineering. In order to investigate the mechanism underlying pore water pressure accumulation under cyclic wave loading and the influence of clay fine contents on the macro- and micro-mechanical characteristics of undrained granular assemblies, this study conducted a series of undrained cyclic triaxial discrete-element method simulations, which constituted a parametric study involving five factors: fine contents, initial void ratio, initial mean effective stress, cyclic stress ratio, and frequency. The discrete element model is established based on rational soil mechanics parameters. And the research results show that there is a threshold fines content (FC) that makes the cyclic liquefaction resistance and cyclic loading times reach the minimum value. Through analysis of the micro-scale particle that participate in the force chains and the contact information, such as mechanical coordination number and contact-normal-based fabric anisotropy, the evolution of internal structure of the granular materials under cyclic wave loading was quantified. The present study shed lights on the underlying pore water pressure accumulation under cyclic wave loading mechanism that effects of the presence of clay fine particles on liquefaction under cyclic triaxial test condition.

Keyword

DEM, Undrained cyclic triaxial tests, Wave loading, Liquefaction, Fine content

Prediction of landslide hazard using LS-RAPID model. A case study in Tia Dinh area (Dien Bien province, Vietnam)

Ha Duc NGUYEN[1]*, Center for Information, Archives and Museum of Geology (Viet Nam Geological Department) (nh14vn@gmail.com)
Ninh Hoang Nguyen[2], Vietnam Institute of Geosciences and Mineral Resources
Duong Huy Nguyen[3], Vietnam Institute of Geosciences and Mineral Resources
Van Thi Hai Nguyen[4], Vietnam Institute of Geosciences and Mineral Resources

Abstract

Landslides are among the most dangerous geohazards in many countries worldwide, including Vietnam. The loss of lives and properties has been getting more severe since the population and economic activities are expanding into mountainous areas, which are most prone to landslides. This study focuses on the Tia Dinh commune in Dien Bien province, situated amidst the northwestern mountains of Vietnam. The central area of the commune has been identified as a high-risk zone for landslides, posing imminent threats to local residents and infrastructure, including the People's Committee office building, health station, schools, and more than 69 houses.

Physical models are often highly regarded for their ability to determine the risk and extent of landslide impacts with high accuracy. However, these models are often only suitable for small, homogeneous geological areas. In large areas with many potential landslide surfaces, the parameters vary greatly, making it difficult to select a representative sample for the entire area. Moreover, in Vietnam, where three-quarters of the territory consists of hilly or mountainous terrain, conducting soil sample testing for all landslide-prone areas is challenging due to financial and time constraints. In areas with an existing risk of landslides, simpler and more practical methods need to be tested and replicated if feasible to quickly predict potential hazard areas.

The LS-RAPID model is advanced and capable of simulating and predicting landslide-prone areas and their potential impact. By applying the LS-RAPID model, this study has produced two main results. Firstly, it predicts the potential hazard under the worst-case scenario, and secondly, it identifies the water level that could trigger landslides in three high-potential landslide areas that have shown many signs of instability. The identified groundwater trigger levels can be combined with real-time water level monitoring devices for early landslide warnings. Predicting the potential hazard of landslides is essential for land-use planning. Therefore, the results of this study make an important and long-term contribution to the efforts to prevent and mitigate damage caused by landslides in the region.

Moreover, the LS-RAPID model application method can be extended to numerous mountainous regions across Vietnam. While the results of this model application may not always achieve pinpoint accuracy, they offer invaluable preliminary predictions and ensure safety, particularly through worst-case scenario assessments, all at a low cost and with rapid deployment potential. This adaptability and cost-effectiveness render the LS-RAPID model a valuable tool in safeguarding vulnerable communities against the hazards of landslides.

Keyword

Landslide, Geohazard, Disaster prevention, LS-RAPID model

[Keynote] Rheological behaviour of pressure-controlled steady slope flow with coexistence of multiple flow regimes

Chongqiang ZHU[1]*, Tongji University (cqzhu@tongji.edu.cn)
Yu Huang[2], Tongji University
Jin Sun[3], Tongji University

Abstract

Natural disasters, such as landslides, debris flows and pyroclastic flows, usually lead to large deformation and complex flow of the granular materials involved. Understanding such behaviour of granular materials is thus important for modelling and simulation of natural disaster events. Instead of deforming homogenously, granular beds could indeed develop regions of intense shear (Artoni et al. 2018), i.e. shear zones, bounded by quasi-static or plug flows in the geophysical flows. Though the study of granular rheology has made significant progress on homogenous steady flows in a single flow regime in the past decades, the understanding of inhomogeneous steady granular flow with coexistence of multiple flow regimes still poses many challenges.

In this work, we explored the rheological behaviour with coexistence of multiple regimes using a pressure-controlled slope flow configuration. Specifically, the inclined flow is bounded on top by a lid that moves parallel to the slope with a velocity U and adjusts its normal position as dictated by a prescribed pressure P, which models the overburden in natural flows. Interestingly, 5 different flowing structures are found with their boundaries clearly delineated by the distinct velocity and volume fraction profiles as the controlled velocity and pressure of the top lid vary. We further investigate the rheology of the flows with coexistence of multiple regimes. The inertial rheology of the materials in the shear zone can be well predicted by the previous models determined based on homogenous simple shear flow. But these models fail to capture the rheology of the creeping zone, where the pressure is independent of the shear rate, similarly to the quasi-statice simple shear flow, but with a much lower magnitude. The deviation of rheology of the creeping zone from simple shear flow is also confirmed by our previous simulations of vertical chute flow (Barker et al. 2022) and inclined slope flow with erodible bottom boundary (Zhu et al. 2023). Moreover, the rheology with coexistence of multiple regimes for the different configurations collapses well, which suggests the possibility of a new rheological model for the different complex flow conditions, and further research to understand its universal physical mechanisms is warranted.

References

Artoni, R., Soligo, A., Paul, J. M., & Richard, P. (2018). Shear localization and wall friction in confined dense granular flows. Journal of Fluid Mechanics, 849, 395-418.

Barker, T., Zhu, C., & Sun, J. (2022). Exact solutions for steady granular flow in vertical chutes and pipes. Journal of Fluid Mechanics, 930, A21.

Zhu, C., Huang, Y., & Sun, J. (2023). A granular energy-controlled boundary condition for discrete element simulations of granular flows on erodible surfaces. Computers and Geotechnics, 154, 105115.

Keyword

granular rheology, multiple flow regimes, shear localization, geophysical flows

Simulating Cyclic Injection-Induced Fatigue in Rocks

Chang Xia[1]*, Hong Kong Polytechnic University (23036821r@connect.polyu.hk)
Qi Zhao[2], Hong Kong Polytechnic University

Abstract

This study focuses on the development of a numerical model for Cyclic Hydraulic Fracturing (CHF), a technique currently employed in subsurface energy extraction due to its benefits in reducing induced seismicity. However, a numerical modelling framework that can accurately replicate the hydraulic fatigue damage caused by CHF is not available. To address this gap, we have created a fully integrated hydro-mechanical damage model using the Discrete Element Method (DEM) method, UDEC. This model introduces a unique time-dependent failure model designed to simulate the hydraulic fatigue response. In addition, we have utilized the Grain-Based Model (GBM) to simulate the formation of heterogeneous incipient cracks. These cracks allow fluid flow following their formation. We have conducted numerical calculations of the fatigue caused by hydraulic injection under various fluid pressure levels. These calculations have been cross-verified with laboratory results, showing a reasonable consistency in breakdown pressures. This validation provides a solid foundation for the accuracy and reliability of our model. Following the development and validation of our model, we carried out field-scale studies using a large-scale model with pre-existing joint sets. These studies allowed us to thoroughly examine the impact of CHF on fracture network propagation and permeability enhancement. Our research provides valuable insights into the effects of CHF, and the findings could potentially guide practical subsurface energy exploitation. The development of this numerical model represents a significant advancement in our ability to understand and predict the effects of CHF, thereby contributing to more efficient and sustainable energy extraction practices.

Keyword

Cyclic injection, Fatigue, Hydraulic fracturing, Induced Seismicity, Discrete Element Method

Numerical Insights into Microbially Induced Desaturation (MID) in Layered Silts and Sands

Patrick Kwon[1]*, Arizona State University (pskwon@asu.edu)
Leon van Paassen[2], Boskalis

Abstract

A numerical reactive transport model was developed to simulate Microbially Induced Desaturation (MID), an emerging bio-mediated ground improvement technique. MID utilizes nitrate-reducing microorganisms to desaturate soil, thereby mitigating earthquake-induced soil liquefaction. The primary goal for the MID is to prompt gas bubble production by microorganisms, resulting in the desaturation of the target soils and subsequently enhancing soil cyclic resistance. This approach is especially notable for its ability to mitigate liquefaction non-disruptively, facilitating mitigation adjacent to and beneath existing structures. Numerical modeling is a valuable option for advancing the understanding of MID treatment, evaluation of field trials, and design of practical applications. The MID numerical model integrates fluid flow dynamics with the MID reactive processes, offering a comprehensive predictive framework for substrate and product distribution and the resultant changes in the soil properties such as porosity, permeability, and degree of saturation due to MID treatment. The reactive transport model employs biochemical reaction equations coupled with Darcy's law. The numerical model is implemented in COMSOL Multiphysics® finite element software and validated with the empirical data from a bench-scale tank experiment. The validation process involved a comparison of the degree of saturation, electrical conductivity, and time-lapse images of the flow front from the tank test with corresponding outputs generated by numerical simulations. This model was tested with various initial biomass concentrations and reaction rates to provide an enhanced understanding of MID treatment. This research significantly contributes to the advancement of MID as a non-disruptive means of enhancing infrastructure resiliency and sustainability through liquefaction mitigation and establishes a foundation for further exploration and application of this innovative technique in the field of geotechnical engineering.

Keyword

liquefaction mitigation, silty sand, modeling, desaturation

Karst geohazard and climate change: case of Lithuania

Jonas SATKUNAS[1]*, Nature Research Centre, Vilnius (jonas.satkunas@lgt.lt)
Vytautas Minkevičius[2], Nature Research Centre, Vilnius
Julius Taminskas[3], Nature Research Centre, Vilnius
Rita Linkevičienė[4], Nature Research Centre, Vilnius
Vidas Mikulėnas[5], Lithuanian Geological Survey
Simonas Danielius[6], Nature Research Centre

Abstract

Karstic phenomena in North Lithuania are related with dissolution of sulphatic (mainly gypsum) interlayers of Upper Devonian formations, that occur under the 1-10 metres thick Quaternary cover. The process results with rapid occurrence of sinkholes very often causing with hazardous consequences. In some places more than 200 sinkholes of different size are counted in one square kilometre. In total, in the karstic region there are counted over 11000 sinkholes. Some of them are 14 m deep and 20 m in diameter.

Monitoring of the karst process comprise: mapping and measuring of volumes of new karstic sinkholes (in cubic meters) and measuring of amount of dissolved of underground gypsum (in cubic meters from 1 square kilometre of karstic terrain during one year. The monitoring displays that during the period 1925-2023 average annual chemical (gypsum) denudation was 232 m^3 km^{-2} year-1. The rate of karst denudation is increasing due to climate change.

In the period 2018-2023 sinkholes of generalised volume of 2.82 m^3 occured in 1 km^2 annually. This volume makes only 1 percent of the volume of ammount of dissolved gypsum, estimated by denudation. Therefore, we assume the average annual karst denudation in amount 232 m^3 km^{-2} year-1 could cause land surface subsidence of 0,02 m during the past 100 years.

Keyword

Gypsum karst, sinkholes, chemical denudation

From Hazard to Opportunity: Success Story of Biogenic Gas Exploration in North Sumatera Basin through Heating Rate Analysis in Offshore Area

Anggit KURNIA[1]*, Pertamina Hulu Rokan (anggit.kurnia@pertamina.com)
Dhanny Triamindo[2], Pertamina Hulu Rokan
Casdira Casdira[3], Pertamina Hulu Rokan

Abstract

The North Sumatra Basin, renowned for its substantial hydrocarbon reserves, has produced over 4178.35 MMBOE of oil and gas, with an estimated 2088.54 MMBOE of remaining resources (S&P Global Inc, 2024). It unveils a narrative beyond traditional thermogenic gas deposits and oils derived from river-delta/lake sources.

Recent exploration drilling has consistently encountered significant shallow gas accumulations at relatively shallow depths, traditionally considered hazards. Geochemical analysis reveals a surprising truth: these shallow reservoirs hold high-quality biogenic gas, exceeding 98% CH4 with low impurities.

The key to this hidden potential lies in the Keutapang Formation, a shallow unit with less than 1,000 meters, boasting a high sedimentation rate and warm thermal gradient. This condition fosters an anoxic environment, favoring bacterial abundance and subsequent biogenic gas generation. By capitalizing on these favorable conditions, we identified a promising biogenic gas window. This was achieved by multiplying the sedimentation rate and thermal gradient to estimate the heating rate (OC/Ma).

Organic richness is meticulously determined using calibrated Total Organic Carbon (TOC) data and the Passey method (1990), further refined by laboratory results. Subsequent analysis, employing the maximum methane yield plot, classifies biogenic gas potential into four categories: non-potential (< 70C/Ma), unlikely (70-90C/Ma), probable (90-120C/Ma), and highly probable areas (120-180C/Ma) – guiding future exploration.

Compared to Thermogenic gas, biogenic gas presents advantages, boasting lower impurities and exploration costs. This study unveils the significant potential for biogenic gas development in the Keutapang Formation in North Sumatra. Our findings offer valuable insights for further exploration, contributing to Indonesia's energy security and facilitating the transition to cleaner energy sources.

Keyword

Biogenic Gas, Sedimentation Rate, Heating Rate, Shallow Gas, North Sumatera Basin

Improving landslide susceptibility assessment using probabilistic back analysis and Markov Chain Monte Carlo simulation

Hyuck-Jin PARK[1]*, Sejong University (hjpark@sejong.ac.kr)
In-Tak Hwang[2], Sejong University
Jung-Hyun Lee[3], Sejong University

Abstract

The physically-based method for analyzing landslide susceptibility is promising because it takes into account the type and process of landslides using a physical slope model. This method uses input parameters, such as slope angle and shear strength of slope materials, which include geometric attributes and geotechnical properties, respectively, to evaluate slope stability. However, applying a physically-based landslide susceptibility analysis over a regional area can be challenging due to limited data availability, which causes significant uncertainty. The primary sources of uncertainty are the shear strength parameters of soil, including cohesion and friction angle. To reduce this uncertainty, this study utilized probabilistic back analysis to acquire supplementary data on the cohesion and friction angle. The study applied the Markov Chain Monte Carlo (MCMC) simulation method to a region with a history of landslides, but with limited data on shear strength parameters. Additional information on cohesion and friction angle was collected from randomly selected locations of past landslides using MCMC simulations. The updated thematic maps were created by obtaining newly acquired data for cohesion and friction angle. We then evaluated landslide susceptibility using the updated thematic maps. The landslide susceptibility results obtained from the updated input parameters were compared with those acquired from previously available limited data. The analysis results using the updated input parameters demonstrated superior performance compared to those using limited field data.

Keyword

Landslide, Markov Chain Monte Carlo, back analysis, uncertainties

Seismic Imaging of Fault Structures Offshore Northern Taiwan Mountain Belt

Ching-Yun HUANG[1]*, National Taiwan University (jessie7532tw@gmail.com)
Cheng-Chun Chung[2], National Taiwan University
Ho-Han Hsu[3], National Taiwan University
Tzu-Ting Chen[4], Woods Hole Oceanographic Institution
Song-Chuen Chen[5], Geological Survey and Mining Management Agency
Liwen Chen[6], National Academy of Marine Research

Abstract

The geological environment offshore the northern Taiwan belt has transitioned from a compressional state caused by collisional orogenic buildup to an extensional state related to the subduction of the Ryukyu Island Arc and the rifting of the Okinawa Trough. This transition has led to the formation of several fault systems. To further understand the geological structures and potential geo-risks in this region, this study applies advanced seismic imaging methods with high-resolution sub-bottom profiler and multibeam bathymetry data to analyze the fault structures from the coast to offshore areas. The results present at least five main NE-SW trending faults, including the Offshore Jinshan Fault, Yehliu Fault, Xiaoyehliu Fault, Badouzi Fault, and Bitou Cape Fault from the west to east. The Offshore Jinshan Fault and Yehliu Fault, each extending to 30 and 26 km, respectively, can be associated with seafloor lineaments and ruptures. Both of these faults rupture the seafloor and form half-graben basins between them. The Offshore Jinshan Fault exhibits characteristics of a normal fault and may correspond to a similar fault onshore known as the Sanchiao Fault. As a result, it could be a significant fault extending from North Taiwan to the East China Sea Shelf. The Xiaoyehliu Fault is a blind fault and extends approximately 13 km, but as it extends seaward, it gradually transforms into a series of minor faults. The Kanchiao reverse fault onshore may correspond to either the Yehliu Fault or the Xiaoyehliu Fault offshore, indicating a post-collision tectonic setting. The Badouzi Fault extends to about 28 km and shows seafloor ruptures within a nearshore range of 11 km. The Bitou Cape Fault only ruptures to the seafloor near the coast and transitions to a blind fault toward seaward, with a length of approximately 10 km. It also may correspond to the Keelung reverse fault onshore. This study reveals that at least three offshore faults rupture the seafloor and may be linked to the onshore faults. Based on our improved seismic imaging results, we propose a fault distribution map and provide essential evidence for further geo-risk assessment offshore northern Taiwan.

Keyword

fault structure, seafloor lineament, seismic imaging, geo-risk, Northern Taiwan

Appraisal of the present-day geodynamics in Andaman Islands through campaign mode GNSS survey

SNEHASIS BHATTACHARYA[1]*, Geological Survey of India (snehasis.bhattacharya@gsi.gov.in)
SOUMITRA BHARGAB DASGUPTA[2], Geological Survey of India
AKSHAYA KUMAR MISHRA[3], Geological Survey of India

Abstract

The Andaman-Nicobar-Sumatra region is one of the most tectonically vulnerable areas of the world, where three tectonic plates e.g. the Indian, Australian and Sunda plates interact with each other by forming a triple junction. Unique tectonic setup of the archipelago carries significant potential to generate mega-thrust earthquakes. After the Sumatra-Andaman mega-thrust earthquake (Mw 9.2) on 26th December 2004, post-seismic crustal deformation studies using campaign mode GNSS (Global Navigation Satellite System) survey were taken up which unequivocally confirmed the convergence being accommodated through thrusting. It also indicated that the post-seismic and inter-seismic periods suffered simultaneous subduction perpendicular extension and contraction leading to transtension and transpression deformational environments respectively. We conducted the campaign mode GNSS (Global Navigation Satellite System) survey with the aim to understand the ongoing crustal deformation of this region. Three (03) yearly sets of campaign mode GPS data have been acquired from thirteen (13) campaign sites located at Radhanagar, Aerial Bay, Kalpong, Kishorinagar and Mohanpur of North Andaman; Karmatang (2 stations), Bajato, Baratang and Kadamtala of Middle Andaman; Saitankhari, Collinpur and Chidiya Tapu of South Andaman during January to March of 2021, 2022 and 2023. We selected the sites so as to cover all the major structural elements as well as different lithounits like dismembered bodies of Cretaceous ophiolite slices and Tertiary sediments (Mithakhari Group, Andaman Flysch Group and Archipelago Group). The GPS data (observation files) was acquired at 30 sec intervals for a continuous period of 4-5 days per site per year. The mask angle of the choke-ring antenna was set at 10° to minimize multipath while maintaining good GDOP (Geometric Dilution of Precision). We processed the acquired campaign GPS data in GAMIT-GLOBK suite of software along with 38 nos. of international GNSS stations located in the neighbouring plates as reference stations and 4 nos. permanent GPS-GNSS stations of Geological Survey of India (GSI) located at Hutbay, Port Blair, Rangat and Diglipur of Andaman Islands. Velocity of campaign sites with respect to the ITRF14 reference frame varies from a minimum of 18.07 mm/yr (Saitankhari of south Andaman) to a maximum of 48.79 mm/yr (Kalpong of north Andaman) with an average azimuth of N33°E. With respect to India fixed frame of reference, velocity of campaign sites varies from 11.84 mm/yr (Kishorinagar of north Andaman) to 39.06 mm/yr (Saitankhari of sou th Andaman) with the magnitude gradually reducing towards north Andaman. The strain analysis solving the Lagrangian displacement equation suggests that the average orientation of the horizontal principal axis of compression is E-W ± 35° across the island with distinct local variation along segments that divide the island into the northern, middle and

southern parts. The area in between Little Andaman and South Andaman shows positive area dilation in contrary to the North Andaman where area contraction is predominant. This study indicates that the North Andaman is in relatively locked position with the subducting Indian plate compared to the rest of the island.

Keyword

Andaman, GPS, GNSS, earthquake, strain

Smart Monitoring System for Flexible Barrier Using Accelerometer and Corrosion Sensors

JunHa BAEK[1]*, Geobrugg Korea (junha.baek@geobrugg.com)
Seung il Choi[2], Geobrugg Korea
Dennis Gross[3], Geobrugg AG

Abstract

Due to climate change, natural disasters are increasing globally. These manifest in various forms such as heavy rain, drought, heavy snow, and earthquakes, and particularly in mountainous regions, disasters occur in the form of landslides, falling rocks, debris flow, and avalanches. As part of the countermeasures against these, flexible barriers are being widely used around the world.

Due to the characteristics of mountainous terrain, flexible barriers are often installed in high-altitude terrain, steep slopes, and deep valleys. However, due to the difficulty of accessing these locations, these flexible barriers often lack sufficient maintenance. Furthermore, although special corrosion-resistant coatings are applied to the flexible barrier to slow down corrosion, long-term corrosion degrades the durability of the flexible barrier, making it difficult to ensure the impact protection function as initially designed. An appropriate solution is needed to solve these problems.

This measuring system was developed as an IoT device to solve maintenance problems due to difficult site access and durability degradation due to long-term corrosion. By tracking and recording the impact energy delivered to the flexible barrier using an accelerometer, managers can easily identify the cause of the impact and take appropriate barriers. In addition, by detecting the progress of corrosion in advance with the built-in corrosion sensor, more efficient maintenance is possible by planning prevention and repair work based on this. Also, thanks to 7 to 10 years' battery life, it reduces the number of unnecessary inspections by managers, thereby reducing the risk and helping with the effective management of flexible barriers.

Ultimately, this system can analyze the measured data for the flexible barriers installed in hard-to-reach areas, enabling predictive maintenance by establishing an appropriate maintenance plan based on this. In addition, by quickly establishing the scale and response to the occurred event through the data, it can prevent damage to life and property, and it is expected to have a significant cost-saving effect.

These IoT devices can measure and transmit data in real time through a dedicated platform. Currently, more than 400 devices are in operation worldwide, continuously collecting and analyzing data. This system greatly aids in disaster prevention by enabling stable maintenance of

flexible barriers, thereby ensuring a safer environment.

Keyword

Smart monitoring system, Flexible barrier, IoT device, Predictive maintenance

Stability Assessment of the Rock-Cut Slopes Based on a Multi-Method Approach

Rajesh Singh[1], DEPARTMENT OF GEOLOGY, UNIVERSITY OF LUCKNOW, LUCKNOW-226007, INDIA.
PRATEEK SHARMA[2]*, DEPARTMENT OF GEOLOGY, UNIVERSITY OF LUCKNOW, LUCKNOW- 226007, INDIA. (prateeksharmarishi@gmail.com)
Rahul Kumar Verma[3], DEPARTMENT OF GEOLOGY, UNIVERSITY OF LUCKNOW, LUCKNOW- 226007, INDIA.
Pranshu Mishra[4], DEPARTMENT OF GEOLOGY, UNIVERSITY OF LUCKNOW, LUCKNOW-226007, INDIA.

Abstract

With its varied physiographic and climatic conditions, India is frequently susceptible to the unexpected occurrence of landslides. The transportation routes in the Himalayan region feature designed slopes that exhibit many sets of discontinuities and are susceptible to structurally controlled failures. The stability of slopes is significantly impacted by several factors, including the existence of primary and tectonic structures, the kind of weathering, and the pace at which cohesiveness is lost as a result of strength deterioration. To assess the present stability condition of slopes, the extensively used geo-mechanical classifications for rock masses are slope mass rating (SMR) and Continuous Slope Mass Rating (CSMR). These simplified methods were adopted for slope stability analysis and support suggestions. The authors attempt to utilize these classification systems for slope stability analysis together with the Geological Strength index-slope (GSI-slope) and Q-slope to investigate the engineering geological conditions of the cut-slope sections along NH-03, Aut to Manali, Himachal Pradesh, India. After studying all slopes, the results from the preliminary kinematic investigation indicated that the wedge failure is dominating and majorly responsible for the rock fall problem in the area. Based on the groundwater rating, surface circumstances, and adjustment factors of the CSMR, the rock cut-slope sections are also characterized using the GSI-slope and indicated unstable to critically stable conditions. Further, along with failure rates of 50%, 30%, 15%, and 1%, the stability analyses used the Q-slope method to calculate the stable slope angle for each location under the present conditions. The results could benefit the ongoing development and enlargement of roads along sections of the Lesser Himalaya transit routes. A comparison of the studies' data indicates that the present investigation has improved accuracy by establishing a comparative relationship between applied categorization methods.

Keyword

Rock Mass Classification, Geological Strength Index- Slope (GSI-Slope), Q-slope

INVESTIGATION OF THE RELATIONSHIP BETWEEN GEODYNAMIC AND GAS DYNAMIC PROCESS IN MINING AREAS

Andrian Batugin[1], National University of Science and Technology MISIS
Alexander KOBYLKIN[2]*, Institute of Comprehensive Exploitation of Mineral Resources Russian Academy of Sciences (19872104@bk.ru)
Evgeny Khotchenkov[3], State Geological Museum. V.I. Vernadsky RAS
Valentin Divakov[4], Katari LLC
Mikhail Shengeriy[5], National University of Science and Technology MISIS
Valerija Musina[6], National University of Science and Technology MISIS

Abstract

Geodynamic and gas-dynamic processes that occur during technogenic impact on rock masses pose a threat to the environment and the population. During scientific research, the location of 27 coal waste dumps was investigated and the following patterns were discovered. Spontaneous combustion of coal dumps which are located in geodynamically active zones occurs to 4 times more often than outside these zones. This phenomenon is explained by the migration of gases from the mines to the dump through the geodynamic zone. The entry of gases into the dump is a trigger that starts the combustion process. The second pattern concerns the nature of the migration of mine gases during the reactivation of tectonic fault by subsidence processes. Based on the results of computer modeling, it was established that when the walls of the fault shift, an alternation of asperities occurs, which creates pressure that causes gas to move towards the surface. The process of gas migration develops in 2 main phases: it is activated by a pulsating increase in gas pressure in the void space (1st phase) and continues to develop after the cessation of the pulse and a decrease in pressure to the initial one (2nd phase). From a practical point of view, this means that even a single pulsating increase in pressure up to 250 Pa can provoke mass transfer of gases along the tectonic fault to the surface in a short time and create a hazard.

This study was supported by a grant No 22-27-00728 from the Russian Science Foundation (RSF), https://rscf.ru/project/22-27-00728 or https://rscf.ru/en/project/22-27-00728/

Keyword

Geodynamic processes, gas dynamic processes, mining, gas migration

GEOMORPHOLOGICAL EVOLUTION AND ASSOCIATED RISK ON THE SLOPES OF CERRO SOLO AND TECHADO NEGRO, TORRE GLACIER VALLEY, SANTA CRUZ PROVINCE, ARGENTINA

Daniela Ines SCHMIDT[1]*, Instituto de Estudios Andinos "Don Pablo Groeber (UBA-CONICET), Buenos Aires, Argentina (danielainesschmidt@gmail.com)
Diego Alejandro Winocur[2], Instituto de Estudios Andinos "Don Pablo Groeber (UBA-CONICET), Buenos Aires, Argentina

Abstract

During the last decades, the Torre glacier experienced a gradual retreat of its front and a notable loss of mass, thickness and volume of ice, causing the relaxation of the slopes that contain it. Both the northern slope of Cerro Solo and southern slope of Cerro Techado Negro are destabilized and susceptible to mass removal movements. In this work, the temporal evolution of the last fifteen years, 2007-2022, on both slopes is characterized and analyzed in order to contribute to the knowledge of the rate of movement in relation to glacier retreat and its influence on the potential slope destabilization process. The analysis of the results showed that in the last three years, 2019-2022, the rate of displacement of the material involved in the slope of Cerro Solo almost doubled its rate of movement compared to a period of four times greater, between 2007-2019. For the slope of Cerro Techado negro, the measurements did noy show significant changes in the movement associated with the main escarpment, however, the presence of new scars and slipped material that covers the slope was identified. In addition to the above, the values obtained for the 2019-2022 period show a loss of glacial ice tha almost doubles the result obtained for the previous twelve-year period, between 2007-2019. This scenario constitutes a geological risk due to the possible occurrence of a sudden event that slides large volume of material into the Torre proglacial lake, causing a sudden rise in the flow of the Fitz Roy River, which could cause damage downstream, in the Los Glaciares National Park and the El Chaltén town.

Keyword

Landslide, GLOF, Torre Glacier, El Chaltén, Patagonian Andes

Study on coastal flooding from Probable Maximum Storm Surge(PMSS) by the changes in Probable Maximum Typhoon Intensity at the nuclear power plant site

JAEWOONG RYU[1]*, Korea Hydro & Nuclear Power Co., LTD. (jwryu4545@khnp.co.kr)

Abstract

The intensity of typhoons is increasing globally due to global warming and flood damage continues to be an issue in the coastal regions around the Korean Peninsula. Although Korea Hydro & Nuclear Power Co., Ltd. evaluated the safety of nuclear power plant sites from Probable Maximum Storm Surge(PMSS) including Probable Maximum Tsunami(PMT) in 2015 after the Fukushima nuclear accident in Japan, there is no clear methodology for estimating Probable Maximum Typhoon Intensity considering future ocean and atmospheric environments due to climate change. Therefore, this study shows the results of a preliminary evaluation of Probable Maximum Typhoon Intensity according to a new methodology which can simulate sea surface cooling effects by typhoon-ocean interaction using an ocean-atmosphere coupled model considering the changes of sea surface temperature and vertical temperature profile. For the evaluation of coastal flooding from PMSS, the standard typhoon is selected by analyzing the historical typhoons and then the standard typhoon is strengthened to Probable Maximum Typhoon within design lifetime of nuclear power plant. In addition, we evaluated the storm surge and significant wave height by the changes in Probable Maximum Typhoon Intensity after 10 and 40 years using storm surge and wave model. There is no significant difference in the significant wave height on the shore after 10 years according to the methods. However, after 40 years, the significant wave height calculated by an ocean-atmosphere coupled model is reduced by up to 0.46m compared to the result from empirical approach. Currently, we are planning to develop technology to predict Probable Maximum Typhoon Intensity for further research at the nuclear power plant site.

Keyword

Probable Maximum Typhoon, Probable Maximum Storm Surge, Ocean-Atmosphere Coupled Model, Sea Surface Cooling Effects

SUSCEPTIBILITY TO LANDSLIDES IN AN AREA OF 48 KM2 IN THE SURROUNDINGS OF BIOTOPO MARIO DARY RIVERA NATURE RESERVE, PURULHÁ, BAJA VERAPAZ, GUATEMALA

Gabriel Estuardo MORALES RECINOS[1]*, Universidad de San Carlos de Guatemala (ggmorales90@gmail.com)

Abstract

This study contains an inventory and landslide susceptibility maps of 482 km area in the surroundings of Biotopo Mario Dary Rivera nature reserve at a scale of 1:25,000 as a helpful tool to identify areas potentially prone to future landslide occurrence.

To carried out this investigation, a first stage of collecting information such as existing geological reports and aerial photographs was done, therefore creating the basis for the 6 thematic maps of conditioning factors (slopes, slope orientations, geomorphology, land use, geology and structural) that the susceptibility methodology requires for Weighted Sum in GIS

Along with this, an inventory of landslides was elaborated through analysis of satellite photographs and reports from 1998 hurricane Mitch, obtaining 47 landslides that were analyzed together with the conditioning factors to build a susceptibility matrix that assigned new values to the maps of conditioning factors therefore make a sum of maps and obtain the final landslide map which located several areas of high susceptibility

Analyzing the resultant map catches the attention an area located to the north in the populated areas of Panimaquito, Cuchilla del Nogal, Cumbre del Carpintero and Rio Colorado due to the high threat that it may represent landslide recurrence and high landslide susceptibility factors, recommending subsequent vulnerability and risk studies.

Keyword

Landslides, Susceptibility, GIS, Vulnerability, Inventory

Estimation of debris flow damage areas using influencing factors and empirical formula

Jaeho LEE[1]*, Kyungpook National University (fabnm2003@naver.com)
Youjin Jeong[2], Kyungpook National University
Junghae Choi[3], Kyungpook National University

Abstract

Most of the landslides in Korea are debris flows that are triggered by rainfalls, such as heavy rains and typhoons that occur in July and August annually. Furthermore, the frequency and magnitude of landslides have gradually increased due to recent climate change. Since debris flows are a mixture of soil and water moving rapidly along the valley. It is important to predict the runout and flow path of debris flows and take countermeasures accordingly. Numerical and analytical models to predict debris flows depend on uncertain input parameters like volume, velocity, and friction coefficient.

Additionally, these models have limited capability in predicting regional areas. Therefore, using a simple empirical formula, this study developed a method to calculate the damage areas caused by debris flow. Applying a random forest algorithm enabled identifying strong correlations between factors that trigger debris flow and damage areas caused. The results indicated that the orientation of the valley mouth, distance to the fan apex, distance to the channel, and the average slope between the debris flow source and the fan apex exhibited a high correlation with the increase in damage area. Rickenmann and Scheidl (2012) classified the morphology of debris flows and presented an empirical formula for calculating the runout distance of an ideal fan-shaped debris flow unobstructed by buildings. Using the empirical formula Rickenmann and Scheidl (2012) developed, we calculated the runout distance of debris flows. We determined the damage area by assigning weights to four factors identified through the random forest analysis. The direction of the valley mouth was given the highest weight of 1 if it was in the same direction as the debris flow, and the weight was gradually decreased in a fan shape, while the weight was linearly decreased as the fan apex and channel became more distant. Finally, the average slope was given less weight because it had less effect as the angle decreased. The four fan-shaped weights with each of these weights were combined to build a damage risk map, and to verify the model, we applied the model to three areas in Korea where actual debris flows occurred: Yeoju debris flow in 2011, Chungju debris flow in 2020, and Yeocheon debris flow in 2023. The actual and predicted debris flow damage areas showed an 81% match, and these results are expected to serve as a useful reference for future urban planning and policy decisions.

Acknowledgement

This work was supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and Korea Foundation of Nuclear Safety(KOFONS) grant funded by the Korea government(Nuclear Safety and Security Commission, NSSC)(RS-2021-KN066110)

References
Rickenmann, D., & Scheidl, C. (2012). Debris-flow runout and deposition on the fan. In Dating Torrential Processes on Fans and Cones: Methods and Their Application for Hazard and Risk Assessment (pp. 75-93). Dordrecht: Springer Netherlands.

Keyword

Debris flow, Damage area, Empirical formula, Influencing factor

Solid Carbon: Safe, durable and scalable geological carbon storage in the ocean crust

Martin SCHERWATH[1]*, Ocean Networks Canada, University of Victoria (mscherwa@uvic.ca)
Kate Moran[2], Ocean Networks Canada, University of Victoria
David Goldberg[3], Lamont-Doherty Earth Observatory, Columbia University
Curran Crawford[4], Mechanical Engineering, University of Victoria
Terre Satterfield[5], Institute for Resources, Environment and Sustainability, The University of British Columbia
Romany Webb[6], School of Law, Columbia University
Adedapo Awolayo[7], Civil Engineering, McMaster University
Ben Tutolo[8], Department of Earth, Energy, and Environment, University of Calgary
Rachel Lauer[9], Department of Earth, Energy, and Environment, University of Calgary
Eneanwan Ekpo Johnson[10], Geophysics/3D Imaging, Natural Resources Canada
Devin Todd[11], Pacific Institute for Climate Solutions, University of Victoria

Abstract

The ocean crust's permeable basalt rock pore space has massive capacity for sequestering carbon dioxide which, after injection, will naturally react with the basalt minerals and turn into carbonate rock, the most durable form of carbon storage. For a realistic total capacity, only taking into account ocean crust that is young and reactive for CO2 mineralization, is covered with at least hundreds of metres of sediment to initially seal CO2, and is located in the deep ocean where any accidental CO2 leakage cannot reach the atmosphere, globally there is potential for sequestering over 100,000 giga-tons of CO2.

We will present the Solid Carbon project which is focussing on all aspects of utilizing the ocean crust for carbon dioxide removal, from (1) carbon capture directly from the air or upper ocean seawater using renewable energy generated in-situ on floating platforms, to (2) planning an demonstration project by predicting the fate of CO2 in the ocean crust and preparing for future monitoring, reporting and verification, to (3) the social, regulatory and investor acceptance aspects around this idea.

CO2 injection into basalt rock as already been proven on land in Iceland (Carbfix) and Washington State (Wallula) where dissolved CO2 was injected, however onshore storage capacity and other required resources (e.g., energy generation) are more limited than offshore where it is also possible to inject pure CO2, and therefore offshore projects can be upscaled more effectively.

Our focus is on the most favourable test site, the Cascadia Basin in the northeast Pacific that alone has about 750 Gt of CO2 storage capacity, and where Ocean Networks Canada is operating a cabled seafloor observatory offshore Vancouver Island to enable open access monitoring, and furthermore where decades of ocean drilling has provided unique knowledge of ocean crust fluid flow, all helping to enable a most informed future sequestration experiment which is what we are currently aiming for.

Keyword

Geological carbon sequestration, CCUS, carbon dioxide removal, climate change mitigation, negative emissions technology

Impact of Climate Change and Rapid Urbanization: A need for Climate Resilience Plans- based on Flash Flood Analysis in Hyderabad Metropolitan area through a Geospatial approach

Anoop V M[1]*, Geological Survey of India (anoop.m@gsi.gov.in)
Annie Daliya Nelson[2], Geological Survey of India
Nisha Rani Rani[3], Geological Survey of India
Muduru LachhnaA Dora[4], Geological Survey of India

Abstract

The study is an attempt to analyze the impact of climate change resultant meteorological disasters say flash floods, a sudden downpour in a short time on an area. One of the fastest developing south cities of India, Hyderabad, a global hub of Information Technology Industry, witnessed such an incident in October 2020.It was one of the worst occurred disasters faced by the city in the past 7-8 decades. More than ten lakh families were affected by inundation and about one lakh severely affected. The existing sewage system cannot drain away the rainwater due to flash flood which creates havoc to normal city life, economic loss, damage to infrastructure and loss of life. Hyderabad City had undergone rapid urbanization in the last decade. Hyderabad is currently having population of 10.5 million with an average annual growth rate of 2.53%.

The present study for climate resilience plan analyzed the change in the Land use Land Cover (LULC) pattern of the city through the last five years; using Sentinel 2A data of high spatial resolution shows about 9.37% growth in the urban built-up. The land use pattern reveals rapid urbanization and its severity on natural drainage system. The constructions along the existing drainage system and lakes due to improper urban planning and human interventions to the natural ecosystem observed during this study.

Drainage and topographic analysis using Digital Elevation Model (SRTM), correlating with LULC layer; it is observed that lack of proper interlinking from major lakes, tanks and water bodies with the existing drainage system and confluence towards the major river Musi is missing due to the encroachment.

Nine major flash flood influencing factors which control the severity of flash flood have been selected and analyzed by assigning weightage with the help of multi integrated approach Analytical Hierarchy Process (AHP).The result shows that the most important flash flood influencing factors are distance to river/waterbody (15.47%), (TWI) Topographic Wetness Index (14.72%), LULC (12.2 %)and precipitation (11.78). Flood susceptibility map have been derived as high (2.42%), moderate (44.15%), low (49.82%) and very low (3.59%) of flash flood susceptible areas. The generated model is validated and 78 % of the flash flood inundated locations are falling under high susceptible area. The study focuses to devise flash flood resilience plans like Strategic Drainage Development Programs in those areas of the high susceptibility, and suggest to bring strict protocols in the infrastructure development along the proximities of lakes, drainage and water body. This study proposes for the implementation of green landscapes, permeable

pavements and measures which helps to channelize the surface runoff in highly susceptible areas and help build resilience. The strategy aims to enhance the use of natural infrastructure to prevent urban flooding similar to City of Vancouver’s Rain City Strategy. Such methodology enables decision-makers to confront climate change- related issues in similar conditions in other cities or townships countrywide where recent cloud burst incidents occurred to determine and prioritize risk adaptation areas during urban planning.

Keyword

Flash Flood, Land Use Land Cover, Analytical Hierarchy Process, Strategic Drainage Development Program, Hyderabad

Integrated assessment of gully erosion susceptibility for risk informed urban planning: A case study of Rundu, Namibia

Giesberta Naipopya Shaanika[1]*, Geological Survey of Namibia (Giesberta.Shaanika@mme.gov.na)
Miguel Vallejo Orti[2], Namibia University of Science and Technology
Michelle Hailonga[3], Geological Survey of Namibia
Israel Hasheela[4], Geological Survey of Namibia
Helmi Ipinge[5], Geological Survey of Namibia
Kaleb Negussie[6], Namibia University of Science and Technology
Norwel Mwananawa[7], Geological Survey of Namibia

Abstract

Gully erosion poses a significant threat to the town of Rundu in the Kavango East Region of Namibia, impacting critical infrastructure such as roads, buildings, sewerage infrastructure, telecommunication infrastructure, while exacerbating land degradation. The Division of Engineering and Environmental Geology (DEEG) of the Geological Survey of Namibia (GSN), conducted a study aimed at identifying the causes of gully formation and developed a predictive model for susceptibility mapping to inform future planning and expansion efforts. The investigation, supported by the Namibia University of Science and Technology (NUST), utilized a combination of remote sensing techniques, on-site observation and mapping, and drone surveys.

The mapping exercise revealed that gullies predominantly occur on the northern side of the town, affecting areas underlain by thick Quaternary sediments of the Kalahari Group. Natural factors such as soil composition and steep slopes, compounded by man-made influences such as insufficient stormwater drainage and the removal of natural vegetation, were identified as contributors to gully formation. A predictive model leveraging Python and random forest (RF) algorithm was developed, utilizing both natural and man-made predisposing factors to delineate areas susceptible to future gully formation. The resulting gully erosion susceptibility map (GESM) highlighted the northern slope between the town and floodplains of the Okavango River to be particularly prone to gully formation, necessitating careful urban planning considerations.

Recommendations for preventative measures were proposed, including the incorporation of engineering control structures for stormwater management, maintenance of drainage infrastructure, and enforcement of proper waste management practices. Furthermore, the study suggests conducting an Urban Hydrology study, implementing nature-based solutions such as re-vegetation of slopes, and adopting traditional methods like stormwater harvesting to mitigate gully formation. By employing predictive modelling and investigation of these hazards, allows for proactive planning and risk-informed urban development, which safeguards infrastructure and the environment from the adverse impacts of geohazards. This proactive approach will help to build a more resilient and sustainable future for Rundu and other vulnerable urban centers faced with similar challenges.

Keyword

Gully erosion, Risk-informed development, Urban resilience

Carbon Capture, Utilisation, and Storage opportunities in South Africa's highest carbon dioxide emissions hub: opportunities for the Just Transition

Taufeeq DHANSAY[1]*, Council for Geoscience (tdhansay@geoscience.org.za)

Abstract

South Africa is recorded as the largest emitter of anthropogenic CO2 on the African continent. The country emits approximately 500 million tonnes of CO2 per annum. Much of these emissions stem from South Africa's reliance on coal as an energy generation feedstock and critical contributor toward the country's socioeconomic development. The coal industry accounts for more than two-thirds of all energy generation and at least 100,000 direct jobs. South Africa has however committed to reducing CO2 emissions. It aims to reduce emissions by at least 40% within the next ten years. This is planned, in part, through the development of alternative energy sources. However, worsening energy crises over the last 5 years, and its dire effect on the country's socioeconomic development imperatives has called for more practical energy solutions. South Africa will therefore still look to coal while attempting to transition toward alternative source of energy. Carbon Capture, Utilisation and Storage (CCUS) is proposed as an intervention to enable this transition. That is, to immediately combat anthropogenic CO2 emissions while allowing the needed time to enable the necessary energy transition. Research and development of CCUS technologies in South Africa have not advanced to pilot scale, largely because of misconceptions that the country does not have suitable geological reservoirs near large point-source emission hubs. This paper presents the findings of a geological investigation to identify suitable CCUS sites proximal to large point-source emitters in the Govan Mbeki Municipality of the Mpumalanga Province. Geological investigations considered, among others, geological mapping, structural geology, borehole data, reflection seismics, mineralogy, petrography, and geochemistry. The results suggest that the central region of the Municipality has at least several gigatonnes of storage potential. This includes deep saline reservoirs and basaltic storage. Crucially, this storage potential lay proximal to several key point-source emitters, including coal mining, energy generation, and petrochemical processing. The proximity to these industries also provides realistic opportunities to develop a carbon utilisation market. This can include the development of alternative sustainable fuels and fertiliser materials. Finally, the availability of potentially significant reservoirs should be considered in the context of the carbon trading market. This may include revision of South Africa's carbon taxation and trading policies.

Keyword

Carbon Dioxide, Coal, CCUS, Energy, Just Transition

Soil CO2 change and rainfall effect in growing season in a karst grassland of Slovenia

Cheng ZHANG[1]*, Institute of Karst Geology, Chinese Academy of Geological Sciences/International Research Center on Karst Under the Auspices of UNESCO (zhangcheng@mail.cgs.gov.cn)
Qiong XIAO[2], Institute of Karst Geology, Chinese Academy of Geological Science/International Research Center on Karst Under the Auspices of UNESCO
Mitja PRELOVSEK[3], Karst Research Institute, Slovenian Academy of Sciences and Arts
Jinliang WANG[4], Institute of Karst Geology, Chinese Academy of Geological Science/International Research Center on Karst Under the Auspices of UNESCO

Abstract

Soil CO2 is a critical driving factor for karst processes and the core index for studying soil respiration and its relationship with atmospheric CO2 source-sink. The rapid dissolution kinetics of karst carbon cycle and its sensitivity to ecosystem suggest that karst carbon cycle is still playing an active role in the global carbon cycle. Taking the typical grassland soil ecosystem in Dinar karst, Slovenia as an example, high-resolution online monitoring of soil temperature, water content and soil CO2 concentration at different depths was carried out during the growing season from June to September in year 2021, the data were recorded in 10-minute time interval. Results showed that mean soil temperatures at depths of 20cm, 30cm and 50cm are 19.69˚C, 18.54˚C and 17.42˚C respectively, implying soil temperature decreases gradually with increase of soil depth. Mean soil water contents at depths of 20cm, 30cm and 50cm are 23.2%, 21.7% and 24.9 % respectively. Soil moisture mainly was controlled by precipitation, i. e. the greater the rainfall intensity, the larger the moisture rises. The ranges of soil CO2 concentrations at depths of 20cm, 30cm and 50cm are 1884-6705 ppm, 2088-5516ppm and 2771-3606ppm respectively, with mean value of 3578ppm, 3468ppm and 3174ppm respectively. During the no-rain days, soil moisture presents a tendency of stair-stepped down, with decrease in day time and basically remain unchanged at night, and controlled by soil moisture, the multi-day changes of soil CO2 showed a jagged falling constantly. Soil CO2 down movement is observed during different rainfall conditions, soil CO2 concentration drops rapidly at the early stage of storm events, suggesting that pulse effect cause by rainfall infiltration is the main controlling factor to push CO2 move down quickly and enter to the underlying karst aquifer furtherly, thus providing critical driving force for carbonate rock dissolution. The value difference of CO2 decrease range and the pre-rain CO2 content suggested that 12%-33% of soil CO2 transported to karst aquifer and were involved in carbonate rock dissolution during the rainfall events. The monitoring results suggest that karst process is a lateral extension of carbon cycle in terrestrial ecosystems in karst area and has soil CO2 sink effect. It means that karst process has the function of alleviating the release of soil CO2 to the atmosphere, i.e. source reduction effect. Accordingly, Vegetation-soil-carbonate dissolution should be considered as a whole for studying the carbon cycle and carbon sink effect in karst area. Systematic monitoring and research should be carried out from the perspective of karst critical

zone, so as to obtain a complete understanding of carbon cycle processes in karst area and reveal their carbon sink effects, thus further evaluating the role of karst carbon cycle in global carbon cycle and in coping with climate change as well.

Keyword

Soil CO2, Rainfall process, Karst processes, Source reduction effect, Slovenia

Evaluation of energy saving effects in university campus rooftop greening through the use of high concentrations of carbon dioxide in lecture rooms

Jeongwoo PARK[1]*, Dong-A University (1822247@donga.ac.kr)
Minju KIM[2], Dong-A University
Chang-Uk HYUN[3], Dong-A University

Abstract

Efforts are underway worldwide to mitigate global warming by reducing greenhouse gas emissions and increasing absorption to achieve carbon neutrality, where net emissions reach zero. Green spaces serve as one of the carbon sinks, and securing green areas within cities is considered an effective approach to practicing carbon neutrality. However, securing green spaces within urban areas is challenging due to the dense urban structure, high real estate prices, and various regulations. As a result, rooftop greening, utilizing the upper parts of artificial structures, is being employed for urban greening due to its low cost and high space utilization. University campuses, like many urban structures, generate significant amounts of carbon dioxide due to their high energy consumption.

This study aimed to implement rooftop greening on the campus of Dong-A University in the urban area and utilize carbon dioxide generated in lecture rooms as fertilizer for rooftop greening. It was confirmed that high concentrations of carbon dioxide (700-1,000 ppm), which enhance vegetation growth, were generated inside the lecture rooms. An experiment was conducted to simulate the supply of carbon dioxide captured inside the lecture rooms to the vegetation of rooftop greening (*Dendranthema zawadskii*). A comparative experimental group was established consisting of vegetation without carbon dioxide supply. Through 3D modeling, it was observed that vegetation supplied with carbon dioxide exhibited a greater growth trend compared to the comparative group.

Additionally, the energy savings between rooftop gardens supplied with carbon dioxide and those without were compared based on the building volume in the study area. Temperature measurement experiments confirmed a 0.53°C insulation effect for vegetation supplied with carbon dioxide compared to vegetation without carbon dioxide supply inside the lecture rooms.

Furthermore, the potential reduction in carbon dioxide achievable through rooftop greening at Dong-A University's Seunghak Campus was calculated. High-resolution aerial images were used to select buildings suitable for rooftop greening on the campus, and the volume of these buildings was evaluated. The experimental vegetation, Dendranthema zawadskii, was reported to absorb 3.65 kg of carbon dioxide per square meter annually. Assuming 60% greening of the rooftop area of the Campus buildings, it was calculated that rooftop greening in the study area could result in a reduction of 85 tons of carbon dioxide per year.

Keyword

Carbon dioxide, University campus, Rooftop greening, Vegetation growth

Artisanal Biochar Production: A Sustainable Pathway for Climate Resilience in Rwanda

Magalie NTAHOKAJA[1]*, University of Rwanda (mntahokaja@yahoo.com)

Abstract

The Republic of Rwanda, grappling with the dual challenges of climate change and sustainable development, is exploring innovative avenues to bolster its resilience against climate adversities while promoting green growth. This study delves into the artisanal production and application of biochar as a multifaceted solution aimed at enhancing agricultural productivity, providing affordable energy alternatives to low-income households, and facilitating Rwanda's transition towards a circular economy. Biochar, produced through the pyrolysis of biomass such as agricultural residues, animal manure, and forest waste, emerges as a carbon-rich, porous material with considerable potential to ameliorate soil fertility, water retention, and carbon sequestration. Aligning with Rwanda's Vision 2050 and the revised Green Growth and Climate Resilience Strategy, the adoption of biochar not only addresses the impending ban on charcoal sale but also capitalizes on the valorization of waste, contributing to the country's sustainable environmental management and economic innovation through carbon credit sales. Furthermore, the study underscores the significance of biochar in mitigating climate-induced agricultural vulnerabilities by enhancing soil health, thereby ensuring food security and livelihood sustainability for the majority agrarian population. Through an empirical lens, this paper presents a comprehensive analysis of the socio-economic and environmental benefits of integrating biochar into Rwanda's green economy blueprint, offering insights into policy implications, practical challenges, and future prospects for scaling biochar initiatives across the region.

Keyword

Biochar Production, Climate Resilience, Sustainable Agriculture, Green Growth, Waste Valorization

Application of Petrography to the Assessment of Philippine Coastal Concrete Structures Exposed to Extreme Weather Conditions

Chelly Mei Nacional TANPOCO[1]*, Earth Materials Science Laboratory, National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City (cntanpoco@up.edu.ph)
Audrei Anne Bonus Ybañez[2], University of the Philippines Resilience Institute, Diliman, Quezon City, Philippines
Nancy Rhoena Ratuita Aguda[3], Earth Materials Science Laboratory, UP National Institute of Geological Sciences
Carlo Abundo Arcilla[4], (1) Earth Materials Science Laboratory, National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, Philippines; (2) DOST-Philippine Nuclear Research Institute, Diliman, Quezon City, Philippines
Kate Balbon Cuyno[5], Earth Materials Science Laboratory, National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, Philippines
Jeremy James Cortez Jimenez[6], Earth Materials Science Laboratory, National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, Philippines
Angelou Faye Rico Nuñez[7], Earth Materials Science Laboratory, UP National Institute of Geological Sciences
Anabelle Pamada Ramirez[8], Earth Materials Science Laboratory, UP National Institute of Geological Sciences
Jam Obong Sabandal[9], Earth Materials Science Laboratory, National Institute of Geological Sciences, University of the Philippines, Diliman, Quezon City, Philippines

Abstract

Extreme weather events are among the expected negative effects from the undeniable increase in both atmospheric and sea surface temperature due to climate change. The Philippines is highly susceptible to these hydro-meteorological hazards and is reliant on coastal infrastructures for protection, and economic development. These structures made from concrete are highly sensitive to changes in both moisture and temperature, and any drastic change from the environment may result in its weakening, and irreparable damage. Thorough assessment of the current quality of coastal concrete structures is necessary to ensure building resilience, prevent economic loss, and potential casualties brought about by these hazards.

This study focuses on the application of petrography to the in-depth assessment of selected coastal concrete infrastructures across different regions in the Philippines. Petrography provides information on the overall concrete quality, including raw material composition, water-cement ratio, occurrence of cracks and air voids, and other concrete deterioration phases. Based on the conducted assessment, common deterioration across all structures includes carbonation of the cement paste, cracking, presence of delayed ettringite formation, and minor alkali-silica reaction. These observed durability issues may contribute to the progressive degradation of concrete over time. Factors contributing to concrete deterioration including raw material source, current site conditions, microclimate, and past extreme events were also investigated for further correlation with the obtained petrographic data. The results gathered from the study will serve as technical

recommendations to the national standards related to coastal concrete construction, particularly on the determination of the appropriate concrete cover thickness, and concrete design mix for coastal environments.

Keyword

Petrography, Concrete, Climate, Resilience

Investigation of hydrochemical and stable carbon isotope compositions as effective tracers for tracing CO2 leakage: lessons from two controlled CO2 release tests

Hyun-Kwon DO[1]*, Jeonbuk National University (iq100pc@gmail.com)
YeoJin Ju[2], Disposal Safety Evaluation Research Division, Korea Atomic Energy Research Institute, Daejeon 34057, Republic of Korea
Seung-Wook Ha[3], School of Earth and Environmental Sciences, Seoul National University, 1 Gwanak-ro, Gwanak-gu, Seoul 08826, Republic of Korea
Sung-Wook Jeen[4], Department of Earth and Environmental Sciences & The Earth Environmental System Research Center, Jeonbuk National University, Jeonju-si, Jeollabuk-do, 54896, Republic of Korea
Seong-Taek Yun[5], Department of Earth and Environmental Sciences, Korea University, Seoul, 02841, Republic of Korea

Abstract

Understanding the impacts of CO2 leakage on hydrochemical and carbon isotope compositions of shallow aquifers during the early stages of CO2 leakage from underground storage sites is essential for developing effective monitoring strategies and addressing public concerns about geologic CO2 sequestration. To address this, two controlled CO2 release experiments were conducted in a siliciclastic shallow aquifer at the Environmental Impact Evaluation Test (EIT) site in South Korea.In the initial experiment, CO2 was injected as CO2-infused water at a rate of 55 m3/day for 26 days, at approximately 22 m below ground level (bgl). In the second experiment, CO2 was injected as a gaseous phase at a rate of 3.5 L/min for approximately 7 days, around 30 m bgl via an inclined injection well. Both experiments were conducted in a ~40 m thick heterogeneous aquifer, with artificially increased pressure gradients to ~10 times the natural gradient to establish flow paths along a monitoring well network. The monitoring well network consisted of four multi-level monitoring wells aligned along the pressure gradient flow direction, supplemented by five full-screened monitoring wells and the two wells for maintaining pressure gradient. In both experiments, the presence and migration of CO2 plume were determined at each monitoring well through decrease in pH, increase in the partial pressure of CO2 (PCO2), and elevated electrical conductivity (EC). Additionally, the carbon isotope composition (δ13C) decreased upon the arrival of CO2 plumes, demonstrating distinctive isotopic signatures between injected CO2 and ambient groundwater. In the first experiment, where CO2 was injected as CO2-infused water, observations from the monitoring well network indicated the migration of the CO2 plume along a preferential pathway. This migration pattern was characterized by overwhelming of induced pressure gradient due to water table mounding at injection point, followed by some degree of sinking, likely due to the higher density of the CO2 plume. Conversely, in the second experiment, where CO2 was injected as a gaseous phase, hydrochemical and isotopic responses were primarily observed in the multi-level monitoring wells along the induced pressure gradient (SMW-1 to 4), rather than the supplementary monitoring wells. This suggests a distinct migration

behavior, with the CO2 plume following the groundwater flow direction instead of a preferential pathway. In summary, our experiments yield significant insights into the behavior of CO2 plumes and underscore the need of adaptive and context-specific monitoring strategies to accurately assess the impacts of CO2 leakage. Such strategies are crucial for ensuring the safety and efficacy of geologic CO2 sequestration projects, emphasizing the importance of continued research in this field.

Keyword

CCS, CO2 leakage, Monitoring, CO2 release experiment, CO2 plume

Enhanced basalt weathering for CO2 sequestration under wheat-corn rotation pattern in Xuyi County, China

Yijaing XU[1]*, Nanjing University (602022290028@smail.nju.edu.cn)
Shaohua Wang[2], Geological Survey of Jiangsu Province/Research Center for Resources Engineering towards Carbon Neutrality of Jiangsu
Yang Chen[3], Nanjing University
Xuefen Sheng[4], Nanjing University
Pengjun Mo[5], Nanjing University
Yijian Wang[6], Geological Survey of Jiangsu Province/Research Center for Resources Engineering towards Carbon Neutrality of Jiangsu
Xiao Jia[7], Nanjing University

Abstract

Enhanced rock weathering (ERW) involves dispersing pulverized alkaline rocks on farmland to accelerate weathering and increase reaction rate with atmospheric CO2, leading to store carbon as HCO3- or carbonate. Various carbon verification methods have been developed, however, there is currently no consensus on carbon verification for large-scale ERW applications.

In this study, we aim to explore carbon capture potential and related agricultural benefits after applying basalt powders to farmland at field scale under winter wheat-corn rotation in Xuyi County, China. Fresh basalt was grinded into two grain size fractions, coarser (<1000 μm) and finer (< 100 μm). Basalt powders with two application rates of 1 kg/m2 and 5 kg/m2, were dispersed into designated blocks (labeled as C1, C5, blk, F1, F5, respectively) of farmland in June 2022. Soil pore water samples were extracted in-situ after precipitation events, approximately every 1-2 months. Crop yield and soil samples were collected after each harvest for further analysis.

Loss of [Ca+Mg] in the soil was calculated based on the aluminum content of bulk soil. The results showed that [Ca+Mg] loss only occurred after the wheat harvest (from October 2022 to May 2023), with C1-F5 soil losing approximately 51.7, 124.5, 40.1, 49.6 and 82.8 mol/m2, respectively (considering a 0.3 m thick soil layer), which is much higher than expected. While soil exhibited varied levels of [Ca+Mg] during corn growth (from June 2022 to October 2022), which may be attributed to biological activity.

No significant soil carbonate was observed due to sufficient rainfall. The DIC content of soil pore water showed that during corn growth, C1-F5 blocks stored 0.60, 0.37, 0.66, 0.95, and 0.89 mol C/m2, respectively. During wheat growth, the values were 0.07, 0.08, 0.14, 0.14, and -0.13 mol C/m2, respectively. Although the observed amount was higher than expected, a decreasing trend coincided with decreased reaction rate as modeling works predicted. It should be noted that using cation concentration of leachate may overestimate the amount of carbon captured since Ca2+ and Mg2+ contribute to 70% of the cation charge, while HCO3- only accounts for about 30% of the anion charge in soil pore water.

Although DIC in leachate/pore water serve as a direct carbon sink, its instability and sampling

challenges may hinder its use as a reliable CO2 drawdown verification proxy. In situ determination techniques are required to overcome these limitations. While the annual carbon sink budget was not substantial, the results showed an improvement in soil acidification from pH 5.4 to 7, and an increase in crop yield compared to the blank treatment. This study contributes to the further understanding of ERW through experiments conducted at a practical scale.

----This work was supported by Jiangsu Province's Pilot Project for the Integration of Mining Areas, China (Sucaizihuan [2021] No.45)

Keyword

enhanced basalt weathering, carbon drawdown, soil mass balance, dissolve inorganic carnbon, soil pore water

Research on a CO2 Internet of Things online monitoring system for marine carbon storage

Jianhua MA[1]*, Sun Yat-sen university (05161935@cumt.edu.cn)
Yongzhang Zhou[2], Sun Yat-sen university
XinYue Wang[3], Fudan university

Abstract

Marine carbon storage plays a crucial role in mitigating global greenhouse gas emissions. However, many potential storage sites are located near densely populated regions, and the risk of CO2 leakage poses significant ecological threats. Therefore, it is imperative to establish rigorous monitoring systems and early warning technologies for marine carbon storage. Considering the dynamic nature of the marine environment and subsurface CO2, monitoring technology must be adaptable to these dynamic characteristics. However, current monitoring methods have limitations in terms of monitoring cycle, cost, and stability, rendering them inadequate for meeting the dynamic monitoring requirements of marine carbon storage. In this regard, online monitoring technology that exploits the Internet of Things (IoT) presents a viable solution for monitoring marine carbon storage. This technology employs sensor networks to take measurements and utilizes wired or wireless communication networks to transmit the data, thereby enabling continuous monitoring and real-time feedback. Although existing research on marine IoT monitoring primarily focuses on the environment and agriculture, insufficient attention has been paid to marine carbon storage. Consequently, this work proposed a design concept for an online monitoring system that leveraged the IoT for marine carbon storage. In terms of sensor deployment, we adopted a strategic approach by initially placing sensors in crucial areas using fixed deployment methods, followed by expanding the monitoring areas through random deployment. We encrypted key monitoring areas for monitoring purposes and optimized topology through mobile deployment. Concerning sensor selection, infrared CO2 sensors were deployed near injection wells to facilitate comprehensive monitoring. In contrast, laser CO2 sensors were positioned in key areas such as wellheads for auxiliary monitoring. In terms of network topology design, cluster head nodes were strategically placed near injection wells or potential leakage sites in areas of high risk. Nodes within the network topology were connected to main cluster nodes, and redundant channels were established to ensure continuous monitoring of data flow in critical areas during emergencies. In peripheral areas, star or tree topologies were employed for data summarization. Sensor nodes and surface buoys were equipped with GPS positioning functionality, while underwater sensors utilized small-capacity capacitors for energy storage, enabling them to operate after short charging periods. The collected data were transmitted to surface buoys using inductive coupling and subsequently packaged and sent to shore-based data management centres via either 4G or satellite communication. Compared to other monitoring methods, the IoT online monitoring system enables continuous monitoring, rapid early warning, and real-time feedback on changes in the environment, making it well-suited to meet the dynamic

monitoring requirements. Furthermore, the IoT online monitoring system can consistently update and enhance the data model by utilizing long-term monitoring data. More importantly, it can analyse the magnitude and route of CO2 leakage through algorithms, integrate geophysical monitoring data, evaluate the risk of leakage and classify storage areas. In summary, an intelligent online monitoring system for marine carbon storage utilizing the IoT was established in this work. This system offers valuable insights into monitoring leakage and managing early warning in carbon storage in marine environments.

Keyword

Internet of Things, CCS, Marine carbon storage, Online monitoring system

Non-repeatable Noise Attenuation on Time-lapse Prestack Data using Fully Convolutional Neural Network

Hanjoon PARK[1]*, Seoul National University (hanjoon67@naver.com)
Jun-Woo Lee[2], Seoul National University
Donggeon Kim[3], The Pennsylvania State University
Dong-Joo Min[4], Seoul National University
Yongchae Cho[5], Seoul National University

Abstract

In 4D seismic exploration, temporal changes in subsurface properties are measured using baseline and monitor data recorded at different times, which is used for monitoring in many areas, such as petroleum production and carbon capture and storage (CCS). However, to accurately detect temporal changes of subsurface properties in 4D seismic survey, it is essential to suppress non-repeatable noises caused by differences in survey geometry, preprocessing factors (e.g. temporal and spatial amplitude gain), source wavelet characteristics, seawater temperature or salinity, and weather conditions. The cross-equalization (XEQ) techniques have been widely used to suppress non-repeatable noises. Recently, several attempts have been devoted to applying machine learning techniques for XEQ; and a convolutional neural network (CNN)-based XEQ technique for post-stack data has been proposed using a masked image-to-image translation scheme. However, in the case of post-stack data, information on subsurface properties is limited because of a series of data processing procedures. To obtain more information, pre-stack data need to be employed.

In this study, we propose an XEQ technique for pre-stack data based on CNN and a masked image-to-image translation scheme, which introduces a mask generated by the eikonal equation. In addition, to solve the problems of signal overlap and amplitude variation of signals that appear in pre-stack data, supplementary methods, such as frequency-wavenumber (f-k) loss function, coordinate conditioning, and logarithmic rescaling, are introduced.

The synthetic data experiments show that the proposed XEQ effectively suppresses non-repeatable noise while preserving 4D signals even for pre-stack data and causes less damage on amplitude information representing the degree of change. Furthermore, the supplementary methods enhance the matching quality and training stability. We conduct sensitivity analysis for factors that can adversely affect XEQ, such as seawater velocity, source wavelet, ambient noise, and inaccurate masks. The sensitivity analysis confirms that the proposed XEQ shows robustness for those factors and successfully suppresses non-repeatable noise.

Keyword

4D seismic survey, CCS monitoring, cross equalization, non-repeatable noise, masked image-to-image translation

Artificial CO_2 release experiments for the development of stationary monitoring system in Korea

JONGHA HWANG[1]*, Korea Institute of Ocean Science and Technology (KIOST)
(jhhwang@kiost.ac.kr)
SANG HOON LEE[2], Korea Institute of Ocean Science and Technology (KIOST)
SEONGHOON MOON[3], Korea Institute of Ocean Science and Technology (KIOST)
SOOKWAN KIM[4], Korea Institute of Ocean Science and Technology (KIOST)
SU HWAN LEE[5], Korea Institute of Ocean Science and Technology (KIOST)
CHUNG HO KIM[6], Korea Institute of Ocean Science and Technology (KIOST)
KI BAEK KWON[7], Korea Institute of Ocean Science and Technology (KIOST)

Abstract

Carbon capture and storage (CCS), which captures carbon dioxide (CO_2) from large point sources and stores it in sub-seabed geological formations, is presently considered as one of the most promising technologies to reduce the anthropogenic CO_2 emissions. According to Korean government's 1st national carbon neutral/green growth basic plan, South Korea plans to sequestrate 4.8 million tons of CO_2 annually through CCS from 2030. To achieve this goal, reliable CCS monitoring is vital.

There are two types of CCS monitoring methods, which are deep-focused and shallow-focused methods. Deep-focused method employs geophysical methods, such as seismic, gravitational and electromagnetic explorations, to monitor the storage reservoir and overburden. On the other hand, shallow-focused method, which is also referred to as the marine-environmental monitoring method, targets the seabed and the water column above a storage reservoir and aims to detect emission of gas/dissolved phase CO_2 and formation fluids from the seabed. However, due to the natural variability of the ocean, it is still challenging to accurately detect CO_2 emission while mitigating the false positive problem.

In this study, we share our experience of manufacturing a prototype of shallow-focused monitoring system for CCS. Our stationary system is intended to detect CO_2 emission near the injection well, which can be the most probable source of sub-seabed CO_2 emission. To mitigate the false positive problem and enhance the detection accuracy, we combined a variety of sensors in our system. Chemical sensors (salinity, pH, DO, pCO_2, oxidation/reduction potential (ORP) and turbidity), passive acoustic sensor, and optical sensor with light sources are attached to the system and several artificial CO_2 release experiments have been carried out to evaluate performance of the monitoring system. From the experiments conducted at a large water tank and at a shallow water depth of around 20 m, our monitoring system showed sufficient performance to detect emission of CO_2 from the seabed. Acoustic recordings of the bubble noise presented distinct frequency spectrum which can be separated from the background noise and correlation between pCO_2 and DO showed distinct deviation with the artificial CO_2 emission.

Keyword

CCS, monitoring, emission of CO_2

Numerical modeling of subsurface fluid injection using the poroelastic finite element code

Chan-Hee JANG[1]*, Kangwon National University (jch@kangwon.ac.kr)
Byung-Dal So[2], Kangwon National University
Soojung An[3], Kangwon National University

Abstract

As climate change remains a critical global challenge, we have focused on carbon capture and storage (CCS) technology as one of the solutions to reduce atmospheric CO2 emissions. Injecting artificial fluids into geological formations alters pore pressure and the subsurface stress field, potentially activating faults. By changing the hydro-geophysical properties of the fault (e.g., porosity and permeability coefficient) due to fault activation, the fault role as a conduit for fluids, which risks causing stored CO2 to leak from the reservoir along the fault. Such events pose economic and human risks while potentially heightening social acceptability concerns, which could hinder project progress. Therefore, numerical modeling to various injection scenarios and geological structures is essential for safe fluid injection prior to CCS project implementation.

With this in mind, we have used poroelasticity theory to develop a numerical modeling code for underground fluid injection scenarios. Poroelasticity theory describes the dynamic relationships that govern the interaction between pore fluid flow and elastic deformation of solids in porous media. The theory is widely used in numerical modeling related to conventional underground fluid injection due to its ability to simultaneously calculate pore pressure diffusion and the stress state's evolution. We performed a comparative analysis with a commercial FEM software, COMSOL Multiphysics, to increase the reliability of the code. In the process, we calculated the behavioral properties of the fluid and the pore pressure change due to fluid injection, and we also explored the influence of geological structural properties on the fluid injection environment. The development of such a code for simulating fluid injection environments aims to deepen the understanding of fluid behavior while localizing the code.

Keyword

carbon capture and storage, numerical modeling, Finite element method, leakage

Repeatability analysis of time-lapse OBC data for CCS in the offshore of Pohang, Korea

YONGHWAN JOO[1]*, KIGAM (jooyh@kigam.re.kr)
BYOUNG-YEOP KIM[2], KIGAM
YUNSEOK CHOI[3], KIGAM
DONGHOON LEE[4], KIGAM
DOWAN KIM[5], KIGAM
WOOHYUN SON[6], KIGAM

Abstract

We conducted Ocean Bottom Cable (OBC) surveys in the offshore of Pohang, South Korea, for CCS 4D seismic monitoring research. During the acquisition of 4D seismic data, differences can arise not only from anomalies caused by injected fluids but also from variations of source and receivers positions, tides, and wave heights. In this study, to analyze the repeatability of time-lapse OBC data without 4D seismic differences, we performed 3D OBC surveys twice with short time intervals. After acquiring two sets of 3D OBC data, we applied identical 3D multicomponent seismic data processing. Especially, Due to the absence of acoustic transponders, we utilized the First-break Picking method to determine the precise positions of Ocean Bottom Cables (OBC). Subsequently, through processes such as trace rotation and PZ summation, we obtained the final seismic volume. To ensure similarity, we performed scaling on the amplitudes of the two final processed seismic volumes, and enhanced their similarity by designing and applying a match filter to both datasets. We calculated the NRMS values of the processed datasets, revealing that although the surveys were conducted in the same area without receiver position change, NRMS values exceeding 15% were observed. It is inferred that the magnitude of time-lapse difference by injected fluids must exceed this threshold for effective 4D seismic monitoring.

Keyword

4D, OBC, Seismic data processing, NRMS, repeatability

[Keynote] Building on Bedrock: Geosciences' Role in Mitigation and Adaptation

Lisa GRAUMLICH[1]*, American Geophysical Union (president@agu.org)

Abstract

Addressing the climate crisis stands as one of the most pressing challenges of our time. For decades, the scientific community has provided the critical evidence that unequivocally links rising greenhouse gas emissions to a cascade of environmental impacts: from more frequent and severe heatwaves and storms to accelerating ice melt and rising sea levels.

While the challenges of climate change are daunting, science also illuminates pathways forward. Fostering a global dialogue across the geosciences, including geology, will continue to spark collaborations and inform mitigation and adaptation solutions that our planet urgently needs. Moreover, bridging the gap between science and policy implementation at all levels of decision-making requires sustained collaboration, enhanced communication channels, and a commitment to evidence-based decision-making.

This presentation will draw on personal experiences on spanning science to action and highlight the influential role of the geoscience community, including institutions like AGU, in transforming science from usable to used. Highlights will include how AGU's efforts in open science and data are increasing the accessibility and usability of information and publications, how global convenings bring together scientists and practitioners to tackle specific climate challenges, and how scientists partner directly with local communities to co-create new knowledge and build climate resilience—collectively demonstrating how geoscientists are translating scientific insights into practical climate solutions.

Keyword

climate action, global cooperation, transdicplenary

Unraveling the Complex Nexus of Geology, Water Quality, and Forage Impact on Enteric Methane Emissions: A Case Study from North Kivu, Democratic Republic of the Congo

Tomple Byamungu Mayange[1]*, Seoul National University and Center of Expertise and Geological Survey - Congo (tomplemayange@gmail.com)
Alain Bindu Lumoo[2], International NGO Safety Organization
Guy Shungu Lama[3], Center of Expertise and Geological Survey

Abstract

Methane (CH4), a potent greenhouse gas (GHG) with approximately 28 times the global warming potential of carbon dioxide (CO2) over a 100-year period, poses a significant challenge to both the environment and livestock. This study delves into the intricate relationships between geological, hydrological, and nutritional elements in North Kivu Province, Democratic Republic of the Congo (DRC), and their combined influence on CH4 emissions.

North Kivu Province is renowned for its abundant geological resources, particularly minerals like tin, tantalum, tungsten (the "3 T's"), gold, and more. These resources owe their existence to the region's distinct geological formations, notably in territories such as Walikale, Masisi, and Beni. However, the pursuit of these valuable minerals has led to extensive artisanal mining activities, which have caused substantial land alterations and degradation. Forests have been cleared, and soil quality has been compromised through excavation and digging. The consequences extend to water quality, as discharges of pollutants from mining operations have infiltrated nearby rivers and water sources (Lowa, Luka, Luviro, Semliki, and Rwindi River), resulting in contamination. In the region, a significant population of cattle, sheep, and goats, primarily originating from East African countries, exclusively engage in grazing on pasture activities and consume water from the region. Consequently, they are susceptible to contamination and, therefore, contribute significantly to CH4. The production of CH4 in the region is influenced by a myriad of factors, notably before and after mining activities. During mining exploitation, the presence of specific minerals, such as Copper, Cobalt, Sulfur, Molybdenum, Iron, and others, contributes to amplifying CH4 production in cow stomachs. This phenomenon arises due to the geological characteristics of the province, which significantly affect the quality of groundwater sources. Moreover, after mining exploitation, the quality of forage plays a crucial role in CH4. Lower-quality forage can extend digestion times and foster increased fermentation in the stomach, ultimately resulting in elevated CH4 production. The diet, in this context, acts as a significant influencer of post-mining CH4 emissions.

In conclusion, the relationship between geological factors and CH4 emissions, though indirect, is profoundly impactful. A comprehensive understanding of these dynamics paves the way for the development of targeted strategies to mitigate CH4, enhance livestock sustainability, and promote environmentally responsible agricultural practices in North Kivu and beyond.

Keyword

Climate Change, Methane Production, Geological Resources, Water Quality, Nutritional Elements

Feasibility study for subsurface imaging using onshore VSP geophone and DAS data

Hanjoon PARK[1]*, Seoul National University (hanjoon67@naver.com)
Donggeon Kim[2], The Pennsylvania State University
Dong-Joo Min[3], Seoul National University
Myunghun Lee[4], Seoul National University

Abstract

Distributed acoustic sensing (DAS) is an attractive technology for 4D exploration because it has low maintenance cost and high sampling density. However, because the response functions of DAS are different from those of geophones, which are commonly used for exploration, it is necessary to analyze its features.

This study is a preliminary study for subsurface imaging combining onshore vertical seismic profile (VSP) geophone and DAS data. Three-component geophone modeling is performed and we implement DAS modeling by changing the response function in the geophone modeling. Then, modeled geophone and DAS data are compared with actual VSP geophone and DAS data acquired at Janghang-ri, Gyeongju. The VSP survey was conducted by the Korea Institute of Geoscience and Mineral Resources' (KIGAM) research project aimed at constructing a deep composite geophysical monitoring system evaluating the activity of earthquake faults in the southeastern region of the Korean Peninsula. The modeling results show that DAS data shows phase lag compared to the data recorded using geophones, because the response function of DAS is average strain while the response function of geophone is particle velocity. In addition, we perform inversion using three-component geophone data and analyze the results. Through this analysis, we propose an imaging strategy that builds the initial velocity structure using geophone data with a high signal-to-noise ratio and then images the reflection layer in a high-frequency band using DAS data with a high sampling density.

Keyword

Distributed acoustic sensing, 4D exploration, imaging, inversion

Numerical Modeling of Two-Way Coupled Simulation for Geological Carbon Storage

Hyun Chul YOON[1]*, Korea Institute of Geoscience and Mineral Resources
(hyun.yoon@kigam.re.kr)

Abstract

When CO2 is injected into the saline aquifer or depleted reservoir for geological carbon storage, physical processes are tightly coupled, affecting the CO2 flooding and its trapping mechanisms. For example, injection induces pore pressure build-up and dilation of pore space, which can uplift the ground surface or tensile/shear failure of the caprock that may result in the leakage of CO2. Thus, rigorous analyses of coupled flow and geomechanics are necessary to predict the long-term security of the geological carbon storage. In this study, we employ the fixed-stress sequential method solving coupled flow and geomechanics. Fixed-stress sequential method is based on an operator splitting scheme, solving the flow operator first via fixing the stress rate and the geomechanics using the intermediate solution, until the two operators are converged within a tolerance value. Through the fixed-stress sequential method, we can couple the two-way physics between the fluid and geomechanics rigorously with unconditional stability and convergence upon the theory of Biot's poroelasticity. From the numerical experiments, we find robust computations of the coupled processes, highlighting the poromechanical effects along with major trapping mechanisms, e.g., residual/capillary and structural trappings for the CO2 geological storage. Compared to one-way coupling from fluid flow to geomechanics, the proposed constitutive relation and algorithm for coupled processes can predict flooding and trapping of CO2 underground more accurately.

Keyword

Geological carbon storage, Fixed-stress sequential method, Two-way coupling

Reservoir simulation study for the injectivity and geomechanical stability in the Gunsan basin

Taehun LEE[1]*, KIGAM (thlee@kigam.re.kr)
Byoungyeop KIM[2], KIGAM

Abstract

In order to realize carbon neutral 2050, one of the key technologies is carbon capture and sequestration (CCS) with the use of renewable or low-carbon energy, and improving of fuel efficiency. CCS is a process that can reduce greenhouse gas emissions by capturing CO2 from large industrial sources and injecting it into deep geological formations. However, CCS requires careful monitoring to ensure that the CO2 does not leak back into the atmosphere or cause environmental damage. Republic of Korea government want to find out the optimal CCS site and Gunsan basin in the Yellow sea of the Korean Peninsula is the one of proposed sites. The Gunsan Basin is located in the the South Yellow Sea, approximately 200 km from the west coast of South Korea and is is a shallow continental shelf with an average water depth of 44 m. The Gunsan Basin is considered as a proper storage option due to its proximity to possible capture sites along the west coast. In this study, geological model was constructed using the for the reservoir simulation and geomechanical simulation. The CCS must occur safe and stable, which requires geomechanical modeling to analyze the effects of formation uplift or subsidence. Case studies were performed for the CO2 injectivity and geomechanical stability.

Keyword

CO2 sequestration, Injectivity, Geomechanical simulation, Uplift, Production scenario

Building an initial velocity for 3D OBC seismic data processing in the Gunsan basin, offshore western Korea

Woohyun SON[1]*, KIGAM (whson@kigam.re.kr)
Byoung-Yeop KIM[2], KIGAM
Yonghwan JOO[3], KIGAM
Moohee KANG[4], KIGAM
Yunsuk CHOI[5], KIGAM

Abstract

Accurate velocity information is crucial for precisely imaging subsurface structures using real seismic data. The 3D OBC data acquired from the Gunsan basin poses challenges due to its limited number of receivers (72 channels), making it difficult to derive precise velocities. To overcome the challenge of obtaining accurate velocities in this survey area, we use seismic data obtained through a long offset (3 km, 240 channels) streamer. Initially, we enhanced the signal-to-noise ratio by applying various high-resolution time-domain data processing techniques (low-cut filter, time delay correction, swell noise attenuation, velocity analysis, SRME, SRWEMR, predictive deconvolution, de-ghost filter, linear noise attenuation, radon filter, and Kirchhoff migration) to the long offset data. Additionally, we applied depth-domain data processing techniques based on MVA (Migration Velocity Analysis) to obtain accurate P-wave velocity with stable convergence of velocity errors. It was confirmed that the stack section derived from accurate depth-domain velocity significantly improved strata connectivity compared to the time-domain result. Consequently, by successfully applying the proposed time and depth domain data processing techniques to long-offset (3 km) data, we derived improved depth-domain stack sections and P-wave velocities. The obtained high-resolution depth domain velocity can be effectively used as the initial velocity for 3D OBC seismic data processing.

Keyword

Depth processing, MVA, Seismic, velocity

Development of a surrogate model to improve the efficiency of groundwater level fluctuation pattern-based hydrologic properties evaluation

JIHO JEONG[1]*, Kyungpook National University (iamwlgh@naver.com)
JINA JEONG[2], Kyungpook National University

Abstract

In this study, a method of aquifer hydrologic property estimation incorporating the deep learning method was developed to improve the estimation efficiency of a process-based model based on groundwater level fluctuation (GLF) patterns. As a reference study, a data-driven method suggested by Jeong et al. (2020) was considered; the uncertainty of the GLF patterns resulting from different yearly patterns of precipitation, which were considered as noise in the previous study, was effectively discarded using the newly proposed method of applying the conditional variational autoencoder (CVAE). The CVAE was used to acquire the specific GLF patterns under certain identical precipitation patterns for all the monitoring stations. The data-driven hydrologic property estimation model was developed to predict two hydrologic parameters (ρ and k) of the process-based model using the generated GLF patterns from the CVAE network as the input variables. The actual GLF and precipitation data that were acquired from nationwide groundwater monitoring stations in South Korea were applied to validate the developed method. It was found that the estimated and target hydrologic properties were highly correlated (correlation coefficients [CC]: 0.9833 and 0.9589 for ρ and k, respectively), which significantly improved the results when compared to the previous study (CC: 0.7207 and 0.8663 for α/n and k, respectively). Consequently, the developed model can contribute to a more accurate hydrologic property estimation of aquifers. Additionally, it can facilitate efficient groundwater development planning since the manual fitting of the process-based model by an expert is not required.

Keyword

hydrologic property estimation, data-driven estimation model, groundwater level fluctuation pattern, precipitation pattern, conditional variational autoencoder

Machine-learning-based microearthquake detection for the southern Korean Peninsula

Byeongwoo Kim[1]*, Yonsei University (kbw8280@yonsei.ac.kr)
Minhwan Kim[2], Kyung Hee University
Tae-Kyung Hong[3], Yonsei University

Abstract

In South Korea, there were considered to have infrequent moderate to large scale earthquakes. Recently, there was apparent increase in moderate-size earthquakes that include the 2016 ML 5.8 Gyeongju earthquake, the 2017 ML 5.4 Pohang earthquake, the 2021 ML 4.9 Jeju earthquake, and the 2023 ML 4.9 East Sea earthquake. The successive moderate-size earthquakes increased public concern on the possible seismic hazards in the Korean Peninsula. We analyze scattered microearthquakes that are difficult to be detected in conventional methods such as short-term to long-term average ratio analysis and matched filter analysis. Conventional methods suffer from ambient noise and station density. We employ a machine learning approach to identify microearthquakes. We collect seismic data since November 2022 from >420 stations deployed in South Korea. We utilize the trained PhaseNet machine learning model to detect P and S phases from seismic records and identify microearthquakes based on coherent phase arrivals across the stations. We observe approximately 600 microevents per month, some of which may be induced by human activities. About 30% of these earthquakes may be natural microearthquakes. We identify more than twice natural earthquakes compared to conventional methods. Microearthquakes are clustered in the central and southeastern regions of South Korea, particularly around Gyeongju and Pohang areas. This method is effective in detecting microearthquakes, contributing to better understanding of seismic activity in South Korea.

Keyword

machine learning, microearthquake, earthquake detection, PhaseNet

Investigation of Important Factors on the Field-scale DNAPLs Contamination by Applying Polynomial Chaos Expansion and Random Forest

Taehoon Kim[1]*, Department of Earth System Science, Yonsei University (kth6379@yonsei.ac.kr)
Weon Shik Han[2], Department of Earth System Science, Yonsei University, Seoul, Republic of Korea
Jehyun Shin[3], Groundwater Environment Research Center, Korea Institute of Geoscience and Mineral Resources,Daejeon, Korea
Peter Kang[4], Department of Earth and Environmental Sciences, University of Minnesota, Minneapolis, MN, USA
Peter Kang[5], Saint Anthony Falls Laboratory, University of Minnesota, Minneapolis, MN, USA
Seonkyoo Yoon[6], Department of Geological Science, University of Florida, Gainesville, FL, USA
Hansung Nam[7], Department of Earth System Science, Yonsei University, Seoul, Republic of Korea

Abstract

A 3D high-resolution subsurface characteristic (HSC) model that integrates porous media (PM) and fractured rock (FR) media, was constructed based on a field investigation. For the realistic model representation, lithologic, hydrogeologic, petrophysical, and fracture information were obtained from various hydrogeologic and geophysical investigation techniques. On the 3D HSC model, a full-physics numerical simulation was conducted to predict DNAPLs contamination. By varying the seven input variables affecting the DNAPLs contamination, 180 numerical simulations were conducted to obtain three output variables: total DNAPLs mass in PM (y1), residually trapped DNAPLs mass in PM (y2), and Total DNAPLs mass in FR (y3). The input combinations and output variables predicted by the full-physics model were then utilized as training and test datasets to generate a surrogate model. In this study, Polynomial chaos expansion (PCE) and random forest (RF) methodologies were employed to train the surrogate models. Subsequently, the performance of the developed PCE and RF surrogate models was evaluated using test data. In addition, to identify and quantify the importance of factors influencing the fate and transport of DNAPLs in porous media and fractured rock, Sobol's sensitivity analysis and feature importance (FI) evaluation based on the PCE and RF surrogate models were conducted, simultaneously. As a result, for y1 and y3, both Sobol's sensitivity indices and FI indicated the depth of the groundwater table was the most influential factor on DNAPLs total mass in PM, followed by permeability anisotropy in PM and the residual saturation of DNAPLs. For the residually trapped DNAPLs mass, the residual saturation of DNAPLs and the depth of the groundwater table were the most and second most influencing factors, respectively. The study provides a comprehensive 3D HSC model for an integrated understanding of PM and FR, employing advanced algorithms from machine learning and statistics to analyze the importance of influencing factors on the DNAPLs fate and transport in the subsurface. The influencing factors explored by Sobol's sensitivity analysis and FI evaluation were consistent, indicating that the results were not algorithm-dependent. This surrogate model-based research framework is expected to be applicable in various hydrogeological fields, offering a cost-effective method to elucidate the complex

dynamic of DNAPLs contamination within the subsurface environment.

Keyword

DNAPLs, Polynomial Chaos Expansion, Random Forest, Site Characterization Model, Fractured Rock

Improvement of performance of in-situ virtual monitoring system of the occurrence probability for high concentrations of naturally occurring radioactive materials in groundwater through the solution of the data imbalance problem

Hyeongmok LEE[1]*, Kyungpook National University (brotherneck@naver.com)
Ji-na Jeong[2], Kyungpook National University

Abstract

Two data-driven models for virtual sensors were developed to estimate the probability of high-concentration occurrence of naturally occurring radioactive materials (NORMs; 238U and 222Rn) in groundwater based on the in-situ groundwater quality monitoring data and geological information of the aquifer. The random forest approach was applied to develop the proposed estimation models based on the actual in-situ groundwater quality data (pH, temperature, oxidation–reduction potential, electric conductivity, dissolved oxygen, and bicarbonate ion concentration), rock type, and f the aquifer depth as the input variables. The NORM concentration measured in the laboratory was used as the output variable. Additionally, this study proposes three data sampling techniques (i.e., under-sampling, synthetic minority over-sampling, and a complex sampling technique using the under- and over-sampling) to improve the model applicability and accuracy. The developed models were validated using the actual data acquired from 201 locations in South Korea. The developed models for 238U and 222Rn showed estimation accuracies of 85% and 80%, respectively, even though the models used only in-situ information without laboratory experiments; the models with over-sampling showed even better performance. All the results verified the usefulness of the developed models in providing immediate information on the in-situ presence of NORMs in groundwater, and the over-sampling technique was confirmed to be an effective and practical solution to the data imbalance problem in data-driven geological estimation models. Thus, the developed models are promising virtual sensors for managing groundwater quality in real time.

Keyword

Groundwater quality virtual sensor, Data augmentation, Sampling technique, Sensitivity analysis

Pollution Sources Identification and Sustainable Management Strategy of Groundwater in Volcanic Islands: A Case Study of Jeju Island Using an Integrated Multivariate Statistical and Machine Learning Approach

Hyuntai AHN[1]*, Korea university (howel0537@korea.ac.kr)
Kyoung-Ho Kim[2], Korea Environment Institute, Sejong 30147, Republic of Korea
Junseop Oh[3], Department of Earth and Environmental Sciences, Korea University, Seoul 02841, Republic of Korea
Hyunsoo Seo[4], Department of Earth and Environmental Sciences, Korea University, Seoul 02841, Republic of Korea
Jaehoon Choi[5], Department of Earth and Environmental Sciences, Korea University, Seoul 02841, Republic of Korea
Hyun-Ji Kang[6], Department of Earth and Environmental Sciences, Korea University, Seoul 02841, Republic of Korea
Sunmi Oh[7], Jeju Province Development Corporation, Jeju 63345, Republic of Korea
Su-Hyung Moon[8], Jeju Province Development Corporation, Jeju 63345, Republic of Korea
Seong-Taek Yun[9], Department of Earth and Environmental Sciences, Korea University, Seoul 02841, Republic of Korea

Abstract

Worldwide, rural areas are mostly experiencing the increase of nitrate (NO3-) concentrations in shallow groundwater, posing a significant threat to the use of groundwater for drinking and domestic purposes. Previous groundwater studies in areas with mixed pollution sources primarily relied on multivariate statistical analysis of hydrochemical data, leading to less reliable outcomes and often incurred high costs due to the need for direct data collection from multiple sites. Therefore, there is a need for cost-effective and reliable data interpretation and evaluation in future groundwater research. This study conducted an integrated approach of multivariate statistical analysis and machine learning-based data interpretation on major hydrochemical (cations/anions) and nitrate isotope data from a total of 706 groundwater samples collected along the groundwater flow path in the southwestern region of Jeju Volcanic Island of South Korea over four years (2019-2022). Initially, wells significantly affected by nitrates were identified using geostatistical analysis techniques such as Robust Principal Component Analysis (Robust PCA) and Kriging. Excluding 43 outliers, the study performed the regression and classification modeling using the Random Forest machine learning algorithm on 663 samples, achieving more sophisticated and efficient interpretation. Specifically, 80% of the data (i.e., 544 samples) were randomly selected as the training dataset, and the remaining 20% (i.e., 119 samples) served as the validation dataset. The target variable was set as PC1, with predictors including land use, altitude, distance to the coastline, soil type, effective soil depth, geology, water level, and the Topographic Wetness Index (TWI). The study found that the spatial distribution of PC1 from multivariate statistical analysis closely matched the spatial distribution pattern of PC1 derived solely from machine learning predictors. This suggests that the pattern of groundwater contamination in volcanic islands follows a certain predictable pattern, independent of the localized distribution of

nitrate pollution sources. Furthermore, the study produced a probability map designating areas with a contamination probability exceeding 0.5 as contamination risk zones through Random Forest classification modeling, and compared the results with the existing map on groundwater resource conservation in Jeju Island. The water quality data-based machine learning approach adopted in this study will be very useful for the sustainable management of groundwater in volcanic island rural areas with multiple pollution sources.

Keyword : Nitrate pollution, nitrate isotope, Robust Principal Component Analysis, Machine learning, Random Forest

Acknowledgements: This research was conducted as part of the "Integrated Environmental Forensic Technology Development for Identifying Sources of Subsurface Environment Pollution (Project Number: 2021002440003)" that was supported by the Ministry of Environment and the Environmental Industry and Technology Institute, and a commissioned research project supported by the Jeju Province Development Corporation (JPDC). Additionally, it recieved research support from the Korea Radioactive Waste Agency(KORAD).

Keyword

Nitrate pollution, Machine learning, Random Forest, Groundwater, Principal component analysis

Evaluation of the Feasibility of Applying Machine Learning Techniques for Landslide Prediction

Hyeyeon JEON[1]*, Kangwon National University (j.hyeyeon@kangwon.ac.kr)
Jiwook Jang[2], Kangwon National University
Jin-Yong Lee[3], Kangwon National University

Abstract

Currently, there is a gradual increase in the frequency of heavy rainfall due to the impacts of climate change, and this increase in heavy rainfall raises the risk of landslides worldwide. The occurrence of landslides can lead to numerous casualties and property damage, so it is important to predict the scale of future landslides to mitigate landslide damage. The purpose of this study is to evaluate the feasibility of predicting landslide occurrences and identifying factors affecting landslides through data obtained from indoor and outdoor surveys and machine learning techniques. In Earth sciences, various methods such as KNN, Naive Bayes, Decision Tree, and Random Forest are applied to enable precise predictions. In particular, methods of identifying landslides using machine learning show outstanding robustness and potential in solving problems. On the other hand, convolutional neural network (CNN) algorithms have strengths in feature extraction and processing of multidimensional data. Additionally, when comparing three machine learning algorithms (support vector machine, Decision tree, Logistic regression) for assessing landslide vulnerability, Support Vector Machine (SVM) proved to be superior to traditional statistical methods, with SVM classification surpassing the analytic hierarchy process approach in all evaluation indicators. It is important to derive parameters that can be used for landslide sensitivity analysis by combining geographic spatial data of landslide occurrences with other environmental data. Moreover, to improve the accuracy of the landslide sensitivity model, it is necessary to integrate additional controls on slope stability. This study evaluated the potential for applying machine learning to large past landslide damage cases, and the location, distribution, and damage status of landslides, along with long-term rainfall and climate information, and the geological characteristics of the area (particle size, density, soil moisture, etc.). Through this research, we hope to estimate the risk of future landslides and contribute to the development of measures to prevent landslide damage. This research was supported by the Basic Science Research Program through the National Research Foundation of Korea (NRF) funded by the Ministry of Education (No.2019R1A6A1A03033167).

Keyword

Machine Learning, Landslide, Climate change

Convolutional LSTM networks for predicting spatio-temporal variability of standardized groundwater level index in South Korea

Sanghoon LEE[1]*, Korea Atomic Energy Research Institute (lshlsh2311@kaeri.re.kr)
Kang-Kun Lee[2], Seoul National University
Ji-Hun Ryu[3], Korea Atomic Energy Research Institute

Abstract

Groundwater level is a well-known quantitative indicator of water or energy resources. It also dictates water pressure and redox conditions, which are important factors in deep geological repository for disposal of high-level radioactive waste or underground storage system of energy such as carbon dioxide. Since the groundwater levels have characteristics that depend on both time and space, it is more informative to analyze spatio-temporal change of the groundwater level. In this study, spatio-temporal prediction of standardized groundwater level index (SGI) that changes according to location and time was attempted by applying convolutional long short-term memory network (ConvLSTM) with standardized precipitation index (SPI) as an input variable. The ConvLSTMs that can predict SGI on a national scale in South Korea was developed, and future groundwater changes were compared and evaluated for multiple scenarios by performing predictions up to 2100 according to future climate changes. Prediction results showed different change pattern of SGI by space within South Korea. In particular, most of the inland areas were greatly affected by the short-term drought indices such as SPI2 and SPI3, while in the Jeju area, the long-term drought index of SPI12 was greatly affected. The difference of SGI patterns according to location was found to be due to surrounding environmental features such as land use and hydrogeological unit. As a result of applying the SSP (Shared Socioeconomic Pathways) scenarios after the completion of the model, the increase of high SGI and the decrease of low SGI were evident over time in SSP2-4.5 and SSP5-8.5, but the SSP1-2.6 scenario considering eco-friendly development showed a similar distribution of SGI to the present. This research suggests that more diverse input variables and observed data should be considered as improvements for the further works. It could lead to more reliable and higher resolution predictions, in order to analyze patterns of the groundwater level change in South Korea and contribute to precise long-term environmental change prediction and policy establishment for water and energy usage.
Acknowledgements: This work was supported by the Institute for Korea Spent Nuclear Fuel(iKSNF) and National Research Foundation of Korea(NRF) grant funded by the Korea government(Ministry of Science and ICT, MSIT)(No.2021M2E1A1085186).

Keyword

Deep learning, Groundwater level, Spatio-temporal prediction

Oil spill analysis around Small Island Developing States through multimodal large model

Xiaohui YU[1]*, Zhejiang University (yuxiaohui0626@gmail.com)

Abstract

Oil spills not only seriously threaten to the ecological development of the ocean, but also have long-term impacts on human health and the sustainable development of small island developing states (SIDS). SIDS are extremely sensitive to oil spills due to their unique geographical location and economic structure. Therefore, it is crucial to accurately identify and predict the spread trajectory of oil spills. To address this challenge, this study proposes to use a model that integrates the multimodal large model, remote sensing data, ocean dynamics models, and oil spill diffusion models to predict the scale and propagation direction of oil spills, as well as the possible damage of coastlines of SIDS to ensure the marine ecological security and sustainable development of them. In addition, the model combines time series analysis and artificial intelligence algorithms to analyze data from historical oil spill events to improve the accuracy of predictions. This research aims to provide a set of decision support tools for SIDS when responding to oil spills to ensure its marine ecological security and sustainable socio-economic development. While assessing potential environmental impacts, this study highlights the need for rapid and efficient response strategies. This model also provides important reference value for achieving many of the goals in the Sustainable Development Goals (SDGs), as well as for international cooperation and regional oil spill emergency preparedness.

Keyword

Small Island Developing States, oil spill analysis, multimodal Model, sustainable development

Prediction of groundwater levels of National Groundwater Monitoring Network in South Korea using LSTM (Long Short-Term Memory)

hyowon AN[1]*, University of Science and Technology (UST) (attorney0107@naver.com)
Kyoochul Ha[2], Institute of Geoscience and Mineral Resources (KIGAM)

Abstract

Monitoring of groundwater level fluctuations over time is important for the sustainable use and management of groundwater resources. The groundwater level data are used for the related researches in groundwater such as water balance analysis and groundwater modeling, and it is essential to evaluate and predict the trends and variations of groundwater levels. Traditionally, time series analysis such as the autoregressive(AR), moving average(MA), and the combined AR and MA model (ARIMA) have been used to predict groundwater levels. But recently, machine learning and deep learning models are widely used due to its high accuracy and ability to handle nonlinearity. In applying these machine learning and deep learning techniques, auxiliary use of weather and environmental variables will compensate for missing data much more efficiently than using only groundwater level data and increase the accuracy of time series prediction. Factors that affect changes in groundwater level include various meteorological data such as precipitation and temperature, and environmental variables such as river level, seawater level, and groundwater usage, etc.

The purpose of the research is to predict groundwater level data by deep learning techniques within a watershed. For the study, we utilized the National Groundwater Monitoring Network in South Korea and used the LSTM (Long Short-Term Memory) model to analyze long-term time series. The model was used with input data such as precipitation, temperature, electrical conduction, and groundwater level of different wells. Other groundwater level data with a similar pattern to the groundwater level of the target well were used as input data to train the model. The results of the study showed that wells with high correlation in the same basin can be usefully used to improve time series predictability. Additionally, these results showed that time series forecasting was much more efficient than using only meteorological data such as precipitation. It is expected that these time series prediction can be useful in watershed-scale groundwater resource assessment and management.

Keyword

Groundwater level, Deep learning, LSTM, Time series Prediction

A deep learning-based proxy model for 3D channel reservoir characterization

Youjun LEE[1]*, Seoul National University (youlee@snu.ac.kr)
Dogyun KIM[2], Seoul National University
Woosueng JO[3], Seoul National University
Jonggeun CHOE[4], Seoul National University

Abstract

Reservoir characterization is crucial for the success of oil field development plans, especially in the case of channel reservoirs where high uncertainties remain due to limited geological information and heterogeneity. Traditional approaches for channel reservoir characterization are ensemble-based methods, which are well-established stochastic history matching techniques with an ensemble of model realizations. Despite of their effectiveness, they often pose computational challenges, as updating multiple model realizations increases costs significantly.

To address this challenge, many researchers have proposed deep learning-based proxy models to reduce simulation costs of reservoir models. To reliably characterize channel features, such as connectivity and pattern, it is necessary to consider spatial variables of reservoir models. Furthermore, if it is limited to a single reservoir model, it is unsuitable for stochastic history matching preferred for channel reservoir characterization. In response, this research presents a novel scheme for a deep learning-based proxy model tailored for stochastic history matching, incorporating spatial static data of reservoir models. Combining convolutional neural networks (CNN) and long short-term memory (LSTM) architectures, the proxy model predicts dynamic data, exploiting CNN's image feature extraction capability and LSTM's proficiency in time-series prediction.

In this study, we perform Ensemble Smoother with Multiple Data Assimilation (ES-MDA) utilizing the proxy model for production forecast of reservoir models. For validation of our proposed method, its performance is compared with ES-MDA using a commercial forward reservoir simulator. We perform this analysis on a 3D channel reservoir, and results demonstrate the proxy model's accuracy in predicting reservoir dynamics, with computational efficiency significantly outperforming the conventional method compared. Channel features and uncertainty quantification of the updated models further confirm the effectiveness of the proposed approach in providing reliable channel reservoir characterization while reducing computational costs.

Keyword

proxy model, history matching, channel reservoir, deep learning

Carbonate structures and reservoir identification based on machine learning methods: A case from the Lower Paleozoic of Jiyang Sub-Basin

Chenglong LIU[1]*, China University of Petroleum(East China) (liuchenglongupc@163.com)
Yanzhong WANG[2], China University of Petroleum(East China)
Yingchang CAO[3], China University of Petroleum(East China)
Shuping WANG[4], China University of Petroleum(East China)
Yujie DU[5], China University of Petroleum(East China)
Kai SHENG[6], China University of Petroleum(East China)
Hao GUO[7], China University of Petroleum(East China)

Abstract

Marine carbonate is a significant target for oil and gas exploration globally, granular carbonate is the best type of reservoir controlled by facies. However, compared to clastic rock, the physical properties of carbonate rock components are similar. Diagenesis, especially cementation, leads to the convergence of rock physical properties and similar logging response characteristics. Hence, identifying granular carbonate reservoirs has always been challenging when studying carbonate rocks. Additionally, as depth increases, the cost of all kinds of data rises, and quality worsens. Limited by sample data, classification schemes, identification methods, and other factors, accurately identifying and characterizing deep and ultra-deep carbonate oil and gas reservoirs is difficult, particularly in identifying granular carbonate reservoirs. In this study, we established a large database based on the comprehensive use of core, slices, and well-logging data, including 2232 data points in the training set, covering 433 slices and more than 700 meters of core observation. According to the petrophysical model, we divided six carbonate rock structures, including micrite, crystal, granular, residual, brecciated, and others. By using a variety of machine learning methods, we have realized the accurate logging identification of the lower Paleozoic granular carbonate reservoir in Jiyang Sub-Basin. The results indicate that ensemble methods, such as subspace KNN and bagging, have the highest accuracy in identifying granular carbonate, reaching up to 87.2%. The most sensitive conventional logging parameters for carbonate rock structures are AC, DEN, and CNL. The identification accuracy of SVM, KNN, and kernel is significantly affected by the structural similarity of carbonate rocks. However, ensemble methods and neural network methods can effectively differentiate similar carbonate rock structures. Additionally, compared with the application of methods, the quality of the database and the pre-processing of the logging data are crucial. This research provides a foundation for the scheme design and method selection to identify granular carbonate reservoirs. This research also serves as a foundation for studying the parameter characteristics of granular carbonate rocks, the distribution and evolution of organic reefs and intra-platform shoals, and the evaluation of fine reservoirs using logging techniques.

Keyword

Deep and ultra-deep reservoir, Granular carbonate reservoir, Carbonate rock structure, Well logging data, Machine learning

Intelligent logging identification of petrophysical facies

Xinhao ZHANG[1]*, China University Of PetroleumEast China (1312909815@qq.com)
Xianguo ZHANG[2], China University Of PetroleumEast China
Huafeng LIU[3], China University Of PetroleumEast China

Abstract

The mature oil fields in eastern China have experienced long-term water flooding development and have generally entered the stage of ultra-high water cut. The differences in reservoir petrology and physical properties have a significant impact on development. Fine understanding of reservoir petrophysical facies is an important geological basis for achieving economic, efficient and green development of reservoirs. In this study, the Paleogene delta facies reservoirs of typical oilfields in the Bohai Bay Basin in eastern China were selected to carry out the study of petrophysical facies classification and intelligent logging identification, so as to reveal the distribution law of petrophysical facies and guide the efficient development of reservoirs.

Using core, thin section and well logs, combining lithofacies and sedimentary microfacies, and using the hierarchical clustering method of porosity-permeability overlap, the reservoir is divided into six types of petrophysical facies (RPF1 to RPF6). Capillary pressure curve analysis confirms that these six types of petrophysical facies have different pore structure characteristics. On this basis, petrophysical facies logging identification was carried out. Since traditional identification methods are difficult to represent complex geological parameters, and most "point-to-point" machine learning methods lack the ability to extract vertical well logging data features, this study uses one-dimensional convolutional neural network (1D-CNN) to give full play to its ability in multivariate sequence data. With the advantage of feature extraction capabilities, the logging identification of reservoir petrophysical facies in non-coring wells is realized.

The results indicate that the RPF1 and the RPF2 are mainly developed in the distributary channel microfacies, and the lithology is medium-coarse sandstone with excellent reservoir quality. 1D-CNN can effectively identify the types of reservoir petrophysical facies. The average F1 score of the six reservoir petrophysical facies is 0.88, which is 0.04 to 0.07 higher than the traditional machine learning method, achieving high-precision identification of reservoir petrophysical facies.

Keyword

hierarchical clustering, petrophysical facies, convolution neural network, logging identification

Productivity Prediction of shale basins in the USA using machine learning and data integration

Sungil KIM[1]*, Korea Institute of Geoscience and Mineral Resources (skim@kigam.re.kr)
Kwang Hyun Kim[2], Korea Institute of Geoscience and Mineral Resources
Jungtek Lim[3], SmartMind

Abstract

This study validates the application of machine learning (random forest, RF) to predict the 36-month production of oil and gas from six shale basins in the USA: Delaware, Marcellus, Barnett, Eagle Ford, Haynesville, and Midland. The input and output parameters of the RF model were 12 production well-related parameters and 36-month production of oil and gas, respectively. The total number of well data is 32,932, which was divided into training (26,345) and testing (6,587) data, respectively. In this study, three points were noted from the training and testing results by RF. First, an RF model based on the six basins-integrated data presented a successful prediction performance, although machine learning application for each basin had been taken as a more usual way. The integrated data-based RF brought a coefficient of determination (R2) of 0.758 and 0.707 for oil and gas, whereas separately trained RF models showed R2 of 0.699 and 0.690 for oil and gas. Second, the RF model from the six basins-integrated data was used as a pre-machine learning model to train separate RF models for each basin. The pre-RF models became a base model to be fine-tuned for well data of each basin. Consequently, those fine-tuned RF models brought the best prediction performance, R2 of 0.763 and 0.711 for oil and gas. Third, the used input parameters to forecast the production were composed of attainable and simple data such as latitude, longitude, true vertical depth, and fracturing-related data. The proposed method is expected to be generally applied to newly developed wells or even new target basins owing to its versatility and applicability.

Keyword

Random forest, Six shale basins, Productivity prediction, Data integration

Fracture identification based on graph convolutional network in continental shale oil reservoirs

Guoqing LU[1]*, China University of Petroleum, Beijing (zsdhdlgq@126.com)
Lianbo Zeng[2], China University of Petroleum, Beijing
Guoping Liu[3], Peking University

Abstract

The identification of natural fractures in continental shale oil reservoirs currently faces the problems of weak conventional logging response characteristics and limited amount of labelled data available from cores or image logs. To address this issue, we propose the Weighted Graph Convolutional Network of Graph Pooling and Edge Generation (GPEG-WGCN) method, which is an improved Graph Convolutional Network (GCN). The novel method determines the size of the graph pooling window according to core fracture heights, integrates the relationship information between the fractures and lithology into the edge generation method, and adds the generated edge weight into the message passing process, thereby effectively improving the accuracy of fracture identification.

The identification process is divided into four steps: first, reconstruct the logging curve and establish vertex sets for each lithology and individual lithologic layer using conventional logging sampling points as vertices . Second, determine the sliding window size based on core fractures and utilize the graph pooling section to filter and merge node information within the sliding window, enhancing the tool's response characteristics to fractures . Third, based on the depth sequence of a single lithologic layer and the Euclidean distance of the same lithologic vertex sets, the connection between vertices is established and overlapping edges generated by the above methods are given higher weights . Fourth, the vertices in the constructed graph are classified through graph convolutional layers, which are integrated into the edge weight information.

This method is applied in identification of fractures in Fengcheng Formation of the Mahu Sag in the Junggar Basin, western China. A conventional logging dataset was labelled by direct core observations from two separate wells in the study area. Compared to the GCN (boundless) without using the edge generation method and EG-GCN with the edge generation method but without the weighted aggregation mechanism, this method had higher accuracy, as well as exhibiting better precision and recall for fracture samples. Collectively, this reflects the superiority of this method in fracture identification by conventional logging data, providing a successful workflow for continental shale characterization.

Keyword

Fracture identification, graph convolutional network, continental shale oil, conventional logging

Cascade Effects of Global Supply Chains Induced by Regional Conflicts Increase Global Inequality

Rongtian Zhao[1]*, Institute of Geographic Sciences and Natural Resources Research (zhaorongtian19@mails.ucas.ac.cn)
Daoping Wang[2], King's College London
Yong Ge[3], Institute of Geographic Sciences and Natural Resources Research
Mo Zhang[4], Institute of Geographic Sciences and Natural Resources Research
Die Zhang[5], Jiangxi Normal University
D'Maris Coffman[6], London's Global University
Qiuming CHENG[7], School of Earth Science and Engineering, Sun Yat-Sen University

Abstract

Regional conflicts have recently emerged as frequent focal points for extreme events, resulting in severe disruptions to global supply chains. Hence, there is an urgent need for a quantitative evaluation and accurate description of the propagation of shocks in regional conflict across multiple sectors and countries. Here, we modeled global multisectoral production losses and the cascading pattern of a grain supply shock in the Russia–Ukraine regional armed conflict by utilizing a geographic input–output method, encompassing 141 aggregated regions and 65 sectors in each region, utilizing the input–output method. Firstly, the grain supply chains are not equal to the impact chains of the grain shortage. Two major chains decide the spread of the impact during the grain shortage crisis: one "grain-processed food/livestock - other sectors" direct impact chain and one "light manufacturing-heavy manufacturing-textile" chain. Secondly, the textile and food processing sectors would face the most direct and significant risks of production losses attributed to disruptions in grain supply, experiencing declines of 17.04%±0.72% and 16.85%±0.5% (the 95% confidence interval), respectively. These risks were projected to magnify to two and three times larger in 2025 and 2030, respectively, due to overlapping effects in the production of multiple sectors. Lastly, using scenario simulations of production recovery, we found that the prolonged conflict and excessive effort might decrease the efficiency of production recovery in underdeveloped regions to amplify the inequality of production resources. If the conflict persists beyond 2025, an efficient resumption of production would become unattainable in underdeveloped regions. Our approach presents a quantitative framework for early planning for unexpected supply chain shocks. The findings support the need to ensure production recovery in underdeveloped countries for sustainable development.

Keyword

Global Supply Chains, Cascade Effects, Regional Conflict, Inequality, Geographic Economic Methods

Innovative input-output geographical cascading model for detection and simulation of induced negative shocks in global supply chains

Mo Zhang[1]*, Institute of Geographic Sciences and Natural Resources Research, CAS (zhangmo@lreis.ac.cn)
Yong Ge[2], Institute of Geographic Sciences and Natural Resources Research, CAS
Die Zhang[3], Institute of Geographic Sciences and Natural Resources Research, CAS
Rongtian Zhao[4], Institute of Geographic Sciences and Natural Resources Research, CAS
Zhiyi Zhang[5], Institute of Geographic Sciences and Natural Resources Research, CAS
Daoping Wang[6], University of Cambridge
Yuxue Cui[7], China University of Labor Relations
Jian Liu[8], Southern Marine Science and Engineering Guangdong Laboratory (Zhuhai)
Qiuming Cheng[9], China University of Geosciences, Beijing

Abstract

Sustainable global supply chains spanning various industrial sectors play a crucial role in promoting long-term economic stability. However, disruptions in input-output chains resulting from induced negative shocks may lead to cascading effects, resulting in substantial losses within specific sectors of the national economy. The quantitative assessment of shock propagation across global supply chains is paramount in mitigating these cascading damages. Here, we developed an innovative approach that integrates input-output model with geographical Petri Net. Termed the input-output geographical cascading (IOGC) model, this framework enables the quantification of economic losses, detection of shock propagation across global supply chains, and identification of risks for countries and sectors over time when subjected to induced negative shocks. To illustrate the model performance, we conducted a case study utilizing the COVID-19 lockdown as a negative shock. Four idealized scenarios were simulated within real-world supply chain networks. The findings revealed that smaller economies exhibited greater vulnerability to economic impacts, potentially experiencing losses nearly 20% higher than the global average. Furthermore, the study unveiled distinct impacts on countries and sectors based on geographical propagation patterns. The IOGC model is also suitable for simulating and analyzing the superposition of multiple shocks, as well as classifying cascade propagation types based on geographical patterns. As a general approach, the proposed IOGC model holds potential for extension to a broad spectrum of negative emergencies or extreme events (e.g., natural disasters, socially catastrophic events) for global supply chains. The outcomes of these simulations and analyses provide crucial early warnings and policy recommendations for nations, facilitating timely interventions to mitigate disaster-induced losses and enabling the rational allocation of resources.

Keyword

Cascading effect, Petri Net, Input-output model, Global supply chain, Negative shock

Research on Petroleum Geological Reserve Prediction Based on Machine Learning

XIAOYU AN[1]*, RESEARCH INSTITUTE OF PETROLEUM EXPLORATION & DEVELOPMENT (anxy21@petrochina.com.cn)
DAWEI LI[2], RESEARCH INSTITUTE OF PETROLEUM EXPLORATION & DEVELOPMENT
QIAN ZHANG[3], RESEARCH INSTITUTE OF PETROLEUM EXPLORATION & DEVELOPMENT
MIN NIU[4], RESEARCH INSTITUTE OF PETROLEUM EXPLORATION & DEVELOPMENT
ZHENZHEN WU[5], RESEARCH INSTITUTE OF PETROLEUM EXPLORATION & DEVELOPMENT
SHIYUN MI[6], RESEARCH INSTITUTE OF PETROLEUM EXPLORATION & DEVELOPMENT

Abstract

As the petroleum industry enters the era of big data, many oil companies have gradually accumulated massive data resources through global exploration and development processes. The key to fully leveraging these big data lies in finding suitable data analysis and processing techniques to identify patterns within existing data and make predictions in both time and space. This, in turn, guides research and decision-making in the field of oil and gas. Machine learning algorithms constitute a category of algorithms that automatically analyze data to uncover patterns and utilize these patterns to predict unknown data. This category includes many mature algorithms. It is a challenge faced by big data analysts to select the most suitable algorithm in practical work. This study, based on a large commercial oil and gas database, evaluates approximately 30,000 oil and gas reservoirs in major oil and gas basins worldwide as the fundamental assessment units. Various machine learning algorithms, namely the Gradient Boosting Decision Tree (GBDT), Bayesian Ridge Regression, and Adaptive Boosting, are employed to predict the geological reserves abundance of oil and gas reservoirs. The paper compares the performance of these algorithms in predicting geological reserves abundance of oil and gas reservoirs, analyzes the advantages and disadvantages of different algorithms, and fine-tunes each algorithm during training to align with the characteristics of the dataset. Ultimately, the Gradient Boosting Decision Tree algorithm demonstrates satisfactory accuracy in predicting the geological reserves abundance, providing inspiration and guidance for the application of machine learning in global oil and gas resource assessment, new project evaluation, and favorable target selection.

Keyword

Global oil and gas resource assessment, Machine learning, Geological reserves abundance prediction, Big data analysts, Gradient Boosting Decision Tree algorithm

Comprehensive Evaluation of Tobacco-planting Soil Fertility Based on Machine Learning: A Case Study of Hezhou City, Guangxi

JUNXI TU[1]*, Sun Yat-sen university (tujx@mail2.sysu.edu.cn)
Wenjie Shen[2], Sun Yat-sen university

Abstract

As an essential attribute of soil, soil fertility has a direct impact on crop yield and quality. The rapid and accurate determination of its distribution is highly significant for sustainable agricultural development. Therefore, constructing a scientific and reasonable regional soil fertility evaluation system is crucial for ensuring economic efficiency while achieving standardized, rapid, and automated evaluation of soil fertility. And the exploration of the relationship between various indicators and fertility as well as the characteristics of abundance and deficiency can guide local soil ecological protection and the optimization of crop cultivation and fertilization programmes. In this study, the main t tobacco-planting area of Hezhou city was taken as an example, and 20 indicators were selected from aspects such as soil nutrients (Sn), physical and chemical properties (Spc), and climatic environment (Sce) to construct a total data set (TDS). Based on the improved fuzzy comprehensive evaluation method, four typical machine learning (ML) models in the field of soil fertility were constructed and the Shapley theory was used to identify the key indicators for constructing the minimum data set (MDS) to iterate the models and screen the model with the best generalization ability and prediction accuracy. The model was further interpreted to innovatively reveal the impact of changes in single-factor content on predicted contribution and fertility, combined with single-factor spatial interpolation to diagnose barrier factors in low-SFI regions. The results showed that the overall fertility of tobacco-planting soil in Hezhou was good, and the soil fertility of the two counties was mainly distributed in grades II and III. The comprehensive fertility of tobacco-planting soil in Fengxiang, Huilong, and Shanhu Town of Zhongshan County, Lianshan, and Fuli Town of Fuchuan County were all above Grade III. The Stacking_1 model based on the MDS had the best overall performance, with an R2 of 0.787, and the error of the mapping result was very small. Total nitrogen (TN) contributed the most to soil fertility, followed by available zinc (Zn), pH, and available phosphorus (AP). The variation trends of factor content, model contribution degree, and soil fertility conform to the membership function images, which also proves that the prediction results are real and reliable. The trends of single-factor content on the predicted contribution and soil fertility were consistent with the membership function images to which they belonged, proving the model prediction results were real and reliable. In low-SFI regions, the soil pH is generally high, and the contents of organic matter (OM), total nitrogen (TN), and available potassium (AK) are low, which should be improved by taking the corresponding measures of zonal precision fertilization. The research results have strong expansibility, replication, and promotion potential, which can provide a reference for the sustainable development of precision agriculture in different regions.

Keyword

Soil fertility, Combined weight, Fuzzy mathematics, Minimum dataset, Machine learning

Leveraging Machine Learning, Natural Language Processes and Knowledge Representations to Facilitate the Discovery of Insights and Analogues in Unstructured Geoscience Literature

Phoebe MCMELLON[1]*, GeoScienceWorld (mcmellon@geoscienceworld.org)
Alistair Reece[2], GeoScienceWorld
Paul Cleverley[3], Robert Gordon University
Sandra Merten[4], Lazuli Consulting

Abstract

GeoScienceWorld (GSW) is a non-profit founded in 2004 by geological societies to advance the dissemination of earth science information, supporting over 250,000 researchers worldwide. The platform includes 210,000+ articles, 39,000+ eBook chapters, and 4.6 million geoscience abstracts and records from GeoRef.

With each new and emerging technology, research data and output in both structured and unstructured formats exponentially increase, driving the need for more sophisticated technologies and tools to find the most relevant information and data when we need it. Full-text indexing and keyword-based retrieval have significantly improved the discovery of information. Extracting geoscience insights across the corpus proves even more challenging. The emergence of Large Language Models (LLM) and text data mining tools have immense potential to address some of these discovery challenges within the geosciences (1-3) however cost-effective and easy access to the tools, technologies, and content repositories and risks associated with security, privacy, and copyright permissions present additional challenges.

To address these issues and challenges, GSW developed a digital assistant, GeoSapien®. A statistical model was developed from GSW's corpus of 140,000+ articles published in over 50 scholarly publications from over 40 leading society publishers. This uses text embeddings (arrays of numbers that can be used to represent words based on their co-occurrence), Natural Language Processing, and Knowledge Representations to put the power of text data mining in the hands of individual researchers. The geoscience domain-specific lexicon and taxonomy of 150,000 terms created from a variety of open sources enables a wide range of visualization options, including clustering, heatmaps, associations in geological time and space, correlation plots, and analogue suggestions. This enables geoscience researchers to test hypotheses, investigate anomalies, stimulate ideation, and discover new knowledge and insights to surface latent patterns from within large volumes of text and links back to the text, allowing researchers to validate sources.

GeoSapien® is currently in beta and initial feedback from the geoscience community is encouraging and we hope to make GeoSapien® available to the international geoscience community later this year.

References
(1) Lawley et al (2022). Geoscience language models and their intrinsic evaluation. Applied Computing and Geosciences 14.
(2) Foroumandi et al (2023). ChatGPT in Hydrology and Earth Sciences: Opportunities, Prospects and Concerns. Water Resources Research, 59(10).
(3) Cleverley, P.H. (2017). Applying text and data mining to geological articles: Towards cognitive computing assistants. Geological Society of America (GSA), 2017 Annual Technical Meeting, Seattle, 49(6).

Keyword

Machine Learning, Unstructured Data, Text Data Mining, Geosciences

An ensemble model for predicting mineral prospectivity: a case study in the Malipo W-Sn mineral district, Yunnan Province, China

Chenyi ZHAO[1], China University of Geosciences, Beijing
Jie ZHAO[2]*, China University of Geosciences, Beijing (jiezhao2014@163.com)

Abstract

The utilization of machine learning and data-driven approaches for mineral prospectivity modeling has become increasingly crucial in supporting regional mineral exploration. However, deep learning-based mineral prospectivity modeling often encounter challenges due to limited labeled data and an imbalanced ratio of positive and negative samples. Insufficient training samples can also lead to inadequate extraction of mineral-related features, diminished accuracy in predicting mineralized areas, and even non-convergences (e.g., overfitting or underfitting) of models. In this study, we propose a novel hybrid ensemble model that integrates various learner methods, including Generative Adversarial Networks (GAN) and pre-training techniques, to effectively address these challenges. In comparison to conventional techniques such as rotation-based generation of new samples from original geological data, GAN-augmented data exhibits close resemblance to the original dataset in terms of both structure and attributes. The process of pre-training involves training a model on a large-scale dataset prior to the target task, which enables it to acquire general features. Pre-trained models serve as a valuable foundation for transfer learning by leveraging acquired knowledge and features from the pre-training phase instead of starting feature representation learning from scratch for a new task. Overall, our proposed ensemble model based on stacking entails training multiple diverse base learners whose outputs are utilized as inputs to train a meta-learner model, subsequently obtaining desired prediction results from these meta-learner models' outputs. The ensemble model runs following the subsequent steps: (1) initially, a set of 20 models was selected for training in the first layer based on their performance encompassing a diverse range of typical classification models such as Logistic Regression (LR), Stochastic Gradient Descent (SGD), Random Forest (RF), Extra Trees (ET), Decision Tree (DT), Multinomial Naive Bayes (MNB), Multi-layer Perceptron (MLP), Support Vector Machine (SVM), K-Nearest Neighbor (KNN), etc.; (2) subsequently, a 5-fold K-Fold cross-validation approach was employed to train these models and obtain meta-features; (3) these meta-features were then integrated with the dataset to form the training set for the second-layer meta-model (i.e., CNN, Bagging, and Boosting); (4) by leveraging the Grid Search Cross-Validation concept, optimal model weights were determined through equidistant sampling within the specified parameter space; and (5) ultimately, a weighted average of prediction results from multiple meta-learners was computed as the final outcome. Those intelligent prediction techniques were applied to analyze the geological, geochemical, and geophysical dataset with the aim of delineating potential areas for W-Sn mineralization in Malipo County, Yunnan Province, China. The ensemble model demonstrated superior performance in the study area and proved to be an efficient tool for mineral prospectivity modeling. Furthermore, the ensemble model exhibited high

flexibility and scalability by allowing adjustments to be made on base learners' types and quantities based on data characteristics, and demonstrated substantial potential for application in various research domains within the fields of geosciences.

Keyword

mineral prospectivity modeling, ensemble model, generative adversarial networks, transfer learning

Drivers of Phanerozoic Marine Biodiversity: Insights from Machine Learning

Guoxiong Chen[1]*, China University of Geosciences (gxchen@cug.edu.cn)
Qiuming Cheng[2], China University of Geosciences

Abstract

Phanerozoic biodiversity dynamics was controlled by both abiotic and biotic factors. However, a rigorous quantitative assessment of the relative roles of these factors in regulating long-term biodiversity dynamics has not been carried out because of the complex interplay between these forces. Here, we developed a machine learning (ML) model, from a data-driven perspective, for reconstructing the Phanerozoic history of marine biodiversity using various time series records of biological and abiotic forces (e.g., continental fragmentation, temperature, sea level, oxygen level and nutrient availability) and their time change rate. First, the ML model is designed to isolate long-term trends in the Phanerozoic biodiversity by separating the complex abiotic controls and interactions. The results show a monotonically increasing curve of biodiversity, with three rapid increases in early Ordovician, Cretaceous and Cenozoic, suggesting biodiversity-dependent dynamics which can be well fitted by logistic model. Second, changes in abiotic factors appear to have collectively modulated the non-directional fluctuations in Phanerozoic marine biodiversity. Among them, temperature, sea level, and oxygen level could have played relative important roles on origination or extinction rate. Notably, the ML-based multi-factor analysis suggest a transition from oxygen level-dependent biodiversification before Paleozoic to oxygen change-dependent model. More broadly, this study amplifies that data-driven machine learning methods could provide a potential path forward for deciphering the complex co-evolution of mass, environment and life.

Keyword

Biodiveristy, Data-driven, Machine leanirng, Phanerozoic, Oxygen level

Intelligent Identification of Target Properties of Downhole Rockfall Funnels in Pulang Copper Mine

JIANGUO CHEN[1]*, China University of Geosciences Wuhan (jgchen@cug.edu.cn)
Xinhan Lv[2], China University of Geosciences (Wuhan
Zhijun Chen[3], China University of Geosciences (Wuhan

Abstract

In the process of underground mineral extraction, it is often necessary to conduct daily inspections manually in the tunnels to ensure the normal progress of production work. However, this inspection method tends to suffer from drawbacks such as frequent inspections, long duration, and high safety risks. To address these issues, this study proposes an intelligent recognition system based on binocular depth cameras to achieve remote automated identification and proportion analysis of rockfall block size and debris, which are used to determine whether there is blockage in the rockfall funnel due to excessively large block size and whether the mining operation is approaching the surface. Challenges such as low light intensity, high levels of dust and water vapor, large differences in rock size, and unclear boundaries pose challenges to the accuracy of intelligent recognition and segmentation. To address these challenges, this study first conducted data augmentation on high-resolution images captured by the binocular camera system in the complex real-world scenarios underground, including geometric and pixel transformations, aiming to enhance the model's learning ability for fuzzy boundaries and objects with large size differences and irregular shapes. Secondly, a stereo vision algorithm was designed to obtain high-precision depth maps, capturing the true size and shape information of ore particles in three-dimensional space, thus overcoming the limitations of traditional two-dimensional image processing in particle size analysis. Based on the original DETR model, we utilized the Deformable DETR network, which has higher recognition capability for irregular shapes and small particle size objects, to conduct detection and size selection of rockfall block bodies. In order to perform more accurate segmentation and proportion analysis of block bodies and fine particles, the Attn Mask R-CNN model used in this study improves upon the original Mask R-CNN model by incorporating channel attention modules and spatial attention modules into the Backbone and FPN positions, according to which the model's segmentation accuracy for rock and mineral block bodies was enhanced. Finally, a gradient-weighted activation mapping method based on non-circular contour detection is proposed, integrating a Hough transform module into Grad-CAM to enhance the network's attention towards non-circular contour objects in the image, thereby achieving the localization and identification of non-rock and mineral block objects such as vegetation roots and iron objects underground, implying that the mining operation is nearing the surface.

Keyword

Intelligent Identification, Machine Learning, Attn Mask R-CNN, Binocular depth perception,

Hough transform

AusGeochem: Unveiling Earth through 4D Geochemistry

Halimulati ANANUER[1]*, Macquarie University (halimulati.ananuer@mq.edu.au)
Yoann Greau[2], Macquarie University
Olivier Alard[3], Australian National University
Suzanne Y. O'Reilly[4], Macquarie University
sally ann.hodgekiss[5], Macquarie University
Bryant Ware[6], Curtin University
Samuel Boone[7], University of Melbourne
Hayden Dalton[8], University of Melbourne
Brent McInnes[9], Curtin University
Fabian Kohlmann[10], Lithodat Pty Ltd
Moritz Theile[11], Lithodat Pty Ltd
Wayne Noble[12], Lithodat Pty Ltd
Andrew Gleadow[13], University of Melbourne
Barry Kohn[14], University of Melbourne
Angus Nixon[15], University of Adelaide
Renjie Zhou[16], University of Queensland
Malcolm McMillan[17], University of Melbourne

Abstract

Decades of geochemical research have accumulated sufficient data to map nearly every corner of the Earth. However, despite this wealth, the quantitative understanding of the Earth system as a whole entity is far from being achieved. Furthermore, the great advancements in geochemical instrumentation have exponentially increased the community's capacity to produce data, resulting in vast amounts of geochemical data that is commonly inaccessible to the public either due to being unpublished or published behind paywalls. To unlock the full potential of such large amounts of data, novel tools are needed to connect the various and numerous datasets at a global scale and through geological times. In response to these pressing needs, the AuScope Geochemistry Network (AGN) and collaborator Lithodat have built the AusGeochem data platform.

Funded under the National Collaborative Research Infrastructure Strategy (NCRIS), AusGeochem is an open-access, cloud-based geospatial data platform designed for archival, dissemination, and interrogation of global Earth Science samples and their associated data, adhering to FAIR (Findable, Accessible, Interoperable, and Reusable) data principles. The platform not only integrates publicly available legacy data, but also enables the seamless upload of geochemical data directly from laboratories, granting users full authorship and control over their data management, including the ability to obtain DOIs for their datasets. This allows the capture of the data at the source and therefore promoting public dissemination. Doing so, it also enables the users to integrate their own datasets and analyse them together within a rich framework of ever-growing public data.

The platform supports bulk upload of various types of state-of-the-art analytical datasets through specialized, bespoke data models, including sample metadata, major and trace elements, fission

tracks, (U-Th)/He, U-Pb, Lu-Hf, and 40Ar/39Ar, with more models currently in development. Each data model serves as relational schemas, unlocking the potential for seamless integration of diverse data types and numerical geoscience techniques in the future. The platform also provides users with powerful on-the-fly data synthesis and visualization tools, including TAS diagrams, spidergrams, bivariate and ternary diagrams, U-Pb plots, and direct exports to IsoplotR. Combining samples with various map layers and contextual paleogeographic reconstructions provides users with a broader perspective to analyze their data in a 4D framework.

Despite being young, AusGeochem has already demonstrated its efficacy within the community. Collaboration with Museum Victoria has provided direct access to centuries-old national collections (> 140,000 geological specimens, 60% currently in the platform); the AusGeochem platform tools helped identify potential mineral deposits using the large CSIRO legacy dataset from magmatic Ni mineralisation associated with mafic-ultramafic rocks from Precambrian Western Australia; recent Nature Scientific Reports published in 2023 have showcased the platform's capabilities in revealing the tectono-thermal evolution of various regions through the innovative tools and dynamic interrogation techniques of the AusGeochem platform.

In conclusion, the AusGeochem platform holds immense potential for advancing numerical geoscience techniques, promoting data interoperability, and driving further research and discovery in the field of geochemistry.

Keyword

AusGeochem, Geochemistry Data, FAIR, AGN, Data platform

Decoding Informative Factors for Large Earthquake Occurrence Recognition from the Earthquake Catalogs with Explainable Machine Learning

Jinsu JANG[1]*, Kangwon National University (jinsujang@kangwon.ac.kr)
Byung-Dal So[2], Department of Geophysics, Kangwon National University, Chuncheon, Gangwon-do 24341, Republic of Korea.
Sung-JoonChang Chang[3], Department of Geophysics, Kangwon National University, Chuncheon, Gangwon-do 24341, Republic of Korea.
Yuen David[4], Department of Applied Physics and Applied Mathematics, Columbia University, New York, NY 10027, USA

Abstract

The spatiotemporal distribution and magnitude of earthquakes, which are important for seismic behavior analysis and hazard assessment, have been documented over a long period of time. Consensus on crucial factors hidden in primary earthquake information such as epicentral distance between earthquakes, time to subsequent events, and magnitude in the earthquake catalog remains elusive. Machine learning (ML) has recently been proposed to gain new insights from huge seismic data. In this study, we explain the ML training and testing process for classifying Large Earthquake Occurring (LEO) or non-LEO cases from spatiotemporally clustered earthquakes to quantify the relative importance of primary earthquake information (e.g., time, longitude, latitude, depth, and magnitude). Our explainable ML models show an AUC > 0.75 when the number of earthquakes in the window is 50. As the classification performance increases, the maximum magnitude of the earthquakes in the window becomes more influential in the ML classification processes. The maximum magnitude is the key factor that increases the classification ability, especially when the five most important statistical features are jointly trained. The ML explanation implies that the seismic moment release, which determines the magnitude of the earthquakes, is an informative factor for the occurrence of large earthquakes with an ML perspective. Our explainable ML provides a new approach to derive implications of earthquake physics from the condensed seismic data.

Keyword

machine learning, earthquake catalog, explainable machine learning, feature extraction, feature importance

Explainable machine learning to uncover hydrogen diffusion mechanism in clinopyroxene

Anzhou LI[1]*, School of Earth Sciences, Zhejiang University (anzhouli@zju.edu.cn)
Sensen Wu[2], School of Earth Sciences, Zhejiang University
Huan Chen[3], College of Oceanography, Hohai University
Zhenhong Du[4], School of Earth Sciences, Zhejiang University
Qunke Xia[5], School of Earth Sciences, Zhejiang University

Abstract

Estimating the water content of mantle-derived magma using clinopyroxene (cpx) phenocrysts serves as a valuable constraint on the water budget in deep Earth. Intricate magma processes and the high hydrogen diffusion rate necessitate careful evaluations of whether the water content in cpx preserves its original state. Machine learning (ML) has been utilized to develop a classifier for judging hydrogen diffusion in cpx. Nevertheless, the opaqueness and complexity of most ML models hinder a clear understanding of their classification principles. To elucidate the mechanistic basis of the ML model, the Shapley theory is integrated to determine the contributions of major elements of cpx as features in a linear additive manner. This study achieves superior classification performance using an extreme gradient boosting model and innovatively presents a quantitative evaluation of feature importance at the sample level for each observation. The results indicate that Na plays a predominant role in the diffusion process surpassing other major elements and its associated hydrogen can easily diffuse out of cpx. Our model also identifies various hydrogen association modes in different elemental compositions and puts constraints on the properties of incorporated hydrogen with non-lattice forming elements in cpx. The findings demonstrate that the application of explainable ML methods in mineralogy holds significant potential for advancing the comprehension of geological phenomena.

Keyword

Water in deep Earth, Explainable machine learning, Clinopyroxene, Hydrogen diffusion

Time-limited lithogeochemistry of marine and terrestrial alternation on the Tibetan Plateau

Xinwei Liu[1]*, Sun Yat-sen University (liuxw69@mail2.sysu.edu.cn)
Qiuming Cheng[2], China University of Geosciences/Sun Yat-sen University

Abstract

Due to the complex formation process of the Tibetan Plateau, there is still considerable divergence in our understanding of its formation history. Traditionally, researchers have primarily studied the uplift of the Tibetan Plateau from the perspectives of paleo-elevation, paleo-fossils, and tectonics. However, since the introduction of the tectonic environment discrimination map by scholars in the 1970s, whole-rock geochemistry of basalt has emerged as a crucial tool for exploring the background of magma formation and geodynamic processes. Nevertheless, research on the uplift history of the Tibetan Plateau from the perspective of tectonic environment transformation remains limited. Therefore, this paper employs a machine learning approach to elucidate the temporal and spatial evolution of the plateau's uplift by analyzing the transition of basalt's tectonic environment.

In this study, we collected and analyzed over 6000 basalt data points from known marine and terrestrial environments, as well as nearly 800 basalt data points from unknown tectonic environments on the Tibetan Plateau, utilizing the Global Geochemical Database. To distinguish between global marine and terrestrial environments, we employed a combination of machine learning algorithms, including random forest, support vector machine, k-nearest neighbor, and convolutional neural network algorithms. The results of our model were highly successful, demonstrating excellent performance in both the training and test datasets, with an accuracy rate exceeding 90%. Building upon these findings, we applied the model to the data from the Tibetan Plateau. Our analysis revealed that since 500 Ma, the Tibetan Plateau region experienced terrestrial phases at 38-62.5 Ma and 83-224.7 Ma, while the remaining periods were characterized by marine phases. Furthermore, we conducted an in-depth examination of the spatial-temporal changes of the marine and terrestrial phases across the Tibetan Plateau, taking into account their age-dependent variations. Through this analysis, we were able to validate the uplift history of the Tibetan Plateau from the perspective of tectonic environment transformation. These findings provide important insights into the evolution and uplift of the Tibetan Plateau. By combining advanced machine learning techniques with geochemical data, we have achieved a deeper understanding of the complex geological processes that have shaped this remarkable region.

Through this study, we have gained a clearer understanding of the formation history of the Tibetan Plateau while providing compelling evidence and fresh perspectives regarding its uplift history. By leveraging machine learning methods, we have enhanced our ability to explore the intricacies surrounding the plateau's formation, contributing to ongoing research in this field.

Keyword

Tibetan Plateau, Tectonic environment, Machine learning

Calculation of crustal thickness and characterization of its spatial distribution in the South American Andes magmatic arcs

Kunyi WANG[1]*, Sun Yat-sen University (wangky28@mail2.sysu.edu.cn)
Qiuming CHENG[2], China University of Geosciences/Sun Yat-sen University

Abstract

The formation and evolution of continental crust is one of the main tasks of geological research, and crustal thickness, as an important parameter of continental crust research, has received extensive attention from many researchers. In addition to measuring crustal thickness using geophysical methods, some researchers have found, through globally compiled geochemical data, that the contents or ratios of certain geochemical elements are closely related to crustal thickness, providing a non-geophysical way of calculating crustal thickness. The question that arises is whether the correlation between these geochemical proxies and crustal thickness validated at the global scale can help in estimating crustal thickness at regional or even smaller scales?

In this study, we collected 30847 global whole-rock geochemical data related to magmatic arcs through the GROROC database (http://georoc.mpch-mainz.gwdg.de/georoc/). Interference from other lithologies and compositions was excluded by previous researchers' data screening methods, resulting in 6,288 samples containing five major and six trace element signatures. Modeling of crustal thickness calculations using a random forest regression model for whole-rock geochemical data showed that the model achieved excellent results on both the training and test sets, with goodness-of-fit greater than 0.95 and no overfitting.

In order to validate the effectiveness of the Random Forest regression model for calculating crustal thickness on a regional scale, the Andean volcanic zones in South America was selected as the study area for testing, and 2,733 samples were collected from a global database (GEOROC) to assess how crustal thickness variations can be captured by the Random Forest model. At the same time, we compare the results of two commonly used geochemical proxies (i.e., Sr/Y, La/Yb(n)) for calculating crustal thickness. The results of the application in the Southern Andean Volcanic Zone (SVZ) show that the range of results from the Random Forest model is more concentrated and the curves tend to be smoother and closer to the results from the geophysical models. In contrast, the crustal thicknesses calculated at regional scales for La/Yb(n) and Sr/Y have a wider range and the curves tend to fluctuate.

In this study, a model for calculating crustal thickness based on geochemical data constructed using a machine learning approach can effectively solve the problem of accuracy for application at the regional scale, avoiding the problem of discrepant estimates when estimating crustal thickness with a single geochemical indicator used previously.

Keyword

Crustal thickness, Machine learning, Andean Southern Volcanic Zone

A data-driven approach for adaptive utilization of geothermal energy worldwide by examining top 100 geothermal cities

Wang XU[1]*, Tianfu Yongxing Laboratory (xuwang19@cdut.edu.cn)
Xiao Li[2], Tianfu Yongxing Laboratory
Yuqing You[3], Tianfu Yongxing Laboratory
Ekekeh Destina Godwin[4], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technolog
Liangjie Zhao[5], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technolog
Di Deng[6], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technolog
Xiaohang Liu[7], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technolog
Xiaoguang Wang[8], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technolog

Abstract

The exploration and development model centered on surface geothermal manifestations can no longer meet the growing demand for geothermal energy. In order to promote the large-scale and commercialization of global geothermal exploitation, it is essential to conduct a comprehensive assessment of the viability, suitability and economy of geothermal exploitation in a certain region, utilizing multi-source data and information. In this study, a global geothermal database for 100 geothermal cities with geothermal industry/utilization was established by artificial and large language model (Geo-GPT) extraction. This database contains administrative information, geographical data, geothermal geological data and geothermal exploitation data etc.. By visualizing geothermal data on global maps with different properties, we were able to identify patterns in geothermal exploitation and extract key factors that drive the evolution of geothermal development suitability. On account of the key dominant factors, a prediction model for geothermal resource potential was developed using a combination of data analysis techniques and a hybrid approach that incorporates both physical and data-driven methods. This model allows for the evaluation of the suitability of geothermal exploitation in specific cities within regions with high geothermal resource potential. Additionally, an analysis of technical and economic sensitivity was conducted to inform effective decision-making for economic and scalable geothermal resources development. Overall, we have integrated database, cloud computing, and artificial intelligence technologies to construct a global geothermal database and an analysis platform. These resources provide robust support for promoting large-scale commercial development and utilization of geothermal energy. The proposed methods and models aim to enhance the utilization rate of geothermal resources, reduce development costs, mitigate risks, and provide new avenues for the sustainable development of geothermal energy globally.

Keyword

Geothermal energy, Large Language Model, Geothermal database, Data visualization, Prediction model

Quantitative analysis of fluid inclusions characteristics based on data drive

Xia QINGLIN[1]*, China University of Geosciences (Wuhan) (qlxia@cug.edu.cn)
Liu Qifeng[2], China University of Geosciences (Wuhan)
Jing Guozheng[3], No.3 Exploration Institute of Geology Resources of Qinghai Province
Hua Qi[4], China University of Geosciences (Wuhan)
Gao Yan[5], China University of Geosciences (Wuhan)

Abstract

Fluid inclusion studies provide a wealth of information about ore-forming fluids, such as temperature, salinity, density, pressure, and composition, for an in-depth understanding of the metallogenic process and the genetic mechanism of ore deposits. However, in the past, fluid inclusion studies were mainly carried out on a few typical deposits, and the amount of data was relatively small, which was not conducive to reflecting the overall characteristics of ore-forming fluids in the whole metallogenic belt. Moreover, fluid inclusion data are multi-source, different structures, complex, and computationally difficult, and it is difficult to analyze it comprehensively and effectively by using traditional linear statistical methods. Therefore, authors adopt a data-driven approach, taking the quartz vein-type tungsten deposit in the Nanling metallogenic belt as a case study, and uses machine learning to further identify the deep information contained in fluid inclusion data from 11 large and medium-sized tungsten deposits. Studies have shown that: (a) Firstly, the data are normalized, and the Wasserstein Distance (WD) is calculated, and it is found that the WD distance of the ore-forming fluid is closer to that of the deposits in the same ore cluster, indicating that they have similar metallogenic environments. In addition, the WD distance of ore-forming fluids of the same type of deposit is also similar, indicating that their mineralization is similar. (b) The obtained data of fluid inclusion freezing point temperature, uniform temperature, density, salinity, gas-liquid ratio, perimeter, area, bubble area and other data were used to carry out K-means clustering. After the normalization of each parameter and then the dimensionality reduction by the t-SNE algorithm, it was found that there was obvious clustering after t-SNE and normalization treatment, and the addition of fluid inclusions morphological data was more conducive to distinguishing fluid inclusions with different properties. Three distinct clusters were obtained by unsupervised clustering: the cluster-A has a higher uniform temperature and lower salinity and density, the cluster-B has a lower uniform temperature and salinity and a higher density, and the cluster-C has a lower homogeneous temperature and higher salinity and density. (c) A dataset of 196 fluid inclusions in the wolframite-quartz stage, 219 fluid inclusions in the quartz-sulfide stage and 90 fluid inclusions in the carbonate-fluorite stage were selected to construct a dataset, and the influence of the unbalanced dataset was eliminated by the SMOTE oversampling method, and 2, 2 and 1 sample data were randomly selected from the inclusions of the three metallogenic stages each time to form a blind test set with freezing point temperature, uniform temperature, density, salinity, gas-liquid ratio, perimeter, area and bubble area as feature inputs. The random forest model was used to intelligently classify the fluid inclusions in each metallogenic stage, and good results were obtained, and the accuracy of the blind test set was

greater than 90%. In conclusion, data-driven methods applied to fluid inclusion studies can obtain more mineralization information than conventional methods.

Keyword

fluid inclusion, mineralization information, data drive

Machine Learning and Magma Fertility Determination: Revealing Spatio-temporal Variation of the Favorability of Porphyry Copper Formation

Yuanzhi ZHOU[1]*, China University of Geosciences, Beijing (yuanzhi@email.cugb.edu.cn)
Zhenjie ZHANG[2], China University of Geosciences, Beijing
Jie YANG[3], China University of Geosciences, Beijing
Peng ZHANG[4], China University of Geosciences, Beijing
Qiuming CHENG[5], Sun Yat-Sen University

Abstract

The magmas associated with porphyry copper deposits (PCDs) often exhibit unique chemical properties, referred to as magma fertility, which can serve as an indicator for the potential for porphyry copper mineralization. However, previous research has predominantly focused on subduction-related PCDs, lacking an understanding of the ore-forming magmas and their formation mechanisms in the post-collision setting. Here, we compiled the whole-rock geochemical composition of ore-bearing and ore-barren igneous rocks from both subduction and collision orogenic belts. We utilized two machine learning (ML) models, Support Vector Machines (SVM) and Random Forest (RF), to classify the metallogenic fertility (fertile vs. unfertile) of magmas. Both models achieved higher classification accuracy (~85-89%) than the bivariate discrimination plots, demonstrating the feasibility and effectiveness of using ML methods to distinguish fertile from unfertile magmas. The feature importance analysis of the RF classifier identified that the most significant parameters of fertile magma are low MnO, low Ho, low Y, and high SiO2. These characteristics further highlight the potential common role of hornblende and garnet fractionation in the deep crust in the formation processes of both subduction- and collision-related PCDs. As a case study, we applied our trained ML models to predict the metallogenic fertility of Mesozoic and Cenozoic magmas in the eastern Gangdese belt in southern Tibet. The results suggest that the magmas in the post-collision stage, especially the Miocene magmas, are notably more fertile than those of the subduction stage. The spatial mapping results of the predicted metallogenic fertility of the Miocene magmas reveal that the most fertile magmas during this period are primarily distributed between 90-92° E, which coincides with the least evolved magmas based on the Hf-Nd isotope mapping. This implies that the upwelling of depleted mantle materials caused by slab tearing has a direct impact on magma fertility. Therefore, this area represents a key prospecting direction in the eastern Gangdese belt. Our ML models may help reveal spatio-temporal variation in the favorability of porphyry copper formation.

Keyword

Machine learning, Magma fertility, Porphyry copper deposits, Spatio-temporal analysis

The formation and evolutionary process of the North China Craton during early Precambrian: Implications from big data analysis

Zhenjie ZHANG[1]*, China University of Geosciences, Beijing (zjzhang@cugb.edu.cn)

Abstract

The North China Craton (NCC) is a venerable landmass with a multifaceted tectonic history spanning approximately 3.8 Ga. The majority (around 90%) of the NCC's continental crust was generated during the Archean period, rendering it a significant field of investigation for comprehending the formation of Earth's early crust and its subsequent tectonic evolution. Nevertheless, controversies persist regarding the genesis and progression of the NCC, with plate tectonics and mantle plumes posited as potential mechanisms governing its crustal evolution. In this study, we have meticulously compiled and analyzed published rock and mineral geochemistry data to unravel the intricate processes underlying the formation and evolution of the NCC. Leveraging the power of big data and machine learning techniques, we have successfully discerned novel patterns, structures, and relationships within these scientific datasets that may have eluded traditional geological approaches. Our findings unequivocally indicate that the North China Craton underwent a protracted phase of intra-oceanic arc aggregation and arc-continent collision, primarily manifesting in the eastern blocks from approximately 3.5 Ga (or possibly even earlier) to 1.5 Ga. Subsequently, after 1.5 Ga, the NCC as a cohesive entity actively participated in the grand global cycle of supercontinent amalgamation and dispersal. These findings extensively contribute to our understanding of the long and complex geological journey undertaken by the North China Craton.

Keyword

North China Craton, big data, machine learning

Application of remote sensing to identify Copper–Lead–Zinc deposits in the Heiqia Area of the West Kunlun Mountains, China

yuhai FAN[1]*, Geological Exploration Institute of Aerial Photogrammetry and Remote Sensing Bureau (170269854@qq.com)

Abstract

The harsh natural environment and inaccessibility of the West Kunlun Mountains are barriers for their investigation via field geology. Remote sensing technology has the advantage of being efficient on a macroscale and not being restricted by terrain or road conditions in sparsely vegetated areas with exposed bedrock. This work focuses on copper–lead–zinc deposits in the Heiqia Area in the West Kunlun Mountains as a case study to illustrate the application of IKONOS remote sensing images as major data sources to fabricate a standard image map, the extraction of information on ore-controlling factors and mineralization through the use of image enhancement methods, and the interpretation of remote sensing data to identify mineral resources. Alteration anomaly information was extracted from ASTER data, verified via field survey and sampling, and used to develop a remote sensing model for utilization in future prospecting efforts. The results of the survey showed that in IKONOS (band 3, 2, and 1 synthesis) images, the copper mineralization zone exhibits interlaced gray-white, blue-gray, and blue tones in a narrow strip-like pattern, while the lead–zinc mineralization zone shows gray-white, light gray-yellow, and yellowish-brown tones in a strip-like pattern. The main remotely sensed alteration anomalies are characteristic of hydroxyl. Six hydroxyl anomalies were delineated in the study area, of which five were found to be copper–lead–zinc deposits. The location of the ore bodies coincides well with the ASTER anomalies extracted. Two Cu – Pb – Zn mineralization belts are present in the study area. The ore-bearing rock series of belt No. Ⅰ is phyllite interbedded with metasandstone, and the ore comprises mainly copper deposits supplemented by lead–zinc deposits. Belt No. Ⅱ is in limestone and consists mainly of lead–zinc deposits supplemented by copper deposits. A remote sensing geological prospecting model for structurally altered Wenquangou Group copper – lead – zinc deposits with a genesis related to hot water basins is established. This provides a basis for future prospecting for similar minerals in the West Kunlun metallogenic belt.

Keyword

High-resolution remote sensing interpretation, ASTER alteration anomaly, field verification, Cu–Pb–Zn deposit, West Kunlun

Machine learning models for investigating the primary water content of pyroxene in mantle-derived magmas

Huan CHEN[1]*, Hohai University (huanchen@hhu.edu.cn)
An-Zhou LI[2], Zhejiang University
Sen-Sen WU[3], Zhejiang University
Cheng SU[4], Zhejiang University
J ZHANGZHOU[5], Zhejiang University
Zhen-Hong DU[6], Zhejiang University
Qun-Ke XIA[7], Zhejiang University

Abstract

Using clinopyroxene (cpx) phenocrysts to estimate the H2O content of basaltic magmas presents a promising avenue for investigating the deep Earth water cycle. However, due to the diverse substitution mechanisms of hydrogen (H) in cpx and the intricate evolution of most magmas, traditional geochemical methods struggle to ascertain whether the measured H in cpx phenocrysts reflects a primary signature indicative of mantle water content.

Support Vector Machine (SVM), a robust and well-established machine learning technique, offers an effective approach for classifying samples into distinct groups based on high-dimensional datasets. By simultaneously considering the complex relationships between H and major elemental compositions in cpx, SVM can discern samples that have undergone H diffusion from those that have not. In this study, we applied machine learning to major element compositions and H2O content of cpx phenocrysts collected from various global locations, and developed a classifier (with an overall accuracy exceeding 90%) capable of distinguishing between pyroxenes affected by H diffusion and those unaffected. Nevertheless, the inherent complexity of machine learning models often obscures a clear understanding of their classification principles. Additionally, we achieved superior classification performance using an extreme gradient boosting model and introduced a novel quantitative evaluation of feature importance at the sample level for each observation. The findings identified various modes of hydrogen association in different elemental compositions, shedding light on the properties of incorporated hydrogen with non-lattice forming elements in cpx.

The trained model holds significant implications for understanding the primary water content of magma and the fluctuations in water content during magma evolution, thereby offering insights into the deep Earth water cycle mediated by basaltic magma. These findings also underscore the potential of employing explainable machine learning methods in mineralogy to advance our understanding of geological phenomena.

Keyword

mantle water content, clinopyroxene, machine learning

Development of clustering model for XRD experimental data from the Ulleung Basin, Korea

Ju Young PARK[1]*, Kongju National University (leahlove6786@gmail.com)
Hongkeun JIN[2], Kongju National University
Sun Young PARK[3], Petroleum Energy Research Center, Korea Institute of Geoscience and Mineral Resources
Byeong-Kook SON[4], Petroleum Energy Research Center, Korea Institute of Geoscience and Mineral Resources
Sungil KIM[5], Petroleum Energy Research Center, Korea Institute of Geoscience and Mineral Resources
Kyungbook LEE[6], Kongju National University

Abstract

X-ray diffraction (XRD) is widely used for reservoir characterization, estimating hydraulic fracturing efficiency and understanding depositional environments. However, mineral composition analysis from XRD depends on the analyst's subjectivity and is time-consuming due to manual matching process of intensity profile. Recently, researchers have developed machine learning models to analyze mineral compositions using XRD data as input data. In the previous researches, the error between mineral compositions analyzed by experts and estimated by machine learning is below 1%. However, the machine learning models showed unreliable performance for few samples, which have outlier mineral composition. It is difficult for the machine learning models to learn peak tendencies of few samples due to the different intensity patterns compared to common samples, which have similar mineral composition. For the few samples, it is reasonable to be analyzed by experts instead of machine learning. The purpose of this research is to classify the few samples among whole samples to be analyzed by expert using k-means clustering. Because the unsupervised model requires only XRD intensity profile, each sample can be categorized into 'expert group' and 'machine learning group' before mineral composition analysis in detail.

The XRD experimental data provided by the Korea Institute of Geoscience and Mineral Resources consisted of 3,100 intensity with an incidence angle ranging from 3.01 to 64.99 degrees with an interval of 0.02 degrees. Among the total 488 samples, 439 samples were used as train data and the remaining 49 samples were utilized as test data. Because k-means clustering provides different clustering results depending on the number of clusters, sensitivity analysis was implemented to select the optimal number of clusters. The number of clusters was selected between 3 to 7 and the optimal number of clusters was determined with the minimum number of false positives (FP) in the confusion matrix. FP means that although samples are classified as machine learning group, they actually have an outlier mineral composition. This is because a smaller FP can increase the precision of the clustering model. After sensitivity analysis for the number of clusters, the optimal number of clusters was selected to be 5 because FP was 0, which shows high precision. Although FP was 1 when the number of cluster is equal to 4, 6, and 7, false negatives (FN) of them is larger, 16, 31, and, 15, respectively, than the 5-cluster case, 3 FNs. FN means that although samples are

classified as expert group, they have an usual composition. This means that a lot of samples are assigned to the expert group, even though they can be analyzed by the machine learning. Therefore, high FN diminishes the efficiency of machine learning-based analysis workflow. The developed clustering model can be used to improve the efficiency of composition analysis, and the outlier samples can be analyzed reliably by expert. Also, these model can be coupled with the previously developed composition analysis model, to create a analyzing system for mineral composition.

Acknowledgement
This study was supported by MOTIE (No. GP2021-010; 2021060001) and MSIT (No. 2021R1C1C1004460).

Keyword

K-means clustering, X-ray diffraction, confusion matrix, Ulleung Basin, Machine learning

A Method of Geological Mapping Based on Deep Learning

Fengdan LI[1]*, Natural Resources Survey of China Geological Survey(CGS)
(13810107437@139.com)
Chang Liu[2], Natural Resources Survey of China Geological Survey(CGS)
Shuang Liu[3], Natural Resources Survey of China Geological Survey(CGS)
Yuanyuan Liu[4], Natural Resources Survey of China Geological Survey(CGS)

Abstract

High-precision identification of mapping objects is an important requirement of geological mapping work. The DGSS team proposed a geological mapping method based on deep learning, which can assist the mapping groups to narrow the working scope of finding key geological bodies and improve the identification accuracy.

1.Main idea

Mapping units and lithologies are the most basic objects of geological maps. The core of the method is to apply deep learning technology and mapping knowledge bases from the geologists' methods, experiences and knowledge to discover the correlation of geological characteristics between multi-specialty(geological, geophysical, geochemical, remote sensing), multi-modal (vector , raster , spatial and unstructed data), multi-scale and mapping units and lithologies, and to predict spatial position and direction, distribution position, and adjacent relationship of them.

2.Progress in key technologies

(1)A series of algorithmic models are proposed to meet the prediction of different geological objects (tectonic, lithologic, and lithologic combinations) to provide modeling capability for pre-study, field survey, and thematic research.A series of model evaluation indicators are summarized from the application perspective.The accuracy of the models exceeds 95%, the recognition accuracy of mapping objects exceeds 90%, and the overall architecture of the geological prediction maps is basically consistent with the geological measured maps.

(2)A set of AI application process synchronized with mapping work are formed to efficiently support sample data collection, processing, organization and modeling.Some software tools have been developed,including organization of various samples,management of process tasks , expression of prediction results, etc.

3.Test analysis

Since 2019, the DGSS team and mapping groups have carried out experiments in more than ten 1:50000 mapping projects.The result is remarkable:

(1)AI has strong ability and level of prediction of geological map in blank area.It also can accurately reflect the geological frame and spatial distribution pattern of the survey area.

(2)It has the ability to expose geological bodies in shallow coverage areas.The predicted geological mapping units can be verified by field survey at new outcrops.

(3)The spatial expression of the prediction results is conducive to the discovery of new problems and information, and has a strong significance for deepening the understanding and analysis of geological problems in the field work.

Keyword

geological mapping, deep learning, mapping object identification, geological prediction map

Data-driven Automated Detection and Characterization of Dinosaur Footprints

Yeoncheol HA[1]*, Department of Astronomy, Space Science, and Geology, Chungnam National University (duscjf1002@o.cnu.ac.kr)
Seung-Sep Kim[2], Department of Geological Sciences, Chungnam National University

Abstract

Dinosaur tracks provide important paleontological information for understanding various aspects of dinosaur biology, including body size, stride length, and speed. However, manual identification and marking of fossilized footprints at track sites are prone to errors due to factors such as poor preservation and atypical shapes. Convolutional Neural Network (CNN)-based models such as VGG16 and Xception have been employed for data-driven classification of fossil images or footprint outlines. However, challenges persist in detecting footprints from multi-resolution images, such as those obtained from handheld and drone cameras. In this study, we introduce a novel approach utilizing the YOLOv8 deep learning algorithm to automatically detect and classify dinosaur footprints. YOLOv8 offers comprehensive capabilities, including detection, segmentation, pose estimation, tracking, and classification in images containing multiple features using bounding boxes. Leveraging transfer learning on pretrained models trained on the Common Objects in Context (COCO) dataset enhances model performance. Our research utilizes the Korea dinosaur footprint image dataset from AI-Hub, in conjunction with independently collected dinosaur footprint data. The training dataset comprises 112,958 images for training and 14,104 images for validation. Computation was performed on the GPU-based supercomputer Neuron, which was provided by the Korea Institute of Science and Technology Information (KISTI). Based on distinctive morphological features, training commenced with labels categorizing footprints into pseudo-footprints (terrain changes, not actual dinosaur tracks), Theropod (footprints typically characterized by three sharp toe mark and longer than wider), Ornithopod (footprints characterized by three toes with blunt claws, with length similar to width), and Sauropod (footprints characterized by five toes, typically oval or circular in shape). The trained YOLOv8 model will automatically detect and classify dinosaur track photographs, including diminutive tracks not included in the training dataset. By overcoming challenges associated with manual identification and classification processes, such as misidentifications and oversights, our deep learning approach offers a more efficient and accurate means of analyzing extensive dinosaur track datasets. Additionally, the adoption of deep learning algorithms in paleontology not only streamlines data analysis but also opens avenues for new discoveries and insights into dinosaur behavior, evolution, and paleoecology on a broader scientific scale.

Keyword

Convolutional neural network, Dinosaur footprint, Deep learning, YOLOv8

Deep Learning 3D Mineral Segmentation with micro-CT and micro-XRF

Yiming WANG[1]*, China University of Geosciences(Beijing) (3001220110@email.cugb.edu.cn)
Jie YANG[2], China University of Geosciences, Beijing

Abstract

The three-dimensional (3D) textures and compositions of minerals play a crucial role in inferring the physiochemical conditions within magmatic systems. Accurate characterization of the 3D characteristics of individual mineral crystals within a sample is of utmost importance. The accelerated progress in X-ray micro-computed tomography (micro-CT) has significantly expanded its application in 3D analysis of many rock types. In addition, micro-X-ray fluorescence (micro-XRF) enables non-destructive analysis to acquire element distribution on the sample surface, serving as a basis for mineral identification. Therefore, the primary objective of this research is to synergistically employ micro-CT and micro-XRF data, along with deep learning algorithms, to accomplish the 3D segmentation of mineral constituents within granite samples. Initially, we design an image registration workflow for multimodal data using 2/3D data from micro-XRF and micro-CT, respectively, to accurately locate the sample cross-section within the 3D data. This facilitates the acquisition of pixel-level sample label information necessary for training the model. Subsequently, based on the U-net network architecture design model, we achieve effective segmentation of multiple minerals data, even when faced with imbalanced conditions. This segmentation approach is then extended to encompass the entire CT dataset, enabling the three-dimensional representation of multiple minerals. The developed workflow enables the segmentation of crystals, facilitating the extraction of 3D features of primary and minor minerals present within the sample. Furthermore, the workflow effectively addresses the challenge of distinguishing non-metallic minerals that exhibit similar densities in micro-CT. This capability opens up opportunities for applying the model to other instruments and techniques, allowing for broader applicability in the field of mineral analysis.

Keyword

Deep learning segmentation, Image registration, Computed tomography, X-ray fluorescence

Multi-scale full waveform inversion based on a convolutional neural network

Hong LIU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences
(liuhong@mail.iggcas.ac.cn)
Wenda LI[2], Institute of Geology and Geophysics, Chinese Academy of Sciences
Lifeng WANG[3], Hainan Branch of CNOOC (China) Limited
Wenlei BAI[4], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

As a most advanced seismic inversion technique, full waveform inversion (FWI) aims to generate high-resolution models of subsurface media by iteratively fitting the observed waveform, which enables us to extract more information from seismic data and create highly detailed velocity models. Due to the influence of the shallow tomographic component (mainly direct and diving waves), the FWI mainly updates the velocity information in the shallow layers, but hardly in the deep layers. RWI (Hu, 1987; F. Wang et al., 2013; Yao et al., 2018, 2020), developed on this basis, can update the background velocity information of the deep subsurface media, but it is still difficult to update the complex structural features of the deeper layers. This is a bottleneck in waveform inversion, which is the difficulty of updating deep velocity features. The development of waveform inversion is also limited by the huge computational effort involved.

Targeting the problems of traditional waveform inversion, researchers in recent years have combined deep learning algorithms with traditional inversion to come up with a number of creative ideas. First, the most widely explored method is to extract the hidden relationship between seismic data and velocity model by an intelligence network, such as mapping observed data (Yang & Ma, 2019; W. Wang & Ma, 2020; B. Liu et al., 2021) or migration imaging (Zhang & Gao, 2021; Y. Wu et al., 2021, 2022) to accuracy velocity model. The second is the use of AI methods as an aid to inversion and is part of the inversion process. Although all of the above methods have produced good results, there are still some problems, such as the lack of generalisability of some of them. Bunks et al. (1995) first proposed a multi-scale inversion strategy from low to high frequencies. Multi-scale FWI, in the process of inversion from low to high frequencies, can weaken the uncertainty introduced by high-frequency components and reduce data redundancy. The multi-scale FWI process, which is more consistent with the laws of physics, first inverts the background velocity through low-frequency information and then gradually reconstructs the fine structure through high-frequency information. The neural network inversion process is similar to FWI in that it also solves the inverse problem with strong nonlinearity. The same multi-scale algorithm can also be combined with AI inversion to make the inversion process more in line with the laws of physics, thus enhancing the inversion effect.

In this abstract, we proposed a multi-scale convolutional neural network (CNN) FWI (Ms-CNNFWI) method, which incorporated a multi-scale strategy into the CNN-based FWI algorithm. CNN-based FWI combined the initial velocity model with the corresponding migration image to estimate the subsurface unknown velocity model iteratively. We test the proposed Ms-CNNFWI

on some different models and demonstrate its effectiveness in reconstructing the velocity model in different subsurface media. Compared to conventional FWI methods, our approach can better invert the velocity structure of the deep layers. Furthermore, compared to other AI inversion methods, our approach exhibits strong generalization performance.

Keyword

Convolutional neural network, Full waveform inversion, Multi-scale

Improvement of YOLO Model for Borehole Breakout Detection Using Data Augmentation

Juyeol YEOM[1]*, Kongju National University (jy0506kr@gmail.com)
Hayoung Kim[2], Kongju National University
Chandong Chang[3], Chungnam National University
Yeonguk Jo[4], Korea Institute of Geoscience and Mineral Resources
Jonggeun Choe[5], Seoul National University
Kyungbook Lee[6], Kongju National University

Abstract

Borehole breakout (BO), caused by stress concentrations in wellbore, provides information for orientation and magnitude of in-situ stress. The stress is crucial for evaluating the stability of subsurface utilization including carbon sequestration. In general, BO is identified by experts manually based on image logs that causes time-consuming and subjectivity issues. Recently, machine learning has been applied to various studies to improve the limitations of the manual stress estimation. However, previous studies encountered difficulties in enhancing BO detection performance in terms of reliability and detection speed. In this study, we develop a real-time automatic BO detection model for image logs using you only look once (YOLO) algorithm with domain-knowledge based data augmentation. The data used in this study were acquired from the two boreholes, A1 and A2, in Gyeongju, Republic Korea. Well A2 was used for training a YOLO model, which consists of 91 datasets including BO images and their corresponding labels i.e., bounding box coordinates, through expert analysis. Well A1 data was used as an unseen data, which were not used during training and testing the model, to evaluate the applicability of YOLO model to other well data. To alleviate the issue of insufficient training dataset, domain-knowledge based data augmentation was applied to 57 training datasets including parallel shift, flipping, and rotation. The number of training datasets increased from 57 to 1,197 after the proposed data augmentation. When the two YOLO models, with and without the data augmentation, are compared. The YOLO model with the data augmentation (Case 2) increased in average precision, 121.8% higher than one of the YOLO model without the data augmentation (Case 1). To verify the performance and reliability of the two YOLO models, the result of BO detection using wells A1 and A2 image logs were compared with the expert analysis. Case 2 model significantly reduced in both false positive and negative detections compared to Case 1 model. Notably, when the two models were applied to 3-meter images from well A1, where no BO exists, Case 1 misidentified 182 BO objects, while Case 2 did only one BO object. These results demonstrated that the proposed data augmentation can significantly improve the performance of YOLO for BO detection. Additionally, the proposed model automatically analyzed BO information including azimuth and opening degree less than 0.1 seconds per 3-meter image log image, offering a higher efficiency than one of manual expert analysis.

Acknowledgement

This study was supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2021R1C1C1004460), the Korea Agency for Infrastructure Technology Advancement (KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant RS-2022-00143541). This study was also supported by the Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE) (No. 20212010200020; No. 20214000000500).

Keyword

Borehole breakout, You only look once (YOLO), Data augmentation, Image log, Machine learning

Mineral Identification and Mapping Algorithm Based on X-ray Fluorescence Spectroscopy and Self-supervised Strategy

Weiming JIANG[1]*, School of Earth Sciences and Resources, China University of Geosciences (Beijing), Beijing, 100083, China. (3001220109@email.cugb.edu.cn)
Jie YANG[2], Institute of Earth Sciences, China University of Geosciences (Beijing), Beijing, 100083, China.

Abstract

Mineral identification and mapping play a fundamental role in geoscience research. In elemental analysis techniques, the X-ray fluorescence (XRF) analysis exhibits the capability to conduct non-destructive elemental mapping on raw samples, presenting a cost-effective alternative, which enhanced the ease of mineral identification and mapping processes. However, XRF images encounter challenges like intricate feature extraction, resolution heterogeneity and noise, thereby impeding effective mineral identification and mapping processes. In recent years, the development of large models has brought about self-supervised masked image modeling, which have the potential to solve the above problems. In this study, a comprehensive model tailored for XRF spectrum employing a spectral self-supervision strategy was introduced to harness the informational properties of the 3-D XRF spectral cubes and mitigate the interference of other factors in the spectrum. The model adopted Vision Transformer structure as a baseline and integrated spatial-spectral self-attention operations to extract both spectral and spatial features from XRF images. Employing the masked image modeling, the model reconstructed the masked XRF image spectrum, thereby facilitating enhanced feature learning capabilities. After model pre-training, we transferred the model and fine-tuned parameters of the model to effectively grasp mineral recognition and mapping techniques. The results showed that the correlation coefficient of our model in spectral reconstruction was over 99%, which indicated that the model's composition and image mask reconstruction strategy comprehensively capture the intricate structural features of XRF images. With an accuracy exceeding 89.5% in mineral classification and segmentation, the model accurately delineates the interspersed mineral structures during mapping. The robustness experiments demonstrated that the model is resistant to spectral resolution heterogeneity and noise within the XRF image spectrum. In general, our model is successful in XRF-based mineral identification and mapping owing to its adeptness in learning spectral image characteristics and robustness, rendering it readily applicable to diverse spectral related downstream tasks within geoscience research domains, thus holding significant promise for further advancement and exploration.

Keyword

X-ray Fluorescence Spectroscopy, Deep Learning, Self-supervision Learning, Mineral Identification, Large Model

GIS Tool Learning with Large Language Model

Zhizhen YU[1]*, School Of Earth Sciences, Zhejiang University (steven.yu@zju.edu.cn)
Zhenhong Du[2], School of Earth Sciences, Zhejiang University

Abstract

Recently, Large Language Models (LLM) have garnered attention due to their powerful emergent capabilities and wide potential for application. However, LLMs exhibit significant limitations when tasked with specific jobs that require high-precision outputs. This is especially evident in the field of Geographic Information Science(GIS), where tasks such as spatial analysis and cartography demand high levels of accuracy and reliability in data. Tool learning is currently a focal point, with the integration of LLMs and tools offering a solution to the accuracy and reliability issues faced by LLMs. Nevertheless, at this stage, due to a lack of GIS tools available for AI utilization among other reasons, most research in tool learning has focused on common tools such as web crawlers, code execution, and API calls, with very limited scientific exploration into GIS tools. This study aims to explore and develop methods for integrating LLMs with professional GIS tools to address the issues of accuracy and reliability when LLMs undertake high-precision tasks within the GIS domain. By achieving such an integration, LLMs will be empowered to proficiently summon GIS tools as needed, thereby significantly elevating the fidelity of outcomes in tasks encompassing spatial data processing, analysis, and the art and science of cartography.

Keyword

Large Language Model, Tool Learning, Geographical Information Science

Improvement and Evaluation of the RAG Application

Jiarui CAI[1]*, School of Earth Sciences, Zhejiang University (qingmu_0722@163.com)
Zhenhong DU[2], School of Earth Sciences, Zhejiang Univercity

Abstract

Recently, there has been a growing interest among researchers in the capabilities of large language models (LLMs) to provide potential solutions for vertical domain problems. One such technology that has gained significant attention is Retrieval-Augmented Generation (RAG). RAG combines domain knowledge with LLMs to enhance their understanding and generation abilities in specific domains, thereby enabling them to address corresponding problems effectively. However, the application of RAG also comes with its own set of challenges. One of the primary concerns is the random generation effects, which can lead to inconsistent and unpredictable results. Additionally, the scarcity of domain-specific corpora poses another obstacle, as it limits the availability of relevant training data for the models. Furthermore, the evaluation systems used to assess the performance of RAG applications often lack clarity and precision, making it difficult to accurately measure their effectiveness. To address these challenges and improve the performance of LLMs in RAG applications, additional methods can be employed. One approach is to incorporate knowledge graph techniques, which can provide structured and organized information to enhance the models' understanding of domain-specific concepts. Moreover, iterative datasets fine-tuning can be utilized to iteratively refine the models' performance by continuously training them on updated datasets. By integrating these methods, the overall performance and robustness of large language models can be significantly improved in RAG applications. This study attempts to achieve above improvements of RAG within the Geoscience field. Meanwhile, establishing reliable evaluation systems is crucial to ensure the effectiveness of these approaches. Such advancements in RAG technology and its successful application in various domains have significant implications for further enhancing its capabilities and expanding its utility.

Keyword

Large Language Model, Retrieval Augmented Generation, Fine-tuning, Evaluation system, Geoscience

Predicting Methane Concentration in Chromitites: An Application of Ensemble Learning Algorithms in Chro-mitites from Greece

Elena IFANDI[1]*, University Brunei Darussalam (elena.ifandi@ubd.edu.bn)
Daphne Teck Ching LAI[2], School of Digital Science, Universiti Brunei Darussalam
Haezan JANGARUN [3], Geosciences Programme, Faculty of Science, Universiti Brunei Darussalam

Stavros KALAITZIDIS [4], Department of Geology, University of Patras

Abstract

Carbon capture and catalytic conversion to methane emerges as a promising carbon-neutral energy production method. We have examined methane-rich chromitites, which recent studies indicate contain minerals acting as Sa-batier catalysts. However, the petrographic and mineralogical features of previously studied methane-bearing chromitites have not been systematically evaluated. This lack of evaluation hinders the identification of prime ex-ploration targets for chromitites as commercial bulk catalysts, as these features can predict methane concentration. We quantitatively determined the abundance and grain size of the main mineral phases via point counting and ap-plied statistical analyses, including contingency tables and Kendall's tau correlations, to consolidate petrographic and mineralogical data. Given the low performance of traditional regression and classification algorithms ($R2 < 1$ and accuracy <50%, respectively), we opted for automated model selection using the Tree-based Pipeline Optimisa-tion Tool (TPOT), which evaluated over 60 algorithms and pipelines. Its results pointed to two models: a pipeline of Multinomial Naive Bayes (MNB) and Extreme Gradient Boosting (XGB) classifiers and the ExtraTrees classifier. With additional manual optimisation, we opted for a stacking classifier that utilised the MNB and XGB algorithms as estimators, yielding an accuracy of 74% and 70% for the training and testing data sets, respectively. Our detailed investigation of the predictors, based on Shapley Additive Explanation (SHAP) values, revealed that the stacking classifier had a more stable performance with less influence from dispersed data values. Our findings suggest that the presence and size of olivine, spinel, and veins can serve as predictors to classify rocks into "low" and "high" methane groups, aimed at enhancing field exploration operations. The notably minor impact of spinel on the overall prediction of methane concentration suggests that it is improbable to be the primary Sabatier catalyst. This research underscores the effectiveness of automated machine-learning algorithms, specifically multiple ensemble learning classifiers, for optimal model selection in addressing intricate geological issues. Despite the inherent complexity of such data, leading to the underperformance of traditional regression algorithms, our approach demonstrates the heightened performance of these classifiers, illustrating a promising avenue for future geological data analysis.

Keyword

green energy materials, chromitites, Sabatier catalyst, geochemical exploration, machine learning

Deep learning-based multiscale digital rock modeling integrating 2D and 3D rock images

Peng Chi[1]*, China University of Petroleum (East China) (pch_upc@163.com)
Jianmeng Sun[2], China University of Petroleum (East China)
Weichao Yan[3], Ocean University of China

Abstract

Digital rock technology has emerged as an effective approach for investigating the microstructure and physical properties of rocks in geological and geophysical research. Nevertheless, rocks possess multiscale features, and conventional imaging techniques with a single resolution fail to capture the complete structural information. Presently, deep learning-based super-resolution techniques are employed to enhance the resolution of low-resolution images, facilitating multiscale rock images fusion. However, current methods primarily concentrate on the multiscale features of pores while neglecting the reconstruction of other constituents like clay minerals. Consequently, these approaches exhibit subpar performance in the multi-component modeling of digital rocks. To fully express the multiscale information of heterogeneous rocks, we applied an Attention-Guided Generative Adversarial Network (AttentionGAN) to integrate micro-CT images and SEM images of rocks, generating large-scale high-precision rock images. A pivotal aspect of this methodology is its emphasis on not only the multiscale pore structure during training but also the distinctive features of various components, including clays and rock skeleton. By employing this approach, we can generate high-quality digital rocks that faithfully encompass the multiscale information. Through analyzing the reconstructed digital rocks, we explore the influence of clay micropores on rock permeability in sandstone. The results showed that larger pores act as the primary fluid flow channels in rocks and undergo a transformation into micropores upon being occupied by kaolinite. During this process, rock permeability experiences a significant decrease, with a more significant effect observed for higher proportions and more complex structure of micropores.

Keyword

digital rock, multiscale fusion, attention-guided generative adversarial network, deep learning

Forecast of Shale Lithofacies Types in the Dongying Fault-depressed Lacustrine Basin Based on Machine Learning

Zhengwei FANG[1]*, School of Geoscience and Technology, China University of Petroleum (East China) (332527810@qq.com)
Liqiang Zhang[2], School of Geoscience and Technology, China University of Petroleum (East China)

Abstract

Shale oil is currently an important type of energy replacement in the fault-depressed lacustrine basins of eastern China. Many nearby provenancesvariable water body and fault activities have resulted in complex and diverse types of shale lithofacies in theses basins. How to accurately forecast the shale lithofacies types is a key challenge in selecting target for shale oil horizontal wells.Considering the shale of Dongying fault-depressed lacustrine basin as the research object, a lithofacies type forecast was carried out based on machine learning. Two machine learning methods, support vector machines (SVM) and extreme gradient boosting (XGBoost) were used to forecast shale lithofacies types under six different conditions.To improve the forecast accuracy, we applied the following approaches: first, the shale lithofacies were finely classified according to mineralogical composition and microstructure and the vertical change of lithofacies types was obtained. Second, we applied paleoenvironmental parameter data with well logging to forecast shale lithofacies types for the first time.Third, two sample extraction modes, namely curve shape-to-points and point-to-point, were used in the machine-learning process. Compared with the forecast results, in the conditon of selecting the curved shape-to-point sample extraction mode and inputing both well logging and paleoenvironment parameter data, using the SVM method can achieve the highest average forecast accuracy. The learning sample quantity and data value overlap of different lithofacies types affected the forecast accuracy mainly.When adopting machine learning methods, increasing the learning sample quantity, selecting the curve shape-to-point sample extraction mode, and using both well logging and paleoenvironment parameter data are effective ways to improve the forecast accuracy of shale lithofacies types in a fault-depressed lacustrine basin. The method and results of this study provide guidance to accurately forecast the shale lithofacies types in an another fault-depressed lacustrine basin.

Keyword

Fault-depressed lacustrine basin, Shale lithofacies, Lithofacies classification, Machine learning, Lithofacies type forecast

A method using convolutional interactive perception network for well logging data prediction.

Xin LUO[1]*, China University of Petroleum (East China) (b22010034@s.upc.edu.cn)
Jianmeng Sun[2], China University of Petroleum (East China)

Abstract

Geophysical well logging data is an important foundation for evaluating underground resources such as oil, gas, and water in subsurface rock formations. Well logging curve prediction is an important approach to replace re-logging and solve the problems of poor or missing effects in certain logging curves. Faced with the extremely low non-linear relationship in complex reservoirs, we propose a convolutional interactive perception network to adapt to more complex well logging curve prediction tasks. The network model focuses on the formation changes reflected by well logging data and introduces wavelet transform technology to extract the change details of well logging curves. Meanwhile, an interactive module is designed to enhance the perception ability of well logging subsequences. Different convolutional kernels are used to effectively capture different temporal patterns and prevent information loss. By introducing physically-driven wavelet transform technology, this model is easily understood and highly reliable for geophysicists. To validate the effectiveness of our method, we conduct experiments using real well logging data for acceleration correction (short-term sequence prediction task) and interval completion (long-term sequence prediction task). The experimental results show that our proposed method outperforms the current mainstream well logging curve prediction models in various sequence prediction indicators. The generated well logging curve data has the highest accuracy, providing a better choice for well logging curve prediction.

Keyword

Well log, Deep learning, Wavelet transform

Characterizing subsurface structures from hard and soft data with multiple-condition fusion neural network

Zhesi Cui[1]*, China University of Geosciences (zhsc0604@163.com)
Qiyu Chen[2], China University of Geosciences
Gang Liu[3], China University of Geosciences

Abstract

Subsurface structures exhibit inherent spatial variability due to intricate and enduring hydrogeological and environmental influences. Limited subsurface observations for estimating subsurface structures lead to substantial uncertainty, potentially introducing significant bias in subsequent simulations of flow and solute transport. Hydrological modeling stands as an effective and economical approach for swiftly characterizing subsurface structures in a noninvasive manner. Both hard (boreholes, etc.) and soft data (seismic data, etc.) are the most commonly used data types to reveal subsurface structures. Consequently, the effective utilization of diverse data acquired from hydrogeological surveys to construct a realistic representation of subsurface structures emerges as a critical concern. Existing deep-learning-based methodologies predominantly focus on the transition from multiple observations to subsurface structures. However, implicit non-linear correlations among diverse data sources often remain underutilized, leading to potential bias and errors. In this study, we introduce a multiple-condition fusion network (MCF-Net) to characterize subsurface structures based on both hard and soft data. To harness the full potential of multiple-source subsurface observations, two distinct neural networks extract implicit features from hard and soft data. The integration of these features is achieved through multiple-condition fusion blocks, designed to capture representative characteristics. These blocks are also adept at reconstructing heterogeneous structures and facilitating hydrological parameterization. MCF-Net exhibits accuracy in estimating subsurface structures across various types of subsurface observations. Experimental results underscore the utility and superiority of MCF-Net in applications of hydrogeological modeling and inversion. To illustrate the reliability of MCF-Net in practical applications, a case study is presented.

Keyword

Deep learning, Deep data fusion, Geomodeling, Multiple conditional simulation

A new sedimentary facies geo-modeling method based on CGAN deep-learning algorithm

Yiming YAN[1]*, China University of Petroleum (yiming@upc.edu.cn)
Liqiang Zhang[2], China University of Petroleum (East China)
Yanjun Lu[3], China University of Petroleum (East China)

Abstract

Obtaining reliable sedimentary facies is crucial for accurately predicting sandstone reservoirs in siliciclastic sedimentary systems. However, for deep oil and gas exploration, the quality of drilling and seismic data is often poor, making it challenging to establish high-precision sedimentary facies maps. Traditional statistical and multi-point geostatistical modeling methods primarily focus on calculating facies distribution probabilities, with high requirements for geological stationarity. With the gradual improvement of deep learning technology, Conditional Generative Adversarial Networks (CGANs) are being gradually introduced into sedimentary facies modeling and have achieved good results. This study explores a Generative Adversarial Network (GAN) with a deep generator and multi-scale discriminator, successfully applied to modeling river facies sand bodies. Using an unmanned aerial vehicle, a digital outcrop of 1 km^2 of the Qingshuihe Formation oil sand outcrop area in the northwestern of the Junggar Basin was obtained as the modeling database. The reliability of the new CGANs modeling method was validated, with results showing a concordance of hard data of up to 95.31%. In addition, we collect and construct a dataset using Google Earth, which contains abundant and realistic fluvial patterns to reflect adequate prior geological knowledge. Extensive experiments have been carried out on this dataset, the results show that the generated images can reflect the fluvial style using little hard data, and the matching rate of the hard data is 94.78%. This outperforms traditional statistical and multi-point geostatistical modeling techniques, providing a solid basis for deep oil and gas exploration. In the future, Conditional Generative Adversarial Networks (CGANs) may exhibit even more outstanding performance in the field of geological modeling due to their efficiency and high-precision modeling results.

Keyword

sedimentary facies, method, geo-modeling, CGAN, deep-learning

Application of BPNN neural network algorithm driven by data and model in bitumen content prediction of Silurian Kepingage Formation reservoir in Tazhong area

Yanjun Lu[1]*, 1809068709@qq.com (1809068709@qq.com)
Yiming Yan[2], 13792483582
Liqiang Zhang[3], 13105439684

Abstract

Abstract: The Silurian Kepingtage Formation on the Tazhong Uplift is an important oil and gas enrichment layer in the Tarim Basin with great exploration potential, and the accurate prediction of bitumen content in reservoir is of great significance to the study of reservoir heterogeneity. Data-driven neural network algorithms usually use rock logging response characteristics and data to predict reservoir bitumen content. This method has the disadvantages of poor interpretability, unclear geological meaning and difficult application in less coring well area. In this study, a mapping relationship is established by reconstructing a high-precision gamma logging data set which can reflect lithologic changes and a deep-shallow resistivity difference data set that can reflect bitumen differences. This mapping relationship can combine bitumen content, logging data and geological significance and propose a model-data dual-driven neural network model. The prediction results show that: The model-data dual-driven neural network model has high prediction accuracy. The correlation coefficient between the measured bitumen content and the predicted bitumen is 0.9066, and the maximum, minimum and average content errors are 0.016%, 3.889% and 0.956%, respectively. The maximum error of the traditional data-driven model can reach 7.63%. The model-data dual-driven neural network model proposed in this paper is of great significance for explaining the neural network ' black box ' decision-making and prediction process.

Keyword

Bituminous sandstone, Bitumen content, Neural network, Kepingtag Formation, Tazhong area

Predicting the lithofacies of Longdong lacustrine shale oil based on the intelligent fusion of multi-scale well logging data

Quansheng MIAO[1]*, School of Geosciences, China University of Petroleum (East China) (1179803918@qq.com)
Xinmin Ge[2], School of Geosciences, China University of Petroleum (East China)
Bowen Sun[3], Research Institute of Exploration & Development, PetroChina Changqing Oilfield
Ruiqiang Chi[4], Research Institute of Exploration & Development, PetroChina Changqing Oilfield
Yanmei Wang[5], Research Institute of Exploration & Development, PetroChina Changqing Oilfield

Abstract

The shale oil in Longdong area of Ordos basin is typically featured with complex mineral composition and developed with nano-scale fractures and pores, bringing heavy heterogeneity and anisotropy of reservoir properties. It is ultra-difficult to characterize the lithofacies and petrophysical parameters based on conventional geophysical well logging data due to the low vertical resolution. We developed a novel method to predict the lithofacies with the aid of the fusion of multi-scale logging data. Firstly, the lithofacies are determined by the mineralogical and geochemical measurement, as well as the core description. We then obtain the quantitative feature parameter from the borehole electrical imaging data and establish their relations with the lithofacies through core calibration. Secondly, the beehive deep neural network dual-cycle fusion algorithm (BC-DNN) is implemented to establish the accurate mapping between the high-resolution feature parameter curves and the conventional resistivity curves, to improve the vertical resolution of conventional resistivity data. Lastly, we use the self-organizing feature maps (SOM) clustering method with optimized constraints to intelligently divide and identify lithofacies from the logging response and high-resolution characteristic curves, which establishes the accurate relations between the clustering results and lithofacies description based on the core calibration logging, to realize fine logging identification of different lithofacies. Researches show that we use the optimal intelligent algorithm to solve the impact of low vertical resolution of conventional logging data on the fine identification of shale logging effectively, which lays a foundation for the study of lacustrine shale oil reservoir classification and sweet spot identification.

Keyword

Lacustrine shale oil, Lithofacies identification, Beehive deep neural network algorithm, Self-organizing feature maps, Multi-scale fusion

Research on Knowledge Sharing of WRF Meteorological Simulation Based on Knowledge Graph Structure

Chunxiao ZHANG[1]*, China University of Geosciences, Beijing (zcx@cugb.edu.cn)
Yazhou QI[2], China University of Geosciences, Beijing

Abstract

As a crucial method for simulating and understanding geographical environments, model-based geographic simulation is vital for extracting geographical knowledge and unveiling geographical laws. The meteorological process, an essential component of the geographic environment, significantly influences various aspects of geographic simulation, thereby impacting the comprehensive simulation and resolution of complex geographic problems. However, the complexity of meteorological models often demands a high level of expertise, involving intricate simulation knowledge and various components such as input data and simulation scheme settings. Consequently, efficiently managing and sharing meteorological simulation knowledge has become a key step in enhancing the scientific rigor and accuracy of simulations.

In this study, we utilize case-based reasoning and knowledge graph techniques to unify heterogeneous knowledge of meteorological simulation. Additionally, we propose a retrieval method that considers both semantic and graph structure similarity to improve the sharing capability of meteorological simulation knowledge.

Firstly, we extract meteorological simulation knowledge from Chinese meteorological simulation literature using the Bidirectional Long Short-Term Memory with Conditional Random Fields model (BiLSTM-CRF). This extracted knowledge is then used to construct a meteorological simulation knowledge base within a knowledge graph, with simulation cases serving as the carriers of knowledge. For instance, in this study, we have constructed and stored 795 cases as nodes and edges in the knowledge graph.

Secondly, we develop a similarity assessment model for meteorological simulation cases that factors in both semantic and graph structure aspects. Specifically, the model utilizes the BERT semantic model, trained on a meteorological simulation corpus, to mine the semantic features of meteorological simulation knowledge cases. Additionally, it extracts structural features of cases stored in the graph and assigns weights using the Analytic Hierarchy Process (AHP) to accurately measure the similarity of meteorological simulation knowledge cases.

Thirdly, we create a visual prototype system for sharing meteorological simulation knowledge. This system can directly recommend parameter schemes for meteorological simulations based on user requirements and provide reference knowledge for geographic system simulation personnel

involved in meteorological processes. To validate the stability of the retrieval system, we selected 300 input cases, and the retrieval results provided the top 5 similar cases for each input. In this scenario, the system achieved an accuracy rate of 91.3%, significantly improving the efficiency of meteorological simulation knowledge sharing and reuse.

Keyword

knowledge graph, meteorological simulation, knowledge recommendation, knowledge sharing, case-based reasoning

Diagenetic facies characteristics and quantitative prediction via wireline logs based on machine learning

Liqiang ZHANG[1]*, China University of Petroleum (zhanglq@upc.edu.cn)
Yiming Yan[2], China University of Petroleum

Abstract

Tight sandstone has low porosity and permeability, a complex pore structure,and strong heterogeneity due to strong diagenetic modifications. Limited intervals of Lianggaoshan Formation in the Fuling area are cored due to high costs, thus, a model for predicting diagenetic facies based on logging curves was established based on few core, thin section, X-ray diffraction (XRD), scanning electron microscopy (SEM), cathodoluminescence, routine core analysis, and mercury injection capillary pressure tests. The results show that tight sandstone in the Lianggaoshan Formation has primary and secondary intergranular pores, secondary intragranular pores, and intergranular micropores in the clay minerals. The compaction experienced by sandstone is medium to strong, and the main diagenetic minerals are carbonates (calcite, dolomite, and ferric dolomite) and clay minerals (chlorite, illite, and mixed illite/ montmorillonite). Four types of diagenetic facies are recognized: carbonate cemented (CCF), tightly compacted (TCF), chlorite coating and clay mineral filling (CCCMFF), and dissolution facies (DF). Primary pores develop in the CCCMFF, and secondary pores develop in the DF; The porosities and permeabilities of CCCMFF and DF are better than that of CCF and TCF. The diagenetic facies were converted to logging data, and a diagenetic facies prediction model using four machine learning methods was established. The prediction results show that the random forest model has the highest prediction accuracy of 97.5%, followed by back propagation neural networks (BPNN), decision trees, and K-Nearest Neighbor (KNN). In addition, the random forest model had the smallest accuracy difference between the different diagenetic facies (2.86%). Compared with the other three machine learning models, the random forest model can balance unbalanced sample data and improve the prediction accuracy for the tight sandstone of the Lianggaoshan Formation in the Fuling area, which has a wide application range. It is worth noting that the BPNN may be more advantageous in diagenetic facies prediction when there are more sample data and diagenetic facies types.

Keyword

tight sandstone, diagenetic facies, logging curves, machine learning

Machine learning-based approach for intermediate volcanic rock tectonic setting determination.

FengRui JIN[1]*, China University of Petroleum (East China) (1677167835@qq.com)
ShiKuo Lu[2], China University of Petroleum (East China)

Abstract

Intermediate volcanic rocks have significant geodynamic and rock formation implications, and accurately identifying the tectonic setting of these rocks is crucial for understanding global tectonic-geodynamics. Due to the diversity of intermediate volcanic rocks in elemental characteristics, genesis environments, and geographic distributions, traditional low-dimensional geochemical methods have limitations in identifying their tectonic setting. With the exponential growth of geoscience data and the advancement of artificial intelligence, machine learning provides a novel approach to address this challenge. Therefore, this study combines machine learning with geological big data to construct a high-precision model for discriminating the tectonic settings of intermediate volcanic rocks and to provide visual representations. A total of 3113 samples' major and trace element geochemical data from intermediate volcanic rocks were collected globally, selecting 48 common whole-rock geochemical characteristics. Unsupervised learning methods such as principal component analysis and t-distributed stochastic neighbor embedding are employed for high-dimensional data reduction. Various machine learning techniques including random forest, support vector machine, artificial neural network, and K-nearest neighbor are utilized for training. As a result, a random forest-based discriminator for intermediate volcanic rocks' tectonic settings is developed with an accuracy of 89.72%. Additionally, a relatively effective identification diagram is proposed to establish a foundation for identifying five tectonic settings: back-arc basin, continental rift, convergent margin, intraplate craton, and volcanic arc. This work extends the application of machine learning in intermediate volcanic rock tectonic setting studies, offering new insights for investigating tectonic-geodynamic processes.

Keyword

Intermediate volcanic rocks, whole-rock compositions, tectonic setting discrimination, machine learning

Assessment of the effectiveness of a convolutional autoencoder for digital image-based automated core logging

Jaesung PARK[1]*, Kyungpook National University (pouy8286@knu.ac.kr)
Swan SO[2], Kyungpook National University
Ji-Na JEONG[3], Kyungpook National University

Abstract

Widely applicable convolutional neural network (CNN)-based lithology classification models are limited to interpret soundness of a trained model and require high computational cost. This study proposes a convolutional autoencoder (CAE)-based classification model to improve the efficiency of rock-core-logging analysis based on digital rock-core images (CAE model I) and suggest a more understandable classification model by extracting the lithological feature information from the network structure of the model. Moreover, input digital-image data transformation using the Canny edge-detection algorithm was implemented (CAE model II). The applicability of the developed models is validated by comparing them with a CNN model and the model proposed by the previous study (RGBE model). While implementing the proposed model, digital images of 85-m-long cores were used, which were acquired from the Satyr 5 well in the Northern Carnarvon Basin, Western Australia. It was found that CAE models I and II showed classification accuracy comparable to the CNN model (CAE model I: 96.4%, CAE model II: 94.9%, CNN model: 97.5%, and RGBE model: 94.4%). The extracted features of the trained CAE models are effective in interpreting the trained network structure. In addition, in terms of computational efficiency and training time, the CAE-based models are significantly better than the CNN model (CAE model I: 7 min 21 s, CAE model II: 7 min 34 s, CNN model: 12 min 6 s, and RGBE model: 24 min 35 s). Overall, the results demonstrate the feasibility of the proposed CAE-based models for automated rock-core logging.

Keyword

Rock-core digital-image data, Lithology classification, Convolutional autoencoder, Convolutional neural network, Automated rock-core logging

Method of Segmenting the Origin of Soil samples in South Korea Using Deep Learning-based Feature Extraction Technology

SUBI LEE[1]*, Kyungpook National University (tnql0502@naver.com)
JINA JEONG[2], Kyungpook National University

Abstract

Isotope data of environmental samples, such as soil, groundwater, or rock, contain information about specific regional environmental characteristics, making it possible to guess the samples' origin. For this reason, isotopic data is widely applied to various research areas, including origin tracking, source tracing of environmental pollution or climate change research, etc. In particular, the ratio of 87Sr, which is naturally abundant in strontium isotope data, varies depending on the type of rocks and geological eras. Therefore, the geographical and geological origin can be inferred by comparing the strontium isotope ratio in the samples with baseline databases of strontium isotope ratios of each region. As a preliminary study to develop a model that can infer the origin of the environmental samples from the isotope data, this study applied a hierarchical clustering method to cluster data based on the geological properties of each geographical and geological origin, including information on rock type, tectonic provinces, major geochemical elements of rocks, and strontium isotopes. Dimensionality reduction techniques, such as principal component analysis (PCA) and autoencoder (AE), a deep learning technique, were applied to identify the complexity of the relationship between the origin and various geological information. The following three cases were considered for clustering: 1) Original data dimensionality, 2) Dimensionality reduction using PCA, 3) Dimensionality reduction using AE. The clustering results for each case were compared using silhouette scores. The actual database (soil samples) acquired from South Korea nationwide was applied to validate the proposed method in this study. Based on the low-dimensional characteristics extracted from AE, which yielded the best results, a total of 7 label were identified through hierarchical clustering, resulting in the creation of a geological origin label map.

Keyword

Machine Learning, Feature Extraction, Sr isotope

Integration of Dense Well Network Architecture Unit Geological Knowledge Base into Generative Adversarial Networks for Modeling Reservoir Architecture in Fan Delta

Chao Jiang[1]*, China University Of Petroleum (East china) (b21010055@s.upc.edu.cn)
chengyan lin[2], China University Of Petroleum (East china)

Abstract

Fan delta reservoir architecture modeling is one of the crucial outcomes of finely describing reservoirs and is essential for numerical simulations and enhancing remaining oil recovery. Multiple-point geostatistical simulation (MPS) is one of the methods used for modeling reservoir architecture in fan delta. MPS typically extracts statistical features from training images (TI) to simulate patterns. However, MPS usually only extracts some stationary features from TIs, struggles to extract non-stationary features effectively, and cannot integrate some known subsurface geological information (such as sand body development scale, sand body stacking patterns, etc.). Generative Adversarial Networks (GANs) are advanced generative deep learning methods with powerful data integration and geological feature extraction capabilities, which have achieved certain results in the field of reservoir geological modeling. Additionally, Conditional GANs (CGANs) address the issue of generative models not being constrained by hard data. Based on CGAN theory, the precision of reservoir architecture modeling in fan deltas can be greatly improved.

This study utilizes conditional generative adversarial networks to simulate fan deltas, improving the structure of CGANs. A conditional loss function is defined based on the inconsistency between input sand body scale, sand body stacking pattern, and the characteristics exhibited by the output facies model, forcing the generator to learn not only geological patterns but also the consistency between input sand body scale information, sand body stacking pattern, and the output facies. A CGAN integrated with a dense well network architecture unit geological knowledge base is proposed for stochastic simulation of reservoir architecture in fan delta. Currently, based on two sedimentary microfacies, distributary channels, and mouth bar, this method can effectively integrate the generation of corresponding conditionally constrained reservoir architecture models for fan deltas and exhibit good architectural structural characteristics. After training, the quality of the generated facies model and the adjustability of the generator are evaluated.

Keyword

fan delta, reservoir architecture, CGAN, 3D geological model

Identification method of low-order faults in ultra-deep carbonate rocks based on convolution neural network

Hao LI[1]*, China University of Petroleum (Beijing) (lihaolalalalala@outlook.com)
Lianbo Zeng[2], China University of Petroleum (Beijing)

Abstract

Strike-slip fault system plays an important role in controlling the development of ultra-deep carbonate dissolved fracture-cave reservoirs. Its structural style, genetic mechanism and distribution are of great significance for reservoir evaluation. This study focuses on Ordovician carbonate rocks with an average buried depth of more than 7000m in Shuntuogole uplift,Tarim Basin. The research based on conventional fault sensitive seismic attributes in the study area has described the main strike-slip faults quite clearly, but the identification of low-order faults between main faults is poor.The "beaded" reservoir is widely developed in the area between the main faults, which shows a series of ellipsoidal strong reflections in the seismic plane and sections. The fault response of coherent attributes is a circle around the beads, which does not have the structural characteristics of typical strike-slip faults, so it is difficult to analyze its genesis and distribution. In this study, through the observation of a large number of outcrops and cores, a geological model of faults passing through the middle of beads is established.Then more than 400 artificial labels of faults are established based on this geological model through forward seismic modeling. These label data are used to train the 3D convolution neural network fault recognition model based on U-net structure.The model is used to identify the faults in the seismic data. The effect of this method is remarkable.The faults are shown to pass through beads rather than surround it in plane and sections, and has a certain strike and extension length. After analysis, the low-order faults across the main faults can be divided into the R fractures, the T fractures and the P fractures derived from the main faults under the Riedel shear mode according to the strike, and those between the main faults are commonly conjugated faults under the pure shear mode. This study provides a better method for restoring the shape of low-order faults in ultra-deep carbonate reservoirs and provides a research basis for the next step of oil and gas exploration in Shuntuogole uplift.

Keyword

Convolution neural network, Seismic fault recognition, Low-order faults

Improvement of Deep Learning-based Inverse Model with Reconstruction of Dynamic Data

Hayoung KIM[1]*, Kongju National University (nicehy1023@gmail.com)
Sungil Kim[2], Petroleum Energy Research Center, Korea Institute of Geoscience and Mineral Resources, Daejeon, Republic of Korea
Jonggeun Choe[3], Department of Energy Resources Engineering, Seoul National University, Seoul, Republic of Korea
Kyungbook Lee[4], Department of Geoenvironmental Sciences, Kongju National University, Gongju-si, Chungnam, Republic of Korea

Abstract

Quantifying geological uncertainty is essential not only for petroleum resource development but also for the stable utilization of subsurface, such as for carbon sequestration. For these purposes, geological characterization is a prerequisite by using geostatistics with static data and inverse modeling with dynamic data. In case of the inverse modeling, it can modify geological properties, which are generated by geostatistics, but data assimilation has a limitation in deriving a reasonable geological model from a geological perspective because it relies on a mathematical approach.

In this study, we aim to develop a deep learning-based inverse model that simultaneously enhances the efficiency and reliability of conventional inverse methods such as ensemble-based method. In detail, the convolutional neural network (CNN) algorithm is designed to predict a geological model in the output layer from the given oil production rates in the input layer. For supervised learning, a total of 800 data pairs, which consist of 2-dimensional channelized model with 25x25 grids and its 720 oil production rates with 90 observation points at 20-day intervals for 8 production wells, were prepared using ECLIPSE100. Notably, the number of neurons in the output layer is set as 200 using feature extraction from 625 grids through a convolutional autoencoder. From the 800 data pairs, 640 and 160 data pairs were used for train and test data, respectively. When the trained CNN model was applied to the test data, it had a limitation in reliably maintaining the channel connectivity of geological models.

To address this limitation, we reconstructed the 720x1 matrix input data into an 8x90 matrix to segregate the production data by wells, utilizing oil production rates from each well at each time point as 1-dimensional convolution channels. It allowed the CNN-based inverse model to extract features of the overall production trends of each well during a training process. The proposed reconstruction of the input data increased the average structural similarity index measure (SSIM) between the true and generated models on the test data from 0.359 to 0.419. Then, the performance of the trained CNN model was compared with that of ensemble smoother (ES) for the reference model, which was set aside as unseen data. The SSIMs for the proposed method and ES were 0.566 (single geological model) and 0.138 (average of 800 geological models), respectively. Therefore, the CNN-based inverse model with the reconstruction of dynamic data can provide a more reliable geological model than ES's results and reduce the time cost of the inverse process by approximately 52% compared to ES's time cost.

Acknowledgments
This research was conducted with the support of the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (No. 2021R1C1C1004460). This work was also supported by Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE), which includes the grant numbers 20225B10300050 and 20214000000500, the latter being a training program of CCUS for green growth. K. Lee appreciates for the donation of commercial softwares from SLB.

Keyword

Convolutional neural network, Reconstruction of dynamic data, Data assimilation, Inverse modeling, Deep learning

Fault detection based on 3D seismic images using an integration of GCN and U-Net

Guoqing LU[1]*, China University of Petroleum, Beijing (zsdhdlgq@126.com)
Lianbo Zeng[2], China University of Petroleum, Beijing

Abstract

Semantic segmentation is a computer vision task applicable to fault detection research using 3D seismic images. The FaultSeg3D method employs a simplified U-Net network to predict fault probabilities. However, due to the convolutional kernels' limited receptive field, the features extracted only represent the faults' local appearance. Merely increasing the model's depth does not optimally broaden the receptive field to capture the macroscopic distribution of faults. Furthermore, in the fault network, which includes faults of varying scales and non-fixed extension directions, the use of square convolutional kernels and regular image grids may affect the detection results for the extension direction and continuity of small-scale faults.

To address the issues mentioned above, we propose a fault detection method named GNU-Net, which integrates U-Net with graph neural networks (GNN) as illustrated in Figure 1. This method comprises two modules: fault segmentation and fault continuity analysis. The fault segmentation module performs semantic segmentation of faults based on 3D seismic images, while the fault continuity analysis module captures the topology structure of the fault graph and analyzes their continuity. The innovations of this method include: (1) A novel method for constructing fault graphs through vertex extraction and edge generation using grid-based 3D fault labels. This method establishes three-dimensional coordinates for the 3D fault labels and grids them. Positions where faults intersect each grid are designated as vertices, and edges between these vertices are generated in the velocity field formed after fault dilation, together constituting the fault graph structure. (2) An enhancement to the FaultSeg3D method, we added a fault continuity analysis module based on Graph Convolutional Networks (GCN). This module extracts hidden features from the U-Net network during the upsampling process based on vertex coordinates, obtaining the feature matrix of the fault graph structure. It then performs information fusion between the fault graph structure and the feature matrix to analyze fault continuity. (3) The modules for fault segmentation and fault continuity analysis are jointly trained and optimized, with a redefined joint loss model that includes both segmentation loss and continuity loss. (4) We have proposed data augmentation for fault topology, which transforms the coordinates of the vertex feature vector in the topology graph through a self-defined rotation matrix.

This method has been applied to the dataset described in the FaultSeg3D paper, achieving an accuracy of 97.39% on the test data and a Dice Similarity Coefficient of 83.37%. Compared to the FaultSeg3D results, these figures represent improvements of 3.96% in accuracy and 15.07% in DSC, respectively. Additionally, this method opens up a new avenue for research and a novel

approach for the intelligent detection of 3D seismic faults.

Keyword

Fault detection, 3D seismic images, Integration of GCN and U-Net

Seismic attribute optimization and fracture prediction model establishment based on artificial intelligence-A case study of dense sandstone reservoirs in the Northern Ordos Basin

Ziyi YANG[1]*, China university of Petroleum(Beijing) (zoeyangy122@163.com)
Lianbo Zeng[2], China University of Petroleum(Beijing)

Abstract

The development of fractures in tight sandstone reservoirs can greatly affect the development of oil and gas reservoirs. In order to improve the efficiency of oil and gas exploration and development. This study will use artificial intelligence methods to optimize seismic attributes, accurately characterize fracture characteristics in the study area, and establish a model of inter-well fracture development strength. In this study, three-dimensional seismic, core, thin section and borehole imaging logging data were used to calibrate conventional logging through core and imaging logging, and labelled sample data for fracture identification model training were established. Based on the fracture indication parameter method, the relative logging response changes of fractures are extracted by fractal, and the absolute logging response characteristics of fractures are extracted by fracture comprehensive parameters. Based on a variety of machine learning methods, the fracture indication parameter method is improved, and the recognition accuracy is improved from small sample classification, multi-scale nonlinear feature extraction, and prediction model variance reduction, so as to integrate the integrated fracture recognition model and realize the intelligent identification of conventional logging fractures. On the one hand, the seismic attributes are optimized by the correlation coefficient heat map method, and the gradient boosting tree ensemble learning algorithm is used to fuse multiple seismic attributes to gradually improve the fracture prediction accuracy and predict the cross-well development strength of fault-related and unrelated fractures. On the other hand, the maximum and minimum principal stresses are generated by finite element numerical simulation, and the rock fracture index in the study area is established according to the stress and rock fracture criteria. Finally, the collaborative sequential Gaussian simulation is used to interpret the single well fracture as hard data, and the numerical simulation results of reservoir geomechanics and seismic prediction results are used as soft data. The weights of the two soft data are automatically determined by matching degree, and finally merged into a more reliable inter-well fracture development strength model. The results show that the fracture intelligent recognition model based on integrated fracture indication parameters, random forest and SVM is used to identify the fractures of 140 single wells in the study area, and the recognition accuracy is more than 85 %. Coherence, curvature, maximum likelihood and ant body seismic attributes are optimized by using the correlation coefficient heat map method. At the same time, combined with the rock fracture index, the model of fracture development intensity between wells is established. The vertical and horizontal distribution of fractures is obtained by the analysis model. The fracture development area in the study area is mostly striped, and the fracture development intensity near the fault is

mostly high.

Keyword

seismic attributes, fracture prediction, SVM, thinlikelihood seismic, artificial intelligence

Carbonate Lithofacies Logging Identification Based on Machine Learning: A Case Study of Longwangmiao Formation in Moxi Area, Sichuan Basin

Mingqiang LI[1]*, China University of Petroleum (Beijing) (1453321427@qq.com)
Dali Yue[2], 15264288905
Wei Li[3], 15265489406
Wurong Wang[4], 18264851267

Abstract

Carbonate reservoir contains abundant oil and gas resources, which is one of the most important reservoir types in the world. Carbonate lithofacies identification and single well prediction are the basis of oil and gas exploration and development. However, under the influence of different sedimentary environments and diagenesis, carbonate rocks have different mineral compositions and fabric forms, which make their petrographic and chemical properties complicated. Moreover, drilling core and imaging logging data are costly but with few data. These factors increase the difficulty of lithofacies identification and prediction, and restrict the expansion of exploration scale and efficient development. Therefore, this paper proposes to integrate multi-scale geological-geophysical information for machine learning to identify carbonate rock facies. Firstly, according to the lithofacies classification scheme, the lithofacies are divided by thin section data, and the fabric characteristics of different lithofacies are defined. Secondly, the core data is used to carry out rock electrical calibration for the imaging logging to complete the petrographic interpretation of a single well, and then the logging parameters corresponding to different rock facies are extracted to establish the logging parameter set of different petrographic training samples. Then, different machine learning algorithms (BPNN, RNN, LSTM) are used to distinguish the lithofacies of core Wells. Finally, parameters and algorithms are selected to identify single well lithofacies of uncored well. Taking Longwangmiao Formation in MX area of Sichuan Basin as an example, four lithofacies types, including granular carbonate, granular carbonate, granular mud carbonate and micrite carbonate, are identified by the above method. By applying the machine learning model in the coring well, the coincidence between the three machine learning algorithms and the coring discrimination is 70.3% (BPNN), 86.6% (RNN) and 91.7% (LSTM), respectively. The analysis of the reasons shows that the logging data has obvious temporal or spatial sequence characteristics, and the vertical distribution of rock facies also has such characteristics. RNN and LSTM, as powerful series models, are better than BPNN in predicting lithofacies. In addition, RNN is prone to gradient explosion and disappearance in the training stage. Considering that log data are usually sequence data with smooth changes on the same lithology, there is a natural intrinsic matching between log data and LSTM. This method integrates the advantages of conventional logging, electro-imaging logging and machine learning algorithm, and can realize petrographic logging identification with high efficiency and high precision, effectively supporting the fine study of sedimentary microfacies of Longwangmiao Formation in MX area, and promoting the exploration and development of this area.

Keyword

Carbonate, Machine Learning, Logging Identification, Lithofacies

Development and Application of an Intelligent QA System for Knowledge of Global Petroliferous Basins

LI DAWEI[1]*, RIPED of CNPC (leedw@petrochina.com.cn)
Lu Qiang[2], China University of Petroleum (Beijing)
An Xiaoyu[3], RIPED of CNPC
Mi Shiyun[4], RIPED of CNPC
Niu Min[5], RIPED of CNPC
Zhang Qian[6], RIPED of CNPC
Wu Zhenzhen[7], RIPED of CNPC

Abstract

Since 1993, China's oil companies have been participating in global oil and gas exploration and development. Over the past 30 years, massive documents and data on global petroliferous basins have been accumulated through the purchase of international commercial oil and gas databases, independent acquisition of operational area data, and scientific research. Based on these massive data of global petroliferous basins, we developed a "Knowledge Base for Global Petroliferous Basins", which includes reports from 1 global-level, 8 regional-level, and 425 basin-level conventional and unconventional petroliferous basins, about 10 GB totally. This knowledge base includes knowledge and data of geological characteristics, oil and gas enrichment patterns, and oil and gas resource potential, etc. In order to fully and deeply mining the knowledge base and facilitate user application, an "Intelligent Question Answering System for Global Petroliferous Basins" was developed. The key involved technologies include document analysis and information extraction technology, graph database and graph search technology, question answering based on knowledge graph technology (specifically including entity word mapping, relationship semantic matching, query to obtain candidate answers, answer sorting, retrieval of candidate documents, deep semantic matching, etc.). The intelligent question answering system solves the different needs of users and provides researchers with an intuitive and fast knowledge mining platform, which has broad application prospects. Moreover, the establishment of the global knowledge graph of petroliferous basins can empower large language model (LLM) for global oil and gas industry in the future, including detecting the illusion of LLM, knowledge editing, and knowledge injection into black box of the large language model.

Keyword

Petroliferous basin, Knowledge graph, Tripple, Intelligent question answering, Large language model

Artificial Intelligence and Machine Learning for the Automated Classification of the Seabed

Umberto DI LAUDO[1]*, National Institute of Oceanography and Applied Geophysics – OGS, Trieste, Italy (udilaudo@ogs.it)
Luca Manzoni[2], University of Trieste, Italy
Silvia Ceramicola[3], National Institute of Oceanography and Applied Geophysics – OGS, Trieste, Italy

Abstract

The interpretation of seabed features is a very time-consuming and costly exercise for geologists. Artificial intelligence (AI) and Machine Learning (ML) techniques can help scientists to automate this process, making it faster. The goal of the project is to build a model that automatically classifies the seabed, recognizing the various morphological elements present (i.e., submarine canyons, escarpments, mass movements etc.) as a support tool for geologists. For this purpose, the model needs a large amount of morphological data in the shallow coastal areas, that are provided by the Italian MaGIC project (Marine Geohazards along the Italian Coasts). The aim is to build a ML model receiving as input a 2D field in which for each coordinate the depth of the seabed, the slope angle, and the profile curvature are provided. As output another 2D field is provided in which each coordinate is labelled with the morphological features that are present. This representation allows the use of techniques of computer vision field and, in particular, of image segmentation. To build such a model we employ as training data the seabed data that have been interpreted in the framework of the Magic project by geologists in order to create the map of the seafloor's elements (target map). Hence human interpretations are used as ground truth to train the model so that it can automatically generate target maps from new input data. Our model consists in a convolutional neural network, specifically a U-Net, that performs a segmentation of the input data. As stated before it takes the 2D field with the three input channels as an input and directly returns the target map, i.e. the geological interpretation and classification of the seafloor's elements. Classifying the seabed using artificial intelligence (AI) involves utilizing machine learning algorithms to analyze underwater data and identify different types of seabed features. The overall aim of using artificial intelligence to classify the seabed is to automate and enhance the process of understanding and mapping underwater environments. The success of the AI model depends on the quality and diversity of the training data. Additionally, collaboration with domain experts, such as marine geologists, can provide valuable insights for accurate seabed classification.

Keyword

Deep Learning, Seabed Classification, Image Segmentation

Predicting Pegmatite-Derived Lithium Anomaly in Stream Sediment Using Machine Learning Methods: A Case Study of South Korea

Jeong-Ho LEE[1]*, Korea institute of Geoscience and mineral resources (jeongholee@kigam.re.kr)
Sang-Gi Hwang[2], Pai Chai University
Chul-Ho Heo[3], Korea institute of Geoscience and mineral resources
Seung-Jun Youm[4], Korea institute of Geoscience and mineral resources
Seon Yong Lee[5], Korea institute of Geoscience and mineral resources
Pyeong-Koo Lee[6], Korea institute of Geoscience and mineral resources
Seong-Cheon Shin[7], Korea institute of Geoscience and mineral resources

Abstract

Demand is surging for lithium, classified as critical minerals essential for the advancement to clean energy technology. In other words, securing lithium and enhancing lithium exploration technologies are emerging as vital issues. In the context of this study, the objective is to develop a predictive model for pegmatitic lithium anomalies in stream sediments as a part of the advancement in lithium exploration technologies. To this end, 1) geochemical data of stream sediment samples (n=23,094) collected throughout the inland of South Korea and geological information (e.g., lithology, fault, dike, pegmatite, etc.) were utilized, and 2) machine learning approaches (e.g., Naïve Bayes, J48, Random Forest, and Stacking) were applied to establish the prediction models. The anomalous values of lithium in the collected stream sediments were calculated by applying geochemical threshold values (e.g., Mean+2Standard Deviation, Median+2Median Absolute Deviation, the 90th, 95th, and 98th percentiles, Tukey inner upper fence, the break in the Cumulative probability distribution diagram). The results of this study showed that the geochemical data of stream sediments contain the geological information on pegmatite, and in the comparative analysis of predictive models developed utilizing the Naïve Bayes, J48, Random Forest, and Stacking techniques for the identification of lithium anomalies, the stacking approach demonstrated superior accuracy. This study confirms the potential of stacking model as an effective method for tracing pegmatite-derived lithium anomalies based on stream sediment geochemical data.

Keyword

Lithium, Stream sediment, Geochemical data, Pegmatite, Machine learning

Physics-Guided Unsupervised Deep Learning Approach for the Inversion of Receiver Functions

BIJAYANANDA DALAI[1]*, CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India (bijayanandadalai@gmail.com)
PRAKASH KUMAR[2], CSIR-National Geophysical Research Institute, Uppal Road, Hyderabad-500007, India
MRINAL K. SEN[3], The University of Texas at Austin, Austin, TX-78758-4445, USA

Abstract

The converted wave technique, known as Receiver Function (RF), is commonly utilized to investigate the complexities of the Earth's crust and mantle. When analyzing receiver functions, deterministic physical methods such as inversions are often used to improve the accuracy of imaging the subsurface geological structures. However, the process can be complicated by the presence of anisotropic and dipping geological formations, which can sometimes limit the effectiveness of inversions. To address these challenges, we present a Physics-Guided unsupervised deep learning approach for inverting the Receiver function data. This method employs unsupervised deep learning enhanced with implicit neural representations to enable the estimation of key Earth model parameters such as thickness (H), S-wave velocity (Vs), anisotropy, trend, plunge, strike and dip without requiring any labeled data.The estimated parameters are then applied in a forward modeling process to generate the receiver functions, with the model being iteratively refined based on the differences between these simulated and the observed receiver functions. Application of this approach to both synthetic and real field data from the Indian shield has demonstrated its effectiveness in inversion task for anisotropic and dipping geological settings. By focusing on the analysis of subsurface structures, we believe this method holds significant promise in expanding the capabilities of subsurface exploration.

Keyword

Deep Learning, Unsupervised, Inversion, Receiver Function, Dip and Anisotropy

Research on data integration system development for excavation construction equipment fleet management

Skhan Park[1]*, LOTTE E&C (parkskhan@lotte.net)
Bong Chan Kim[2], LOTTE E&C

Abstract

A variety of large-scale data is being generated by geology, construction equipment, and process at excavation construction sites, but data connection technology for efficient use is lacking.
Future construction sites are expected to develop so that manufacturers establish equipment operation plans in connection with construction information (BIM) and provide fleet management services through the convergence of manufacturing and IT services, such as automated operation and failure prediction and maintenance. Telematics technology for domestic smart construction equipment is expanding from the existing one-way telematics system for each construction equipment manufacturer to a two-way connected system. However, due to the narrow domestic market situation and weak base domestic construction sites, domestic smart construction equipment telematics technology is only in the introduction stage.
Currently, products with machine guidance and control applications and remote control services are being provided, focusing on excavators. However, most of the detection sensors for smart construction equipment used are imported, and domestic investment in detection sensors to develop integrated control and management software for general construction equipment is still insufficient. This study seeks to develop an IoT device that can collect data from not only smart equipment but also existing non-automated excavation equipment, regardless of manufacturer, to generate basic data necessary for construction site operations.
A data integration system with a management system that can utilize basic data collected from equipment is needed. This study aims to promote the establishment of a smart construction ecosystem by developing an open platform such as providing API so that data can be easily utilized in various places, such as developing IoT devices that can collect data regardless of the manufacturer.

Keyword

fleet management, site geology, data integration system, construction equipment, excavation

AI in solving geological problems using the example of uranium deposits in Kazakhstan

Abish SHARAPATOV[1]*, Department of Geophysics and Seismology, Satbayev University (a.sharapatov@satbayev.university)
Alisher Saduov[2], PhD student of Department of Geophysics and Seismology, Satbayev University
Nazerke Assirbek[3], Department of Geophysics and Seismology, Satbayev University
Nurlan Samanbetov[4], Geophysicist LTD "Geoken", Almaty, Kazakhstan

Abstract

Aim:
This research is primarily related to the synthesis of machine learning and geostatistical research methods to optimize the scope of work in predicting lithology and delineating uranium deposits of the formation-infiltration hydrogenic type.

Methods:
The study is based on the hypothesis of combining geostatistics and artificial intelligence can make a significant contribution to geological predictive mapping of ore bodies, thereby optimizing uranium resource exploration and mining processes.
The methodological framework of the study in pre-processing mode to overcome data integrity issues mainly results in the lack of results in the studied geological attributes. A higher reclassification of the lithology data was carried out, increasing the wide variety of lithology classes in seven manageable categories. This reorganization was critical to improving navigation through the dataset in the next step of machine learning. The RandomForestClassifier algorithm was used to build predictive models using a set of geophysical measurements obtained from well logging data. Additionally, cubic spline interpolation techniques were integrated to measure the spatial distribution of lithological classes, resulting in continuous stratigraphic visualization.

Results:
RandomForestClassifier has demonstrated impressive accuracy, especially in distinguishing between non-uranium and uranium-bearing forms, which are critical in dozens of uranium explorations. The models have demonstrated exceptional accuracy and completeness, especially for pay zones, reaching 99% accuracy. The F1 scores further highlight the balanced predictive performance, reinforcing the usefulness of the models for reliably producing statistically significant lithologies.
Conclusion:
The results of the study combine the effectiveness of machine learning with the failure of geological approaches, the essence of significant optimization of the scope of work performed in geological mapping and mineral resource accounting. The models have confirmed the ability to predict high-threshold lithologic classes and productive horizons, signifying Western advances in resources and exploration planning; in similar well logging data in similar geological conditions.

The effectiveness of using AI in geosciences depends on the quality and completeness of the input data; with the complexity of geological processes, it requires the involvement of expert assessments.

Keyword

Artificial Intelligence, Geophysics, Geology, Uranium deposits, Work optimization

A new approach of mineral targeting in a concealed shear zone complex by Knowledge-Driven multi-thematic Mineral Prospectivity Mapping

PRASHANTH KUMAR K[1]*, GEOLOGICAL SURVEY OF INDIA
(prashanthkumar.k@gsi.gov.in)
CHHAYA MINZ[2], GEOLOGICAL SURVEY OF INDIA
PANKAJ JAISWAL[3], GEOLOGICAL SURVEY OF INDIA
PAWAN BARAIUD[4], GEOLOGICAL SURVEY OF INDIA
ADITI DAS[5], GEOLOGICAL SURVEY OF INDIA

Abstract

Over the last two decades, several successful case studies of mineral prospectivity mapping were carried out worldwide using multi-thematic data integration techniques. The present study envisages an assessment of the mineralization potential of North Singhbhum Mobile Belt (NSMB) using a GIS-based multi-thematic data integration method to generate mineral prospectivity maps with respect to base metal mineralization. NSMB is a 200km long, Proterozoic fold belt of eastern India juxtaposed between the Singhbhum Craton (SC) in the south and Chhotanagpur Granite Gneiss Complex (CGGC) in the north. The curvilinear Singhbhum Shear Zone (SSZ), marks the boundary between SC and NSMB and is developed along the southern fringe of the NSMB. NSMB in general, and SSZ in particular is a known host for multi-mineral deposits of structurally controlled and hydrothermal origin. The central and western parts of the SSZ is less explored as the exposures are limited and the terrain is largely soil-covered as compared to the eastern part. A systematic approach to target the possible extension of mineralisation by integrating geological data set from the Geological Survey of India's 1:50,000 scale map series (lithology, stratigraphy, structure), geochemical data from National Geochemical Mapping (NGCM) Program and gravity and magnetic data from National Geophysical Mapping (NGPM) Program has been attempted in this work. Spatial evidence thematic maps and variables are ranked for base metal mineralisation based on theoretical knowledge and information gathered from earlier exploration works. The ranked thematic variables were empirically evaluated for their spatial association with the known mineral occurrences. These ranked predictor maps were converted into rating maps using the Analytic Hierarchy Process (AHP) and a mineral prospectivity map was obtained for base metal mineralisation using the weighted multi-class index overlay method. The output shows an accuracy of 66% with a False Positive Rate (FPR) of 33% and sensitivity of 66%. The mineral prospectivity map of base metal reveals a regional and contiguous zone of high prospectivity along SSZ. The obtained mineral prospect zones were validated in the field through surface indicators as well as through chemical analysis of different sample media. The sub-surface continuity of anomalous values obtained from the surface sampling was further tested by selective drilling which intersected significant sulphide-rich zones. One borehole intersected a 1.5m zone of Cu with an average grade of 0.48% and another borehole intersected a 3.5m zone of Mo with an average grade of 0.1% associated with anomalous Cu, Au, U, and REE. From the synthesis of all data and field observations, it is evident that the regional scale multi-thematic data integration can

effectively be used for identifying the most prospective sub-domains which, in turn, can be targeted for advanced stages of exploration.

Keyword

North Singhbhum Mobile Belt, Singhbhum Shear Zone, Mineral Prospectivity Mapping, GIS

Intelligent Identification Technology for Sandstone Thin Sections

Yili REN[1]*, Research Institute of Petroleum Exploration and Development, China National Petroleum Corporation (renyili@petrochina.com.cn)
Xi LIU[2], Research Institute of Petroleum Exploration and Development, China National Petroleum Corporation
Xin LI[3], Research Institute of Petroleum Exploration and Development, China National Petroleum Corporation
Yanxu HU[4], Research Institute of Petroleum Exploration and Development, PetroChina Huabei Oilfield Company

Abstract

Thin sections identification can represent the mineral composition, rock structure, and pore structure of the reservoir, and is an important means of studying reservoir evolution and reservoir quality. Traditional identification methods rely on visual observation, which faces challenges such as low efficiency, insufficiently precise and quantitative results, and a scarcity of experts. This method cannot provide detailed representation of the reservoir, necessitating the development of intelligent identification techniques. The images of thin sections differ from ordinary natural images in many unique ways, such as multi-channel images, blurred features, and small yet clustered objects. Therefore, universal algorithms cannot be directly applied. Moreover, intelligent identification techniques differ from ordinary natural scenes, and intelligent identification methods need to be tackled urgently.

Taking clastic rock reservoirs as an example in this article, new deep learning algorithms developes for the specific characteristics of thin section image data and the unique requirements of intelligent identification scenarios, focusing on aspects such as backbone network design, feature extraction, and loss function. Research conducts on intelligent mineral composition recognition for multi-channel images, pore structure analysis based on deep learning, and rock structure evaluation using computer vision. Consequently, the following achievements and innovations have been made.

First, proposed a set of full stitching, seven-channel, position-free image acquisition method, as well as rock particle segmentation, mineral composition, and pore type labeling scheme, forming a set of intelligent thin-section identification data annotation methods that facilitate modeling and annotation simultaneously.

Second, an instance segmentation network Swin-based HTC for multi-channel images is proposed to recognize mineral composition, enabling the extraction of features such as extinction, interference color, and cleavage. The instance segmentation effect (mAP) of 12 mineral particles, including quartz, feldspar, calcite, miscellaneous base-mud, dolomite, and authigenic clay minerals, reaches 0.80.

Third, a semantic segmentation network PoreSeger based on semi-supervised training to construct a pore intelligent recognition model and a throat identification method based on key point identification is proposed. The semantic segmentation effects of pores reach an IoU of 0.76 and

F1-Score of 0.85, as well as the throat identification model has an mAP effect of 0.91. On this basis, a set of pore structure quantitative characterization parameter system is proposed to achieve the quantitative characterization of clastic reservoir pores.
Fourth, based on the Mask2Former framework, a multi-channel image-oriented rock particle segmentation network CoreSegr is proposed to achieve the extraction of rock particle edges and the identification of categorical attributes (rigid particles, plastic particles, non-land-derived debris, and filling materials). Based on this, quantitative characterization parameters and calculation methods such as compaction index and roundness index are proposed to achieve the characterization of rock structure.
Through the research in this article, the entire process of thin sections identification has been intelligentized and automated. Moreover, multiple result charts which can achieve diversified visual identification results display and provide more detailed and specific visual data for energy storage analysis can be drawn based on this methods. Compared with manual identification, the thin section intelligent identification system is more objective, and the identification results are more detailed.

Keyword

thin-section analysis, deep learning, mineral composition identification, pore structure analysis, rock structure evaluation

A study on the analysis and prediction model of lime dosage for artificial intelligence-based mine drainage treatment

SEONG-SOOK PARK[1]*, Hanyang University (pss2907@hanyang.ac.kr)
GA-HYEON LEE[2], Hanyang University
SOON JEE SEOL[3], Hanyang University
DUK-MIN KIM[4], Sangji University
SUN-JOON KIM[5], Hanyang University
MI-SUN PARK[6], Korea Mine Rehabilitation and Mineral Resources Corporation (KOMIR)

Abstract

Mine drainage containing suspended solids (SS) and potentially toxic elements has contaminated abandoned mine areas in South Korea, as well as surrounding rivers and agricultural land. Mine drainage has been treated nationwide since 1992 by active or passive treatment methods. As typical coal mine drainages in South Korea, Fe, Mn, and Al as well as SS are the main contaminants. At the treatment facilities, metals are precipitated by pH adjustment using slaked lime. The dosage of lime showed a pattern that varied with the flow rate, pH, and influent metal ion concentrations.

However, the relationship between these inputs and lime dosage has not been studied beyond the empirical equation. Thus, in order to effectively manage mine drainage as a long-term plan, we predicted the lime dosage for two mine drainage treatment facilities (ST and HT) in South Korea using a machine learning (ML) technique that is currently attracting attention as a data-driven artificial intelligence (Al) approach.

Since most of the data was handwritten and some of it was not chemically valid, we removed the bad data (161 (ST), 565 (HT)) from the original data of ST (2,145) and HT (2,160) mine drainage treatment facilities accumulated over six years. The input data of ML model were selected as pH, flow rate, and metal ion concentrations (Fe, Mn, and Al) of the influent, which highly correlated with the lime dosage (label). The convolutional neural network (CNN) model was designed and trained to predict the lime dosage. Although the data was measured once a day for six years, it was insufficient to train a CNN model. Additionally, the data revealed a significant imbalance in the lime dosage. Fancy PCA data augmentation technique was used to compensate for the limited amount of data and maintain the characteristics of the original data. ST and HT data were divided into 3 groups based on the lime dosage, and the augmented ratio of each group was set to 20:30:40 to address the data imbalance based on lime dosage. The trained CNN model produced a lower MAE (mean absolute error) and a higher R2 than the empirical equation for the test dataset which was not used during training process.

The use of ML techniques to predict lime dosage is expected to increase the cost-effectiveness of mine drainage treatment facilities and provide basic design data for new facilities.

Keyword

prediction, artificial intelligence, mine drainage, treatment, convolutional neural network

The intelligent identification and regional capacity estimation of submarine polymetallic nodules based on Segment Anything Model

Jingpeng LIU[1]*, Qingdao Institute of Marine Geology (ljingpeng@mail.cgs.gov.cn)
Baoguang Li[2], Qingdao Institute of Marine Geology
Guohui Su[3], Qingdao Institute of Marine Geology

Abstract

Abstract: Polymetallic nodules are a kind of autochthonous polymetallic mineral resource distributed on the oceans seabed. They are currently one of the most important deep-sea mineral resources and strategic resources, and further exploration and development of which holds of great strategic significance. Obtaining the distribution density of nodules in the submarine mining areas and estimating the regional production capacity and economic value is an indispensable part of the exploitation and utilization process of polymetallic nodules. Traditional measurement methods primarily rely on rough manual calculations, which has the problems of time-consuming, labor-intensive, and inefficient. In order to solve these problems, some research efforts have attempted to introduce deep learning models for the purpose of automated estimation and analysis of polymetallic nodules, but a substantial amount of real, reliable, and pre-labeled samples are required for training and validation of models. Segment Anything Models (SAM) is a large-scale image segmentation model that leverages prompt-based learning to be able to segment any object in any image without additional training, featuring generalization, efficiency, and inferability. To this end, this paper proposes an intelligent identification method for seabed polymetallic nodules based on the SAM model. To address the issue of lacking datasets annotated with polymetallic nodule labels, this paper combines the SAM model to construct a semantic segmentation model framework suitable for nodule targets, achieving accurate segmentation of nodule regions and seafloor substrate regions. Considering the problems of speckle noise and nodule tightness or adhesion in the segmentation results, this paper utilizes morphological image processing methods such as image denoising, opening and closing operations, and contour recognition to accurately obtain the rectangular contour range of the nodules, which lays a solid foundation for the calculation of the index parameters related to nodules. Based on the target segmentation and recognition of polymetallic nodules, further functionalities such as morphological recognition, size calculation, and parameter calculation are implemented to achieve the estimation of regional polymetallic nodule production capacity. The experimental results show that the semantic segmentation model framework based on SAM is able to moderately identify the nodule distribution without the need of labelled datasets for model training and validation, and the recognition accuracy and recall of the model in the image are 94.87% and 95.78%, respectively. Compared with existing methods or models, the main advantage of this approach is that it can automatically and intelligently identify polymetallic nodule targets with a single click, and to achieve the estimation of regional nodule production capacity without the need for other auxiliary information or data. This approach has the advantages of time-saving, manpower-free and

accuracy. It can provide support for further development and utilization.

Keyword

Polymetallic nodules, semantic segmentation, target recognition, Segment Anything Model

Borehole Thermal Resistance Estimation and Optimization for In-Situ Borehole Heat Exchangers

Byoung Ohan SHIM[1]*, KIGAM (boshim@kigam.re.kr)

Abstract

The borehole thermal resistance (BTR) of a borehole heat exchanger (BHE) plays a crucial role in the efficiency of ground-source heat pump (GSHP) systems. Researchers have extensively studied methods to enhance BTR, focusing on factors such as backfill material, pipe material, and tubing configurations. Lower BTR values lead to improved system performance and allow for shorter borehole heat exchangers. Two critical elements affecting BTR are the thermal conductivity of the backfill material and the pipe configuration. To investigate these factors, in-situ thermal response tests were conducted at seven BHE sites. The demand for thermally enhanced grout (TEG) products has increased as a means to reduce BTR commercially. In this study, we estimated the BTR for each of the seven BHEs using three calculation methods: Paul, Multipole, and Koenig. Additionally, we compared simulation plots, considering shank spacing and the thermal conductivity of the backfill material, with the interpretation results from the thermal response tests (TRT). Our simulations incorporated various grout materials with thermal conductivities ranging from 0.5 to 2.5 W/mK. However, the actual thermal conductivities of the grout backfilled in the borehole fields fell between 0.76 and 1.73 W/mK. The calculated BTR values were then applied to the GSHP design for an existing building, determining the required total BHE length. Notably, our results revealed significant differences in BTR estimation models, particularly in cases of low grout thermal conductivity. This case study provides valuable insights for BHE installations, especially when adapting TEG and aiming for cost-effective designs. By optimizing BTR, we can enhance GSHP performance while minimizing drilling requirements and overall capital costs.
Acknowledgements: This work was supported by the Basic Research Program (24-3411: Development of Climate Change Adaptation Technologies for Securing and Utilizing Large-Scale Groundwater Resources) at Korea Institute of Geoscience and Mineral Resources (KIGAM).

Keyword

borehole thermal resistance, borehole heat exchanger, ground-source heat pump, grout thermal conductivity, thermal response tests

Interdisciplinary and shared 3D geomodels of the Los Humeros and Acoculco geothermal systems (Mexico)

Philippe CALCAGNO[1]*, BRGM (p.calcagno@brgm.fr)
Eugenio Trumpy[2], CNR
Luis Carlos Gutiérrez-Negrín[3], Geoconsul
Domenico Liotta[4], CNR & Aldo Moro University

Abstract

The European-Mexican geothermal GEMex project aimed at developing non-conventional geothermal resources in the easternmost region of the Trans-Mexican Volcanic Belt. Two sites under development by the Comisión Federal de Electricidad (CFE, Mexican National Power Company) were investigated to assess possible superhot resources and to assist in developing an Enhanced Geothermal System, respectively in Los Humeros and Acoculco (Mexico).

In Los Humeros, geothermal energy is exploited since the 80's by CFE where dozens of wells have been drilled. The goal is to better understand the geothermal field under exploitation and to aim expected super-hot fluids to be exploited. The geothermal target is mainly located in the basament, pre-calderic rocks.

Acoculco is far less known. Only two exploratory boreholes have been drilled, showing high temperature but a lack of fluid. Here, the expectation is to develop the field using EGS techniques. According to existing studies, the geothermal target is probably located in the basement composed of calcareous, granitic, and metamorphic rocks.

On both sites, European and Mexican partners constructed 3D geomodels to describe and interpret the geothermal systems. The geomodels evolved from preliminary knowledge to the extensive integration of geological, geophysical and geochemistry data further acquired. European-Mexican teams developed the characteristics of the modelling in a "Knowledge and Data Sharing - Modelling - Validation" cycle. The construction of the geomodels was performed in a collaborative and interdisciplinary way to enable a consensual interpretation and representation among the several experts of the geoscientific disciplines involved in the process.

The outcome consists in four and five geomodels, dedicated to Los Humeros and Acoculco sites, respectively. These were developed at various scales depending on the needs of the investigations. The 3D geomodels were used by partners during the course of the project as input for computations and simulations based on the geometry of the geological structures. In addition, the geomodels are shared in open access media* for further use and evolution beyond the project.

The collaborative and interdisciplinary work to produce the geomodels benefited from many European and Mexican scientists. Authors want to acknowledge the contribution of all the experts of the H2020 GEMex project who participated to some degree in the discussion and revision of the several stages of the Los Humeros and Acoculco geomodels.

The authors wish to thank the technical experts from CFE for their assistance and support. This work presents results of the GEMex Project, funded by the European Union's Horizon 2020

research and innovation programme under grant agreement No. 727550, and by the Mexican Energy Sustainability Fund CONACYT- SENER, Project 2015-04-268074. More information is available on the GEMex Website: http://www.gemex-h2020.eu.
*Calcagno, P., Trumpy, E., Gutiérrez-Negrín, L.C. et al. A collection of 3D geomodels of the Los Humeros and Acoculco geothermal systems (Mexico). Sci Data 9, 280 (2022). https://doi.org/10.1038/s41597-022-01327-0

Keyword

Interdisciplinary integration, 3D geomodelling, geothermal exploration, Los Humeros, Acoculco

CEEGS - Novel CO2-based electrothermal energy and geological storage system

Marko KOMAC[1]*, INTRAW (m.komac@telemach.net)
Ricardo Chacartegui[2], University of Seville, Spain
Anita Stein[3], European Federation of Geologists
Marko Komac[4], European Federation of Geologists

Abstract

CEEGS is a 3-year long Horizon Europe funded project, that is developing a cross-sectoral technology for the energy transition, combining a renewable energy storage system based on the transcritical CO2 cycle, CO2 storage in geological formations and geothermal heat extraction. The technology is a highly efficient, cost-effective, and scalable (small- to large-scale) concept for large-capacity renewable energy storage. Extended capacity is obtained due to the underground system. It can be integrated into the grid, heating and cooling districts and industries. It also has the capacity for partial CO2 sequestration. The main objective of the project is hence to provide scientific proof of the techno-economic feasibility of the technology, raising the current low Technology Readiness Level (TRL) from 2 to 4 by addressing gaps in the interface between surface trans-critical cycle and the subsurface CO2 storage.

Based on theoretical principles models, simulations, and processes in which advanced numerical simulations integrate reservoir behaviour, wellbore design and surface plant design are being developed. Results from these help in experimental verifications of using digital functional and laboratory models. Most crucial components will be validated with results from the CO2 pilot-scale projects. To be successfully implemented, every new technology needs to be evaluated and benchmarked from social, economic and sustainability aspects. For this purpose, tools to evaluate impacts and concept deployment with a) renewables, b) hard-to-decarbonise industries, c) district heating and cooling, and d) in grid balance, are essential to the project too. Consequentially, CEEGS consortium included among the project's tasks social acceptance studies, Life Cycle Assessment (LCA) and Techno-Economic Analysis (TEA).

Consortium expects to achieve several key elements of the impact – facilitate decarbonisation of heating/cooling and electricity sectors, provide large storage solutions for excess electricity generated, propose storage solutions that are interoperable with the existing grids and develops technologies for renewable energy production.

In addition to the abovementioned CEEGS technology integration at TRL4, expected results are defining geological availably and geological system design to guide future exploration and feasibility studies; designing new system components and engineering solutions to make the concept technological and economically viable, and solving open issues on TCO2/underground storage design; validation of technical assumptions and complete risk analysis, including social acceptance that fosters decision-making in a stage-gate process, drafting a complete business model to simulate further investments towards TRL 5-7 and beyond.

Important outcomes of the CEEGS encompass full set of technical benchmark data for component and system level, their interoperability compliance with the grid and renewable energy sources, newly derived knowledge on interface and load change-effects on equipment and the CEEGS technology, scale-up and commercialisation needs of CEEGS components in partnership with companies, potentially to Demonstration Plant level by engineering solution provider, its full commercialisation and clear understanding of the process economics and feasibility including CAPEX and OPEX of the CEEGS system for different plant scales and geographical regions.

Keyword

Energy storage, Renewables integration, Thermoelectric Transcritical CO2, CO2 sequestration

The Impact of Fluid-Rock Interaction on Environment in Geothermal Sites of Kuril-Kamchatka Island Arc

Julia Vladimirovna FROLOVA[1]*, Lomonosov Moscow State University (ju_frolova@mail.ru)

Abstract

Geothermal exploration and development of geothermal sites requires the investigation of their engineering geological setting and an assessment of the hydrothermal activity impact on the environment. Alteration of rocks due to the interaction with thermal fluids changes their physical-mechanical properties and promotes a broad range of geological phenomena that is indicated by many researchers on various geothermal sites all over the world. These processes have a great impact on the environment and influence on exploitation of the geothermal field. There are known cases when they caused economic damage, disrupting the production and reinjection wells, damaging geothermal stations, and even leading to human casualties.

In this work, we consider the influence of hydrothermal alteration on physical-mechanical properties of rocks and describe the geological phenomena associated with hydrothermal activity on the most well-known hydrothermal systems of the Kuril-Kamchatka island arc such as Mutnovsky, Pauzhetsky, Koshelevsky, Kambalny, Bolshe-Banny, Geysers Valley, Semiachinsky, North-Paramushirsky, and volcano Baransky. The Kamchatka Peninsula and the Kuril Islands are located at the ocean-continent transition zone of the northwestern segment of the Pacific “Ring of Fire”, which is one of the most dynamic structure on the Earth. Its tectonic position above the subduction zone provides the increased convective heat flow. The geological, hydrogeological and geothermal conditions of the region are favorable for the formation of hydrothermal systems. The studied hydrothermal systems are hosted in the volcanic formations of Neogene-Quaternary age, which generally characterized by sufficiently high strength and deformation properties. The circulating thermal fluids cause large-scale alteration in composition, porosity, and properties, both by weakening or strengthening the rocks depending on conditions. Hydrothermal alteration captures the parent rocks and changes their properties down to the depth of hundreds meters and deeper. The most intense alteration takes place on the surface near thermal water discharges, where the rocks undergo argillization, finally turning into clay-rich soils that leads to significant decrease in mechanical properties by 2-3 order of magnitude. Hydrothermal alteration of rocks and changes in their properties promotes a broad range of geological phenomena including slopes instability with landslides initialization, hydrothermal explosions, migration and change a regime of thermal manifestations, surface deformation and subsidence, reduction of well production, formation of silica deposits from waste thermal water etc. These processes influence on the exploitation of geothermal field, and in some cases could be hazardous for the economic or tourist development of geothermal site.

Keyword

hydrothermal alteration, Kuril-Kamchatka arc, physical-mechanical properties, hazardous processes, landslides

On Policies and Mechanisms for Collaborative Promotion of Electricity Market and Carbon Market under the Dual Carbon Goals

Jia LIU[1]*, Development Research Center of China Geological Survey (ljia@mail.cgs.gov.cn)
Wei Gao[2], State Grid Talent Exchange Service Center

Abstract

Abstract: The holding of the 28th Conference of the Parties to the United Nations Framework Convention on Climate Change (COP28) and the implementation of the European Union Carbon Border Adjustment Mechanism (CBAM) will have a profound impact on the low-carbon development of some export enterprises in China's industries. Faced with the pressure of approaching carbon peak time, China has accelerated the construction of a future electricity spot market, restarted the National Certified Voluntary Emission Reduction (CCER) market, and expanded the national carbon market, aiming to reduce greenhouse gas emissions through market mechanisms and achieve the dual carbon goals. However, the electricity and carbon markets have not yet been connected, and the two systems still need to be effectively coordinated and connected in areas such as accounting and verification, data exchange and unified certification among different environmental rights. In terms of carbon emission data accounting and regulation, the country has successively issued technical guidelines to standardize and guide the emission control enterprises that have been included in carbon market in their carbon measurement methods and verification technologies. At present, enterprises mainly use the emission factor method to measure the direct and indirect carbon emissions of greenhouse gases based on the guidelines and policy standards issued by the Intergovernmental Panel on Climate Change (IPCC) of the United Nations. This method provides a basic framework for carbon measurement in the electricity and carbon markets, but there are still shortcomings in data accuracy, completeness, and timeliness. More scientific, precise, and systematic measurement is needed to ensure market fairness and transparency. In this regard, the study aims to sort out the coupling relationship between the electricity market and carbon market, in particular the mechanism of effective transmission of carbon costs to electricity costs, and the deduction method of green electricity in enterprise carbon emission accounting by drawing on the experience of European countries and the U.S. Besides, the establishment of carbon monitoring standards that are compatible with international standards and an internationally recognized green power certification system is tentatively explored. In terms of data reliability, it is recommended to apply advanced technologies such as AI, IoT and big data, combined with multiple information sources for real-time monitoring, to improve the accuracy of emission data.

Keyword

electricity market, carbon trading market, environmental rights, coupling mechanism

Geothermal Water Chemistry and Water Rock Interaction in the Olkaria Geothermal Reservoir, Naivasha Kenya.

Edwin Wafula WANYONYI[1]*, Kyushu University (wedwin.wafula@gmail.com)
Kotaro Yonezu[2], Kyushu University

Abstract

The United Nations' sustainable development goal number 7 focuses on the provision of affordable and clean energy; where from the year 2022 report, the amount of renewable energy consumption increased from 2010 to 2019, yet still only 17.7% of the final energy consumption could be attributed to renewable energy (UNSTATS, 2022). One of these critical resources is geothermal energy. The Olkaria geothermal area has a high potential for geothermal generation with a current installed capacity of 985 Mwe and is the 6th largest producer of geothermal energy in the world. The study of the origin, evolution, and nature of these geothermal fluids is important to geoscientists since it determines the type and quality of utilization that can be applied to a particular geothermal prospect. The isotopic signature showed a strong influence of local precipitation on the geothermal fluid whereby the geothermal system was mainly recharged through fractures and faults and later modified through high-temperature water-rock interaction with the local rock of volcanic origin. Even though the system was majorly composed of fluid of meteoric origin, the solution chemistry showed that Na, Cl, and SiO2 were the most significant elements in the solution, which is not typical of normal meteoric waters, ostensibly showing the high level of water-rock interaction and fluid modification that the Olkaria geothermal water had undergone from the fluid of origin. Based on the variation of the major cation/proton activity ratios for Na+, Al(OH)-4, Ca2+, and K+ as well as the activity of H2CO3 in the geothermal water samples evaluated in this study, at the reservoir temperatures considered, all the wells had attained nearly the same relative abundance of these major cations Na and K. This is usually the case for waters that have attained equilibrium with minerals in solution, especially in the Olkaria case where the Na/K ratios were controlled by equilibrium with albite and K-feldspar. The analysis of the saturation state with respect to the silica minerals quartz and chalcedony for the Olkaria geothermal water showed that quartz controls the concentration of silica in reservoir fluid given that the wells had high temperatures above 250°C. The high temperatures were related to the proximity of the heat centers to magma sources that have been shown from resistivity studies to be between 6-8 km at depth in Olkaria. Boehmite precipitation acted as the major tank for aqueous aluminum concentration, with aluminum hydroxide being the main aluminum species in the solution. In general, most of these reactions are supported by fluid migration through the structurally controlled Olkaria geothermal reservoir.

Keyword

Olkaria, Geothermal, Mineral, Equilibria, Chemistry

Transgeo Project - How to reuse abandoned oil and gas exploration wells, opportunities and constraints in Hungary

Ferenc FEDOR[1]*, Department of Geology and Meteorology, University of Pécs (fedor.ferenc@geochem-ltd.eu)
János Kovács[2], Department of Geology and Meteorology, University of Pécs
György Márton[3], CROST Regional Development Nonprofit Ltd.
Klára Bődi[4], Mining Property Utilization Nonprofit Public Ltd
Julie Elizabeth Friddell[5], Helmholtz Centre Potsdam GFZ - German Research Centre for Geosciences
Hannes Hofmann[6], Helmholtz Centre Potsdam GFZ - German Research Centre for Geosciences

Abstract

Abandoned oil and gas wells are a problem all over the world. However, given the right market, geological and technological conditions, these wells can be used for underground gas storage or geothermal heat and/or power generation. In the TRANSGEO project, led by the Helmholtz-Centre Potsdam German Research Centre for Geosciences, partners from Germany, Hungary, Croatia, Slovenia, and Austria are investigating the potential of five different geothermal technologies (BHE – Borehole Heat Exchanger, BTES – Borehole Thermal Energy Storage, HE – Hydrothermal Energy, ATES – Aquafer Thermal Energy Storage, EGS – Enhanced Geothermal System) to provide energy and/or heat for agriculture, industry, and municipalities. The project will carry out a socioeconomic analysis of the problem, review existing projects, and select pilot project sites based on the best practices and criteria catalog-based IT tool. The criteria catalog will be used as a basis for the decision tree, and platform-independent software will be developed to support the selection. A review of the conditions for implementation will be carried out, and on this basis, a transnational strategy will be developed.
Hungary has a long history of geothermal energy use, which mainly focus on hydrothermal heat recovery. Because of the past oil and gas exploration activity nearly 2000 deep wells already being remediated or abandoned, and almost 8000 currently in hydrocarbon production in Hungary. As a result of previous oil and gas exploration activities, nearly 2,000 deep wells have already been remediated or abandoned, and nearly 8,000 hydrocarbon wells are in production in Hungary. Reuse of these wells in hydrothermal projects could result in significant cost reductions as they do not need to be abandoned and new wells do not need to be drilled for geothermal purposes. The presentation aims to showcase the Hungarian experience in addition to the general project overview.

Keyword

Transgeo, hydrothermal, abandoned oil and gas well, reuse

Hydrochemical features of geothermal waters in the Namaqua-Natal Province, South Africa

Musarrat SAFI[1]*, Council for Geoscience (musarratsafi@gmail.com)
David Ngobeni[2], Council for Geoscience
Senzangakhona Ndumo[3], Council for Geoscience

Abstract

Geothermal energy is under-explored in South Africa, however the Council for Geoscience has initiated exploring the potential of geothermal energy in South Africa. This study investigated the geology, geophysics, hydrochemical (major ions) and stable water isotopes of Shu Shu in the Namaqua-Natal Province, South Africa. This study aimed to locate the reservoir and its conduits, focusing on the geothermal flow (such as recharge zones, upwelling zones, and outflow plumes) and identify the nature of the resource fluids.

The geology of the area was mapped, which gave a better understanding of the structural controls. The geothermal waters were tested for their physical properties (temperature, pH, total electrical conductivity and salinity (sal)) and sampled for ions (HCO3, Cl, SO4, Na, Ca, Mg, K, and Fe, SiO2) and stable isotopes. The ions were analysed using an induced coupled plasma-optical emission spectrometer. Oxygen-18, deuterium, and tritium were analysed using an isotope ratio mass spectrometer and laser water isotope analyser. Magnetotelluric and gravity surveys were conducted at Shu Shu to investigate the circulation depths of the geothermal waters.

The results indicated that the geothermal waters ascended to the surface via fractures and a thrust fault (trending N-S) separating the various thrust sheets in the area. The constant water flow is mainly related to a fracture network connected to a recharge source indicative of no interference at the source (either from abstraction or severe drought).

Furthermore, Shu Shu geothermal water surfaces on the banks of the Tugela River at 50.5 °C, 1452 µs/cm (electrical conductivity), classified as Na-Cl-type water. This signature may represent either deep saline fluids or central upflow zones of the liquid-dominated hydrothermal system.

By integrating the geology of Shu Shu, the hydrochemistry of the geothermal water samples, and geophysics surveys, the conceptual model revealed that the geothermal source is located at a depth of 1500- 2200 m and heated to ~106-159 °C. From this investigation, the data suggests that this area in Namaqua-Natal Province has the potential to harness geothermal energy.

Keyword

Hydrochemistry, geology, geothermal waters

Fracture-matrix interactions of deep geological systems in the context of energy geosciences and carbon management

Qinhong Hu[1]*, China University of Petroleum (East China) (huqinhong@upc.edu.cn)

Abstract

The cost-effective development of shale petroleum and enhanced geothermal systems (EGS) involves hydraulic fracturing of deep (several thousands of meters below the surface) shale (for oil and gas) and granite (for geothermal energy) formations to create stimulated fracture networks for a sufficient flow of petroleum molecules and hot water to the producing wellbores for an economic development of petroleum and heat. These are different from other fields of energy geosciences involved in the energy transition, such as carbon capture, utilization, and storage (CCUS) for minimizing carbon emissions, underground hydrogen storage for an emerging hydrogen energy economy, as well as deep geological repository of high-level nuclear wastes for further increasing the share of nuclear energy. These arenas commonly involve shallow (hundreds of meters) geological formations of sandstones, carbonates, salt rocks, and basalt with coupled reservoir-caprock systems for a large-volume storativity and injectivity in reservoirs/excavated structures as well as efficient sealing capabilities for caprocks to prevent inadvertent leakage or loss of stored supercritical CO2, H2, or high-level nuclear wastes; in addition, the presence of natural fractures is considered to be a negative factor for the desired storage/capping systems. Fractures, either naturally present or hydraulically stimulated, play an important role in regulating the production of petroleum and hot water in tight matrix of shale and granite, and fracture-matrix interaction with intertwined coupled thermal-hydraulic-mechanical-chemical (THMC) fields and processes dictates how mass (petroleum) and heat transfer/extraction can be sustained for shale petroleum system and EGS viable in the pathways to carbon neutrality.

Microscopic characteristics of porous matrix – pore shape, pore-size distribution, pore connectivity – influence macroscopic behavior of fluid flow and chemical transport, and can therefore affect the performance of deep geological systems with natural and hydraulically-stimulated fractures in their desired usage of either extracting or storing various forms of energy-related fluids. This work discusses various, and complementary, approaches to investigating pore structure (geometry and topology), and the resulting anomalous imbibition and diffusion for typical geological formations associated with energy geosciences. These experimental approaches include imbibition, tracer diffusion, porosimetry (mercury intrusion porosimetry, vapor absorption and capillary condensation, and nuclear magnetic resonance with cyroporometry), and imaging (Wood's metal impregnation, focused ion beam/SEM). Results show that the nm-sized pores, combined with low pore connectivity, lead to extremely low diffusion in tight matrix as measured using liquid diffusion and laser ablation-ICP-MS. Chemical diffusion in sparsely-connected pore spaces is not well described by classical Fickian behavior; anomalous behavior is suggested by percolation theory, and confirmed by results of imbibition tests from a sample/fracture face and imaging approaches. Our evolving complementary approaches, with each component method

having its unique advantages for a holistic understanding of how microscopic pore structure affects macroscopic fluid flow and chemical transport, provides a rich toolbox for tackling the fracture-matrix interactions involving several orders of difference in porosity and permeability.

Keyword

deep systems, carbon neutrality, preferential flow, mass transfter, pore connectivity

Optimal Selection and Development Plan Design for Buried Hill-Type Hot Dry Rock Targets in the Jiyang Depression

Shaozheng Wang[1]*, China University of Petroleum (East China) (wangshaozheng1105@163.com)
Yaoqi Zhou[2], China University of Petroleum (East China)

Abstract

The development and utilization of geothermal resources in China have primarily focused on shallow hydrothermal resources. The exploration and development technologies for deep geothermal resources are still in their infancy. Exploiting deep geothermal resources can enhance the proportion of renewable energy in the overall energy structure, improve the stability and diversity of the energy supply, enhance national energy security, and provide robust support for achieving the "carbon peak" and "carbon neutrality" goals. The buried hill zone in the Jiyang Depression of the Bohai Bay Basin possesses significant exploration potential for geothermal reserves. However, the hill-type hot dry rocks are deeply buried and have complex geological origins, and systematic studies on deep hot dry rocks in the Jiyang Depression are currently lacking. This paper utilizes 1:200,000 gravity data, 1:50,000 aeromagnetic data, drilling, and seismic exploration data, employing the Parker-Oldenburg inversion iteration algorithm, gravity-seismic joint stripping method, gravity and magnetic forward and inverse method, and magnetotelluric sounding method to interpret deep faults and buried hill uplifts that control the geothermal structures, establishing a conceptual model for the genesis of geothermal resources. Based on six indicators: Curie depth, Moho depth, geothermal gradient, reservoir lithology, cap rock thickness, and the scale of buried hills, five hot dry rock targets were optimally selected. For typical buried hill uplift targets within the depression, geological models of Ordovician hot dry rock reservoirs were constructed using Petrel and 3DGeoModeller software, and simulations were conducted with COMSOL software for different production and injection well distances, reinjection temperatures, production and injection volumes, and exploitation periods. The study reveals that the Jiyang Depression possesses a unique geothermal genesis characteristic of "crust-mantle endogenic heat, structure-controlled heat, buried hill heat storage, and cap rock insulation," forming a composite geothermal system in the basin with "conductive-type hot dry-hydrothermal coexistence, convective-type hydrothermal replenishment" as the main features. A checkerboard well pattern, a reinjection temperature of 20°C, a well spacing of 600m, and a production and injection intensity of 1500m3/d, constitute the optimal exploitation plan for a proposed 50-year extraction period. This has significant implications for efficiently developing buried hill-type hot dry rock geothermal resources.

Keyword

Jiyang Depression, Geothermal Resources, Hot Dry Rocks, Geological Modeling, Development Simulation

Feasibility analysis of thermal solar energy storage in heterogeneous deep aquifer

Yating W[1]*, 15735513435 (15735513435@163.com)
Xiaoguang W[2], 19102863595

Abstract

This study investigates the feasibility of utilizing ATES (aquifer thermal energy storage) for seasonal solar heat storage through geostatistical modeling and hydro-thermo coupling simulations.Storing solar energy underground as heat is a promising method for energy storage and conversion, with great potential to address the temporal and spatial mismatch between energy demand and supply. Thermal energy storage in deep aquifers can convert intermittent solar energy into stable high-temperature geothermal energy. In this study, a new solar energy storage and conversion system is proposed where solar energy is first converted into heat using parabolic troughs and then stored in deep aquifers through high-temperature hot water circulation. Geostatistical modeling and hydro-thermo coupling simulations are adopted to investigate the feasibility and efficiency of solar energy storage in deep aquifers.

The study area selected is the Xiongan region in northern China. The thermal source is a parabolic trough solar energy collection system, and the reservoir is situated within sandstone at a depth of 2000 meters underground. Utilizing current local meteorological data, the solar thermal collection system is modeled, providing precise hourly data input for the underground aquifer thermal energy storage system. This study is primarily dedicated to analyzing the thermal-hydraulic response of the aquifer storage system under various operational parameters. Specifically, the research analyzed how factors such as injection rate, well spacing, and reinjection temperature influence temperature distribution, temporal and spatial evolution, and storage efficiency. Simulation results indicate the critical importance of selecting appropriate system parameters to maximize heat recovery rates.These findings contribute to a deeper understanding of the mechanisms behind solar energy storage in deep aquifers and offer valuable insights for field applications.

Keyword

Thermal energy storage, solar energy, geothermal, hydro-thermo coupling, thermal solar systems

The potential for GigaWatt-Hour Subsurface Thermal Energy storage in Mine shafts

Zoe SHIPTON[1]*, University of Strathclyde (zoe.shipton@strath.ac.uk)
Neil Burnside[2], University of Strathclyde
Win Eng Ewe[3], University of Strathclyde
Jessica Dassow[4], University of Edinburgh
Graeme Flett[5], University of Strathclyde
Stephanie Flude[6], University of Strathclyde
Ian Molnar[7], University of Edinburgh
Indrani Mukherjee[8], University of Strathclyde
Paul Tuohy[9], University of Strathclyde
Huachuan Wang[10], University of Strathclyde
Shangtong Yang[11], University of Strathclyde

Abstract

We examine the use of abandoned mine shafts for interseasonal storage of curtailed wind energy in the form of heat. Surface engineered thermal stores are currently limited by size and the need for insulation, and the thermal storage opportunity within flooded mine shafts is substantial. As an example of the scale of the opportunity, in 2020, UK wind curtailment payments were £282M: enough to power 1.25 million homes: equivalent to £4 per MWh. If heat generated using curtailed wind can be safely stored in mines, then utilising 1% of UK mine entries could potentially provide heat for 10% of UK homes during a ‘worse case weather week’ (cold, still winter days, when heat demand is highest). This requires heating the shaft water to 55 degrees centigrade so that it can be used directly in heat pumps.

Here we examine the implications of raising the water temperature to 55 degrees and cycling the temperature within the shaft for: mineshaft stability, geochemical evolution of the water within the shaft, heat and water flow in the rock mass around the shaft. We also explore the wider energy system demands. Finally, we outline the experimental heat injection planned for 2024 at an abandoned mineshaft site in Scotland.

Keyword

energy storage, minewater, energy system

New understanding of Mesozoic-cenozoic tectonic features and geothermal potential evaluation in Weibei Basin

Xiaoxin SHI[1]*, CHINA UNIVERSITY OF PETROLEUM (b21010008@s.upc.edu.cn)
Yaoqi ZHOU[2], CHINA UNIVERSITY OF PETROLEUM

Abstract

This article analyzes the tectonic pattern of the Mesozoic-Cenozoic and evolution process in the Weibei Basin by reprocessing and interpreting seismic data, identifies the main stratigraphic interfaces and fault systems in the deep part of the Weibei Basin. Combined with the tectonic evolution history of the Tan-Lu Fault Zone, it is believed that the Mesozoic-Cenozoic in the Weibei Basin have different structural patterns. The tectonic pattern of the Mesozoic in the Weibei Basin is controlled by the northward extension of the activity of the Yi-Shu fault zone, which in the middle section of the Tan-Lu fault zone, and has the characteristic of "graben-horst interphase". The tectonic pattern of the Cenozoic is controlled by strike slip-extension, forming a dustpan shaped basin characterized by overlapped on the sourth, while the north, east, and west are faults. Weibei Basin is located in the eastern part of the North China Platform, with a high temperature background. Based on the geothermal data of the Weibei Basin and the research results on the restoration of ancient geothermal fields, it is proposed that Weibei Basin has a good condition for the formation of geothermal resources.The thermal source of Weibei basin mainly comes from the mantle, and the deep and large fault on the boundaries becomes the main channel for the thermal flux. The thick sediment layer of the Cenozoic Basin provides good preservation conditions for the formation of deep geothermal resources.The formation and distribution of geothermal resources in the Weibei Basin are closely related to the evolution of the geothermal field and the Tan-Lu Fault Zone, which is controlled by the activity of the Tan-Lu Fault Zone in the Mesozoic-Cenozoic and the Mesozoic tectonic pattern. The Zaohu fault nose zone in the eastern part of the Weibei Basin is located above the high part of the Mesozoic structure, close to the boundary fault, and is a favorable area for the formation of geothermal resources. The top limestone karst reservoir of the Ordovician is a favorable target for the exploration of hydrothermal geothermal resources,and its deep part has the possibility of forming HDR geothermal resources, and the amount of geothermal resources is estimated.

Keyword

Weibei Basin, Mesozoic-Cenozoic, Tectonic pattern, Hydrothermal geothermal resources, HDR

Characterizing geothermal heat pump system in relation to thermal property of different rocks by laboratory and field tests

Youngjin KIM[1]*, Daesung heatenersys Co.,Ltd (mkiss79@naver.com)
Hyoungchan Kim[2], Korea institute of Geoscience and Mineral Resources
Seyeong Hamm[3], Pusan National University

Abstract

For cooling and heating of homes and buildings, geothermal heat pump (GHP) system replaces fossil fuels and contributes to the reduction of CO_2 emission. In order to install GHP system, we should reflect and predict accurate rock characteristics. In this study, thermal conductivity measurements of several rock types in Korea by divided-bar method thermal response test (TRT) were conducted and the two methods were compared in terms of the measurement characteristics. In order to improve the efficiency of the existing GHP system, the measurement results of the divided-bar method were applied to the Ground Loop Design (GLD) program and the GLHEPro ver. 4.1.7 program. The relationship between thermal properties (thermal conductivity, thermal diffusivity, specific heat, and density) of the rocks was analyzed for designing geothermal heating and cooling system design. Thermal diffusivity values were estimated as 0.096 ~0.135 m2/day, the thermal conductivity values 2.5 to 3.5 W/mK, and the heat exchange length 6.4 to 7.8 km. The higher the thermal conductivity, the lower the thermal diffusivity. In the range of 0.096 to 0.135 m2/day of the thermal diffusivity, thermal conductivity values were between 2.5 and 3.5 W/mK and heat exchange lengths were between 6.4 and 7.8km. The higher the thermal conductivity, the lower the thermal diffusivity. In addition, the higher the thermal conductivity and the lower the thermal diffusivity, the shorter the heat exchange length. On the other hand, with the density of 0.80 mg/cm3 and thermal diffusivity of 0.096 ~ 0.135 m2/day, when the specific heat changes from 0.80 to 0.86 J/gK, the heat exchange length increases from 7.4 to 7.8 km. Therefore, as the thermal conductivity, density, and specific heat increase, the thermal diffusivity decreases; and the thermal diffusivity decreases, the heat exchange length decreases. Hence, reducing thermal diffusivity is an important factor for shortening heat exchange length.

Keyword

heatpump, geothermal, conductivity, thermal property, heat exchange

Toward Sustainable Development of Offshore Wind Power at Active Margins - Importance of Submarine Geohazard Risk Assessment-

Yasukuni Okubo[1]*, Geothermal Energy Research & Development Co., LTD. (yasu-okubo@jcom.home.ne.jp)
Yasukuni Okubo[2], Science Council of Japan

Abstract

Offshore wind power is attracting a lot of attention in Japan. The objective of Japan is to establish projects of 10 GW by 2030 and 30 GW - 45 GW by 2040. However, there are risks in development unique to Japan. The risks derive from the bathymetry in an island arc active margin, which greatly differs from the one in continental inactive margin such as Europe. Around Japan, most of the promising offshore areas shallower than 200 m lie within 50 km off the coastline. In case of 50 m or shallower water depth, the areas lie within 10 km off the coastline. Further, Japan is in severe meteorological and oceanographic conditions and prone to earthquakes. In this geographical context, in addition to storm surges and high waves, impacts of the external forces of earthquakes, tsunamis, and typhoons in the limited shallow seafloor areas near the coast are big. Therefore, there is a high possibility that geohazards will occur in the seafloor. These "submarine geohazard risks" include liquefaction caused by earthquakes, high waves and submarine landslides. It is known that liquefaction is also closely related to scouring. Here, we point out three issues, (1) Submarine geohazard risks-aware development, (2) Developing systematic guidelines for submarine geohazard risks, (3) Need for utilization of existing offshore geoscience data, human resource development, and industry-government-university collaboration. Since there is a possibility that submarine geohazards may occur, we need to recognize such submarine geohazard risks toward sustainable development. In order to ensure full-scale development and stable operation in the future, it is urgent to develop systematic guidelines regarding submarine geohazard risks through collaboration of industry-government-university including experts. Promoting use of the existing data and improving the data sets by industry-government-university collaboration leads to efficient survey and additional investigation planning and activating technological development and human resource development. To this end, it is desirable to promote open access of submarine data and to establish a platform for open discussion. Accordingly, Japan can improve her status by enhancing international human resource development.

Keyword

offshore, renewable energy, wind power, geohazard, active margin

[Keynote] Submarine Geohazards Resistant Design Concept for Anchors and Cables of Floating Offshore Wind

Shinji Sassa[1]*, National Institute of Maritime, Port and Aviation Technology (sassa@p.mpat.go.jp)

Abstract

The offshore renewable energy systems are subjected to diverse forms of submarine geohazard risks, such as seabed liquefaction induced by earthquakes and ocean waves and associated large-scale sediment flows and submarine landslides. Amid global climate change, the ocean wave conditions are becoming more severe along more than half of the world's coasts. This fact makes floating offshore wind facilities that are installed in relatively deep waters compared with the bottom-fixed offshore wind facilities more susceptible to liquefaction under both earthquakes and severe ocean waves. Based on the state-of-the-art understanding of the seabed liquefaction-induced impact on coastal and offshore infrastructures, this paper presents a novel submarine geohazards-resistant design concept for anchors and cables of floating offshore wind. Seabed liquefaction governs the fate of floating or sinking of a structure resting in the seabed. Namely, under conditions where the overall density of a structure is lower than the mass density of a liquefied seabed ground, the structure floats up, whereas under conditions where the overall density of a structure is higher than the mass density of a liquefied seabed ground, the structure sinks into the liquefied seabed. In the case of the latter, the structure may settle into the seabed ground in association with the liquefaction and scour. A range of the field and experimental evidence show that pipeline floatation is closely linked with the seabed liquefaction. Our recent centrifuge test results demonstrate that the sinking and flotation of a pipeline and a cable is controlled by the relationship between the overall density of a structure and the mass density of a liquefied soil. The corresponding structure-liquefied soil density ratio equal to unity serves as an index value below which floating takes place and above which sinking ensues. Another recent finding from our field observation and experiments show that seabed liquefaction governs the fate of floatation, sinking and burial of a living organism in the seabed. Under conditions where the body density of a living organism is lower than the mass density of a liquefied ground, the benthic organism floats up, whereas under conditions where the body density of a living organism is higher than the mass density of a liquefied ground, the benthic organism sinks deep into the liquefied seabed. Accordingly, the living organism body density-liquefied soil density relationship determines the floatation with the associated transport and burial of the living organism during liquefaction. These results give rise to a novel design concept of the mitigation measures for such submarine geohazard risks-resistant anchors and cables that takes account of the relationship between the anchor/cable body density and the mass density of a liquefied soil. Importantly, the stability of a floating offshore wind can be kept continuously during the seabed liquefaction by preventing floatation, burial and settlement of the anchors and cables while keeping essentially the same depth in the ground. This also ensures a higher horizontally-moving resistance force for the anchors and cables owing to the higher mass density of the liquefied seabed ground than the

ambient fluid against submarine landslides.

Keyword

Liquefaction, Floating Offshore Wind, Anchors and Cables, Design, Submarine Geohazards

Numerical simulation of the flow impact due to submarine landslide exerting on offshore wind turbines with a monopile type foundation

Kazuki MURATA[1]*, Port and Airport Research Institute, Japan (murata-ka@p.mpat.go.jp)
Shinji SASSA[2], Port and Airport Research Institute, Japan
Yasuhiro AIDA[3], Department of Oceanic Architecture and Engineering, College of Science and Technology, Nihon University
Tomoki IKOMA[4], Department of Oceanic Architecture and Engineering, College of Science and Technology, Nihon University

Abstract

Submarine landslide flow or liquefaction phenomena around coastal zones due to earthquakes and ocean waves can cause damage and failure of oceanic structures, breaking of the mooring chain of floating facilities, a collision between vessels, and scour of surrounding seabed. However, the corresponding detailed processes need to be sufficiently examined and evaluated. An understanding based on model experiments of the full spectrum of physical behaviour and dynamics could be very costly. Here, we take a numerical simulation approach to reproduce such phenomena.

The authors focus on the MPS particle method, which is one of the particle simulation methods developed by Koshizuka et al. (1999), and evaluate the applicability of its two-phase flow model to submarine landslide phenomena through the reproduction calculations of past model experiments. Then, we study the basic characteristics of impact pressure acting on offshore wind turbines with a monopile type foundation caused by submarine landslides that manifest in coastal areas. The results show that the high-density fluid model of the MPS can qualitatively reproduce the submarine landslide phenomenon up to a flow distance of 50m in the case of pure sand. This presentation highlights a significant effect of submarine landslide flow occurring in coastal or marine areas around a shallow-water-depth-installed monopile type foundation.

Keyword

Submarine landslides, Particle method, Offshore wind turbine, Geohazardrisk

Wave-Induced Liquefaction and the Stability of Offshore Structures in Seabed Soils in a Drum Centrifuge

JUNJI MIYAMOTO[1]*, TOYO CONSTRUCTION CO., LTD. (miyamoto-junji13@toyo-const.co.jp)
SHINJI SASSA[2], National Institute of Maritime, Port and Aviation Technology

Abstract

Wave-induced liquefaction of seabed soils is an increasingly important research subject concerning the stability of offshore wind farms, offshore platforms, submarine power cables or other such facilities. This study explores the relationships between wave-induced liquefaction in sand beds and the initiation and progress of instability of marine structures such as pipelines, monopiles, and suction buckets under severe wave loading, based on centrifuge modelling. Centrifuge wave tests in a drum channel were performed with viscous scaling introduced such that the time-scaling laws for fluid wave propagation and consolidation of the soil were matched.

The experimental results showed that the instability of the structures is attributed to the occurrence and progress of liquefaction of the sand bed around the structures. Under severe wave conditions, liquefaction occurred at shallow soil depth in the loose sand beds, and the liquefied zone propagated downwards in the course of wave loading. In the study of pipeline stability, upon the occurrence of liquefaction at a shallow soil depth, the buried pipe started moving upwards and the motion of the pipe increased markedly in association with the downward progress of liquefaction during wave loading. Similarly, in the cases of a monopile and a suction bucket, they started significant structural rocking, when liquefaction occurred and progressed downward to a certain depth. The residual displacement of the structures increased markedly with the downward progress of the liquefied zone, eventually leading to their collapse.

The effects of a gravel layer replacement over a sand bed on countermeasure against wave-induced liquefaction are also discussed. Specifically, the scour protection with gravel replacement around the monopile was used for countermeasures against wave-induced liquefaction leading to the pile instability. The experimental results showed that the scour protection increased liquefaction resistance, depending on the diameter ratios of the scour protection and the pile, however, it could not prevent the collapse of the monopile once liquefaction occurred.

Overall, we present several valuable insights into the complex interactions between wave, seabed, and structures, shedding light on the characteristics of the instability and mitigation strategies for marine structures such as buried pipes, monopiles, and suction bucket foundations relevant to offshore renewable energy systems in the context of wave-induced liquefaction.

Keyword

Wave-Induced Liquefaction, Centrifuge Modelling, Marine Structures

Assessment of Submarine Geological Risks to Offshore Wind Power in Japan Coastal Areas

Koki KIMURA[1]*, Kiso-Jiban Consultants Co., Ltd. (kimura.koki@kiso.co.jp)
Hideo NOMURA[2], Kiso-Jiban Consultants Co., Ltd.
Kiichiro KAWAMURA[3], Graduate School of Science and Technology for Innovation, Yamaguchi University, Yamaguchi, Japan

Abstract

In recent years, offshore wind power is rapidly gaining momentum for development in the coastal areas of Japan. Foundations, anchors, and power cables of offshore wind farms are installed on the seabed, in which various geohazards exist. Therefore, it is important to identify geohazards and assess the geological risks relevant to the seabed for the development of offshore wind power. As Japan is in an active margin and seismically active regions, and the seabed in the coastal areas of Japan is characterized by steep topography, it is necessary to identify hazards specific to Japan's waters and evaluate the risks.

Potential submarine geohazards in Japan include: shallow gas, submarine landslides, active faults, submarine dunes and sand waves, gravity flows and their deposits, channels, mud volcanoes, tsunamis due to sector collapse, volcanic tsunamis, creep, submarine fans, old river channels and buried valleys, liquefaction, soft soil layers, deltas, tidal currents, etc. Amongst them, this paper focuses on five of the most influential geohazards and discusses their effects on wind turbines and cables, as well as the methodology used to identify the geohazards. In addition, examples of geohazards that have actually appeared in the coastal areas of Japan are presented.

Furthermore, this paper reports the methodology established to assess the geological risks for the development of offshore wind power that coexists with geohazards.

Keyword

Submarine Geohazard, Offshore Wind Power, Geological Risk, Active Margin

Seismic characteristics of Changyun Rise western offshore central Taiwan (eastern Taiwan strait) and their possible connections to Late Pleistocene - present Choshui River system

Yi Hao WANG[1]*, Institute of Oceanography, National Taiwan University (r11241309@ntu.edu.tw)
Jih-Hsin Chang[2], Institute of Oceanography, National Taiwan University

Abstract

In last decade, the seafloor bathymetry and geology of the western offshore central Taiwan (eastern Taiwan Strait) has been substantially surveyed because it has been considered one of the best sites for offshore wind power development in the world. A large amount of geophysical data has been collected especially high-resolution reflection seismic data (Sparker) for shallow part of sedimentary layers and stratigraphy. Presumably they are very likely to be landward linked to Late Pleistocene-present depositional system of the alluvial river (i.e., Choshui River, the largest river drainage system in western central Taiwan). In this study, we revisited the characteristics and structures revealed from selected sparker profiles and explored the possible relationships between submarine and terrestrial depositional systems. Major bathymetric feature offshore central Taiwan is Changyun Rise, which is composed of nearshore area, eastern swale, eastern Changyun Ridge, western swale, and western Changyun Shoal from east to west. In nearshore area, bathymetry is generally shallow (< 30m) and is dipping seaward, and the sparker profiles is mainly dominated by seaward dipping reflectors overlying on poorly continuous reflectors. Seawards, seafloor in eastern swale become being dominated by sandwaves overlying the poorly continuous reflectors. Further seawards, the bathymetry in eastern Changyun Ridge is distinct with layered, low amplitude, and gently dipping reflectors. Further west, the bathymetry and seismic features of western swale reflectors is very similar to those of eastern swale. The westernmost part of Changyun Rise is western Changyun Shoal. It is predominated by sandwave and most reflectors beneath sandwaves are generally indistinct. Only at the westernmost end of the Changyun Shoal we can recognize dipping reflectors. Consider that dipping reflectors and underlying poorly continuous reflectors are widespread outward of the Choshui River system in eastern Taiwan Strait, we propose that they most likely represents the distal clinoforms of the Choshui River system developed in response to various sedimentary processes during the Last Glacial Period.

Keyword

Changyun Rise, Choshui River, Sparker seismic, Taiwan Strait

Thermolithospheric Model (THERMOMAG) to Curie Isotherm Calculations

Suze Nei Pereira GUIMARAES[1]*, Federal Rural of Rio de Janeiro University
(suzeguimaraes@ufrrj.br)
Beatriz Lessa[2], National Observatory
Fábio Pinto Vieira[3], National Observatory

Abstract

The variation in temperature and pressure deep within the Earth's lithosphere directly affects a wide variety of rock properties and your physical processes. Performing a correlation of crustal thermal modeling from the analysis of the deep temperature can bring valued insights about the variation of temperatures at depth and magnetic petrology. In this work, we present a THERMOMAG thermolithospheric model, which is a method of geothermal investigation in the magnetizable crust, thus delimiting the Curie isotherm.

Two geothermal parameters related to the rock interfere directly in the 1D crustal thermal modeling, considering the steady state of heat transfer by conduction: the thermal conductivity (λ) and the radiogenic heat production rate (A) in the crustal layers. Considering a variation rate in these two parameters, the geothermal model of crustal temperature distribution becomes more significant in the geothermal gradient analysis.

The use of Curie depth from the spectral analysis of anomalous magnetic field data, considering the bottom of layers from deeper sources, as being the magnetic boundary of the crust, can to complementary the analysis of the crustal thermal distribution in a indirect way. Basing in the inclinations of the amplitude spectrum (fitting straight lines) and in the use of the combined filtering technique to verify the results of the spectral depth calculations and thus minimize errors.

Thus, the THERMOMAG thermos-lithospheric model is based on a cross-checking of geothermal and magnetometric Curie depth results. This check is carried out in each analysis cell, considering its geotectonic context. A thermomagnetic correction factor (β) is introduced for an improved approximation of the Curie isotherm depth results obtained indirectly. Thus (β) is adjusted for different geotectonic contexts, taking into account the geostructural provinces to which they were related. Therefore, the Curie isotherm data, corresponding to temperature of magnetization from magnetite (Fe3O4 - 580oC), which can be related to the magnetic basement in the lower crust can be determined by the Curie depth acquired through the spectral analysis of the aeromagnetometric data corrected by the thermomag factor acquired through the cross- check of direct measurements (geothermal) of crustal temperature. Future perspectives aim to improve the windowing in the spectral analysis of magnetometric data for the calculation of subsurface layers and to improve the script of this model encompassing the thermomagnetic correction factor adjusted to each geological context by new acquisitions of direct temperature data.

Keyword

Curie isotherm, geothermal gradient, magnetometry, thermolithospheric model, crust magnetized layer

Significance of Strong Amplitude Reflectors Observed in Geothermal Areas for Deep Geothermal Resource Exploration

Jun MATSUSHIMA[1]*, The University of Tokyo (jun-matsushima@edu.k.u-tokyo.ac.jp)

Abstract

Seismic reflection surveying technology has evolved in the background of oil and natural gas exploration and is predominantly utilized in the field of elastic wave exploration. This method not only provides the highest-resolution underground structural information but also offers diverse characteristics of subsurface properties. However, when applying this technology primarily designed for sedimentary basins (stratigraphic structures) to geothermal zones mainly composed of volcanic rocks, its applicability is often questioned due to its lower effectiveness. This is partly because the layers constituting geothermal zones are heterogeneous rather than stratified, causing elastic waves to scatter, resulting in poor reflection waves being observed. Despite its less-than-optimal applicability compared to oil exploration, seismic exploration in geothermal zones has shown effectiveness in several aspects, one of which is observing strong amplitude reflectors. Fracture systems are characterized as low-velocity zones in elastic terms; thus, as fractures develop, the acoustic impedance in these systems decreases, leading to a significant contrast in acoustic impedance with surrounding layers. As a result, strong amplitude reflection waves are produced, making them easier to detect. Such strong amplitude events may suggest the presence of fracture systems. Furthermore, there are examples of strong amplitude reflection surfaces being observed at depths of several kilometers in geothermal zones, first discovered in Italy's Larderello-Travale geothermal area and also observed in the country's Amiata volcano-geothermal zone. Various discussions have been conducted on the causes of these strong amplitude reflectors, including theories involving critical fluid-containing fracture systems and brittle-ductile transition zones accompanied by high-pressure fluids. In any case, these strong amplitude reflectors at deep levels may serve as indicators for the development of deep geothermal resources. This presentation comprehensively introduces cases of strong amplitude reflection surfaces in geothermal zones and discusses the significance of observing these surfaces.

Keyword

Deep geothermal resource, Seismic reflection survey, Strong amplitude reflector

DEVELOPMENT OF THE RENEWABLE GEOTHERMAL ENERGY IN UZBEKISTAN

Elena Aleksandrovna GOLOVKO[1]*, Ministry of Mining Industry and Geology of the Republic of Uzbekistan (sidorovaelena87@gmail.com)
Irina Petrovna Sidorova[2], Institute Geological and Geophysics
Rasuljon Isomodinovich Sakhobidinov[3], Institute Geological and Geophysics

Abstract

Uzbekistan is among those states that have already achieved energy independence. The country's sources of electricity generation are natural gas and oil products. Geothermal energy, being a renewable energy source, can become an alternative to hydrocarbon resources, which will undoubtedly contribute to strengthening the energy security of the country in providing electricity, heat supply and drinking water to the population living in settlements remote from the central energy supply. Geothermal energy is the only source of carbon-free electricity that is both renewable and capable of delivering variable baseload power at the scale needed for the Uzbekistan energy transition. Preliminary studies already have been carried out. Following a multidisciplinary approach, it is necessary to carry out geological and geophysical studies of the selected areas with anomalous Heat Flow. The stage Exploration includes several research sub-stages:

1. Geological exploration;
2. Geophysical subsurface;
3. Pre-feasibility study.

The conductive anomalies that we have identified in the Earth's crust are associated with deep, weakened permeable zones, which provide increased heat and mass transfer. The use of a complex of geophysical methods in the exploration of the construction site and operation of the reservoir can significantly reduce the cost of deep heat resources and make petrothermal energy competitive compared to traditional energy.

Based on the results obtained, a 3D model of the Muruntau area with the geothermal station with a new settlement was built. This is practically very important, since the of the Muruntau quarry expansion is planned to the north-west and the old village needs to be removed. As a result of complex geophysical studies the places of optimal laying of geothermal wells and, accordingly, the construction of a geothermal station to provide the new village with electricity were identified. At the last years geothermal investigations were been carried out on the World Bank project REP-1/5 “Development of the renewable geothermal energy in Uzbekistan”.

Keyword

geothermal energy, geophysical subsurface, hydrocarbon resources, Uzbekistan, energy independence

Porous media heat transport experiments reveal local thermal non-equilibrium (LTNE) and non-uniform flow

Haegyeong LEE[1]*, Institute of Applied Geosciences (AGW), Karlsruhe Institute of Technology (KIT) (haegyeong.lee@kit.edu)
Manuel Gossler[2], SWM Services GmbH, Munich, Germany
Kai Zosseder[3], Chair of Hydrogeology, Technical University of Munich, Munich, Germany
Philipp Blum[4], Institute of Applied Geosciences (AGW), Karlsruhe Institute of Technology (KIT), Karlsruhe, Germany
Peter Bayer[5], Martin Luther University of Halle-Wittenberg, Department of Applied Geology, Halle, Germany
Gabriel C. Rau[6], School of Environmental and Life Sciences, The University of Newcastle, Callaghan, Australia

Abstract

Heat transport in sedimentary aquifers has drawn attention for various applications in Earth Sciences, especially for sustainable geothermal system design and hydraulic property characterization of aquifers. Heat propagation in porous media is commonly described, assuming a simplification of the heat transfer mechanism between fluid and solid phases termed as local thermal equilibrium (LTE). While previous studies have illustrated that local thermal non-equilibrium (LTNE) may be present in the context of water flow through porous aquifers, experimental data is still lacking. To investigate LTNE effects, we conducted systematic flow-through experiments with temperature sensors inserted in different sized glass spheres (5 to 30 mm diameter) for solid temperature and sensors placed on the outside to measure the fluid temperature. Temperature breakthrough curves in response to steady-state flow with different seepage velocities from 9 to 61 m/d and a temperature step input were measured. Experimental results demonstrated stronger LTNE effects with increasing flow velocities and grain sizes. Crucially, the experiments also exhibited significant non-uniform flow which impeded investigation of subtle LTNE effects. The experimental data was therefore analyzed using a 2D numerical model to explore the impact of the heat transfer coefficient on LTNE in the presence of non-uniform flow. Integrating non-uniform flow into the model revealed the magnitude and nature of LTNE effects. These findings will contribute to the understanding of heat transport mechanisms in natural porous media and their relation to heat transfer coefficient and non-uniform flow.

Keyword

Heat transport, Local thermal equilibrium, Local thermal non-equilibrium, Laboratory experiment, Non-uniform flow

Experimental investigation of formation damage potential during thermal water reinjection on Upper Miocene (Pannonian) sandstones from Szentes geothermal field, Hungary

Péter János KORONCZ[1]*, Doctoral School of Earth Sciences, University of Pécs
(pkoroncz@gamma.ttk.pte.hu)
János Kovács[2], Department of Geology and Meteorology, University of Pécs
Eszter Keresztény-Borbás[3], Doctoral School of Earth Sciences, University of Pécs
Ferenc Fedor[4], Department of Geology and Meteorology, University of Pécs

Abstract

Late Miocene sandstone formations in Hungary has been utilized for thermal water production for almost 150 years. Due to the intensive water production, pressure drawdown has increased in the geothermal systems. Although sustainable utilization would require the reinjection of cooled geothermal brine into the host formation, most of the geothermal sites suffer from reinjection issues. Despite of the high amount of production wells, formation damage processes during reinjection are less investigated and understood earlier.

To understand the link between formation damage mechanism and rock textural characteristics is crucial for a long-term water reinjection design.

In this study, it is aimed to characterize late Miocene friable sandstone reservoirs from Szentes geothermal field and investigate the formation damage potential of these formations.

Petrophysical interpretation of core data (porosity, permeability ultrasonic velocity, pore throat size distribution) was used to describe the physical properties of these reservoir sandstones. Grain size distribution, petrographycal thin section analysis and scanning electron microscope imaging were used to investigate textural and pore scale features (authigenic clay minerals) that can affect the permeability during the reinjection.

Laboratory core flooding experiments were performed on sandstone samples at reservoir conditions. The aim of these tests was the investigation of pore-clogging phenomena and subject long-term rock-water interaction.

Keyword

formation damage, water reinjection, core flooding, Szentes geothermal field

Study of seasonal characteristics of near-surface geo-temperature obtained by long-term monitoring in Japan

Osamu MATSUBAYASHI[1]*, A.I.S.T. , Japan (o_matsubayashi@hotmail.com)
Hideki Hamamoto[2], Center for Environmental Science in Saitama

Abstract

The goal of our study is to help improve the performance of thermal energy utilization systems using ground source heat pump, by closely looking at near-surface geo-temperature changes as an environmental controlling factor for the energy extraction. Geothermal specialists including the present authors have jointly started to make long-term monitoring of 1m-depth geo-temperature at different sites in Japan (Ehara et al., 2021), and they have acquired data set of near-surface geo-temperature over a period up to 10 years. The initial purpose was to confirm the effect of global warming and/or heat island phenomena by the geo-temperature observations, while the high-frequency components should be attenuated and their daily change component automatically vanishes, in particular.

It is generally considered that the yearly change of near-surface geo-temperature may be explained by a sinusoidal periodicity basically (ex. Miyazaki, 2023). But we have a view that more detailed investigations could reveal some fundamental differences of the heat transfer mechanism which governs seasonal characteristics of near-surface geo-temperature among the seasons. In this work we divide our time-series data into four seasonal segments, i.e., spring, summer, fall and winter, to evaluate the relative intensity of different modes of heat transfer mechanism at/near the earth's surface for each of the segments. In spring and summer geo-temperature has a rising trend with time, whereas in fall and winter it has a falling trend, as we anticipated. But, those two trends are not symmetrical at all, as we found in this study.

So, we have compiled the season-average values of 1m-depth geo-temperature for consecutive years at our observation sites in Kanto Area, Japan, and found that the year-to-year variations in "summer" for most of the sites have a smaller standard deviation value comparing with other seasons. We interpret that this is caused by the effect of high bulk heat capacity in "summer" due to the contribution of enhanced latent heat by the presence of water on/near the ground surface. On the other hand, the ground surface is very dry in "winter" period, so that bulk heat capacity of the ground surface is generally substantially smaller than in "summer". The fact which we have found would help evaluate the near-surface geo-temperature behavior, especially when some practical geo-heat extraction systems with ground source heat pump are applied to a real field.

Keyword

geo-temperature, 1m-depth, long-term, monitoring, seasonal characteristics

Application of play fairway analysis to identifying geothermal prospect areas in Sulawesi Island, Indonesia

Angga Bakti PRATAMA[1]*, Kyoto University (angga.pratama.84k@st.kyoto-u.ac.jp)
Katsuaki KOIKE[2], Kyoto University
Heru Berian PRATAMA[3], Kyoto University

Abstract

Numerous geothermal prospects exist in the Sulawesi Islands due to a variety of geological factors, plate subduction, seismic activity, and volcanic activity. However, development of the geothermal areas priority needs to be selected to acquire an effective and efficient development. This study aims to improve the accuracy and dependability of geothermal resource delineation using a Play Fairway Analysis (PFA) to identify areas suitable for geothermal resource development. This technique quantitatively assesses geothermal resources using geological data (surface geothermal manifestations, active faults, earthquakes, and volcanoes) combined with geophysical data, environmental-governance data, and expert judgment. In addition, potential heat source-related zones are estimated using data on surface manifestations and volcano locations. These heat source data are then combined with gravity and magnetic data to validate each other. The distributions of active faults and hypocenters detect the possibility of permeable zones that act as ascent fluid pathways. To provide factual identification of geothermal resources for development, the national parks and local government development plans were also considered. Furthermore, all the input data is integrated by normalization and weighting process. Finally, the highest potential areas are defined by high probability anomaly founded along the faults which located closed to the volcano and surface manifestation.

Keyword

Play Fairway Analysis, Geothermal resource, Data integration, Heat source, Permeability

Incorporating Mineral Compositions in Shallow Wells into Multicomponent Geothermometer to Improve Reservoir Temperature Estimation in the Patuha Field, Indonesia

Brenda Ariesty Kusumasari[1]*, Kyoto University (brenda.kusumasari.e12@kyoto-u.jp)
Koki Kashiwaya[2], Kyoto University
Yohei Tada[3], Kyoto University
Koike Katsuaki[4], Kyoto University

Abstract

Geothermometry is known for determining reservoir temperature based on the following presumptions: (1) the fluid-mineral reaction reaches equilibrium, and (2) the fluid composition remains unchanged by near-surface reactions, mixing, or dilution. Restrictions on using geothermometry arise due to the constant occurrence of near-surface interactions, mixing, and dilution. This study aims to clarify the effectiveness of multicomponent geothermometry that considers potential surface processes for accurately estimating reservoir temperature. This technique uses a complete chemical study of water to estimate reservoir temperature more accurately. An evaluation technique for mineral selection is applied, aiming to achieve a more accurate estimation of reservoir temperature. One of the few vapor-dominated geothermal systems is the Patuha Geothermal Field (PGF) in West Java Province, Indonesia. The initial temperature value ranging from 180-260°C was obtained using basic multicomponent geothermometry computing, which automatically selects minerals assemblage from the thermodynamic database. This study later found that some of the automatically chosen minerals were not the best representative minerals. Therefore, minerals are manually selected and identified from the shallow wells at two points within the research area to evaluate the basic computing result. After this, the process demonstrates that quartz, andesine, albite, pyroxene, and muscovite are superior mineralogical assemblages. Using multicomponent geothermometry simulation, the reservoir temperature for the research region is estimated to be around 210°C. The comparable outcomes of solute and multicomponent geothermometry imply that both techniques can enhance one another rather than work against one another to produce a reservoir temperature estimate of the highest caliber.

Keyword

Reservoir, Geothermometry, Mineral

The role of the upper crustal thermal structure in defining the global Golden Zone of hydrocarbons

Carlos Alberto Alberto Vargas[1]*, Universidad Nacional de Colombia (cavargasj@unal.edu.co)
Alejandra J. Angulo[2], Universidad Nacional de Colombia

Abstract

This study focuses on identifying hydrocarbon accumulation patterns of economic significance through the analysis of sedimentary sequences situated within a thermal range of 60 to 120°C, referred to as the "Golden Zone." Within this zone, there exists a conducive environment for the coexistence of petroleum system elements with minimal degradation or transformation of hydrocarbons generated from source rocks, particularly in the hydrocarbon expulsion zone ranging from approximately 120 to 200°C. To facilitate the delineation of regions with relevant hydrocarbon potential, we have developed global distribution maps of the Golden Zone. These maps are derived from a global geothermal gradient model, utilizing the Curie Point Depth (CPD) distribution, which is constrained by direct well temperature measurements, alongside a comprehensive model of sedimentary thicknesses compiled from data provided by various institutions. Our findings reveal significant variations in the distribution of the Golden Zone across different geotectonic settings. Depth intervals for the Golden Zone range from 500 to 3000 meters at the top and from 1000 to 5000 meters at the base, with thicknesses spanning from 5 to 3000 meters. Along active tectonic margins, sedimentary sequences tend to be thin, often displaying abrupt contrasts with the basement, and where one or both isotherms defining the Golden Zone lie beneath the basins, hindering optimal development. However, exceptions to this trend are observed in forelands and certain intermountain basins. In contrast, passive margins exhibit Golden Zone regions characterized by a wide range of sedimentary sequence thicknesses within basins of varying ages and extensions. This comprehensive mapping and analysis of the Golden Zone contribute valuable insights into hydrocarbon prospecting efforts, aiding in the identification of regions with significant economic potential for future exploration and development endeavors.

Keyword

Curie Point Depth, Golden Zone, Hydrocarbons, Geothermal Gradient Map, Global Distribution

Turning point of geothermal resources development in the world

Yasukuni Okubo[1]*, Geothermal Energy Research & Development Co., LTD. (yasu-okubo@jcom.home.ne.jp)

Abstract

In descending order of geothermal installed capacity, the countries are US, Indonesia, Philippines, Turkey, New Zealand, Kenya, Mexico, Italy, Iceland, and Japan. Among these, Indonesia, Turkey and Kenya have been growing rapidly since 2010. In other countries, the growth in installed capacity has been slow. In particular, Japan is in a decline. The reasons are that it is difficult to develop a power plant in a national park and that there is a conflict with “Onsen”, a traditional tourism industry. Since the oil crisis in the 1970s, Japan has been promoting geothermal development. At the beginning, the potential was assessed using Curie point depth analysis. Following the success the Curie point depth analysis has become widely used around the world. Now Japan, to break away from stagnation, once again performs the Curie point depth analysis in order to develop a new type of power generation using supercritical CO2 and supercritical water. In the Kakkonda geothermal area, a strong reflector was discovered by seismic survey. A similar strong reflector was discovered at Larderello, Italy. Both are interpreted as an aggregation of fractures, where supercritical water resides. In non-volcanic countries such as Germany, which has begun geothermal power generation since 2000, binary cycle power generation is being actively developed, and its installed capacity is rapidly increasing. In Kenya, a large-scale geothermal power plant is developed in a national park where many natural animals live. As well as in Iceland, geothermal resources in Kenya are located on the divergent plate boundary. As geothermal resources are abundant, so further development is expected in the future. Surplus geothermal water and CO2 from geothermal wells are also used to grow flowers in greenhouses. This is a show case of integration of power generation, tourism and agriculture. Geothermal resource development faces a turning point. Going forward, we need to study the rapidly growing country, to develop new technologies, to utilize low-temperature hot water for binary cycle power generation and to promote integration with other industries such as tourism and agriculture.

Keyword

geothermal power plant, Supercritical CO2, strong reflector, kenya, Japan

Underground Resources and their Uses in the Energy Transition: Hydrocarbon exploration, geothermal energy, and natural gas, CO2 and H2 storage in the Polish Basin as a part of the Central European Permian–Mesozoic Basins.

JAROSLAW ZACHARSKI[1]*, Polish Geological Institute - National Research Institute (jzach@pgi.gov.pl)
ADAM WÓJCICKI[2], Polish Geological Institute - National Research Institute
RAFAŁ LASKOWICZ[3], Polish Geological Institute - National Research Institute
HUBERT KIERSNOWSKI[4], Polish Geological Institute - National Research Institute
MARIUSZ SOCHA[5], Polish Geological Institute - National Research Institute

Abstract

The European Union member states have adopted strategies to address climate change, including a gradual energy transition achieved by decreasing the share of fossil fuels to reduce manmade CO2 emissions. Such strategies promote the use of renewable energy sources (including geothermal energy) and natural gas as a low-carbon fossil fuel, as well as implementing CO2 and H2 storage (CCS/CCUS). Natural gas is also considered a source of blue hydrogen. In Poland, activities connected with the energy transition form part of government strategies and of geological and mining law, under which a framework for industrial-scale natural gas, CO2, and H2 storage is being implemented. It is also intended to serve the development of projects using geothermal energy. To fully utilise the available resources and storage potential, the studied area must be properly identified in terms of its geological structure, surface infrastructure, transmission pipelines, CO2 emission sources, social aspects, and environmental protection.

Poland currently has ten underground storage facilities, nine of which are used to store natural gas (working gas capacity: 3 bcm) and one used to store crude oil and other petroleum products. Seven were built using depleted hydrocarbon reservoirs and three in salt caverns.

In recent years, the Polish Geological Institute – National Research Institute (PGI-NRI) has conducted, coordinated, and participated in domestic and international research projects on the underground storage of natural gas, CO2, and H2, as well as on identifying opportunities for hydrocarbon exploration, and on the conditions for the development of geothermal energy in Poland. The most promising sites, including salt structures, working and depleted gas fields, and saline aquifers suitable for storing substances, have been identified in the Permian–Mesozoic formations located in western, northern, and central Poland.

This part of Poland is also known, as one of the best areas for the production of hydrocarbons (the south-eastern part of the Southern Permian Basin) and as an optimal area for the development of geothermal energy for both heating and recreational purposes (Mesozoic formations).

For these reasons, multi-energy firms have recently considered the development of new energy storage facilities in such locations, which PGI-NRI identified.

However, when conducting exploration work to use underground geological structures optimally, energy firms aim to minimise the technical and geological risks. Research currently conducted at PGI-NRI enables the identification of various possibilities for the use of underground structures

and resources, which is particularly relevant in the design and planning of works, especially in the Polish Basin.

Keyword

Hydrocarbons, CCUS, Geothermal energy, Energy transition, The Polish Basin (Europe)

PTA and TTA the fundamental difference in Geothermal prospect well test

Fathia ABDI ATTEYE[1]*, L'Office Djiboutien de Développement de l'Energie Géothermique (ODDEG) (fathiaabdiatteye@gmail.com)

Abstract

After completion and during exploration drilling, geothermal wells are subject to well testing. The objective of well testing is to determine the wellbore production capacity and condition. Well testing essentially include pressure and temperature logging of the wellbore. The data are then subject to analysis and interpretation. Pressure Transient Analysis (PTA) is the analysis of pressure of the well. For decades Pressure transient analysis has been considered as the most effective way for diagnosing a well situation. A new tool being currently developed is the Temperature transient analysis (TTA), also make diagnosis of the well condition. A Geothermal well test comprise three test, multi injection rate, pressure fall off and pressure build up. During multi injection the injectivity index is calculated from the pressure vs flow rate. This value give us an insight to the well productivity hence permeability. In the pressure fall off when there is no more fluid injection into well then the pressure suddenly falls. From the pressure fall off trend we can apply analytical graphical method to know the current reservoir condition. This is done by analyzing pressure change linearity with the logarithm of time. This association help identify parameters such as transmissivity, permeability, reservoir initial pressure, skin factor. This paper will be exploring the fundamental difference between PTA and TTA and how to use TTA to determine the reservoir parameters similarly to PTA.

Keyword

Temperature transient analysis, Pressure transient analysis, Geothermal well

Combination of Fuzzy Logic and Geostatistics for Detecting Potential Zones of Geothermal Resource over Java Island, Indonesia through Multi-Sensor Satellite Image Data

Tedi Atmapradhana[1]*, Kyoto University (tedi.atmapradhana.83a@st.kyoto-u.ac.jp)
Tedi Atmapradhana[2], Kyoto University
Asep Saepuloh[3], Bandung Institute of Technology
Koike Katsuaki[4], Kyoto University

Abstract

Indonesia, situated within the dynamic tectonic confines of the Ring of Fire, boasts a wealth of geothermal potential. However, the current total capacity of geothermal power plants is still limited. To increase the use of geothermal resources needs a cost-effective and accurate resource exploration technique. Thus, this study endeavors to refine our understanding of geothermal potential by employing a novel approach combining Weighted Fuzzy Logic (WFL) and geostatistics, termed Fuzzy Ordinary Kriging (FOK). Through this methodological fusion, we aim to detect and delineate areas with high geothermal potential. The datasets harnessed in this methodology encompass a diverse range of sources, including multisensor image data from Landsat 8 Operational Land Manager (OLI), nocturnal thermal data from ASTER Thermal Infrared Sensor (TIRS), as well as geophysical data such as aeromagnetic and gravity data, alongside mineral spectral data taken from field measurements. The analysis of ASTER TIR thermal imagery contributes to estimating the land surface temperatures, while Landsat 8 data, specifically bands 3, 4, 5, 6, and 7, facilitates the assessment of vegetation condition using the Vegetation Index Considering Greenness and Shortwave Infrared (VIGS) algorithm. Furthermore, aeromagnetic data aids in discerning the magnetic properties of rocks around volcanic formations, while gravity data is instrumental in identifying the Bouguer anomalies over the study regions. Based on the FOK, the highest potential areas are located in the western part of the island, around Mt. Gede, and a part of the eastern regions, around Mt. Arjuna. Some anomalies are also detected in the island's northern part around Mt. Muria.

Keyword

Remote sensing, Geothermal resource, Potential mapping, Landsat 8 imagery, ASTER TIR imagery

Carbon emission reduction: Contribution of geothermal energy and practice in China

Liqiong JIA[1]*, Development and Research Center of China Geological Survey (jialiqiong1225@163.com)

Abstract

As a kind of natural energy from the earth's interior, geothermal energy is characterized by large reserve, wide distribution, good stability, high utilization coefficient, and positive effects of energy-saving and emission-reduction. It is of great significance for promoting green and low-carbon energy transition, reducing greenhouse gas emission, and achieving global climate goals and sustainable economic development. The potential of the global geothermal energy resource is estimated to be 1.25×10^27 J, equivalent to 4.27×10^16 t of standard coal. As a country with abundant geothermal resources, China accounts for about one-sixth of the global total. Shallow geothermal resources are widely distributed, especially concentrated in the central and eastern areas (including Beijing City, Tianjin City, Hebei Province, Shandong Province, Jiangsu Province, Anhui Province, Henan Province, Shaanxi Province) and some northeastern areas. The annual exploitable amount in over 336 cities at or above the prefecture level is approximately equivalent to 700×10^6 t of standard coal. 80% of the land in these areas are suitable for utilizing shallow geothermal energy and could be able to provide a cooling area of 32.575×10^9 square meter in summer and a heating area of 32.268×10^9 square meter in winter for building . Hydrothermal geothermal resources are mainly distributed in twelve large and medium-sized sedimentary basins, such as the North China Plain, Songliao Plain, and Sichuan Plain. The geothermal resource is equivalent to 1.02×10^12 t of standard coal and the annual exploitable amount is equivalent to 1.7×10^9 t of standard coal. Hydrothermal geothermal resources are relatively few in the uplift mountain areas. The high-temperature geothermal resources in the mainland are mainly distributed along the intensive hydrothermal activity zone, the southern Tibet-western Sichuan-western Yunnan region. The power generation potential of those high temperature resource is 7120 MW, accounting for 84.1% of the national total. The hot dry rock resource in China has huge potential and is considered to be the main direction for future geothermal exploration and development. It is estimated that the resource potential of the hot dry rock at a depth between 3 km and 10 km in the mainland is 2.5×10^25 J, equivalent to 856×10^12 t of standard coal. Calculated on 2% of exploitable resources, the exploitable heat energy from hot dry rock is equivalent to 17.2×10^12 t of standard coal. China's direct utilization of geothermal energy has consistently ranked first in the world for many years. By the end of 2021, the installed capacity for geothermal direct utilization had been equivalent to 100.2 GW and the total annual energy use had exceeded 820 PJ. The heating (cooling) area exceeded 1.33×10^9 square meter. According to the official targets set by National Energy Administration, by 2025, the heating (cooling) area of geothermal energy in China will increase by 50% and the installed capacity of geothermal power generation will double compared to 2020. By 2035, the heating (cooling) area and installed capacity will double

compared to 2025. It is expected that geothermal energy will play a more and more important role in contributing to the global sustainable development.

Keyword

Geothermal energy, Carbon emission reduction, Low-carbon energy, Sustainable economic development

Colombia's natural hydrogen potential: first exploration insights

Valeria RAMIREZ JUYA[1]*, Ghent University (valeria.ramirez@ugent.be)
Felipe Gonzalez Penagos[2], Atlas Research Group
Alejandra Carrillo Ramirez [3], University of Pau
Isabelle Moretti[4], UPPA-LFCR

Abstract

The global energy landscape has been dominated by fossil fuels for several decades. Nonetheless, the world is currently routed on research on clean and sustainable energy sources including hydrogen. Most of the investigations have been focused on H2 from hydrocarbons (gray and blue H2) and water (green H2), besides, the discovery of substantial natural hydrogen gas reservoirs could represent a lucrative opportunity for the hydrogen economy.

In the particular case of Colombia, a geologically diverse country, there is a great potential for hydrogen accumulation in regions such as the ophiolites in the western Cordillera, characterized by the rich composition of Fe and Mg plus the proximity with the volcanic complexes of the central Cordillera which displays surface emissions of gases, hydrothermal fluids and intrusive igneous formations beneficial for fluid-rock interaction.

Colombia's numerous sedimentary basins, including the Cauca-Patía and Chocó, present an intriguing potential for hydrogen accumulation, including the Putumayo foothills with high concentrations of CO2 in wells and an increased 3He/4He ratio in the eastern foothills, indicating potential hydrogen presence. However, due to their status as border areas, there is limited foundational information for initiating research.

The regional geology of the Northern Andes, including the Romeral (western flank of the Central Cordillera) and Dagua (Western Cordillera) terrains, features basaltic rocks, tholeiitic MORB-affiliated complexes, mafic-ultramafic formations, and ophiolitic sequences. Complex fluid circulation related to hydrothermal systems, fumaroles, and intrusions along the Cordillera within the Pacific subduction tectonic framework further enriches the continent. High-pressure reactions in subduction zones could be the origin of potential natural hydrogen and abiotic methane generation, especially in the deeper depths associated with serpentinization processes. Current models lack deeper sources of H2 and CH4 abiotic, emphasizing the need for further research.

Aiming to start exploration of H2 in Colombia, the ophiolites were selected to make the first approximation of soil gas measurements. The zone of study is geologically composed of Ginebra ultramafic complex, Amaime formation, Ginebra Amphibolite, and the thrusting regime of the Guabas-Pradera fault system. The data collected showed high concentrations of H2, especially over the fault trace, surpassing 1000 ppm. This groundbreaking discovery confirms the presence of natural hydrogen emissions in the country and opens the door for future in-depth studies.

Keyword

natural hydrogen, ophiolites, Hydrogen economy, Colombia, energy

Sustainable and ethical mining: future challenges and new perspective

Mariagabriella Andrisani[1], ISPRA Geological Survey of Italy
Giovanni Decaterini[2], ISPRA Geological Survey of Italy
Stefano Decorso[3], ISPRA Geological Survey of Italy
Federica Ferrigno[4], ISPRA Geological Survey of Italy
Fiorenzo Fumanti[5], ISPRA Geological Survey of Italy
Maurizio Guerra[6], ISPRA Geological Survey of Italy
Gabriele Leoni[7], ISPRA Geological Survey of Italy
Mauro Lucarini[8], ISPRA Geological Survey of Italy
Agata Patane[9], ISPRA Geological Survey of Italy
Monica Serra[10], ISPRA Geological Survey of Italy
Daniele SPIZZICHINO[11]*, ISPRA Geological Survey of Italy
(daniele.spizzichino@isprambiente.it)

Abstract

The new model of economic development linked to the fourth industrial revolution and the need to achieve the objectives of containment of climate-altering emissions is determining a massive and continuously growing demand for mineral resources essential for the creation of green technologies and for the carbon footprint reduction. The growth in demand has given rise to an international race to acquire them, generating political and economic conflicts. The need for the supply of mineral resources is highlighting the critical aspects both fort the whole European and Italian industry, essentially linked to the strong dependence on imports. In this period, issues relating to mineral raw materials, in particular those considered critical/strategic, are at the top of the political agendas throughout the world, clearly reiterating what has characterized the entire history of humanity: who holds the ownership of raw materials holds the power. Based on this awareness, the EC declared its concern about raw materials and developed the regulation proposal for the safe and sustainable supply of critical raw materials, the so-called Critical Raw Materials Act (CRMA) which will come into force before summer of 2024. The CRMA will also oblige member states to undertake specific actions to achieve strategic targets aimed at reducing dependence on foreign markets. Among these, the development of the National Mining Plan for the definition of the mining potential of each Member State and the characterization of extractive waste deposits, including abandoned ones. The waste deposit may represent potential new deposit of critical and non-critical resources, which could be reused in a circular economy perspective. Italy has an important mining history, which began in pre-Roman times. Due to economic policy choices, the activity relating to the extraction of metal minerals ended by the end of the last century. This caused the decline of university education and loss of knowledge and training and lifelong learning of mining industry professionals. The closure of the most profitable mines, accompanied by the abandonment of large mineral research projects, also led to a rapid decline in interest in the whole value chain from university education, with the progressive closure of degree courses in Mining Engineering and in Geology of Mineral Resources, till the removal of large companies in the sector. ISPRA Geological Survey Dept., as part of the National Critical Raw

Materials WG (created in January 2022), is already preparing to address the new challenges imposed by the ecological and digital transition. In Italy as in Europe, the first action to be undertaken is the cultural one, dispelling three false myths such as the absence of critical strategic materials in the old continent, the passed vision that sees mining activity as always associated with environmental damage and disaster and the certainty that recycling and recovery can be sufficient to meet the growing demand for CRMs without which no green and blue transition will ever be possible. The aim of this work is to illustrate and start the debate on new paradigm of sustainable and ethical mining as a future model of development.

Keyword

Mining, CRM, circular, economy

Research on the Effect of Pressure on Thermal Cracking of Immature/Low Mature Source Rocks

Fengtian BAI[1]*, Jilin Univerisity (baift@jlu.edu.cn)
Wei Guo[2], Jilin University
Youhong Sun[3], China University of Geosciences

Abstract

The effect of pressure on thermal cracking of source rocks has been investigated on different pressure using two typical immature/low-maturity hydrocarbon source rock (oil shale) samples from China. The thermal pressure simulation experiments were carried out through a cyclic heating method. With inert gas and water as the pressure transmission medium, three experimental conditions were studied: no water and no pressure, low water pressure (300 bar), and high water pressure (500 bar). A systematic organic geochemical study of the simulation experiment products was carried out, and the hydrocarbon generation characteristics of immature/low-maturity hydrocarbon source rocks at different evolution stages were obtained. The dynamic thermal cracking characteristics of hydrocarbon source rocks from immature/low-maturity to maturity to high maturity under pressure conditions were discussed. The results show that with the increase of thermal evolution degree, the maturity of the source rock (oil shale) gradually evolves from immature/low mature to mature to high mature, and the gas production of the sample gradually increases and reaches the maximum at the high mature stage, and liquid hydrocarbon production shows a trend of first increasing and then decreasing, and reaches the maximum at the mature stage, and the quality of the liquid hydrocarbon continues to improve, and the quality of the liquid hydrocarbon continues to improve, and the main peak carbon moves forward and the high carbon long chain hydrocarbons break continuously to form short-chain hydrocarbons, and the odd carbon advantage of medium high carbon number nC21~nC31 gradually weakens, and the hydrocarbon generation potential of the source rock gradually decreases. The influence of pressure on hydrocarbon generation and cracking is shown in the inhibition of volume expansion reaction, and the influence on the maturation process is shown in the inhibition of demethylation and dehydrogenation aromatization of organic matter structure. The pressure has little effect on the gas yield of immature low mature source rock (oil shale) samples, but will significantly inhibit the gas yield of low mature high mature samples. The increase in pressure can promote the generation of liquid hydrocarbons in the pyrolysis system of source rocks. The total production of liquid hydrocarbons in Huadian and Fushun samples increases with the increase of pressure, especially in the low evolution stage, the greater the pressure, the more significant the promotion. We hope this study can provide theoretical support for the hydrocarbon generation mechanism of shale oil, shale gas, and conventional oil and gas.

Keyword

Source rock, Pressure, Thermal evolution, Organic geochemical, Hydrocarbon generation

Oxidative pyrolysis characteristics and kinetic analysis of low-medium maturity organic rich shale

Sunhua DENG[1]*, Jilin university (denghua13@163.com)
Dongxue Yu[2], Jilin university
Wei Guo[3], Jilin university
Chaofan Zhu[4], Jilin university

Abstract

Organic-rich shale is abundant in China and holds potential as a supplementary energy source for conventional oil and gas. In-situ oxidation conversion technology is expected to enable large-scale development of this resource. This paper systematically investigates the oxidative pyrolysis behavior and kinetic characteristics of organic-rich shale with varying degrees of maturity under an air atmosphere, utilizing thermogravimetry-Fourier transform infrared spectroscopy.

The findings indicate that as the shale matures, the initial oxidative pyrolysis temperature of the organic matter decreases. However, at a medium maturity level, the expulsion of hydrocarbons reduces the content of organics inside the sample, which hampers the oxidation-assisted pyrolysis process. Consequently, there is a decrease in oil and gas yield and an increase in coke formation, leading to a corresponding decline in combustion performance. The oxidative pyrolysis kinetics of low-medium maturity organic-rich shale are calculated using the Friedman, Ozawa Flynn Wall (OFW), and Kissinger Akahira Sunose (KAS) methods. The results demonstrate that an increase in the degree of organic matter maturation effectively reduces the activation energy of organic matter oxidative pyrolysis reactions in low maturity shale. Similarly, once the organic matter reaches a medium maturity level, the activation energy of the oxidative pyrolysis of shale shows an increasing trend.

This study sheds light on the influence of organic matter maturation on the oxidative pyrolysis behavior of organic-rich shale. It aims to provide a theoretical foundation for the in-situ development of low-medium maturity organic-rich shale.

Keyword

Organic rich shale, Low-medium maturity, Oxidative pyrolysis, Pyrolysis kinetics

Design and simulation of a high-efficiency cooling system for high temperature drilling fluid

Rui JIA[1]*, Jilin University (jiarui@jlu.edu.cn)
Siyuan SUN[2], Jilin University
Haoxin FENG[3], Jilin University
Yihang KOU[4], Jilin University
Gege TANG[5], Jilin University

Abstract

Under the guidance of the goal of achieving carbon peak and carbon neutrality, the development and utilization of geothermal resources have been increased; at the same time, oil and gas drilling is developing towards deeper areas with the increasing demand for oil and gas resources in China's social development. These have led to increasingly prominent high-temperature issues faced by drilling fluids. Due to the large depth of deep oil and gas drilling and the high geothermal gradient in geothermal drilling, the bottom hole temperature may exceed 200 ℃, causing the temperature of the drilling fluid to exceed 180 ℃ after circulation. Continuous high temperature can deteriorate the mud performance, affect the service life of downhole mechanical drilling tools and underground instruments, reduce drilling speed, and pose a threat to the safety of drilling operations. Therefore, during deep oil and gas drilling and geothermal well excavation, timely cooling of the drilling fluid and reaching a suitable temperature is essential for drilling safety. Our research summarized the commonly used methods and characteristics of the current frequently-used high temperature drilling fluid. In regard to the energy-saving characteristics of air cooling and the advantage of high cooling efficiency of the coolant with forced cooling, a high-efficient cooling system for high temperature mud has been put forward. The air cooler and the tube and shell heat exchanger in the cooling system have been designedchecked and simulated, and the reliability of the design has also been verified. As a result, the high-temperature drilling fluid with an initial temperature of 80 ℃ and a flow rate of 1800 L/min can be cooled below 40 ℃. Compared to directly performing forced cooling on high-temperature drilling fluids, it saves 60.7% of energy consumption. At the same time, the cooling effect of the cooling system has also discussed at different drilling fluid temperatures, flow rates, and air temperature conditions. The results showed that as the initial temperature of the drilling fluid entering the cooling system increased or the flow rate decreased, the temperature difference between the inlet and outlet of the cooling system increased, demonstrating an improvement in cooling capacity, with the air cooler playing a more significant role. When the drilling fluid temperature or the flow rate is too high (drilling fluid temperature exceeds 90 ℃ or flow rate exceeds 2200 L/min), the selected parameters of the cooling system designed in this article cannot meet the requirements, and it is necessary to add equipment or adjust equipment parameters in the cooling system. As the temperature rises, the outlet temperature of the drilling fluid increases linearly, and the temperature difference between the inlet and outlet gradually decreases. The cooling capacity of

the cooling system decreases, mainly due to the rapid decrease in the cooling effect of the air cooler. The cooling capacity of the shell and tube heat exchanger gradually increases. When the temperature reaches 40 ℃, the shell and tube heat exchanger plays a dominant role.

Keyword

high temperature drilling fluid, cooling system, air cooler, heat exchanger, design and simulation

Projection of natural gas demand in China based on a hybrid model from sector perspective under carbon-neutral strategy

Xiaoqian GUO[1]*, CAGS (xiaoqianGuo88@163.com)

Abstract

As a main substituted clean energy, natural gas is regarded as the main transition energy under the carbon-neutral strategy in China. In recent years, natural gas consumption in China has kept a 7% increasing rate and the projection of natural gas demand has received significant attentions for China's energy policymakers with the rapid increasing external dependence. A series of numerous theoretical and empirical analyses around the world focus on energy demand causal analysis and projection analysis. However, these causal analysis model and projection model are separated in most of the studies. In this research, we established a hybrid model to analyze the influencing factors and future demand together for natural gas in China. Firstly, causal analysis was adopted to investigate influencing factors for three main consumption sectors, including Industrial, Residential and Transport. According to the unit root tests and co-integration test, 6 factors with a closely relationship with natural gas consumption are chosen, including resident consuming level, urbanization, industrialization, per-capita GDP, GDP of transport and natural gas vehicle number. Then, grey model and regression analysis were combined to make projection based on the chosen factors for each sector. And the natural gas demand is 100.3, 340.7 and 44.3 billion cubic meters for Residential, Industrial and Transport sector, respectively, and the total natural gas demand for China is 581.86 billion cubic meters in 2030. Besides, two specific policy recommendations were put forward for nature gas in China: (1) As the biggest demand sector, technological innovation and structure optimization are necessary for Industrial sector to improve the natural gas utilization efficiency; (2) Infrastructure construction of natural gas is still important for Residential sector with the increasing sector consumption.

Keyword

natural gas, hybrid model, demand projection, sector perspective

Magnetite powder as an enhancer in biogasification of phenolic pollutants

Minjae KIM[1]*, Pukyong national university (alswo274@pukyong.ac.kr)
Juyun Lee[2], Pukyong national university
Seonmin Kang[3], Pukyong national university
Joonyeob Lee[4], Pukyong national university

Abstract

Hydroquinone is a representative phenolic pollutant produced from various industrial organic wastewaters, such as those from coal gasification, chemical processes, and refining. Due to its toxicity, proper treatment of hydroquinone wastewater (HW) is necessary before its release into the environment. Anaerobic digestion presents a promising carbon neutral technology for treating organic waste and wastewater, achieving simultaneous reduction of organic pollutants and generation of energy-rich biogas. However, high-rate anaerobic digestion of HW poses challenges due to thermodynamic limitations on anaerobic hydroquinone degradation and inhibition of methanogenesis by hydroquinone.

Magnetite is recognized as one of the major types of naturally occurring iron ore on Earth. Magnetite powder (MP) can be derived from iron ore and recovered from waste such as steel slag through hydrothermal treatment. MP can act as a mediator, accelerating electron transfer between anaerobic bacteria and methanogenic archaea in anaerobic digestion. The addition of MP has the potential to be an effective strategy for enhancing the anaerobic digestion of HW, but relevant research on this topic has been seldom reported.

Thus, this study conducted sequential batch experiments with and without MP to investigate the effects of MP addition on anaerobic digestion of hydroquinone, focusing on anaerobic hydroquinone degradation and methane production. Results demonstrated that anaerobic degradation of hydroquinone was significantly improved in the MP-added reactors, with methane production rates in the MP-added reactors increasing by 238% compared to the control reactors. Further details will be presented in the conference.

This research was supported by Learning & Academic research institution for Master's, PhD students and Postdocs (LAMP) Program of the National Research Foundation of Korea (NRF) grant funded by the Ministry of Education (RS-2023-000301702). This research was also financially supported by the Korea Ministry of Environment as Waste to Energy-Recycling Human Resource Development Project (YL-WE-21-002).

Keyword

Magnetite, Anaerobic digestion, Hydroquinone, Waste to energy

A spectroscopic assessment of the microstructural evolution in a suite of Indian coals and their potentiality for energy storage applications

Archchi Sarkar[1]*, Pandit Deendayal Energy University (sarkar.archchi@gmail.com)
Rincy Anto[2], Pandit Deendayal Energy University
Uttam Kumar Bhui[3], Pandit Deendayal Energy University
Sudip Bhattacharyya[4], Geological Survey of India

Abstract

The need for efficient energy conversion technologies and storage systems is being driven by the growing need for clean energy with little environmental effect. Coal being a cheap and plentiful source of carbon and carbon-based products, may offer a workable option for long-term, sustainable use in a variety of areas of human civilization. The key to producing various carbon-based nanomaterials is to chemically modify the crystallites present naturally in coals. In order to produce these next-generation biomaterials, it is also crucial to properly delineate the chemical moieties in coal, as the carbon concentration of coal changes with different rank. In the present study, an attempt has been made to understand the evolution of the macromolecular structure in a suite of Indian coals based on the characterization of their bulk and solvent-extracted compositions and their potential applications in the development of energy harvesting and storage systems, using the help of different spectroscopic techniques viz. FT-IR, UV-Visible and Total Synchronous Fluorescence spectroscopy (TSFS), and XRD analysis. Background-subtracted X-Ray Diffractograms exhibited an increment in the intensity of characteristic 002 band (indicated by a decreasing FWHM), which is consistent with the intensity of the coalification process and demonstrated by their corresponding vitrinite reflectance (VR) values. The lattice parameters indicate that lower rank coals are structurally less ordered than higher rank coals investigated in the study. The bulk and solvent-extracted compositions of the coals were determined using spectroscopic techniques, revealing the presence of different polycondensed aromatic ring structures, and their potentiality for energy storage has been discussed in accordance with their corresponding ranks. It was also observed that inorganic impurities present in the coal samples have minor effect on the efficiency while structural parameters are the major contributors on the potential properties in battery application.

Keyword

Coal, Energy storage, Fluorescence spectroscopy, XRD, Carbon-based nanomaterials

Characterization of pore structure in semi-deep and deep lacustrine tight sandstones: A case study of the Triassic Chang 6 in Longdong area, Ordos Basin, NW China

Taping He HE[1]*, 710233010@qq.com (b22010021@s.upc.edu.cn)
Yaoqi Zhou[2], zhouyq@upc.edu.cn

Abstract

In recent years, tight oil, an important unconventional oil and gas resource, has become a research hotspot of global oil and gas exploration. The typical representative of the tight oil reservoir is the Chang 6 reservoir of the Yanchang Formation in Ordos Basin. Its lithology is tight, and the pore throat is small and complex, making it difficult to describe the microscopic pore throat characteristics. Under the influence of pore throat structure, tight sandstone reservoir seepage characteristics are also more complex, which is an important factor affecting oil and gas exploration and development. Therefore, how to effectively characterize the microscopic pore throat characteristics of tight sandstone reservoirs is a key issue in the study of unconventional oil and gas resources. To clarify the characteristics and influencing factors of Chang 6 reservoir in this area, the rock mineral composition, diagenesis, and physical properties of Chang 6 tight sandstone in the Longdong area of Ordos Basin were studied utilizing rock core photos, casting thin sections, field emission scanning electron microscope, high-pressure mercury injection and constant rate mercury injection, and the influence of diagenesis on pore throat was qualitatively analyzed. The results show that deep-water gravity flows mainly developed three types of sediments: sandy debris flows, turbidites, and seismic slide deposits. The reservoir pore types are mainly residual intergranular pores, dissolution pores, and micropores. The pore throats are mainly distributed in the range of 0.004-100 μm, less distributed less than 0.1 μm, and more than 1 μm. The pore radius of each sample is concentrated between 60-348 μm. The throat radius of each sample is dispersed between 0.12-1.5 μm, and the roaring type is fine-micro roar type, showing strong heterogeneity. The throat mainly controls reservoir permeability, and the proportion of small throat increases with the decrease of permeability.

Keyword

Ordos basin, Semi-deep and deep lacustrine, Tight sandstone, Characterization of pore structure, Chang 6

Two decades of research on injection-induced seismicity: What have we learned?

David EATON[1]*, University of Calgary (david.w.eaton@ucalgary.ca)

Abstract

Injection-induced seismicity – earthquakes triggered by anthropogenic fluid injection into the subsurface – has been well documented for over half a century, including associations with hydrocarbon production. Yet, the past two decades have witnessed an explosion of research on this topic, commencing with seminal work on the relationship between injection, pore-pressure diffusion and induced seismicity. At about that time, it was recognized that induced seismicity poses a serious risk for enhanced geothermal systems (EGS), leading to the introduction of traffic-light systems for use as reactive-control protocols for operations. In the early 2010s, growing realization of the scale and scope of induced seismicity linked to massive saltwater disposal (SWD) in the U.S. midcontinent provided the impetus for considerably expanded research activity. Scientific debate ensued over the potential for hydraulic fracturing, as well as gigatonne-scale carbon capture and storage (CCS), to trigger felt earthquakes. In the case of hydraulic fracturing, it is now well established that the risk of induced seismicity is real, with notable published examples in North America and China. Basic screening tools have been developed, and widely deployed, to aid in the assessment of fault slip potential, but exhaustive mapping of potentially seismogenic fault systems remains a challenge even using modern 3D seismic data. Building on advancements in artificial intelligence, the seismological community has adapted machine learning methods for use in basic processing of continuous data from seismograph networks as well as to test hypotheses for intrinsic geological susceptibility to fault activation to better explain the patchy nature of seismic activity in unconventional hydrocarbon fairways. There have been debates about the relative importance of various triggering mechanisms, such as direct pore-pressure effect on fault strength, as well as variations in poroelastic stress that modify fault loading conditions. Out of this has emerged a recognition that slow (aseismic) fault slip could also play an important role. Vigorous scientific debates have focused on controls on the magnitude of injection-induced earthquakes, such as net injected volume and injection rate.

What have we learned from the past several decades of research, and what challenges remain? In situ measurements of pore pressure using downhole gauges have reasserted the importance and large spatially extent, of elevated pore pressure within disposal zones. Traffic light systems have been widely adopted by regulators, but with remarkable inter-jurisdictional variability in response thresholds. The advent of risk-based and adaptive approaches for traffic light systems offers significant promise. New monitoring methods, including satellite interferometric synthetic aperture radar (InSAR) and distributed acoustic sensing (DAS), are promising approaches for the detection of aseismic processes that could be important, including for related hazards such as casing deformation. In the context of the energy transition, the advent of competing uses for pore

space arising from growth of EGS, CCS, SWD and extraction of critical minerals from brines, poses challenges for understanding cumulative effects of these operations for induced seismicity.

Keyword

Induced Seismicity, conventional oil and gas, CCS, geothermal, earthquake

Applications of low-field NMR techniques in CO2 sequestration in hydrocarbon reservoirs

Yanbin YAO[1]*, China University of Geosciences, Beijing (yyb@cugb.edu.cn)
Hao Wu[2], China University of Geosciences, Beijing
Chao Cui[3], China University of Geosciences, Beijing
Pengwei Mou[4], China University of Geosciences, Beijing

Abstract

Developing effective novel methods is crucial for global-scale carbon storage. One potential approach involves injecting CO2 into deep subsurface formations like oil and gas reservoirs. This solution is not only capable of reducing CO2 emissions, but also enhancing hydrocarbon recovery through effectively displacing oil and gas by CO2. However, some challenges need to be addressed when implementing CO2 storage in hydrocarbon reservoirs. These challenges include: 1) insufficient reservoir data, particularly regarding reservoir properties; 2) a lack of understanding of the short-term and long-term interactions between CO2 and reservoir rocks and fluids; 3) the integration of CO2 storage and enhanced hydrocarbon recovery. To overcome these research obstacles, it is crucial to conduct a comprehensive and accurate assessment of reservoir and caprock properties, as well as continuously monitor the dynamic interactions of fluids after CO2 injection. In recent years, Nuclear Magnetic Resonance (NMR) has emerged as a valuable and non-destructive experimental technique for studying hydrocarbon reservoirs. Numerous researchers have utilized NMR technology to comprehensively analyze various aspects of reservoir pore-fracture systems, and the presence and distribution of water and hydrocarbons in reservoirs. Overall, NMR technology holds immense potential in the study of CO2 geological sequestration and enhanced hydrocarbon recovery. It offers an efficient, accurate, economical, and sustainable method for monitoring CO2 sequestration processes, playing a vital role in understanding CO2 storage in hydrocarbon reservoirs. However, it is important to acknowledge that NMR technology still faces challenges, and future research should focus on addressing these issues and refining and promoting its application.

Keyword

CO2 storage in hydrocarbon reservoirs, NMR, Enhanced hydrocarbon recovery, Dynamic interactions of fluids

Advancements in the Exploration and Production of Coal-Associated Unconventional Natural Gas in China: Geological Insights and Technological Innovations

Dameng LIU[1]*, China University of Geosciences Beijing (dmliu@cugb.edu.cn)

Abstract

The global coal-associated unconventional natural gas (CAUNG) resources are widely distributed in Russia, Canada, China, the United States, and Australia etc. China has huge amount of CAUNG resources, mainly distributed in the Ordos Basin, Qinshui Basin, and Zhungeer Basin, which is an important foundation for promoting the development of clean energy and economics. In this paper, firstly, the sedimentary and basic geological characteristics of coal-associated reservoirs is summarized; the geochemical characteristics and gas-bearing research status of coal-associated reservoirs is discussed; the symbiotic combination mode and reservoir forming elements of coal-associated reservoirs is studied. On this basis, the geological genesis of stacked CAUNG systems and block scale CAUNG enrichment theory are summarized, and a comprehensive analysis technology system for multiphase fluids in CAUNG reservoirs based on the synergy of multiple technologies such as nuclear magnetic resonance (NMR) is summarized. Thirdly, the differential fracturing technology system based on the fracturability of CAUNG reservoirs is evaluated; the dynamic change prediction technology of permeability in CAUNG reservoirs is analyzed; the evaluation and prediction methods for favorable areas of CAUNG reservoirs are summarized. On the basis of summarizing the current research status, the main scientific problems that urgently need to be solved in the field of CAUNG in China are proposed: (a) The CAUNG migration and accumulation effect and the geophysics-based fine description technology; (b) co-development compatibility evaluation for stacked CAUNG and multiphase fluid characterization method; (c) Geological control factors for high-quality CAUNG layers and optimal selection of favorable areas. The resolution of these issues will be conducive to further promoting the development of geological theory and the efficient development and utilization of CAUNG resources in China.

Keyword

China’s coal-associated unconventional natural gas, advancements in exploration and production, geological theory, evaluation techniques, key scientific issues

Effect of intraformational mudstone on CO2 plume migration and distribution: Insights from Sleipner geological storage project

Huixing ZHU[1]*, Jilin University (zhuhx@jlu.edu.cn)
Tianfu Xu[2], Jilin University
Hailong Tian[3], Jilin University

Abstract

Stratification of strata is commonly observed in geological formations. For instance, sandstone reservoirs, which are frequently used for CO2 geological storage, often exhibit the presence of low permeable interlays such as mudstone or shale. However, existing numerical simulation studies tend to overlook the impact of these intraformational mudstone layers on the migration of CO2 plume, thereby compromising the reliability of simulation results. One of the primary reasons for this oversight is the limited exploration accuracy at most sites, which hinders the identification and accurate characterization of these mudstone interlayers within the sandstone. The Sleipner CO2 geological storage project, as the world's first commercial endeavor in this field, has conducted comprehensive geophysical exploration work that includes a detailed characterization of formation structure and CO2 plume migration. This project presents an exceptional opportunity to investigate and address this issue. The exploration results indicate that the sandstone reservoir at this site has a thickness exceeding 200 meters and is compartmentalized into nine sub-reservoirs by eight layers of thin mudstone, each with a thickness ranging from 1 to 2 meters. Additionally, within the thin mudstone, there exists localized permeable zones known as "feeders", which serves as conduits for CO2 migration towards the shallower region. To quantitatively investigate the influence of intraformational mudstone on the migration and distribution of CO2 plume, a geological model was constructed based on the latest Sleipner benchmark model, and the multiphase flow simulator TOUGH2 (ECO2N module) was invoked for simulation purposes. The simulation results demonstrate that the presence of thin interlayer mudstone and feeders exerts a significant influence on the spatial distribution of CO2 plume. Specifically, the combination of multiple thin layers of mudstone and "feeders" enhances the vertical homogeneity of CO2 distribution, thereby preventing its confinement to the injection horizon observed in the scheme solely comprising thin mudstone layers. Moreover, it prevents CO2 accumulation at the top of reservoir due to buoyancy effects as seen in the scheme lacking thin mudstone layers, consequently ensuring optimal utilization of middle and lower reservoir spaces. This comprehensive exploitation of vertical reservoir space effectively restricts horizontal migration range for CO2, thus minimizing potential leakage along concealed faults. Moreover, the presence of thin mudstone layers mitigates the pore pressure buildup at the interface between the top sandstone reservoir and the overlying mudstone cap, thereby ensuring the integrity of the primary cap and enhancing storage security.

Keyword

CO2 geological storage, CO2 plume migration, Intraformational mudstone, Sleipner project

Effect of the surfactant on the storage ratio of supercritical CO2 in pore spaces of the subsurface CO2 reservoir rock: based on laboratory experiments

Jeonghyeon BYEON[1]*, Major of Earth and Environmental Sciences, Division of Earth Environmental System Science, Pukyong National University (naro98@pukyong.ac.kr)
Sookyun WANG[2], Department of Energy Resources Engineering, Pukyong National University
Seon-ok KIM[3], Department of Energy Resources Engineering, Pukyong National University
Minhee LEE[4], Major of Environmental Geosciences, Division of Earth Environmental System Science, Pukyong National University

Abstract

Geological sequestration of carbon dioxide (GSC) is one of practical carbon capture and storage (CCS) technologies, having minimal adverse side effects. Research and technology development for the GSC is critical to improving the CO2 injection efficiency and increasing the storage capacity in geological CO2 reservoirs, particularly for countries with high CO2 emissions and limited storage sites. In this study, laboratory scale experiments were performed to evaluate the effect of the surfactant on the supercritical CO2 (scCO2) storage ratio increase in the storage formation under practical subsurface conditions.

For experiments, the stainless-steel column (diameter: 4.5 cm; height: 10 cm) packed with glass beads (diameter: 0.1-1.5 mm) was prepared to simulate the porous media of the CO2 storage formation. The column's pore spaces was saturated with distilled water or a nonionic surfactant solution (Tween 80: polyoxyethylene (20) sorbitan monooleate) and the scCO2 was injected into the column at the CO2 storage conditions (high temperature and pressure). The scCO2 storage ratio in pore spaces of the column was determined by measuring the amount of remaining scCO2 in pore spaces after the scCO2 flow in the column. Surfactant in pore water may affect the scCO2 storage ratio in porous media by changing interfacial tension, contact angle and viscosity in the pore water-scCO2 (two-phase system). Laboratory experiments were performed to identify these property changes in a two-phase system and to quantify the correlation between the property change and the scCO2 storage ratio change. The stainless-steel high-pressure reactor vessel (diameter: 6 cm; height: 6 cm) was saturated with distilled water (or surfactant solution). The scCO2 was injected into the reactor vessel under the actual CO2 storage conditions. The interfacial tension between the scCO2 and solution was measured by using the pendant bubble method. The contact angle between the scCO2 and solution at the boundary on the glass plate was measured by using the captive bubble method and the viscosity of the solution was measured by using a viscometer (CAS, CL-L2).

The scCO2 storage ratio showed an average improvement of over 50% as the surfactant concentration in pore water increased, compared to the distilled water-saturated column. As the pore pressure of the scCO2 was increased from 8 MPa to 20 MPa, the scCO2 storage ratio in the column's pore spaces was increased by over 20-30%. The interfacial tension decreased by over 50% due to the increase of surfactant concentration (0 to1.0 wt%). The contact angle increased by over 20% with the increase of surfactant concentration. From this study, the effect of the

surfactant on the scCO2 storage ratio in a two-phase system under practical subsurface storage conditions was quantitatively investigated, obtaining the correlation between the hydraulic property change due to the surfactant and the scCO2 storage ratio change and supporting important information to maximize the scCO2 storage capacity in the CO2 reservoir rock.

*This work was supported by Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE) (20212010200010, Technical development of enhancing CO2 injection efficiency and increase in storage capacity).

Keyword

CO2, CCS, contact angle, interfacial tension, surfactant

Material Balance Equation for CO2 Storage Capacity Estimation in Saline Aquifer

Sangkeon PARK[1]*, Seoul National University (skpark0111@snu.ac.kr)
Hyunmin Oh[2], Seoul National University
Hyunjee Yoon[3], Seoul National University
Yeongju Kim[4], Seoul National University
Byungin Choi[5], Computer Modelling Group
Wenyue Sun[6], School of Petroleum Engineering
Hoonyoung Jeong[7], Seoul National University

Abstract

Estimation of CO2 storage capacities is important in developing carbon capture and storage projects. Material balance equation (MBE) methods, which are widely utilized, offer a straightforward approach for estimating of CO2 storage capacities. However, previous MBE methods use an original fluid in-place volume that is calculated using volumetric methods without validation of the original fluid in-place volume. The accurate estimation of the original fluid in-place volume, indicative of the pore volume, is imperative as it substantially influences the CO2 storage capacity. In this study, we developed an MBE method that yields precise evaluations of CO2 storage capacities by validating the original fluid in-place volumes within saline aquifers. In the proposed MBE method, brine extraction for mitigating pressure buildup can be considered. The accuracy of the proposed MBE method was assessed by comparing with a commercial reservoir simulator in a synthetic aquifer example and the Sleipner model. In the synthetic aquifer example, the proposed MBE method yielded an accurate CO2 storage capacity estimate, achieving a relative error of 2.085% despite relying on short-term (1-year) injection data. Similarly, when applied to the Sleipner model, this method maintained its high accuracy, with the relative error of 1.6873%. The proposed MBE method also provided accurate estimation of CO2 storage capacities under various circumstances such as different horizontal grid sizes, porosities, horizontal permeabilities, CO2 injection rates, shut-in periods, OWIP estimation methods, numbers of input data points, brine extraction rates, heterogeneity of porosity and permeability.

Keyword

Carbon Storage, CO2 Storage Capacity, Material Balance Equation

Anisotropic reservoir characteristics influencing the CO2 sequestration behavior in shale with simultaneous enhanced gas recovery and a case simulation

Li LI[1]*, Sichuan University (lilill@stu.scu.edu.cn)
Jun Liu[2], Sichuan University

Abstract

CO2 injection into shale reservoirs serves a dual-purpose by facilitating the geological CO2 sequestration with enhanced gas recovery (CS-EGR). However, the mechanism of anisotropic reservoir characteristics (permeability and in-situ stress) determining the CS-EGR responses remains unclear. In this work, the shale-based CS-EGR behavior is simulated based on an integrated thermo-hydro-mechanical (THM) coupled model, where the interactions of gases (CO2 and CH4) in multi-phase (free/adsorbed) are clarified in a systematic manner. The results indicated that the stronger anisotropic in-situ stress enables more CO2 in the free phase to be trapped in the shale reservoir and ensures a more distinct decreased amplitude of matrix porosity. Besides, it is also concluded that anisotropic permeability has a greater influence than in-situ stress on the gas migration during CS-EGR – for both free and adsorbed gases. According to a single shale layer model, higher horizontal permeability or lower horizontal in-situ stress positively makes an improved CS-EGR performance – from the adsorbed gases perspective. By the comparison of 7 cases, the decrease in free CH4 is tender after CO2 flooding under greater difference between vertical and horizontal in-situ stress. It is also concluded that under sufficient CO2 flooding, constant ~65% and ~35% of free gases in shale reservoirs are free CO2 and free CH4 at most (mass fraction), respectively. In addition, this work simulated two contiguous shale layers with variable permeabilities or in-situ stresses, indicating that the gases competitive adsorption behavior during the CS-EGR is primarily determined by the horizontal permeability or in-situ stress of the lower layer. The two-layer model also suggests that greater horizontal permeability difference between the two layers enhances the magnitude of CO2 accumulation and CH4 desorption. Nevertheless, a case application of this work to the Longmaxi formation and its implications are also expressed. Hopefully, this work is helpful in enhancing the knowledge on the accurate forecast on a shale-based CS-EGR outcome under the objective reservoir anisotropies.

Keyword

enhanced shale gas recovery, heterogeneous permeability, anisotropic in-situ stress, CO2 sequestration, THM coupled model

Experimental Study on Interaction of Sc-CO2 with Feldspar and Clay Minerals and its Implication to Carbon Sequestration in Sandstone Reservoirs

Yiming Luo[1]*, China University of Geosciences, Wuhan (yimingluo@cug.edu.cn)
Jianmei Cheng[2], China University of Geosciences, Wuhan
Ying Yu[3], China University of Geosciences, Wuhan
Mengting Xiao[4], China University of Geosciences, Wuhan
Yujiao Liu[5], China University of Geosciences, Wuhan
Ruirui Zhao[6], China University of Geosciences, Wuhan
Kaisar Ahmat[7], China University of Geosciences, Wuhan

Abstract

CO2 Mineral trapping is one of the safest means of carbon sequestration in saline aquifers. When injecting supercritical carbon dioxide (sc-CO2) into sandstone reservoirs, the mineral components and in-situ conditions may significantly influence the CO2-water-rock interactions and the CO2 trapping mechanism. In this study, three series of hydrothermal batch reactions have been carried out to investigate the reactions between sc-CO2 and siliciclastic minerals (plagioclase, potassium feldspar, chlorite, and montmorillonite). The effluent sampling and scanning electron microscope (SEM) are used to monitor the changes in the fluid hydrochemistry and mineral surface morphology during the study. The results show that mineral dissolution in the CO2-water-plagioclase reaction system is more obvious than in other mineral systems at 18MPa and 120°C. Higher temperatures further promote the dissolution of plagioclase and the generation of secondary minerals. It is also found that calcium feldspar is more soluble than sodium feldspar when the temperature is below 120°C and sodium feldspar will be more soluble than calcium feldspar when the temperature is above 120°C. Moreover, the montmorillonite also promotes the reactions due to its large surface area. For the CO2-water-plagioclase-chlorite reaction system, the simultaneous dissolution of plagioclase and chlorite in CO2-saturated water would lead to competition for H+. These inhibit the initial mineral dissolution. As the dissolution of chlorite provides Fe and Mg, when the concentration of Ca2+ is increased to meet the requirements for ankerite precipitation, the demand for elements such as Fe and Mg will conversely promote chlorite dissolution.

Keyword

CO2 mineral trapping, Feldspar and clay, Hydrothermal batch reaction of autoclave, Supercritical carbon dioxide

Molecular simulation of CO2 injection in methane-bearing coal models with different pore structures

Ruikang CUI[1]*, China University of Petroleum (East China) (Ruikang_Cui@163.com)
Jianmeng Sun[2], China University of Petroleum (East China)

Abstract

Deep coalbed methane (CBM) is a new field of CBM exploration with great resource potential. CO2 injection enhanced coalbed methane recovery (CO2-ECBM) technology can not only improve the coalbed methane production rate and reduce the methane content of coal seam, but also achieve the storage of CO2 and achieve the purpose of greenhouse gas emission reduction, which has both economic and environmental benefits. Compared with the middle-shallow coal reservoir and the Longmaxi Formation shale reservoir in Sichuan Basin, the pore structure of deep coal reservoir is more complex. The pore type is dominated by micropores (pore size <2nm), and the specific surface area of micropores accounts for more than 99%. In order to study the effect of micro - and nano-scale pore structure on the process of CO2 adsorption and CH4 displacement, a minimum energy coal model containing adsorbed methane was determined by using the large canonical Monte Carlo (GCMC) simulation method. The desorption behavior of CH4 after CO2 injection in a microporous - mesoporous model (pore size 2-50nm) was studied. The results show that methane exists in the form of micropore filling, adsorption state and free state in mesoporous. CO2 drives out methane gas mainly by occupying the adsorption site. The micro-nano scale pore structure controls the process of CO2 adsorption and CH4 displacement and fluid migration behavior. The stronger the adsorption potential of micropores, the stronger the adsorption capacity of coal for the mixed gas of CO2 and CH4, which is not conducive to CO2 replacement of CH4. Mesoporous pores directly affect the diffusion and transport behavior of CO2 and CH4. By analyzing the types of diffusion in micropores and mesoporous pores, it is found that transitional diffusion and Knudsen diffusion are dominant in micropores, while transitional diffusion and Fick diffusion are dominant in mesoporous pores. This study reveals the methane desorption behavior and CO2 displacement mechanism in coal reservoirs, which is of significant importance for utilizing CO2 to enhance coalbed methane recovery and capture and sequestration of CO2 in coal reservoir pores.

Keyword

Deep coalbed methane (CBM), CO2 storage, Molecular simulation, Gas injection displacement

Keyword

Deep CBM, Yulin area, deep 8# coal, reservoir physical properties, resource potential evaluation

Exploration of shale gas from lower Gondwana shale beds of Jharia Coalfield, India– a potential game changer in clean energy domain

KAUSIK KUMAR GHOSH[1]*, GEOLOGICAL SURVEY OF INDIA (kausik.ghosh@gsi.gov.in)
Krittibas Das[2], GEOLOGICAL SURVEY OF INDIA
Jitendra Kumar[3], GEOLOGICAL SURVEY OF INDIA
Sudip Bhattacharyya[4], GEOLOGICAL SURVEY OF INDIA

Abstract

Unconventional natural gases like shale gas are in focus for its sustainable clean and green energy field. Shale gas is chiefly composed of methane, which burns much more cleanly than other fossil fuels. The gas is generated from organic-rich shale through biogenic and/or thermogenic processes. Shale gas reservoirs act as both source and reservoir rock for hydrocarbons generation. Pursuing challenges in energy needs in a sustainable manner, shale dominated lower Gondwana litho-assemblages of Jharia Coalfield was explored through exploratory drilling to determine the shale gas potentiality and quantitative estimation of shale gas resources.

A total of 8951m of drilling through 7 boreholes was carried out. A comprehensive multi-parametric approach was undertaken through measurement of in-situ shale gas content by gas desorption study, petrography, Rock-Eval pyrolysis, adsorption isotherm study, pore analysis, SEM-EDX, XRD and gas chromatography for detailed characterization of shale reservoir. The estimated Gas-In-Place (GIP) of 24,200 million cubic meters (MCM) shale gas was assessed over 100 sq. km. area. Significant gas content upto 7.36 cc/gm (average: 1.51 cc/gm) from a total of 1010m thick carbonaceous shale was determined. This finding may open up a new vista for unconventional source of energy from lithounits, which are devoid of economic coal seams.

The calculated high palaeogeothermal gradient (up to 6.5˚C/100m) renders the maturation of the organic matter in the thermogenic stage. Source kerogen of carbonaceous shale reveals mostly Type-III & Type-IV (late mature to post-mature stage) with total organic carbon (TOC: 3.87-34.12%) and Hydrogen Index (HI: 4-148) indicating excellent source rock potentiality for gas generation. The maximum temperature corresponding to the maximum hydrocarbon yield (Tmax) ranges from 448°C to 606°C indicating excellent maturity for gas generation. Pore study indicates the dominant control of the mesopores on the gas adsorption capacity and pore interconnectivity. Dominance of quartz over the accessory clay minerals in these shales has rendered enhanced brittleness, suitable for better hydro-fracturing capability during production. The high-pressure N2 adsorption isotherm study also suggests the favorable condition for shale gas reservoir, where the gas saturation level increases with depth. High gas recovery factor (82-95%) also strongly implies excellent production potentiality. High proportion of CH4 within the combustible gas content (avg. 93.02%) is highly suitable for its use as fuel in Greenfield energy domain. Considering the excellent reservoir potentiality, the carbonaceous shale horizons of Jharia Coalfield may be the game changer, providing shale gas as a major share in the clean and green energy domain of the Indian energy mix in the near future.

Keyword

Shale Gas, Jharia Coalfield, Maturity, Kerogen, Reservoir potentiality

Structural deformation and microstructure evolution of marine shale from the upper Yangtze region of China

Yiwen JU[1]*, University of Chinese Academy of Sciences (juyw03@163.com)
Hongjian Zhu [2], University of Chinese Academy of Sciences
Kun Yu[3], China University of Mining and Technology

Abstract

Tectonic stress may deform or damage the shale rocks, thus affecting their macro or micro structures to varying degrees. The Lower Paleozoic marine shale samples from the upper Yangtze region of China, were studied through focused ion beam scanning electron microscopy (FIB-SEM), gas adsorption, and mercury intrusion, to evaluate the effect of structural type and deformation mechanisms on the reconstruction of shale pore and fracture structures. Results indicate that shale in monoclines contains mostly organic matter pores, while shale in folds or faults resulted from strong tectonic activities contains largely mineral interparticle pores, dissolution pores and fractures. Comparatively, fold- related shale has more micro pores and fault-related shale has more macro pores than monoclinic shale. The pore difference in shale of different structural parts can be attributed to an uneven distribution of local structural stress. Brittle shale contains mainly micrometer- sized pores and fractures, which are conducive to gas migration and accumulation; while ductile shale is dominated by nanometer- sized pores, which are conducive to gas adsorption and occurrence. The total pore volume of the shale increases with brittle deformation and decreases with ductile deformation. The total specific surface area of the pores is loosely connected with brittle deformation, but has a positive relationship with ductile deformation. Based on these results, the paper discusses the controlling factors and evolution models of micro- nano shale pores and fractures under structural deformation, and concludes that the structural stress on shale results in the modification of shale compositions, the evolution of pores and fractures in shale, and the storage and migration of shale gas.

Keyword

marine shale, tectonic deformation, microstructure, evolutionary model, upper Yangtze

Fracture Diagnosis and Inter-Well Interaction Analysis - Correlating Fiber Optic Data with Coupled Geomechanics-Thermal-Flow Simulations

Chuanyao Zhong[1], University of Alberta
Juliana Leung[2]*, University of Alberta (juliana2@ualberta.ca)

Abstract

Recent advancements in fracture-diagnostic tools, particularly fiber optic technologies such as Distributed Temperature Sensing (DTS) and Distributed Acoustic Sensing (DAS), have enhanced real-time monitoring and analysis of fracture hits, stress shadowing, and temperature and production variations. However, integrating field DTS/DAS data with production responses remains challenging. This study employs numerical simulation, and its capability to address these coupled geomechanics-thermal-flow problems is systematically evaluated. The model is used to explore temperature-strain responses, subsequently assessing the impact of fracture network properties on temperature responses and to derive insights into fracture diagnosis. Finally, the simulation results are used to interpret observations from field DTS/DAS data. Very few prior studies have investigated the impact of fracture interference on the fracture development and production of child wells. Attempts to include DTS data in evaluating the production performance of these offset wells are limited.

Detailed mechanistic models are constructed to simulate various fracture distributions and fracture hits scenarios. 3D thermal flow models, incorporating detailed wellbore modelling, are integrated with geomechanical calculations. Multi-scale fracture responses are simulated, e.g., physical opening/closure of hydraulic fractures (HF), induced secondary fractures, and pre-existing natural fractures. A commercial simulator is used, and a systematic examination of available model setup options was conducted to attain the most accurate responses. This modelling framework is validated against both established numerical and analytical standards. Two innovative features have been integrated: first, the matrix apparent permeability is dynamically updated according to pore pressure to capture the impact of nano-scale flow behaviours; second, natural fracture properties are updated in response to the stress variations, capturing their dilation/closure. Several field cases based on the Montney Formation are replicated. Simulated temperature, strain rate and production responses are compared to field DAS/DTS supplied by an industrial partner.

The simulation outcomes reveal the near-wellbore temperature behaviours as they respond to various HF properties and secondary fracture network distributions. The thermal effects exert a significant influence on the strain responses around HF. The results also indicate that while fracture hits hinder the growth of adjacent new fractures, they also enhance the production of nearby stages, particularly during the early phases. Frac hits lead to slower cooling during injection and faster warm-back during shut-in and flowback near the wellbore. These effects become more pronounced with closer proximity but diminish as the intensity of frac hits increases.

This study is the first to identify and outline the optimal configurations for maximizing the potential of commercial software packages in representing the complex behaviours of hydraulic fracturing. A quantitative framework is introduced to correlate simulation responses with DAS/DTS data. This type of analysis proves beneficial across various geological energy applications. The results underscore the sensitivity of downhole temperature, strain/stress and production responses to fracture network properties and treatment-monitor well interactions. Various scenarios are simulated and compared with field data. The findings offer valuable insights into leveraging real-time DTS/DAS data from the field for fracture diagnosis, fracture hit analysis, and production data interpretation

Keyword

fracture, numerical simulation, distributed sensing

Pore-scale Investigation of the Effect of Surfactant on Storage Efficiency in CO2 Geosequestration

Chan Hee KIM[1]*, Korea Institute of Geoscience and Mineral Resources, Daejeon, Republic of Korea (kchnice1@kigam.re.kr)
Kue-Young Kim[2], Korea Institute of Geoscience and Mineral Resources, Daejeon, Republic of Korea
Gidon Han[3], Korea Institute of Geoscience and Mineral Resources, Daejeon, Republic of Korea
Weon Shik Han[4], Department of Earth System Sciences, Yonsei University, Seoul, Republic of Korea
Jae-Hong Lim[5], Pohang Accelerator Laboratory, Pohang, Republic of Korea

Abstract

Geosequestration of carbon dioxide (CO2) plays a crucial role in mitigating atmospheric CO2 levels. Therefore, securing reservoirs for large-scale CO2 storage is essential to achieve emission targets. Given the limitations of utilizing pore spaces in storage systems, enhancing pore space utilization becomes crucial in CO2 geosequestration. Among the various proposed technologies, we here focus on the utilization of surfactants. Surfactants are used to reduce capillary forces. With their hydrophilic polar heads and hydrophobic aliphatic tails, surfactants effectively lower the CO2-water interfacial tension (IFT). This study experimentally investigates the effect of surfactants on CO2 flow and storage efficiency in a sandstone at pore-scale. Two-phase flow experiments were conducted under various pressure conditions (6-16 MPa) where CO2 transits from gaseous phase to supercritical state. High-resolution three-dimensional images were obtained during the experiments using synchrotron-based X-ray microcomputed tomography. We compared microscale parameters such as interfacial curvature and contact angles, and additionally assessed mesoscale parameters including capillary pressure and relative permeabilities. Our results showed that low surfactant concentration of 0.05 wt% can lead to an increase in CO2 saturation throughout the core sample. Moreover, the measured microscale parameters such as contact angle and IFT revealed a positive effect of surfactant on storage especially when CO2 was gaseous phase (< 7 MPa). Our study implies that the use of surfactant could effectively enhance CO2 storage capacity, especially in depleted gas reservoirs where CO2 is injected in gaseous phase at the early stage of injection.

Keyword

CO2 geosequestration, Surfactant, Storage efficiency, Pore-scale, Synchrotron-based X-ray microcomputed tomography

A novel method to enhance hydrate production and CO2 sequestration in clayey silty reservoir via splitting grouting

Xiaochu WANG[1]*, Jilin University (wangxiaochu@jlu.edu.cn)
Wei Guo[2], Jilin university
Yuan Wang[3], Jilin university
Rui Jia[4], Jilin university
Pengyu Zhang[5], Jilin university

Abstract

During the pivotal period of energy transition between carbon neutrality and carbon peaking, it is crucial to develop technologies which integrate efficient fossil energy development and carbon sequestration. Unlike traditional fossil fuels (coal, oil and natural gas), natural gas hydrate (NGH) has the advantages of high energy density and non-pollution, recognized as the most promising clean energy source of the 21st century. However, the NGH production also faces several significant challenges that need to be addressed such as low production rate, low production range and short stable production period. Meanwhile, conventional CO2 storage technologies also face shortcomings such as low carbon storage efficiency, poor confinement effect and CO2 leakage.
Therefore, in this work, an environmental-benign method to enhance hydrate production and CO2 sequestration in clayey silty reservoir via splitting grouting is introduced. As a novel method for achieving the three goals of all reservoir skeleton reinforcement, permeability enhancement and CO2 sequestration improvement, is proposed to stimulate NGH reservoir. Herein, the formulation based on CO2 foamed ultrafine cement grout was established. The results showed that the grout has good fluidity with initial viscosity ~500 mPa·s and consolidation time in the range of 28-50 min. Meanwhile, the consolidation performance evaluation was studied, and it showed that the consolidation is with porosity in the range of 9.41%-46.59%, permeability in the range of 51.23 mD-789.07 mD, and compressive strength in the range of 3.31 MPa-3.88 MPa. The internal pore channels are uniformly distributed with a large number of stomatal strings, which can be used as a multistage seepage channel for gas and water production from hydrate decomposition. Meanwhile, CO2 is converted to carbide and permanently sequestered in the grout consolidation. To further examine the stimulating behavior, the effect of hydrate saturation, grouting well diameter, grouting flow rate, and in-situ stress on splitting pressure and grouting volume were analyzed, and it was found that the grout has good ability to split fracturing and grout diffusion under the conditions of axial pressure of 5 MPa, confining pressure of 4 MPa, and hydrate saturation not more than 0.30. In addition, an environmental-benign high-efficient reservoir stimulation method on a laboratory scale was proposed. The findings could provide fundamental insights and recommendations for the implementation of splitting grouting in NGH reservoirs.

Keyword

natural gas hydrate, clayey silt, reservoir stimulation, CO2 sequestration, splitting grouting

Utilization of porous media for CO2 and H2 storage in Hungary

Dóra Cseresznyés[1], Supervisory Authority for Regulatory Affairs
Orsolya Gelencsér[2], Lithosphere Fluid Research Lab, Eötvös Loránd University, Budapest, Hungary; Doctoral School of Environmental Sciences, Eötvös Loránd University, Budapest, Hungary
Csilla Kiraly[3], Geographical Institute, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary
Zsuzsanna Szabó-Krausz[4], Lithosphere Fluid Research Lab, Eötvös Loránd University, Budapest; Centre of Environmental Sciences, Eötvös Loránd University, Budapest, Hungary
Ágnes Szamosfalvi[5], Supervisory Authority for Regulatory Affairs
Ákos Kővágó[6], Lithosphere Fluid Research Lab, Eötvös Loránd University, Budapest HUN-REN Institute of Earth Physics and Space Science, Sopron, Hungary
Csaba Szabó[7], Lithosphere Fluid Research Lab, Eötvös Loránd University, Budapest
György Czuppon[8], Institute for Geological and Geochemical, HUN-REN Research Centre for Astronomy and Earth Sciences, Budapest, Hungary
Dániel Breitner[9], Green-Ventures Ltd. Budapest, Hungary
Gyorgy FALUS[10]*, Supervisory Authority for Regulatory Affairs (gyorgy.falus@sztfh.hu)

Abstract

To achieve the net zero economy, energy transition is needed in whole Europe. Carbon capture and storage (CCS) is a promising way to decrease the emitted CO2. Subsurface hydrogen storage can be one of the key methods for the energy transition. In this study both technologies are under spotlight to show their viability in the Pannonian Basin, Hungary. The available formations of thick strata with regional extent marked by facies with varying porosity and permeability from excellent aquifers to low permeability aquitards. This represents an enormous potential to store and seal off large volumes of pore fluids. Porous rocks (e.g. sandstone) are among the most potential reservoirs to inject and store CO2 on geological time scale. This could be an option for short- or long-term hydrogen storage as well. However, the mechanisms of storage, and the effect of the CO2 or hydrogen for the reservoir are not straightforward. To understand the interactions in the rock-water-gas system, investigation of natural reservoirs, laboratory experiments and geochemical modelling with PHREEQC have been carried out.

In case of CO2 geological storage, natural CO2 occurrences (Mihályi-Répcelak) have been compared with sandstones of the same formation which have not been flooded by CO2 (Ölbő). The comparison of the petrographic and geochemical features revealed which processes are a response or partially connected to the CO2 flooding. Dawsonite [NaAlCO3(OH)2] is missing in the investigated Ölbő sandstone and siltstone samples. In Mihályi-Répcelak area dawsonite formation was induced by CO2 flooding. The CO2 that precipitated as dawsonite seems to be magmatic in origin (Cseresznyés et al. 2021). In contrast, the isotopic signature of siderite suggests that it was only partially formed as a response to CO2 flooding, the rest being an early diagenetic mineral. The isotopic composition of siderite present in the unflooded Ölbő sandstones also supports this scenario.

In case of underground hydrogen storage, abiotic reactions were investigated which can occur in the sandstone reservoir. Among the rock forming minerals, K-feldspar and pyrite were investigated. K-feldspar ($KAlSi_3O_8$) is one of the pH sensitive silicate minerals, meanwhile pyrite (FeS_2) is a redox sensitive accessory mineral of sedimentary rocks. Geochemical modeling and static batch reactor experiments have been conducted in the pressure and temperature range of subsurface hydrogen storage to track the effect of hydrogen on K-feldspar and pyrite (described in Gelencsér et al. 2023). Results show that K-feldspar behaves similarly both under hydrogen and nitrogen atmosphere. Pyrite can react with hydrogen resulting in partial alteration of pyrite surface (to pyrrhotite [FeS] precipitation) and hydrogen sulfide (H_2S) production, whereas the reference experiments with nitrogen did not show any H_2S or the appearance of pyrrhotite.

Acknowledgements: Project no. 971238 has been implemented with the support provided by the Ministry of Culture and Innovation of Hungary from the National Research, Development and Innovation Fund, financed under the KDP-2020 funding scheme. This work was supported by O&GD Central Ltd., Hungary.

Keyword

utilization of porous media, subsurface CO_2 and H_2 storage, geochemical modeling, Pannonian Basin

Acoustic Simulation Study of Coal Rock

Xiaojuan SUN[1]*, China University of Petroleum (East China) (Lavender6sxj@163.com)
Jianmeng Sun[2], China University of Petroleum (East China)

Abstract

Our country's coalbed methane reservoirs exhibit characteristics of "high stress, low permeability, and heterogeneity." The composition and physical properties of coal formations are highly complex and diverse. This study focuses on the mixed-phase fluid in coal reservoirs and simulates the dynamic propagation process of ultrasound in rocks, along with various acoustic parameters such as wave velocity, waveform, spectrum, amplitude, and attenuation coefficient. The aim is to investigate the variations in acoustic parameters with different saturation levels of gas and water in coal samples and summarize the relevant relationships between coal properties (gas content, water content) and acoustic response characteristics. Additionally, the study simulates the variations in acoustic parameters under high temperature and high pressure conditions. The research findings indicate a strong positive correlation between longitudinal and shear wave velocities and density of coal formations. As the water saturation of coal increases, both Vp and Vs exhibit exponential growth, with Vp showing a more significant response to changes in water saturation. Conversely, with increasing gas saturation (Sg), both Vp and Vs exhibit exponential decreases, with Vp being more sensitive to changes in water saturation. Under conditions without axial and confining pressures, as the pressure increases, the gas density, Vp, Vs, and amplitude increase while the attenuation coefficient decreases gradually.

Keyword

coal reservoir fluids, acoustic velocity, gas saturation, gas content

Comparison of Gas-bearing Parameter Evaluation Methods for Deep Shale Based on Pressure-holding Coring Technique

Xiao LI[1]*, China University of Petroleum (East China) (392052416@qq.com)
Xianguo Zhang[2], China University of Petroleum (East China)
Shuangfang Lu[3], Northeast Petroleum University
Wenbiao Li[4], Northeast Petroleum University

Abstract

Gas-in-place (GIP) content and adsorbed gas ratio of deep shale under stratigraphic conditions are two key parameters for the objective assessment of shale gas resource potential, screening of sweet spots, as well as the formulation and optimization of development plans. Over the past decades, relevant scholars and engineers both at home and abroad have carried out various researches and explorations for the evaluation of the above key parameters. So far, direct methods based on field degassing data have been proposed and widely used, including the USBM method, polynomial fitting method, Amoco curve fitting (ACF) method, improved curve fitting (MCF) method, and the newly proposed process analysis method and carbon isotope fractionation (CIF) model. However, different methods have their own advantages, disadvantages and applicable conditions. There are many differences in the results of the evaluation of gas-bearing parameters for the same sample (especially for deep shale samples), and there is still a lack of systematic and convincing comparative studies on the evaluation methods of shale gas-bearing parameters. Pressure-holding coring technique is currently recognised as the most effective means of validation and offers the possibility of resolving the above scientific controversies and industry pain points. In this study, the Well P1 in Luzhou area, Sichuan Basin, was selected, and one conventional and three pressure-holding coring were carried out at different depths. The GIP content of the above samples was evaluated using the USBM method, polynomial method, ACF method, MCF method, process analysis method and CIF method respectively, and the applicability and accuracy of the above methods were verified based on the comparison of the pressure-holding coring measured data.

The results demonstrate the gas content obtained is significantly higher because pressure-holding coring samples have excellent sealing and minimal lost time. (2) The GIP content is underestimated by the USBM method, while the polynomial fitting, ACF, and MCF methods overestimate it. The process analysis and CIF methods can evaluate the GIP content of deep shales more accurately. Based on the comparative results of the adsorbed gas ratio calculated using the process analysis and the CIF methods (33.49% and 24.53%, respectively), it is recommended that the CIF method be given priority when evaluating deep shale gas-bearing.

Pressure-holding coring technique can not only be used as an effective support for the results of gas content standard calculation, but also can be used to design the coring process to explore the isotope fractionation characteristics of shale gas in the complete output process, which can help to better understand the mechanism of isotope fractionation, and help the rapid and efficient

development of shale gas exploration and development.

Keyword

GIP content, Adsorbed gas ratio, Deep shale gas, Luzhou area, Sichuan basin

Preliminary assessment of CO2 storage capacities in the northern portion of the offshore Orange Basin, South Africa.

Nangamso DUNGA[1]*, Council for Geoscience (ndunga@geoscience.org.za)
Nigel Hicks[2], Council for Geoscience
Andrew Green[3], University of KwaZulu-Natal

Abstract

Separation between the South American and African plate's occurred along the present day Atlantic margin during the Middle to Late Jurassic leading to the formation of the volcanic passive margin along the west coast of Southern Africa. The margin then later developed into the large Orange Basin flanking the west coasts of South Africa and Namibia.

Carbon dioxide capture, utilisation and storage (CCUS) has been identified as one of the fundamental approaches to mitigating global climate change through the capture and injection of anthropogenic CO2 into suitable geologic reservoirs. South Africa hosts three offshore sedimentary basins which have potential for industrial-scale (>1 million tons) CO2 storage. The Orange Basin on the country's west coast represents the largest and most promising CO2 repository in South Africa, as it covers an area of 145000 km2 to the 2000 m isobath and hosts known, but currently unexploited, hydrocarbon accumulations indicating suitable trapping and reservoir mechanisms. The study aims to further CCUS, sedimentological, petroleum geology and sequence stratigraphic knowledge through the mapping and definition of geological aspects of a 28000 km2 area along the continental shelf in the northern portion of the basin.

Within offshore frontier sedimentary basins, legacy data are important tools in basin-scale exploration for potential CO2 storage. Based on single-channel 2D seismic reflection data and well data, six seismic units (A-F) are revealed, separated by major sequence boundaries. Internal seismic reflector geometries and sedimentology suggest depositional regimes from syn-rift structurally defined sedimentation, followed by incipient ramp development, and lastly progradational sedimentary shelf propagation. Single-channel 2D seismic reflection data and well log data are further utilised to provide evidence of reservoir/seal pairs in saline aquifers that may represent potential storage sites for CO2 injection, stratigraphic and structural traps have been identified. These include continental sediments, fluvial to lacustrine sandstones, of Late Hauterivian-Early Barremian, developed within syn-rift graben systems formed during early continental breakup and the opening of the Atlantic Ocean, and the laterally extensive shelf-bound shallow-marine-sheet and deltaic sandstone packages of Middle Albian-Cenomanian and Turonian. These systems are correlated with analogous hydrocarbon-bearing sequences of the Orange Basin and other mapped and known systems throughout South Africa and Namibia. Using conservative assumptions, at P10; P50 and P90 scenarios, the total CO2 storage capacity is 178Mt at a P90 probability level (355Mt at P50; 607Mt at P10) for shelf and syn-rift sandstone reservoirs. Furthermore, structural closures within the study area have capacities of 22Mt at a P90 scenario (44Mt at P50; 75Mt at P10).

Keyword

Orange Basin, depositional environments, CCUS, CO2 Storage, Seismic reflections

Nano-petrophysical studies for energy geosciences in the context of carbon neutrality.

Qinhong Hu[1]*, China University of Petroleum (East China) (huqinhong@upc.edu.cn)

Abstract

The research on nano-petrophysics, namely the study of rock properties and their interactions with fluids (gas, liquid hydrocarbons, and aqueous solutions) in nanopores of tight rock formation, has been receiving much attention because of the utilities of a range of tight rocks (e.g., mudrocks, granite, salt rock; basalt) in emerging energy and resources geosciences in terms of carbon management. This presentation will cover micro-scale pore structure and its emergent effect on macro-scale fluid flow and chemical transport in porous and fractured media for geological and engineering applications, such as the remediation of contaminated sites, geological repository for high-level nuclear waste, shale petroleum development, enhanced geothermal systems, and underground carbon and hydrogen storage. These systems commonly need effective reservoirs (sandstones, carbonates) for large-volume storage (e.g., effective porosity) and impermeable cap rock (mudrocks and salt rock) for containment (e.g., permeability, diffusivity, and tortuosity). This work studies 10+ representative rock samples from typical geological formations encountered at CCUS, such as Berea sandstone, Crab Orchard sandstone, Guelph dolomite, and Indiana limestone (as depleted sandstone or carbonate oil/gas reservoirs & saline aquifers) with Woodford claystone and Himalayan salt rock as cap rocks. Various and integrated experimental approaches are presented about important processes of diffusion, imbibition, and sorption and associated parameters (e.g., effective vs. “isolated” porosity, tortuosity), as well as ongoing coupled thermal-mechanic-hydrological-chemical processes under reservoir-relevant setting, for a cost-effective and confident utilization of these tight rocks for the storage or storage of fluids.

Keyword

shale petroleum, CCUS, EGS, hydrogen storage, nuclear waste repositiry

Carbon fixation mineral—Geological characteristics and synthetic experiments of Dawsonite

Yangchen ZHANG[1]*, China University of Petroleum (East China) (807545537@qq.com)
Xiyu Qu[2], China University of Petroleum (East China)
Qian Li[3], China University of Petroleum (East China)

Abstract

Carbon dioxide mineralization capture is the most durable and stable form of geological storage, and has become a hot spot for carbon sequestration research in recent years in the context of "dual carbon". As a natural carbon dioxide tracer mineral, the formation of dawsonite is closely related to carbon dioxide infusion, and it may also be an important carbon fixation mineral for carbon dioxide geological storage. The condition of massive and stable presence of dawsonite in geological background is a key issue that constrains the carbon dioxide mineralization capture, and is also an important influencing factor in the search for carbon dioxide geological burial sites. In order to explore the conditions for the rapid synthesis of dawsonite by using carbon dioxide, we conducted a series of experiments for the three main influencing factors of temperature (100/120/140/160/180/200°C), pH (8.5/9/9.5/10/10.5) and reaction time (6/12 hours), and based on scanning electron microscopy (SEM), X-ray diffraction analysis (XRD) to clarify the optimal conditions for the synthesis of dawsonite. The experiments suggests that: In the range of pH 8.5–10.5 and temperature 100–180°C, the products were all pure dawsonite, and the synthesis amount showed a trend of increasing and then decreasing with the increase of pH and temperature, at the temperature of 200°C, the crystallinity of dawsonite decreased and the content of pseudo-boehmite increased. The prolongation of reaction time did not have an obvious promotion effect on the quality of the products, and the prolongation of reaction time at the temperature of 200°C would accelerate the dissolution of dawsonite instead. Overall, 140°C and pH 9.5 are the best conditions for the synthesis of dawsonite using carbon dioxide and probably the ideal conditions for geological sequestration of carbon dioxide.

Keyword

Dawsonite, Carbon dioxide-water-rock interaction, Carbon dioxide sequestration, Mineralization capture, Synthetic

Multi-objective optimization of impure CO2-EOR implementation using CNN-GRU neural network and NSGA-II algorithm: a case study on H59 block of Jilin oilfield China

guangxu CHEN[1]*, Jilin University (chengx22@mails.jlu.edu.cn)
Hailong Tian[2], Jilin University

Abstract

For approaching the maximum benefits, various optimization methods for CO2-EOR projects have been used to co-optimize CO2 storage and oil production. However, few methods are capable of simultaneously considering all the three concerned objectives (i.e., carbon storage, oil production and economic efficiency). In addition, the impact of CO2 impurity on the optimization objectives was rarely reported in previous works. The target of this work is to access the optimal operation parameters with which the CO2-EOR projects are expected to simultaneously obtain the maximum cumulative oil production, net present value, and minimum cumulative gas production.
The convolutional neural network (CNN) was combined with the gate recurrent unit (GRU) neural network to build a novel robust proxy model (CNN-GRU). An intelligent optimization technique coupling CNN-GRU neural network and the Non-dominated Sorting Genetic Algorithm II (NSGA-II) algorithm was proposed to optimize the impure CO2-EOR implementation. Numerical model based on the H59 block of Jilin oilfield, China was employed to generate data for training and testing the built proxy model. The proposed optimization method in this work was applied to obtain the optimal operation parameters (including CH4 fraction in CO2 injection stream, gas mixture injection rate, and producer back-pressure).
The built CNN-GRU proxy exhibits higher prediction accuracy than the GRU proxy and the proposed optimization technique finds the Pareto Front of the optimum solutions. The cumulative oil and gas production increase with the fraction of CH4 in the CO2 injection stream. Considering the global warming potential, the co-injection of CH4 with CO2 improves carbon storage efficiency. Whereas, in terms of economic efficiency, the CH4-CO2 co-injection will increase the disposal cost of produced gas and water, resulting in a lower net present value. This work is desired to provide significant insights for decision-makers in carrying CO2-EOR projects.

Keyword

CO2-EOR, CO2-CH4 co-injection, Multi-objective optimization, CNN-GRU neural network, NSGA-II algorithm

Geochemical Characterization of Pimienta Formation, Mexico as a Potential Hydrogen Source

Alexis Rosa NUMMER[1]*, UFRRJ (rosanummer@gmail.com)
Ana Paola Silveira Martins[2], casada
Douglas J. Betancourt[3], casado
Efrain J. Betancourt[4], casado
Efren Solorzano[5], casado
J. L. P Rabe[6], casado

Abstract

The key objective of the geochemical analysis in this study is to describe shale resources system in terms of their organic geochemical characteristics. The target is the Pimienta formation. This is calcareous shale located in the southern portion of the Burgos Basin, in Mexico, located in the upper Jurassic portion. The stratigraphic column of Pimienta fm. consists of the Lower Oligocene, which is made up of calcareous light gray shale, the Lower Eocene is constituted by light, gray, shales, in which at the bottom of formation traces of light gray sandstones, with fine to medium quartz grains and dark lithics been identified. The mineralogy analysis indicated that mudstone, wackestone and packstone constituted 72% of the carbonate and 11% of clay containing illite, montmorillonite, glauconite and kaolinite. Permeability in the reservoir ranged between 1,600 to 2,000 nD, with total porosity ranging between 5.2 and 9.6%, a median Young's Modulus of 40^106 GPa, a static Poisson's Ratio of 0.25. The present study has been performed to understand the geochemical properties of this formation as a potential source of hydrogen using underground in-situ gasification processes. The main findings of the Geochemical analysis are: Gas Chromatography – Oil/gas ratio in Pimienta Formation shows gas contains 1,302 ppm-23,138 ppm methane, and a small amount of ethane87ppm-3,471ppm) and trace amount of propane, ranging from 60ppm to 542ppm. Drying coefficient of natural gas (C1/C1+) is ranging from 0.9975 to 0.9985. The results show that through the analysis the TOC present in Pimienta is a good rock quality (Quality Generating Rock sources). In average is superior to 2%. As a result of the evaluation the type of Kerogen is II / III and hydrocarbon as oil /gas. Vitrinite reflectance (VR) - The results indicated that hydrocarbon was identified all over the formation. It was possible to establish this formation as hydrocarbon generator system for the Superior Jurassic Play. Rock Eval pyrolysis - Analysis were conducted on the initial and pyrolysis non-extracted and extracted rocks from the sequential experiments. The study of pyrolysis provides knowledge about the chemical composition and maturity of the organic matter contained in the generating rock. The laboratory tests indicated that the water saturation is about 25.5%, oil saturation is about 55.7%, gas saturation is about 18.8%. Dry helium porosity % is about 7.7%. Hydrogen Index (HI) and Oxygen Index (OI) - It is an indicator of the presence of non-oxidized hydrogen in the system, a high HI indicates a greater potential for oil generation. The type of Kerogen can also be inferred from this index. Hydrogen can be classified between 50-200 for gas, between 200-300 for gas and oil and superior 300 is only for oil. Pimienta Shale went through three maturation windows (oil

window, transition between oil and gas windows and gas windows) as it dips south. The results shows that zones of high TOC with hydrocarbon > 1,200 ppm, kerogen type II-III. The study was able to identify sweet spot in the studied unconventional reservoir.

Keyword

unconventional reservoir, Quality Generating Rock sources, organic geochemical characteristics, Potential Hydrogen Source

Comprehensive division of exploration and development units: case studies from three blocks in the southern Qinshui Basin

HUI WANG[1]*, North China University of Science and Technology (huiwang90@ncst.edu.cn)

Abstract

Coalbed Methane (CBM) reservoirs typically exhibit significant heterogeneity, leading to the simultaneous presence of high-yield wells and low-efficiency wells within the same geological unit. To address this issue, it is urgent to require the development of a systematic approach to segment exploration and development areas. This study examines three blocks of Anze, Mabi, and Zhengzhuang in the SQB's slope region. The key metrics, such as the 'conversion depth of coal adsorption saturation' and 'lateral pressure coefficient', were calculated to delineate the boundaries of the study area. These calculations facilitated the division of the study area into five primary geological units. Further refinement was achieved by considering additional other factors like structure, lithology, and hydrogeology, resulting in the subdivision into 11 secondary units. Building upon these subdivisions, the study proposes an evaluation methodology for CBM recoverability, tailored to the specific characteristics of CBM resources, desorption, and reservoir transformability. As a result, the study area was divided into three unique units for CBM development, namely Type I, II, and III. These categories align with regions of high, medium, and low yield respectively. This classification is substantiated by the history production data gathered from approximately 1000 CBM wells collected from the study area .

Keyword

coalbed methane reservoir, gas content, producing potential

Evaluation of Multi-scale Natural Fractures in Coalbed Methane Reservoirs

Yidong CAI[1]*, China University of Geosciences Beijing (yidong.cai@cugb.edu.cn)

Abstract

In this work, the seismic, well logging, core and thin section data were used to evaluate the multi-scale natural fractures. Herein, take Shanxi Formation 3# and Taiyuan Formation 15# coal seams in Zhengzhuang block of southern Qinshui Basin as an example, the multi-scale natural fractures were identified and characterized. The plane distribution characteristics of natural fractures were revealed, the characteristic parameters of natural fractures were defined, and the main controlling factors of natural fractures were discussed. The results showed that natural fractures of coal reservoir in the study area can be divided into large-scale fractures, meso-scale fractures, small-scale fractures and micro-scale fractures according to multi-scale characteristics. Large-scale fractures are mainly developed near the eastern fault zone but are less developed in the middle zone. Meso-scale fractures are developed near the central and eastern fault zones, and the least developed in the northwest and southwest. Small-scale fracture development area mainly concentrated in the middle, and the fracture development degree in other areas is generally poor. Micro-scale fractures are relatively developed in the central part and less developed in the southwest. The comprehensive prediction shows that the multi-scale fracture development is generally poor, and the fracture development is in the central and eastern part of the study area. The fracture characteristic parameters are generally low, the fracture opening is mainly between 0.5-1μm, the fracture porosity is mainly 0.02%, the fracture permeability is mainly between 0.01-0.02mD, and the fracture permeability only a small range of high value area exists in the middle of the study area. Tectonic stress, coal lithotype, vitrinite content, vitrinite reflectance, and rock mechanical properties should have important effects on fracture development, among which tectonic stress and rock mechanical properties were deemed as the main factors controlling fracture development.

Keyword

Southern Qinshui Basin, CBM reservoir, Multi-scale natural fractures, Evaluation methods

Numerical Simulation Study on the Effect of Horizontal Well Reservoir Stimulation for Gas Hydrate Production

Xiaoyang LI[1]*, Institute of exploration techniques, China Geological Survey (770613273@qq.com)
Xiaohang LIU[2], Nankai University
Yongqin Zhang[3], Institute of exploration techniques, China Geological Survey

Abstract

According to the analysis of technical bottlenecks in marine gas hydrate production, one new kind of gas hydrate reservoir stimulation method for improving reservoir permeability and compressive strength was proposed. In this method, the chemical reagents of three components were developed and injected into hydrate reservoir by hydraulic fracture. Through the lab tests, it was found that the chemical reaction could release transient heat to increase the decomposition rate of hydrate. In addition, the chemical reaction product had the honeycomb structure to support fractures and increase permeability at least 60 times. Based on the geological condition of marine hydrate in the South China Sea, three hydrate development models were simulated to study hydrate production capacity. And these three models included horizontal well(HW), horizontal well with fractures(HWF), horizontal well with the stimulation of chemical reagents(HWS). Compared with HW, the simulation results showed that the total gas production of HWF in one year was 7 times of HW, while the cumulative gas production of HWS was 12 times of HW, significantly enhancing the daily production and development efficiency. Furthermore, the evolution patterns of hydrate saturation, temperature-pressure field in production time for three production methods were studied, and the influencing factors of fracture conductivity, fracture half-length and fracture number on hydrate production enhancement were explored. Through the simulations, it provided the new method and theoretical support for the optimization of marine hydrate reservoir stimulation scheme.

Keyword

gas hydrate, reservoir stimulation, horizontial well, transient heat, production enhancement technology

Early-Stage Risk Assessment for a Potential Commercial-Scale Geological Carbon Storage Site in Utah, USA

Ting XIAO[1]*, University of Utah (xiaotinguu@gmail.com)
Brian McPherson[2], University of Utah
Hailong Tian[3], Jilin University

Abstract

Carbon capture, utilization, and storage (CCUS) in geological formations is playing a key role in mitigating CO2 emissions and achieving the “net-zero” goal for greenhouse gas emissions. Risk assessment is critical for CCUS projects, especially in early stage, because it influences the development and quantitative analyses of reservoir simulations, as well as the subsequent plans for monitoring, characterization, and external communications. This study summarizes the early-stage risk assessment developed and applied to the Uinta Basin Carbon Storage Assurance Facility Enterprise (CarbonSAFE) Phase II project sponsored by the U.S. Department of Energy (DOE), located in the east Uinta Basin, Utah, USA.

The Uinta Basin CarbonSAFE Phase II project seeks to establish the technical and economic feasibility of commercial geological carbon dioxide storage (GCS) with high-resolution characterization data, technical analysis, economic evaluation, and environmental analysis. Identifying constraints and risks that might prevent commercial-scale CCUS development is a key component of this project. To date, the project team has evaluated risks to project values including economic, environmental, legal, social, technical, operational, and management aspects. With a feature, event, and processes (FEP) list that summarizes potential risks for a typical CCUS project, project members, CCUS experts, and external advisory board members identified risks that might potentially impact the project deployment and their likelihood and severity. The results are valuable for subsequent risk evaluations by considering key risk factors for this specific CCUS site and the strategies of community engagement.

Keyword

Geological Carbon Dioxide Storage, Uinta Basin, Risk Assessment, CarbonSAFE

Microscale gas occurrence mechanism in coalbed methane reservoirs

Fengrui SUN[1]*, China University of Geosciences Beijing (sunfengrui@cugb.edu.cn)
Dameng Liu[2], China university of geosciences Beijing
Yidong Cai[3], China university of geosciences Beijing
Yongkai Qiu[4], China university of geosciences Beijing

Abstract

At present, the exploration and development of major coalbed methane (CBM) fields in the world continues to strengthen. Elucidating the gas occurrence mechanism in coalbed methane reservoirs is one of the basic tasks before carrying out numerical simulations. The academic community generally agrees that methane is mainly in the adsorption state in CBM reservoirs, with some free gas and dissolved gas, and has developed the single-layer adsorption theory and the multi-layer adsorption theory represented by the Langmuir model and the BET model. Until now, the molecular force field superposition mechanism of gas occurrence in microscale pores under different coal rank conditions is still unclear, and there is still a lack of systematic research on the differences of gas occurrence mechanism in different adsorption layers and the nature of adsorption/desorption between adjacent adsorption layers. In this paper, the macroscale coal rank control mechanism of adsorbed gas is firstly studied, and the statistical nature of the Langmuir model is revealed. It is found that gas molecules show the duality of "Newtonian mechanics-Vibration dynamics" in the surface control field; the gravitational field model can well explain the phenomenon of gas stratification under different coal rank conditions, and reveal the nature of adsorption/desorption between adjacent layers; the residual pressure is relatively low in low-rank and high-rank coal matrix, and relatively high in medium-rank coal matrices; the residual pressure equation can also provide theoretical analysis basis for the enhanced gas recovery of low-pressure CBM wells.

Keyword

Coalbed methane reservoirs, gas occurrence mechanism, microscale gravitational field model, molecular force field superposition, "coal rank-pressure" coupling control

Effect of SCCO2-H2O-Coal Reaction on the Pore Structure of High-rank coal

Junyan Jun ZHANG[1]*, 1060247389@qq.com (1060247389@qq.com)
Qiang Gui Zheng[2], +8615110084688
Sheng Lin Gao[3], +8615350715799
Ji Li[4], +8615128438350

Abstract

Coal reservoirs using for CO2 geological sequestration not only reduces greenhouse gases, but also promotes the development of coalbed methane (CBM), which has dual significance in protecting the environment and improving CBM extraction. In this experiment, temperature and pressure at different depths of the geological strata were used as experimental variables. Supercritical CO2 (SCCO2) and distilled water were injected into the 3# anthracite coal sample from the southern part of the Qinshui Basin to observe the changes in the pore structure of the coal sample pre and post experiment. The pore structure characteristics of the coal samples were measured by the mercury intrusion tests (MIP) and low temperature N2 adsorption methods (BET) . The surface morphology changes of coal samples can be observed through scanning electron microscopy experiments (SEM). The experimental results show that the SCCO2-H2O-Coal reaction has a significant effect on the modification of mesopores or mesopores (pore size of 2-50nm) in coal samples,but has almost no effect on micropores (pore size<2nm) or macropores (pore size>50nm). The causes of the phenomenon can be summarized as follows: 1. the original pores in coal were expanded during the SCCO2-H2O injection; 2. the closed pores in the coal were opened, increasing the connectivity of the coal; 3. the minerals in coal, especially carbonate minerals, are dissolved, resulting in the formation of more pores. In addition, SCCO2 can physically extract small molecule organic matter from coal. The acidic environment formed by the injection of SCCO2-H2O into coal seams can also disrupt the connection bonds between the basic structural units of coal molecules and other functional groups on the side chains, thereby promoting the development of pores and fractures in coal. In summary, the transformation effect of SCCO2-H2O-Coal reaction on the pore structure of high rank coal reservoirs will affect the adsorption and desorption performance of coal seams, thereby affecting the recovery rate of CBM.

Keyword

Supercritical CO2-H2O, Pore Structure, CO2-ECBM

Monitoring methane gas emissions in coal mine areas of North Korea based on Sentinel-2 satellite data

Minju KIM[1]*, Dong-A University (330140@donga.ac.kr)
Jeongwoo PARK[2], Dong-A University
Chang-Uk HYUN[3], Dong-A University

Abstract

As abnormal climates such as extreme heatwaves and heavy rainfall occur worldwide due to the increase of greenhouse gases, the importance of reducing greenhouse gas emissions is emphasized. Methane, a greenhouse gas with a significant impact on climate change, has a global warming potential approximately 82.5 times that of carbon dioxide over a 20-year period. Reduction of methane gas emissions, which cause relatively strong global warming effects, is essential for mitigating climate change, and it is important to identify and manage emission sources and quantities through continuous monitoring. Satellites can effectively detect methane emissions in inaccessible or extensive areas by providing periodic and global data. In particular, Sentinel-2 satellites, with their short revisit period and relatively high-resolution images covering various bands from visible to shortwave infrared, can be effectively utilized for methane gas detection. Previous researches have been conducted on methane detection using shortwave infrared bands of satellites such as GHGSat and WorldView-3 for known methane emission sources. In this study, we utilized Google Earth Engine (GEE), a cloud platform for efficient analysis of large-scale satellite data, and Sentinel-2 satellite data to detect and monitor methane gas emissions from coal mines in the vicinity of Suncheon, South Pyongan Province, North Korea, including the 2.8 Jikdong Coal Mine, a region with restricted access. The results of this study are expected to contribute to international efforts aimed at reducing methane emissions globally and to be utilized as foundational data for sustainable environmental management and climate change mitigation. Furthermore, it demonstrates the practicality of methane emission monitoring using remote sensing technology.

Keyword

Methane, Sentinel-2, Google Earth Engine, Greenhouse gas

Simulation study of the high-temperature nitrogen injection in-situ conversion process: a case study in Songliao Basin shale formation

Chaofan ZHU[1]*, Jilin University (chaofan_zhu@jlu.edu.cn)
Wei Guo[2], Jilin University
Qiang Li[3], Jilin University
Sunhua Deng[4], Jilin University
Yuan Wang[5], Jilin University
Rui Jia[6], Jilin University

Abstract

China’s oil shale reserves are 739.1 billion tons and 45 per cent of which are in Songliao Basin. Therefore, a pilot project is conducted in Songliao Basin, aimed at technical preparation for commercial in-situ oil shale processes production. Because N2 is readily accessible and has no damage to the formation, the high-temperature nitrogen injection in-situ conversion process (HNICP) is the most basic convection heating technique, which is used in the pilot project. In this study, the Wellington reaction model is adjusted to describes the pyrolysis behavior and characteristics of shale in Songliao Basin, China. Based on the geological data and production date of the pilot project in Songliao Basin, a simulation model matching the production test scheme is established to investigate subsequent production performance and the evolution of reservoir physical properties for 550 days. Finally, the effect of injection temperature, total organic carbon (TOC), and enclosing area on the recovery factor is analyzed. The results show that the oil production rate can be divided into four stages for the HNICP of oil shale. In the third stage, prechar accumulation is very severe in the main fracture. However, the prechar accumulation relieves the heat short problem in the main fracture. The high temperature is beneficial to the production of oil, HC, and prechar. The formation plugging in the low TOC shale formation is more serious. Because of the spontaneous imbibition of oil in the formation away from the main fracture, the small enclosing area is beneficial to the production of oil.

Keyword

Oil shale, In-situ conversion process, Reaction mechanism, High-temperature nitrogen

Numerical Simulation of Oil Recovery Performance and Long-term CO2 Storage Potential after Different CO2-EOR Operations

Zejin FAN[1]*, Jilin University (3030966868@qq.com)
Huixing ZHU[2], Key Laboratory of Groundwater Resources and Environment, Jilin University
Tianfu XU[3], Key Laboratory of Groundwater Resources and Environment, Jilin University

Abstract

The CO2-EOR (Enhanced Oil Recovery) technology has emerged as a crucial approach for achieving carbon neutrality, enabling simultaneous carbon sequestration and oil production, thereby enhancing its economic viability. Recent studies on CO2-EOR have provide valuable insights into the optimization of oil production. However, the fate of injected CO2 has often been disregarded. In this study, the oil components were incorporated into the reactive transport simulator TOUGHREACT to achieve a comprehensive description of multiphase flow, multi-component miscible process, and geochemical reactions involved in CO2-EOR. Therefore, the evolution of CO2 in different phase states (gas/supercritical, dissolved, and solid) can be effectively characterized. A CO2-EOR project in Jilin Oilfield in China was used to verify the model, and gained a good match between pressure and oil production rate with actual data, then the oil recovery efficiency and CO2 sequestration efficiency of several typical CO2-EOR operations were compared. The results showed that miscible WAG (Water Alternating Gas injection) method (CO2-water slug ratio 1:1) can obtain the best oil recovery factor (92%) when injecting the same volume of CO2, followed by continuous miscible CO2 injection (83%), immiscible WAG injection (gas-water slug ratio 1:1, recovery factor 76%) and continuous immiscible CO2 injection (66%). Similar results were seen in the CO2 sequestration efficiency when CO2-EOR operations were stopped, which were 94% of miscible WAG, 92% of immiscible WAG, 77% of continuous immiscible injection and 65% of continuous miscible injection, respectively. Due to the horizontal flow of the fluid is limited, and the presence of hydrocarbon components in the gas phase further reduces the CO2 dissolution amount, the injected CO2 in continuous injection cases mainly gathered in gas phase around the injection well during the 500 years' sequestration period. The dissolution rate of CO2 into the water was controlled by the consumption rate of the CO2-water-rock reaction. In the CO2 gas-water phase zone, minerals such as calcite and albite are constantly dissolved under the acidic condition, resulting in a maximum increase of 0.1% in porosity. In compared, WAG injection stored more CO2 (70%) in liquid phase in the formation, effectively reducing the risk of CO2 gas breakthrough. The CO2 involved in the water-rock reaction to form the minerals could be up to 5% of the total sequestrated amount through 500 years, which improved the stability of the entire system.

Keyword

CO2-EOR, CO2 sequestration efficiency, Geochemical reactions, Carbon footprint

Autothermic Pyrolysis in situ Conversion Process for Oil Shale Recovery

Wei GUO[1]*, Jilin University (guowei6981@jlu.edu.cn)
Chaofan Zhu[2], Jilin University
Qiang Li[3], Jilin University
Sunhua Deng[4], Jilin University
Yuan Wang[5], Jilin University

Abstract

In China, oil shale has not been applied in large-scale industrial processes owing to its poor efficiency and high energy extraction costs. The autothermic pyrolysis in situ conversion process (ATS) is an oil shale high-efficiency heating extraction method that uses the residual potential heat after kerogen pyrolysis.

Herein, a large-size oil shale (Φ: 100 mm, L: 500 mm) in situ pyrolysis experimental apparatus, which considers the overburden pressure, was designed to study the feasibility, characteristics, and energy efficiency of ATS. Two ATS pilot tests were conducted at different depths (approximately 70 and 480 m) in the Songliao Basin, China. The pilot tests were performed for nine years, from 2013 to the present.

The results demonstrate that the ATS of oil shale is successfully triggered at 300 °C. The autothermic pyrolysis reaction is steadily advancing, proving the feasibility of the method in laboratory-scale experiments. According to their optical characteristics and chemical composition, ATS reaction zones can be divided into residue, autothermic, pyrolysis, preheating, and virgin zones. Compared with the high-temperature nitrogen in situ conversion process, pyrolysis oil obtained from ATS contains more light components. When the oil recovery via ATS reaches 69.1%, the energy efficiency reaches 3.46, which is much higher than 0.51 by nitrogen.

The cumulative oil and gas production of the shallow-ground pilot test was 1.6 ton and 1500 m3, respectively. In addition, the cumulative oil and gas production of the deep-ground pilot test was 3.0 ton and 18,000 m3, respectively. During the two pilot tests, long-life downhole heating technology and equipment were developed and applied. The compound reservoir reconstruction technology, which includes shock wave fracturing, hydraulic fracturing, and acid fracturing, was studied. To improve the pyrolysis efficiency, oil recovery and quality to the oil shale oil was studied.

This study shows the advantages and feasibility of ATS using experiments and pilot tests, which can be used for the large-scale commercial development of oil shale.

Keyword

in situ Conversion Process, Autothermic Pyrolysis, Oil Shale

Study on promoting mechanism of electric field on pyrolysis and seepage of oil shale products

Qiang LI[1]*, College of Construction Engineering, Jilin University (lqiang1982@jlu.edu.cn)

Abstract

The in-situ exploitation technology of oil shale is environmentally friendly and is an crucial means to solve the energy crisis in the world today. The degree of pyrolysis of kerogen, fluidity of heavy oil and its state of occurrence in pores of oil shale in the process of exploitation seriously affect the production efficiency. In situ exploitation technology of High Voltage - Power Frequency is to break down the oil shale layer by applying high voltage to the formation, and then pyrolysis the oil shale through the processing frequency electricity. It can centrally heat the oil shale layer and has the characteristics of high energy utilization. It is worth noting that, different from traditional electric heating, the electric field of High Voltage - Power Frequency technology occurs in the oil shale layer, the electronic structure of the molecules is changed and the polar molecules are deflecting under the electric field, thus, the physical and chemical properties of oil and gas products are changed, affecting the production efficiency of in-situ exploitation technology of oil shale. In this study, the fluidity and chemical properties of oil and gas products under the electric field are studied on a multi-scale by combining experimental and theoretical analysis. The macroscopic fluidity and chemical properties of the product under high temperature electric field are studied by Viscosity Test, Fourier Transform infrared spectroscopy (FTIR) analysis and Gas chromatography-Mass spectrometry (CG-MS) analysis. The electronic structure, band structure and interfacial adsorption of oil and gas molecules under electric field are simulated by Density Functional Theory (DFT) and Molecular Dynamics (MD), and their chemical properties and physical properties such as adsorption and infiltration Angle at different mineral interfaces are analyzed. Based on the physicochemical properties obtained from the study at molecular and macro-level studies, the mesoscopic transport model of oil and gas products in the pores of oil shale is established by finite element method. Combined with the multi-scale study, the mechanism of electric field to promote the production efficiency of oil shale is revealed.

Keyword

oil shale, Electric field, Molecular dynamics, Density functional theory, transport model

Altering Pore Morphology of Organic-Rich Shale through SC-CO2 Exposure

Ogochukwu OZOTTA[1]*, University of North Dakota (ogochukwu_ozotta@yahoo.co.uk)
Oladoyin Kolawole[2], New Jersey Institute of Technology
Chioma Onwumelu[3], University of North Dakota

Abstract

The alteration of pore structures in organic-rich shale through the interaction with CO2 is a topic of significant interest due to its impact on various projects. This study focuses on investigating the effects of supercritical CO2 (SC-CO2) exposure on samples obtained from the Upper Bakken (UB) and Lower Bakken (LB) formations. The duration of exposure was set at 3, 8, 16, 30, and 60 days, and a comprehensive evaluation of chemical and structural changes during this process was conducted using multiple techniques such as X-ray diffraction (XRD), gas adsorption (N2) isotherm, and fractal theory.

The findings revealed notable transformations in the composition of the shale samples following CO2 saturation. Specifically, the concentration of quartz increased in the UB samples, while it decreased in the LB samples. Clay minerals and other minerals exhibited a decreasing trend in both UB and LB samples after exposure to CO2. Additionally, the pore size distributions (PSDs) displayed a shift towards smaller pore sizes at all diameters, indicating a reduction in the number of pores because of the reaction with CO2.

The fractal dimension, which characterizes the complexity and roughness of pore surfaces, demonstrated an increasing trend as the samples were exposed to CO2. This suggests that the pore structure became rougher and more intricate after 8-16 days of CO2 saturation. However, after 30-60 days of saturation, the fractal dimension decreased, indicating a transition towards a more homogeneous pore structure.

Furthermore, the dissolution of clay minerals contributed to an increase in pore volume, while carbonate dissolution resulted in an augmentation of the specific surface area. These empirical findings provide valuable experimental evidence to further examine the mechanisms involved in the geological storage of CO2 in organic-rich self-sourced plays.

In summary, this study sheds light on the pore structure alterations that occur in organic-rich shale when exposed to SC-CO2. The findings highlight changes in mineral composition, pore size distribution, fractal dimension, and the impact of clay and carbonate dissolution. This research contributes to our understanding of the geological storage of CO2 in self-sourced plays and provides a foundation for further investigations in this field.

Keyword

organic-rich shale, unconventional, CO2 sequestration, pore morphology, gas adsorption

Unveiling the Sub-10 Nanometer Realm: Innovative FIB-HIM Approach to Shale Nanopore Characterization

Jianguo WU[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS)
(wujianguo@mail.iggcas.ac.cn)
Guoliang Li[2], Institute of Geology and Geophysics, Chinese Academy of Sciences (IGGCAS)

Abstract

Nanopores in shale serve as crucial storage sites and transportation channels for oil and gas. However, characterizing shale nanopores, especially those below 10 nanometers (sub-10 nm), poses significant challenges with current technologies. In response, we have developed an innovative scheme using focused ion beam-helium ion microscopy (FIB-HIM) to capture 2-D and 3-D digital rocks of shale pores down to the sub-10 nm level. Taking Longmaxi shale samples from the Sichuan Basin as a case study, the application of the novel FIB-HIM approach in the characterization of shale nanopores is introduced. The imaging results reveal the morphology of sub-10 nm pores and demonstrate three types of spatial relationships of nanopores in 2-D: independent, touching or merging, and nesting. A 3-D digital core with a precision of 3 nm is reconstructed, showcasing the pore connectivity patterns under the involvement of sub-10 nm pores. Quantitative results rectify errors in traditional methods, highlighting the significant impact of sub-10 nm pores on the evaluation of resource reserves and productivity. For experimental samples, the surface porosity increases by 10.73%, the pore circumference by 43.02%, and the specific surface area by 76%. The novel approach revises the unimodal pore size distribution obtained from traditional methods into a multimodal distribution, consistent with the multi-stage formation model of organic nanopores. The 3-D digital core reveals that the pores unveiled by FIB-HIM exhibit higher coordination numbers and a higher proportion of internal connectivity volume, indicating greater connectivity probability and providing more flow pathways. Compared to conventional focused ion beam-scanning electron microscopy (FIB-SEM) techniques, the novel approach offers several key advantages: (1) Enhanced resolution for visualizing morphological features of sub-10 nm pores. (2) Revised pore size distribution curves, along with recalculated parameters such as porosity, pore circumference, and specific surface area. (3) Improved accuracy in reconstructing the 3-D connectivity of nanopores, elucidating the positive impact of sub-10 nm pores on connectivity. Our novel FIB-HIM scheme provides robust technical support for a comprehensive understanding of shale nanopores. It also furnishes experimental models for both resource assessment and research into fluid transport mechanisms, thereby showcasing significant potential applications in the field.

Keyword

Shale, nanopore, focused ion beam-helium ion microscopy, porosity, connectiviy

Formation dry-out from CO2 injection into coal seam: Salt precipitation and injectivity alteration

Xiaoxiao SUN[1]*, China University of Geosciences, Beijing (xsun90@cugb.edu.cn)

Abstract

Sequestering CO2 into deep coal seams stands out as a leading method to mitigate anthropogenic CO2 emissions. This is primarily due to the significant storage capacity afforded by CO2 adsorption to coal under high pressure. However, within deep coal seams, groundwater typically exhibits exceedingly high salinity levels. As water evaporates during CO2 injection, salt precipitates from the aqueous phase, leading to alterations in the porosity and permeability of the coal. Our objective is to specify how serious salt precipitation is for CO2 storage into coal seam and whether its importance has been overlooked. In this study, we injected supercritical CO2 into a coal core fully saturated with NaCl brine to investigate salt precipitation induced by the evaporation process under varying gas types (CO2 and nitrogen), gas flow rates, and formation water salinity. Scanning electron microscopy was employed to analyze the location and morphology of salt precipitation crystals under both static and gas flow conditions. Additionally, measurements of water saturation, porosity, and permeability within the core samples were conducted concurrently during gas injection to displace formation water. The results show that gas flow displaces a portion of movable water, leading to the drying of residual water under gas flow conditions. Gas flow within fractures significantly impacts salt crystallization, while the salt within the matrix experiences comparatively minor effects due to gas infiltration limitations. Monitoring of nuclear magnetic resonance-T2 spectra during gas flow reveals a reduction in moisture content within fractures, with moisture gradually migrating from the matrix to the fractures as drying progresses. The presence of salts within coal markedly decreases porosity and permeability, particularly evident with increasing formation water salinity. Gas flow velocity inversely correlates with the magnitude of these effects, with a weaker impact observed at higher gas flow rates. Interestingly, in high-pressure CO2 gas environments, salt precipitation effects are less pronounced compared to nitrogen gas environments.

Keyword

CO2 sequestration, Salt precipitation, Coal seam, Permeability

Influence of sediment properties on methane hydrate enrichment in fine-grained sediments

Chenyang BAI[1]*, China University of Geosciences at Beijing (baicy@cugb.edu.cn)

Abstract

Methane hydrates predominantly accumulate in silt-clay sediments, where sediment characteristics such as particle size and mineral composition critically influence their accumulation. The northern South China Sea (SCS) hosts significant fine-grained methane hydrate reservoirs, representing a key area for study. This study analyzed the particle size and mineral composition of 597 sediment samples from methane hydrate reservoirs and adjacent layers across seven sites in the Dongsha, Shenhu, and Qiongdongnan areas of the northern SCS, describing the properties of fine-grained methane hydrate reservoirs. Scanning electron microscopy (SEM), specific surface area (SSA) measurements, and irreducible water saturation tests were employed to elucidate the influence of sediment properties on methane hydrate accumulation in fine-grained sediments. Results indicate that mineral composition significantly impacts both methane hydrate reservoirs and non-methane hydrate layers. The methane hydrate reservoirs exhibit low illite-smectite (I/S) mixed layers and high felsic mineral content, attributed to the adsorption and constraint of gas and fluid by the complex microstructure of I/S mixed layers. Sediment particle size plays a crucial role in determining methane hydrate saturation and morphology within fine-grained methane hydrate reservoirs. Methane hydrate reservoirs with sediment particle sizes above 16 μm primarily feature dispersed, low-saturation methane hydrates formed by pore filling. Conversely, methane hydrate reservoirs with sediment particle sizes below 8 μm predominantly contain visible, high-saturation methane hydrates formed through particle displacement. This study elucidates the mechanisms of methane hydrate enrichment in fine-grained sediments, offering significant insights for exploration, development, and understanding environmental impacts.

Keyword

Methane hydrate, Sediment properties, Fine-grained sediments, Accumulation mechanism, South China Sea

The Geochemical characteristics and Genetic mechanism of tight gas in Shahezi Formation,North Songliao Basin, China——Take Xujiaweizi Fault Depression as an example

YiXuan RAN[1]*, National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China), Qingdao 266580, China (ran18645949951@163.com)
Jian Wang[2],
National Key Laboratory of Deep Oil and Gas, China University of Petroleum (East China), Qingdao 266580, China

Abstract

In recent years, the tight gas exploration and development of Shahezi Formation in the northern Songliao Basin has made strategic breakthroughs, and the long-term test production has achieved remarkable results, which has become an important replacement field for Daqing oilfield. Among them, The tight gas in Shahezi Formation in Xujiaweizi fault depression has become a new and important exploration field for deep gas exploration in the basin and has made continuous breakthroughs. In order to understand the generation and distribution law of tight gas in deep-layer of North Songliao Basin, this study focuses on the geochemical characteristics and accumulation period of tight gas, based on analysis of geochemical data such as tight gas compositions, carbon isotopes and Inclusion homogenization temperature. According to the result of these analysis, the tight gas in Shahezi Formation is dominated by methane with a light portion of heavy hydrocarbons and generally non-hydrocarbon, such as carbon dioxide and nitrogen. There is a widely distribution of $\delta^{13}C_1$ which is ranges from -33.2‰ to -27.8‰, while $\delta^{13}C_2$ is higher and have a relatively intensive distribution from -29.2‰ to -22.4‰. Carbon isotopic distribution of tight gas is characterised by a normal pattern, some partial reversal of carbon are observed. The identification of tight gas shows that the main type of tight gas in Shahezi Formation are coal-formed gas and there are two accumulation periods including Nenjiang period and Qingshankou period. The mix of high maturity coal-formed gas in Nenjiang period and relatively low maturity coal-formed gas in Qingshankou Period is the major cause of carbon isotope reversal. In addition, it is notable that carbon dioxide in study area are inorganic origins and distributed nearby the basement faults, resulted from the magma degassing in Yingcheng Period volcanic magma activity.

Keyword

Tight gas, Carbon isotopes, Geochemical characteristics, Shahezi Formation, North Songliao Basin

Sensitivity analysis of non-condensable gas in SAGP method on 3-dimensional heterogeneous oil sands reservoir

Sunghyun KIM[1]*, Department of Geoenvironmental Sciences, Kongju National University, Gongju-si Chungnam, 32588, Republic of Korea (kimsunghyun97@gmail.com)
Seunghoon LEE[2], Department of Geoenvironmental Sciences, Kongju National University, Gongju-si Chungnam, 32588, Republic of Korea
Namhwa KIM[3], Department of Energy Resources Engineering, Inha University, Incheon, 22212, Republic of Korea
Hyundon SHIN[4], Department of Energy Resources Engineering, Inha University, Incheon, 22212, Republic of Korea
Changhyup PARK[5], Department of Energy and Resources Engineering, Kangwon National University, Chuncheon, 24341, Republic of Korea
Kyungbook LEE[6], Department of Geoenvironmental Sciences, Kongju National University, Gongju-si Chungnam, 32588, Republic of Korea

Abstract

The steam assisted gravity drainage (SAGD) method, which is the most popular method in Canada, utilizes steam to reduce bitumen viscosity. However, natural gas use for steam generation significantly contributes to greenhouse gas (GHG) emissions (ECCC, 2023). A total of 85 Mt-GHG came from the oil sands industry in Canada in 2021, which is 45% of Canada's oil/gas sector GHG emissions. Aligning with the recent carbon-neutral trend, the province of Alberta in Canada has implemented a policy to limit GHG emissions from the oil sands industry to 100 Mt-GHG. Green and Jackson (2016) anticipated that this emission cap would lead to a decrease in Alberta's total oil production by approximately 3.34 billion barrels due to constraints on steam generation. Thus, there is a need for more eco-friendly thermal methods.

The steam and gas push (SAGP) method, developed by Butler in 1999, is suitable for such improvement. This method differentiates from SAGD by additionally injecting non-condensable gas (NCG) along with steam. SAGP alleviates the issue of heat loss to thief zone compared to SAGD and allows for more effective maintenance of temperature and pressure of the steam chamber. This reduction in unnecessary steam usage ultimately reduces the cumulative steam-oil ratio (cSOR), enabling more efficient utilization of steam in the oil sands thermal process.

This study investigated the sensitivity analysis of the SAGP method according to the type and mole fraction of NCG in three-dimensional heterogeneous oil sands reservoirs. The reservoir model has a grid system of 100x860x43m with a grid size of 2x10x1m, comprising a total of 184,900 grids. Production simulation was implemented over 15 years using CMG's STARS software. Methane (CH_4), nitrogen (N_2), and carbon dioxide (CO_2) were used as NCGs, with their mole fraction at 0, 0.5, 1, 2, and 4 mol% for sensitivity analysis. The results showed that lower mole fraction leads to a decrease in cSOR and an increase in cumulative oil production regardless of NCG type. Specifically, at 0.5 mol%, all NCG types reduced cSOR compared to the SAGD method, promoting eco-friendly oil sands production. CO_2 exhibited a relatively lower cSOR than one of CH_4 and N_2 except 0.5 mol% case. These findings propose the possibility of eco-friendly

production of oil sands resources through the SAGP method, especially by utilizing CO_2 as NCG, further reducing GHG emissions.

Acknowledgement

This research was supported by the Korea Agency for Infrastructure Technology Advancement (KAIA) grant funded by the Ministry of Land, Infrastructure and Transport (Grant RS-2022-00143541). In addition, this research was supported by the National Research Foundation of Korea (NRF) grant funded by the Ministry of Science and ICT (MSIT) (No. 2021R1C1C1004460) and Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (MOTIE) (20225B10300050). K. Lee appreciates the software packages, including AccuMap, AccuLog, and QUE$TOR, provided by the S&P Global and Computer Modelling Group (CMG) license through university donation program.

Keyword

steam and gas push (SAGP), non-condensable gas (NCG), steam assisted gravity drainage (SAGD), sensitivity analysis, oil sands

Prediction of CO2 flooding channels based on seismic azimuthal anisotropy

Mei YANG[1]*, China University of Petroleum(East China) (my901829@163.com)
Yongrui Chen[2], China University of Petroleum(East China)
Junhua Zhang[3], China University of Petroleum(East China)
Deyong Feng[4], Geophysical Research Institute of Shengli Oilfield, Sinopec
Liang Qi[5], Geophysical Research Institute of Shengli Oilfield, Sinopec
Yuntao Zhang[6], Geophysical Research Institute of Shengli Oilfield, Sinopec
Xiaochen Li[7], Geophysical Research Institute of Shengli Oilfield, Sinopec
Qingsong Cao[8], China University of Petroleum (East China)

Abstract

CO2 flooding is a tertiary oil recovery technology with broad application prospects. Many oil fields at home and abroad have incorporated carbon capture, utilization and storage (CCUS) projects into the green and low-carbon strategic development system.

Since 2007, the pilot experiment of CO2 miscible flooding has been carried out in the G89 well area of Shengli Oilfield. There are 11 CO2 injection wells and 23 production wells in the core area. The study area has good storage and flooding conditions: 1) The cap layer is oil shale with stable deposition; 2) The reservoir is beach-bar sand with low porosity and low permeability, which requires CO2 flooding to improve EOR; 3) There are two large faults in the north and south of the study area, which are good for sealing and conducive to carbon dioxide storage. In 1992, 2011 and 2021, three rolling exploration with non-repeated acquisition were carried out, which provided data conditions for the dynamic monitoring of carbon dioxide flooding. In particular, in the data of 2021, the aspect ratio of the geometry is 0.72, which belongs to wide-azimuth exploration. Besides rich offset information, there are also original azimuthal information suitable for determining the dominant direction of CO2 injection.

In our research, firstly, well seismic calibration and analysis are carried out, and then forward simulation of CO2 flooding is carried out on the basis of petrophysical experiment. The forward modeling shows that: 1) After CO2 flooding, the basic characteristics of seismic reflection remain unchanged, which are "two strong and one weak"; 2) After CO2 injection, the amplitude of the reservoir section is significantly enhanced, and the time is about 4ms down; 3) In different orientations, the amplitude changes according to azimuth after CO2 injection, with azimuthal anisotropy. The model study provides a theoretical basis for our practical application. When the actual data is applied, the OVT gathers is extracted from the high density data after normal moveout by inline and crossline, and then stacked according to the azimuthal information of the data. Considering that the stratum above the injection layer is not affected by carbon dioxide plume, the caprock-T7 standard layer is used to carry out amplitude consistency during stack. After consistency processing, the max-amplitude information of the target layer is extracted, the data is arranged according to polar coordinates, and the ellipse fitting is carried out. The direction of the long axis is the dominant injection and production direction. The prediction agrees with the post-stack difference attribute extracted by time-lapse seismic data (2011 and 2021), and also

agree with the tracer in well.

Keyword

CO2 flooding, consistency processing, azimuthal anisotropy, CCUS, OVT gathers

Investigation of Characteristics of Gas Hydrate Decomposition under Microwave Stimulation

Yue Zhu[1], Changchun Institute of Technology
Baochang Liu[2]*, Jilin University (liubc@jlu.edu.cn)

Abstract

As a kind of clean fuel with huge reserves, the exploitation of natural gas hydrate has become one of the research hotspots in the world. Among many exploitation methods, depressurization combined with heating stimulation is considered as one of the most promising methods. As a unique bulk heating method, microwave could heat gas hydrate quickly and efficiently.

In this paper, the decomposition characteristics of methane hydrate by microwave stimulation were studied under continuous and intermittent microwave heating. Under continuous microwave stimulation method, the decomposition rate of methane hydrate was higher at the initial stage, and the decomposition heat mainly came from microwave volume heating. With the hydrate decomposed, the free water content increased, the microwave penetration depth of the reservoir decreased. The macroscopic heat transfer became the main mechanism of hydrate decomposition in the remote microwave source regions. With the increment of microwave power, the average gas production rate increased from 0.303 L/min to 0.882 L/min. The decomposition time of hydrate decreased with microwave power increased. Intermittent microwave heating could improve the energy efficiency ratio effectively. When the intermittent heating cycle was 5+1 min, the energy efficiency ratio was 2.103, which was 59.32% higher than that of the continuous microwave heating.

Furthermore, the experiments of microwave hydrate decomposition enhanced by different microwave absorbent were studied. C (conductive graphite), TiO2 and Fe3O4 with powder particle size of 1 μm were added into the reservoir as microwave absorbents. The experimental results showed that the average gas production rate and the energy efficiency ratio of C, TiO2 and Fe3O4 groups were increased by 48.5%, 24.3% and 93.5% compared with the blank control group, respectively.

The characteristics and laws of gas hydrate decomposition under microwave stimulation were revealed. The research results could provide theoretical basis and guidance for the process of gas hydrate exploitation in the field.

Keyword

Gas Hydrate, Microwave Stimulation, Microwave Absorbent, Enhanced Microwave Heating

Fatigue life analysis of oil shale in-situ conversion combustion heater

Shui haoche[1]*, jilin university (shuihc21@mails.jlu.edu.cn)
Wang yuan[2], jilin university
chen zhilin[3], jilin university
guo wei[4], jilin university

Abstract

Oil shale, as an unconventional oil and gas resource, can generate the required oil and gas through high-temperature pyrolysis. In-situ conversion technology is the most commonly used method for oil shale exploitation, which involves injecting a high-temperature heat carrier directly into the oil shale layer using downhole heaters to achieve oil and gas recovery. Components of the combustion heater are made of metal materials, and the uneven temperature distribution experienced by these materials during the beginning, process, and termination of operations can lead to fatigue conditions such as high-temperature creep, micro-cracking, and micro-deformation. To prevent these occurrences, fatigue life analysis of downhole combustion heaters is necessary to provide practical guidance for engineering operations. This study combines actual operational experiments of combustion heaters with finite element simulations to analyze the influence of temperature, structure, and stress amplitude on the fatigue life of the heaters. The findings suggest that the fatigue life of the heater is most significantly affected by the metal gasket, with lower fatigue life observed at higher tail gas temperatures. Heating operations notably reduce the fatigue life of the heater, while cooling operations have minimal impact. Circular metal gaskets exhibit higher fatigue life compared to square ones, and thicker gaskets generally result in longer fatigue life. Stress amplitude has the most pronounced impact on the fatigue life of the heater, as doubling the stress amplitude quickly leads to fatigue failure of the metal gaskets.

Keyword

oil shale, heater, fatigue life, metal materials

Numerical Simulation Study on the Influence of Intermittent Gas Injection on the in-situ Conversion Development Effect of Oil Shale Autothermic Pyrolysis

Yijian ZENG[1]*, Jilin University (1304520112@qq.com)
Chaofan ZHU[2], Jilin University
Yanwei LI[3], Jilin University
Wei GUO[4], Jilin University

Abstract

Autothermic pyrolysis in situ conversion process is a method that utilizes the internal heat of oil shale to thermally decompose it, characterized by its environmentally friendly, low pollution, and high energy efficiency features. The autothermic in situ conversion technology initiates the thermal reaction by injecting air into the formation after thermal triggering, resulting in the appearance of ineffective heating zones, oil and gas oxidation, and so forth. This paper introduces the intermittent gas injection approach to control the autothermic stage and employs numerical simulation methods to investigate the temperature field, kerogen concentration field, and oil saturation field in oil shale formations under intermittent gas injection conditions, as well as to analyze the energy efficiency. The results demonstrate that (1) injecting 20,000 m^3/day of nitrogen at 550°C continuously for four months in the preheating stage, followed by injecting 10,000 m^3/day of air at 25°C to trigger autothermic reactions, leads to substantial oil production one year later. During this stage, intermittent gas injection is implemented, with one month of gas injection cessation alternating with one month of injecting 10,000 m^3/day of air at 25°C, repeated for two years. This intermittent gas injection method yields the best development effect, reaching an energy efficiency peak of 3.51 in the 3.7th year, while conventional autothermic conversion reaches an energy efficiency peak of 3.22 in the 5.3rd year. (2) Intermittent gas injection for autothermic in situ conversion of oil shale results in a 2% reduction in cumulative oil production compared to conventional autothermic in situ conversion, a slight decrease of 1% in cumulative natural gas production, and a significant decrease of 30% in cumulative injected compression energy. However, the energy efficiency is improved by 0.29. This study provides valuable guidance for optimizing the autothermic in situ conversion process for oil shale.

Keyword

Oil shale in-situ conversion, Intermittent gas injection, Autogenous thermal method, Development effect

Numerical Simulation Study on the Impact of Complex Fracture Network on In-Situ Conversion of Oil Shale

Yanwei LI[1]*, Jilin University (yanwei22@mails.jlu.edu.cn)
Chaofan Zhu[2], Jilin University
Yijian Zeng[3], Jilin University
Han Tian[4], Jilin University
Wei Guo[5], Jilin University

Abstract

In-situ conversion of oil shale is an environmentally friendly, economically efficient, and high energy conversion rate method of extraction. Oil shale formations are characterized by developed fracture, current simulations of oil shale in-situ conversion have not taken into account the impact of fracture pattern.This paper focuses on the oil shale of the Xunyi region in China's Ordos Basin as the research subject. By employing the statistical method of stochastic fracture modeling, a discrete fracture model is developed. Integrated with numerical reservoir simulation software, a comprehensive coupled model of seepage, heat transfer, and chemical reactions is constructed. The study examines the effects of hydraulic fracture permeability, fracture density, fracture length, fracture production, and the fracture dispersion on the concentration of kerogen, the production of oil and gas, and the energy efficiency rate during the in-situ conversion process. The results indicate that higher permeability of hydraulic fracture can lead to thermal shortcuts. An increase in fracture density has a significant impact on early stage production. When the power-law exponent D of fracture length approaches 2,extreme channeling phenomena may occur. The optimal fracture trend is parallel to the well direction. The greater the dispersion of fractures, the more achievable it is to attain uniform and stable heating. The optimal scheme selected for the Xunyi oil shale target area is a main fracture permeability of 50 md, fracture density of 0.00015 m3/m3, fracture length power-law exponent D of 2.5, a fracture trend of 90°, and a Fisher K of 50.This research can provide guidance for enhancing the exploitation of oil shale in targeted areas of the Ordos Basin, Xunyi region.

Keyword

Discrete Fracture, In-Situ Conversion, Energy Efficiency, Seepage Heat Transfer, Ordos Basin

Evaluation of Nong'an oil shale reservoir stimulation based on gas injection

Qiang Li[1], College of Construction Engineering, Jilin University
Qingfeng BU[2]*, College of Construction Engineering, Jilin University (buqf@mails.jlu.edu.cn)
Youhong Sun[3], School of Engineering and Technology, China University of GeosciencesBeijing
Wei Guo[4], College of Construction Engineering, Jilin University

Abstract

Hydraulic fracturing, as an effective reservoir stimulation technology, is critical in the process of oil shale in situ conversion. In this study, the Nong'an Oil Shale In-situ Conversion Pilot Project is taken as the research object, which examines the generalized changes in reservoir stimulation volume and microfracture density in the stimulated area during hydraulic fracturing and gas injection. The findings revealed that hydraulic fracturing resulted in a greater reservoir stimulation volume, with permeability in the stimulated area increasing to 324.6 mD. Water replacement in the stimulated area was achieved by injecting lower-temperature nitrogen, which helped to reduce reservoir stimulation volume shrinkage and close microfractures. However, permeability dropped by 80.54%, and seepage area fell to 2660.7 m3.

The gas injection and mining procedure is separated into two phases: warming and cracking. The former is to accelerate the drying of the formation in the stimulation area, while the permeability of the stimulated area is restored to 22.87% of the original area. The latter aims to increase the permeability of the reformed area to 704.842 mD through the process of hydrocarbon expulsion by organic matter cracking. The reservoir stimulated area can be classified as cracking, high seepage, or low seepage based on the difficulty of the injected gas flow and the range of high-temperature influence.

Keyword

Oil shale, In-Situ conversion, Reservoir stimulation, Gas injection mining, Nong'an

Carbon Dioxide Storage Potential of Cenozoic Saline Aquifers in the South Yellow Sea Basin

Yong YUAN[1]*, Qingdao Institute of Marine Geology (yuany010@126.com)
Jianwen CHEN[2], Qingdao Institute of Marine Geology
Jianqiang WANG[3], Qingdao Institute of Marine Geology
Ke CAO[4], Qingdao Institute of Marine Geology

Abstract

Geological carbon dioxide (CO2) storage refers to the engineering approach of injecting captured CO2 into deep geological reservoirs to achieve the long-term isolation of CO2 from the atmosphere. CO2 storage in underwater reservoirs is a valuable method of reducing carbon emissions. Saline aquifers such as those in the South Yellow Sea Basin (SYSB), have great potential for geological CO2 storage. Thus, we use the recommended calculation method of USDOE and a formation volume model to determine the geological conditions for CO2 storage and estimate the CO2 storage capacity of the Cenozoic saline aquifers in the SYSB (depth: 800–3200 m). Overall, the SYSB exhibits weak fault activity and seismicity, medium and low geothermal fields, four types of source sandstone reservoir, and four sets of carbon reservoir–caprock assemblages developed from the Cenozoic strata, providing relatively good geological conditions for CO2 storage. The estimated capacity of the Cenozoic strata ranges from 39.59 Gt to 426.94 Gt (average: 155.25 Gt). The Yantai Depression has a lower geothermal gradient and terrestrial heat, weaker seismic activity, and double the storage capacity of the Qingdao Depression, indicating that it is the most suitable area for Cenozoic CO2 storage in the SYSB, whereas the Laoshan Uplift is not suitable for storage. This study provides a scientific basis for the selection of offshore CO2 storage sites.

Keyword

geological storage, carbon dioxide, saline aquifer, storage capacity, South Yellow Sea Basin

Experimental Study and Numerical Simulation of Rock Fracturing Based on High Voltage Electric Pulse

LI XIAOLE LI XIAOLE[1]*, College of Construction Engineering, Jilin University
(lxl22@mailes.jlu.edu.cn)

Abstract

In the process of in-situ transformation of oil shale, the reservoir needs to be heated, and the permeability of the reservoir needs to be improved in order to transfer the heat effectively. Moreover, the process of replacing the oil and gas from the cracked oil shale to the extraction wells also puts high demands on the reservoir, which also needs to be modified.

High-voltage pulsed discharge reservoir fracturing as a promising new technology applied to oil shale .formations.This technique of pulsed discharge in water generates a powerful shock wave. In a short period of time, it will produce a strong destructive force on the rock structure, causing damage to the rock body until it is destroyed,.and finally forming a network of volumetric seams in the reservoir, which can effectively improve the permeability of the reservoir.Through the combination of physical experiments and simulation analysis, we analyze the extension law of reservoir cracks under different discharge parameters and analyze its correlation.ABAQUS software was used to establish a finite element model of oil shale, and numerical simulation of impact fracturing was carried out to analyze the fracturing effect of reservoirs under different discharge parameters, and to provide a theoretical basis for the further development of reservoir fracturing technology.

Keyword

impact fracturing, high-voltage pulse, experimental study

Evaluation of CO2 Storage Potential in Offshore East Sea, Korea

Taekhyun KWON[1]*, KNOC (eunsil.jung@knoc.co.kr)
Ye-seul Choi[2], KNOC
Taekhyun Kwon[3], KNOC
Inyoung Choi[4], KNOC
Joonyoung Kwak[5], SLB
Minki Kim[6], SLB
Hoseob Lee[7], KNOC

Abstract

Korea National Oil Corporation(KNOC) is developing the 1st large-scale CCS demonstration project in Korea using the Donghae-1 (East Sea) depleted gas field to pursue the greenhouse gas reduction roadmap by the Korean government. The CCS demonstration project aims to inject 1.2 million tons of CO2 per year into Donghae-1 depleted gas field. In an effort to the government roadmap on carbon reduction, additional storage potentials near the Donghae gas field are required for future scale-up.

In this study, CO2 storage potentials of Donghae-1 gas field and the vicinity area were explored based on the previously acquired data such as seismic, logging, core, production data and the additional stratigraphic and sedimentary environment analysis. Also. Geophysical property analysis and seismic inversion work were performed to build an integrated geological model and dynamic model for capacity estimation.

KNOC evaluated the storage capacity of 1) Donghae-1 depleted gas field where proven containment and sealing capacity as the main CO2 storage, 2) the lower saline aquifer layers extended from the depleted gas reservoirs, 3) the saline aquifers above the gas reservoir with the similar geological concept which is shale-filled canyon, and 4) the saline aquifers in the vicinity of the gas field as an upside potential candidates.

Acknowledgment

This work was supported by Korea Institute of Energy Technology Evaluation and Planning(KETEP) grant funded by the Korea government(MOTIE)(20212010200010)

Keyword

CO2, CCS, carbon neutrality, depleted reservoirs

Evolution of fluid occurrence states during oil shale pyrolysis under inert and oxidative conditions

Junfan PAN[1]*, Jilin University (panjf22@mails.jlu.edu.cn)
Wei Guo[2], Jilin University

Abstract

The occurrence state of different fluids in the complex pore space determines their distribution and migration in the reservoir. Revealing the evolution law of fluid occurrence state under different pyrolysis conditions is of vital significance for the efficient exploitation of oil shale. In this paper, oil shale pyrolysis under inert and oxidative conditions at different temperatures (200-800 ℃) was conducted. Rock eval pyrolysis and X-ray diffraction (XRD) were used to determine the composition changes of pyrolysis residue, while low-temperature N2 isotherm adsorption/desorption analysis (LTNA) was used to characterize the evolution of pore space. Nuclear magnetic resonance (NMR) measurements were carried out on solid samples saturated with oil and water, and T2 spectra were calibrated according to LTNA results. The component decomposition method based on Gaussian fitting was used to identify the occurrence state of fluid. The results show that with the increase in temperature, the content of organic matter decreases, and the clay minerals transform into an amorphous form at high temperatures. The pore volume and pore size tend to increase with temperature. The porosity of solid residues produced by oxidative pyrolysis is larger than that of residues generated from inert pyrolysis. NMR spectra can be decomposed into three to five independent component spectra, respectively characterizing micropores (< 10 nm), small pores (10-100 nm), mesopores (100-1000 nm), macropores (1000-10000 nm) and microcracks (>10000 nm). Bound fluid and irreducible fluid are distributed in the micropores and small pores, while movable fluid exists in the mesopores, macropores, and microcracks. The content of movable fluid increases with the increase in temperature, and the content of movable fluid under oxidative conditions is higher than that under inert conditions. The variation trend of the contents of oil and water with the same occurrence states is basically identical. In micropores, clay-bound water is the main fluid while movable oil dominates in microfractures.

Keyword

Oil shale, Pyrolysis, Pore structure, Occurrence state, Nuclear magnetic resonance

Research on the inherent mechanism of rock mass deformation of oil shale in-situ mining under the condition of thermal-fluid-solid coupling

Shuo ZHANG[1]*, College of Construction Engineering, Jilin University (961978810@qq.com)

Abstract

In situ exploitation of oil shale is the focus of future research. Since the mechanical properties and pore structure of oil shale will change after heating, it may face some problems such as land subsidence during its exploitation. At present, few people have studied the deformation of oil shale mining process. In this paper, the structure of oil shale heated at different temperatures was tested by MICP, SEM and CT experiments, and the mechanical tests in parallel and vertical bedding directions were carried out. Combining mechanical properties with structural changes, the constitutive model of in-situ mining deformation of oil shale is established for the first time by using statistical damage mechanics and fracture mechanics. The thermal-fluid-solid coupling model of oil shale in-situ mining was established by COMSOL, and the deformation caused by oil shale mining with a depth of 200m and a thickness of 1m was studied. The results show that before 300 ℃, the mechanical properties have increased due to the expansion of mineral particles and the increase of the continuous enhancement of particles. After 300 ℃, due to the thermal stress and the pyrolysis of organic matter, there are many macro fractures parallel to the bedding direction in the oil shale. This anisotropic structure causes its mechanical properties to decline in different degrees in the vertical and parallel bedding directions. The established constitutive equation considering the parallel bedding fracture and damage can well reflect the stress-strain relationship of oil shale in vertical and parallel bedding directions at different temperatures. The final simulation shows that the oil shale with a depth of 200m and a thickness of 1m will have a settlement of 6.5cm after mining, but combined with the overlying strata and size effect, it is estimated that the final surface settlement will be less than 6.5cm. This article provides important data and theoretical support for the study of the mechanical performance of oil shale and the geological effect

Keyword

In situ mining of oil shale, pore structure, mechanical properties, constitutive model, thermal-fluid-solid coupling simulation

Effect of decrease in pore water salinity induced by depressurization in clayey silt gas hydrate reservoirs on the migration characteristics of illite

Jiang LEI[1]*, Jilin University (leijiang20@mails.jlu.edu.cn)
Wei Guo[2], Jilin University
Yuan Wang[3], Jilin University

Abstract

Achieving long-term efficient production in clayey silt hydrate reservoirs with low permeability and high clay content is challenging, with fines migration being one of the main influencing factors. Illite has a high percentage in the reservoir, and the effect of the decrease in pore water salinity caused by hydrate depressurization on its migration characteristics cannot be ignored. This work investigated the fines migration characteristics of illite under the condition of pore water salinity decreased, and the effect on reservoir seepage characteristics was analyzed by the pressure difference, pore size distribution, clay content and zeta potential. The decrease in pore water salinity induced by hydrate decomposition has a significant contribution to illite migration, even under conditions where the fluid dynamics are insufficient to make a difference. A critical salinity of 3.21% exists for illite migration. A critical salinity of 3.21% exists for illite migration. When the salinity has not decreased to the critical value, the damage of illite migration to the seepage capacity of the reservoir is limited; once the salinity decreases below the critical value, illite is released in large quantities, and the damage to the seepage capacity of the reservoir is worsened. Under low decomposition pressure, illite is more likely to form flocculated structures and lead to reservoir seepage capacity impairment in the form of clogging, while at high decomposition pressures it is more likely to be in the form of bridging. This work suggests that considering the impact of fines migration during hydrate production is critical to achieving commercial exploitation in the future.

Keyword

Gas hydrate, Clayey silt sediment, Illite, Fines migration, Low salinity

Enhancement on the development of methane hydrate in the clayey silty reservoir by stratified split grouting

Hangkai Chen[1]*, Jilin University (chenhangkai@foxmail.com)
Wei Guo[2], Jilin University
Xiaochu Wang[3], Jilin University
Jinsheng Sun[4], China National Petroleum Corporation

Abstract

During the transition period between carbon neutralization and carbon peaking, methane hydrates tend to be the most promising energy resource for replacing the coal resources. In the last two decades, past experiences on field trials have shown that low-permeability and low-strength of clayey silty reservoir are the main barriers to realize the commercial production on hydrates. At present, split grouting is expected to become a new generation of reservoir stimulation for clayey silty reservoir with the better effect, which means to inject a specific slurry into the reservoir, wait until the slurry solidifies inside the reservoir. The consolidated body then would become mass transfer channels with high permeability as well as the high strength reservoir skeleton.

However, the current studies for split grouting have some limitations such as low injection volume, difficulty in injection, and short stimulation range. In other words, there is still a lot of work need to be done before large-scale application for commercial production.

Therefore, in this study, to further discuss the performance of the stratified split grouting in the stimulation of clayey silt reservoir, a three-dimensional experimental system was adopted. The hydrate-bearing sediments were prepared according to the physical properties of clayey silt samples obtained from Shenhu area in South China Sea. To study the influence of stratified split grouting, different grouting pipe designs were adopted to realize the changes of grouting morphology, distribution and other factors. For the in-situ samples after stratified spilt grouting, computed tomography was used to observe the morphology of consolidation in samples and explore the slurry diffusion mode. In addition, the permeability and pore distribution characteristics of in-situ samples were analyzed by nuclear magnetic resonance (NMR).

Overall, this work further proved the feasibility of stratified split grouting with ultrafine cement slurry to stimulate the clayey silt reservoir. Meanwhile, it elucidated the diffusion mechanism of the foamed cement slurry in the sediment during the stratified splitting grouting process. In addition, the in-situ NMR tests of cement-sediment coupler further demonstrate the exceptional effect in terms of permeability. Finally, the analysis of the gas production behavior of grouting parameters revealed the mode of influence of each stimulation parameter. This work will serve as a reference for the selection of suitable stimulation parameters, and grouting equipment design solutions in the development of methane hydrate.

Keyword

methane hydrate, clayey silt, stratified split grouting, reservoir stimulation, reservoir protection

Fracture propagation and evaluation of dual wells, multi-fracturing, and split-time in Fuyu oil shale

Bin Zhu[1]*, Jilin University (zhubin20@mails.jlu.edu.cn)
Qiang Li[2], Jilin University
Wei Guo[3], Jilin University

Abstract

Reservoir stimulation is crucial for in-situ exploitation, it can promote a fracture network and increase the heat transfer area. Therefore, it directly affects heat injection and products transportation efficiencies. Conventional reservoir stimulation techniques, such as hydraulic fracturing are widely used. However, hydraulic fracturing in a vertical well tends to generate simple fractures that are unfavourable for heat transfer, and real-time fracture propagation is difficult to monitor, thus failing to precisely control the hydraulic fracturing scale. In addition, there are few qualitative and quantitative criteria in reservoir-scale fracture evaluations for interpreting the overall hydraulic fracturing effect. Consequently, in this study, dual wells, multi-fracturing, and split-time technology (DMS) were designed and conducted based on microseismic monitoring in field experiments to find real-time fracture propagation. Furthermore, based on Hugot's research on connecting microseismic events by spatiotemporal sequences, we proposed a step-index and path intensity considering microseismic event intensities to evaluate the effect on hydraulic fracturing. The results showed that a three-dimensional fracturing zone with a 60×30×8 m length, width, and height was generated at a 476–484 m depth, which corresponded to the designed hydraulic fracturing and facilitated heat transfer and product migration. Higher pump pressure and rate harmed hydraulic fracturing, blocking proppant migration during which the FK1-4 coefficient of viscosity reached 70 N·s/m2, 1.4 times greater than that of FK1-2 and FK1-5 according to Poiseuille's law. The hydraulic fracturing effect in FK1-4 was superior than that in FK1-2 and FK1-5. This study serves as a reference for monitoring oil shale exploitation via in-situ pyrolysis.

Keyword

Oil shale, Hydraulic fracturing, Microseismic event, Fracture propagation, Fracture evaluation

Calculation method and application of cap rock's effective thickness of X Gas Reservoir

Zhengchun SHEN[1]*, China university of petroleum,Geophysical Research Institute,Shengli oilfield,SINOPEC (shenzhengchun.slyt@sinopec.com)
Cunfei MA[2], China university of petroleum
Chengyan LIN[3], lcydcm@upc.edu.cn
Chunmei DONG[4], China university of petroleum
Hongwei HAN[5], Shengli oilfield branch company,SINOPEC

Abstract

A method of computing cap rock's effective thickness is proposed based on that cap rock's heterogeneity may result in different capillary sealing ability within cap rock. Using data of thin section, SEM, breakthrough pressure, porosity, permeability and other test data of argillaceous cap rock and sandstone reservoir, the boundary between cap rock and reservoir can be defined, which includes breakthrough pressure limitcritical lithology(grain size) and petrophysics limitSubsequently the evaluation criteria of cap rock's capillary sealing ability is established. With gamma ray curve, interval transit time curve and test data, a logging interpretation model
is established to quantitatively recognize cap rock's lithology and to calculate porosity, permeability and breakthrough pressure.
A comprehensive evaluation on capillary sealing ability of cap rock has been made to first remove the cap rock with no capillary sealing ability and then to obtain the effective thickness. Our results show that between cap rock and reservoir of X gas reservoir
the breakthrough pressure limit is 2 MPa; the critical lithology(grain size) is argillaceous coarse siltstone; the porosity limit is about 6%and the permeability limit is about 0.02×10-3μm2. Cap rock's capillary sealing ability has been divided into five grades from Ⅰ to Ⅴ. By removing grade Ⅳ and Ⅴ which correspond to no capillary sealing ability, the effective thickness of single cap rock is obtained between 4 and 10 m. Correlation between the height of gas column and the effective thickness suggests the robustness of the method. Based on the effective thickness, a weighted average of breakthrough pressure has been taken to obtain equivalent breakthrough pressure, and the whole capillary sealing ability of cap rock has been evaluated as moderate effectively
The Calculation method for cap rock's effective thickness introduced in the article has guiding significance for the CO2 Geological Sequestration, and has application value for evaluating the potential of CO2 Sequestration.

Keyword

cap rock, effective thickness, capillary sealing ability, logging interpretation, equivalent breakthrough pressure

Hydrocarbon migration and accumulation in shale play

Rujiao CHENG[1]*, China University of Petroleum (Beijing) (crj666666aj@163.com)
Feiyu WANG[2], China University of Petroleum (Beijing)

Abstract

Since 2000, significant breakthroughs have been achieved in the exploration and development of shale oil and gas in North America, prompting an increasing number of countries to focus on the exploration and development of unconventional oil and gas resources such as shale oil. Traditional views suggest that shale oil (or tight oil) is generated in situ from source rocks and remains in place or is preserved in adjacent tight reservoirs through limited short-distance migration. However, in recent years, with the accumulation of global data on shale oil and gas exploration and development, more and more researchers have recognized the existence of large-scale and long-distance migration of oil and gas in unconventional reservoirs. Here, we present a case study of the large-scale migration and accumulation of shale oil from the Paleogene upper Xiaganchaigou formation (E32) in the western Qaidam Basin, China.

The study established a three-dimensional geological framework of the shale reservoir in the study area using the petroleum system simulation software of Trinity, characterized the spatial thermal maturity variation of the shale reservoir based on the actual temperature data of wells, and calibrated the organic maturity of the shale reservoir using measured source rock residual hydrogen index (HI). In this shale reservoir, characterized by a significant thickness (approximately 1-2 km), source rocks ranging from immature to whole oil generation window stages are distributed. Along a dipping geological profile, as burial depth increases, the maturity of the source rocks progressively increases. Extensive shale oil discoveries and extractions have been produced at different depth intervals. Interestingly, oil-source correlation reveals that although the crude oil originates from E32 shale, there are significant differences in maturity indicators (such as biomarker parameters and concentrations) between the crude oil and the in-situ shale. The crude oil maturity is notably higher than that of the indigenous source rocks. Furthermore, mature crude oil has been discovered in shallow, immature shale areas, indicating significant hydrocarbon migration and accumulation in the E32 shale play.

The physical characteristics of crude oil also support this understanding. Along a dipping geological profile, as burial depth increases, the API gravity and gas-oil ratio (GOR) of the crude oil also systematically increase. However, based on kinetic simulations of hydrocarbon generation from organic facies and maturity of source rocks, the predicted GOR values of hydrocarbon fluids generated in situ source rocks are much lower than actual GOR values of production fluids. Therefore, we are more confident in the existence of large-scale hydrocarbon migration and accumulation within the E32 shale reservoir in the study area. According to estimates based on crude oil biomarker concentrations, the lateral migration distance of crude oil exceeds 5 km, while the vertical migration distance exceeds 1 km. This study provides valuable insights: the hydrocarbon generation from organic-lean source rocks in-situ may be a small quantity, and

migration facilitates the enrichment of shale oil, forming sweet spots, which significantly expands the scope of unconventional oil and gas resource exploration, enabling shale oil exploration in low maturity even in immature shale areas.

Keyword

Qaidam Basin, Upper Xiaganchaigou formation, Shale oil, Maturity, Hydrocarbon migration

A novel approach for predicting in-situ stress in coal reservoirs based on acoustic emission: Analysis, comparison, and application

Shuheng TANG[1]*, China University of Geosciences, Beijing (tangsh@cugb.edu.cn)
Kaifeng WANG[2], China University of Geosciences, Beijing
Songhang ZHANG[3], China University of Geosciences, Beijing
Zhaodong XI[4], China University of Geosciences, Beijing

Abstract

In-situ stress is a crucial parameter in the field of coalbed methane (CBM) geology and development, involving various aspects such as evaluating favorable development zones, engineering drilling and completion, hydraulic fracturing, and CBM production process. Accurately predicting in-situ stress has been a long-standing scientific challenge. To develop an effective and precise method for predicting in-situ stress, this study focuses on coal reservoirs in the southern Qinshui Basin. Rock mechanics and acoustic emission (AE) experiments were conducted based on directional compression of coal specimens, providing an in-depth analysis of the stress-strain process and characteristics of AE signals. A method for identifying apparent Kaiser point (AKP) and predicting in-situ stress based on wavelet analysis (WA) of AE signals was established. Comparative analyses were performed with traditional methods in the CBM field, such as hydraulic fracturing (HF) and well logging inversion (LI). This novel approach was applied to predict in-situ stress in the Shizhuangnan block coal reservoir. The results indicated that, the stress-strain characteristics of directional coal specimens are typically delineated into four stages, exhibiting a strong alignment with the stage characteristics observed in AE. The points of AE energy release during compression-induced damage generally occur in the mid-late stage of elastic deformation, the crack propagation stage, and the fracture instability stage. WA of AE signals enables precise identification of the sought apparent Kaiser point (SAKP) corresponding to the current in-situ stress, typically observed as the first relatively strong energy release point. The novel method proposed in this study achieves an average accuracy of 91.4%, surpassing conventional AE slope analysis (87.7%) and well logging inversion (78.0%). HF method, in principle, provide two-dimensional stress measurements and neglect the mechanical heterogeneity of coal reservoir, resulting in significant errors in predicting the maximum horizontal principal stress. Both HF and LI methods are constrained by engineering factors and are costly, making large-scale in-situ stress prediction during early exploration impractical. In contrast, AE method is easier to implement and account for the heterogeneity and mechanical anisotropy of coal reservoir, resulting in higher predictive reliability. The new method proposed in this study was applied to predict in-situ stress in the Shizhuangnan block coal reservoir in the southern Qinshui Basin. The stress state of vertical stress (σv), maximum horizontal principal stress (σH), and minimum horizontal principal stress (σh) undergoes two transitions at depths of 660 m and 950 m, with a predominance of strike-slip ($\sigma h < \sigma v < \sigma H$) and normal faulting stress state ($\sigma h < \sigma H < \sigma v$). The lateral stress coefficient (K) undergoes a transition at a depth of 923.6 m, with vertical stress

becoming the dominant factor. Hydraulic fracturing indicates the development of vertical fractures. The method proposed in this study offers a novel approach for predicting in-situ stress in coal reservoir, providing valuable insights for similar studies in other regions and deep coal reservoir.

Keyword

In-situ stress prediction, Acoustic emission, Apparent Kaiser effect, Wavelet analysis, Coal reservoir

Identifying Miocene sedimentary rocks for CO2 storage in the Gunsan Basin

CHANGYOON LEE[1]*, Korea institute of Geoscience and Mineral resources
(chngynlee@kigam.re.kr)
SUN-YOUNG PARK[2], Korea institute of Geoscience and Mineral resources

Abstract

We investigated the Gunsan Basin, also known as the northern South Yellow Sea Basin, to assess its potential for CO2 storage, with a focus on the sedimentary basin's history for facies modeling. The Gunsan Basin was formed during Cretaceous and underwent multiple tectonic events. Its initial formation was associated with rifting processes followed by subsidence due to thermal contraction. The study area is located close to a strike-slip fault, which significantly influenced the accommodation of depositional systems. Following the final syn-rift or uplift-related stage, the basin entered a post-rift or post-uplift stage characterized by thermal subsidence in Early Miocene. Although the post-rift units are typically characterized by coarse-grained sediments, the basin experienced relatively deep subsidence near the strike-slip fault due to local tectonics. This tectonic activity led to the formation of the lake environment from the previous alluvial plain. This transition in the Early Miocene occurred over a relatively short period, resulting in the localized development of the lake near the strike-slip fault. The presence of the lake environment is crucial for CO2 sealing, with the littoral area retaining coarse-grained sediments suitable for CO2 storage. Using 2D-attribute seismic data, we generated trend maps to understand lateral rock variations and applied geo-statistical methods to determine their properties.

Keyword

CO2 storage, Gunsan Basin, facies modeling

Geological Surveys in Ibero-America and land use planning

Enrique Armando CASTELLANOS ABELLA[1]*, Ministry of Energy and Mines
(eacastellanos@gmail.com)
Vicente Gabaldón[2], ASGMI

Abstract

Geological knowledge is vital for territorial planning. It has always been used intuitively and, more recently, it is carried out in coordination with the national geological surveys. Geology and land use planning are mutually dependent. The granting of geological and mining concessions, the management of geosites and geoparks, studies of hazard, vulnerability and risk, and other geological works must always be verified with land uses for approval or not. On the other hand, investments, both in buildings and roads, national, strategic or regional land use planning, take into account the geological information generated by geological surveys.

This work presents a summary of how these national organizations contribute and, at same time, benefit from land use planning. Examples from Ibero-America presented in a workshop of the Association of Ibero-American Geology and Mining Surveys (ASGMI) on the role of geological surveys in land use planning and management are analyzed. Some countries that have assigned land-use planning functions to their respective national geological surveys are highlighted. Other countries, with smaller or even no geological surveys, have less significant land use planning roles. Although deficiencies still persist in practice, there is an institutional framework that has achieved great progress in the region.

The need to implement communication actions to more effectively disseminate geoscientific knowledge of the territory is recognized, with greater emphasis on risk reduction, geological heritage, and mineral and hydrogeological resources. It is concluded that it is important that geological surveys incorporate in their lines of action a holistic transdisciplinary vision of geodiversity, which includes not only strictly geological knowledge of the territory, but also that which contributes to adaptation to climate change, including active processes. Biodiversity and the impact of anthropogenic activity on ecosystems. Finally, it is very convenient to share experiences and information related to regulations and legislation as a guide for the support and consolidation of the activity of geological surveys in relation to land use planning and management and as elements of support for the energy and ecological transition.

Keyword

Ibero-America, geology, landuse planning, geological survey

Developing QGIS Plugins for 3D Geological Modelling

Michel M. NZIKOU[1]*, Center of Exploration Targeting - UWA
(michel.nzikoumamboukou@uwa.edu.au)
Mark Jessell[2], Center of Exploration Targeting - UWA

Abstract

As the demand for advanced geological analyses and visualizations increases, the integration of three-dimensional elements within GIS platforms becomes essential. This initiative seeks to enhance the usability of existing Loop3D algorithms by leveraging recent developments and innovations within QGIS to address the complexities associated with 3D geological modelling.

To achieve this goal, a QGIS plugin has been developed to provide a user-friendly interface for industry, geological survey and research projects. The plugin focuses on several key areas, including data processing and integration, visualization techniques, and the incorporation of field and knowledge-based geological parameters into the QGIS ecosystem. These enhancements aim to streamline the various processes involved in map deconstruction that provide inputs for 3D geological modelling codes.

Furthermore, extensive 3D modelling calculations have been integrated to facilitate the transition to 3D geological modelling, whether conducted remotely or locally using docker technology.

This project explores the evolving landscape of QGIS development, specifically targeting the enhancement of its capabilities for 3D geological modelling. Through practical applications, our work demonstrates the enhanced QGIS 3D geological modelling capabilities and their relevance in real-world scenarios. Additionally, we outline potential future directions for QGIS development in the realm of 3D geological modelling, underscoring the importance of ongoing collaboration, innovation, and the integration of cutting-edge technologies.

This exploration contributes to the broader discussion on open-source GIS platforms, highlighting their adaptability to meet the evolving needs of the geospatial community in the context of three-dimensional geological modelling.

Keyword

LOOP3D, Modelling, QGIS, Plugin, Docker

New Arabian Shield Lithostratigraphic and Lithodemic Code (ASLLC) and its Application to the Terranes of the Arabian Shield

Mahrous M. ABU EL-ENEN[1], Saudi Geological Survey
Paul MACEY[2], International Geological Services
Saad M. AL GARNI[3], Saudi Geological Survey
Rami A. BAKHSH[4], King Abdulaziz University
Alan S. COLLINS[5]*, The University of Adelaide (alan.collins@adelaide.edu.au)
Mohammed ELKOMI[6], China National Geological & Mining Corporation
Joachim JACOBS[7], University of Bergen
Peter JOHNSON[8], Arabian Shield Stratigraphic Commission
Fayak H. KATTAN[9], Arabian Shield Stratigraphic Commission
Pierre NEHLIG[10], BRGM: French Geological Survey
Cees W. PASSCHIER[11], Johannes Gutenberg University, Mainz
Robert J. STERN[12], The University of Texas at Dallas
Martin J. WHITEHOUSE[13], Swedish Museum of Natural History
Wadee A. KASHGARI[14], Saudi Geological Survey

Abstract

A more precise understanding of a nation's geology is a necessary first step to better address many policy issues related to finding and exploiting its resources. In this context, the Saudi Arabian government, through the Saudi Geological Survey, has commissioned a decade-long remapping of the exposed Precambrian geology of the Arabian Shield at 1:100,000 scale. As part of this process an Arabian Shield Stratigraphic Commission has been assembled and tasked with developing a new lithostratigraphic and lithodemic code (ASLLC) to act as a guide for mapping.

During 2023, the commission made three traverses across the Shield. Through these, and a subsequent workshop, the new ASLLC was developed. We present it here for the first time. The ASLLC builds from the existing Saudi Arabian lithostratigraphic code, which it updates, and merges aspects of both the North American and British Geological Survey codes. During this process, we addressed a number of issues that have emerged over the use of these codes in low-grade accretionary orogens, such as the Saudi Arabian Shield. One innovation is to define a new class of "highly deformed rocks" within which, structural lithodemes are defined that are collected within higher ranked "shear zone" and "shear zone system" or, for rocks exclusively deformed by brittle deformation, "fault/fault zone" and "fault system".

The Arabian Shield has been split into various terranes over the last decades. A primary task of the ASSC is to test the veracity of each terrane as more mapping and geochronological data is released over the project's life. Fourteen terranes have been initially defined. These are the Midyan, Jiddah, Hijaz, Bidah, An Nimas, Al Qarah-Malahah, Tathlith, Hulayfah, Nuqrah, Ha'il, Suwaj, Ad Dawadmi, Ar Rayn and Siham-Khida terranes. A geochronology database for these terranes has been audited and revised, and the existing stratigraphy has been compiled with stratigraphic code issues and scientific questions identified for all terranes.

In this presentation we will present the ASLLC and use examples of terranes from the Arabian

Shield to illustrate its applicability to discuss how it will guide mapping. Although designed for the Arabian Shield, we suggest that this code has considerably wider application. The integration of new mapping with up-to-date stratigraphic techniques and methodologies, a new generation of geophysical data and a targeted geochronological program, provides a unique opportunity to obtain a better scientific understanding of the development of the Saudi Arabian Shield, and of arc-terranes in general. It is aimed at ensuring that the mineral prospectivity of the Arabian Shield becomes better understood, and will guide future land use policy in Saudi Arabia as the Kingdom develops its mineral resources.

Keyword

Saudi Arabia, Lithostratigraphic, Lithodemic, Code, Arabian Shield

[Keynote] The Australian national geological survey organisation's (Geoscience Australia) provision of geoscience data to inform national policy and decisions using the Digital Atlas of Australia

Steve HILL[1]*, Geoscience Australia (steve.hill@ga.gov.au)

Abstract

Geoscience Australia hosts Australia's national geological and geographic capability enabling national-scale, evidence-based decisions by government, community and industry. A new means of delivering geospatial data, the Digital Atlas of Australia, brings together, curates and connects trusted national geospatial datasets from across government into an interactive, secure, and easy-to-use online platform. As part of this, the Digital Atlas will be the single access point to Australian Government data on geography, people, economy, and the environment. Exploring data by location will empower governments, businesses and communities to make better data-driven evidence-based decisions about planning, infrastructure and investment at the local, regional and national level.

On 31 March 2023, The Digital Atlas beta prototype government environment was made available to select stakeholders from across federal government. As a whole of government geospatial capability, the Digital Atlas for government enables authenticated government users to explore, visualise and analyse readily available, curated, open, location data alongside their own data in a secure environment. By 30 June 2023, the Digital Atlas of Australia beta prototype will be made available to the public—representing the initial operating capability. The final "go live" release of the Digital Atlas of Australia is then planned for the first half of 2024. The sustainment and incremental development of the platform and data links will then continue. Digital Atlas of Australia can be accessed at www.digital.atlas.gov.au

Keyword

Geospatial, Location, Mapping

Contribution of geoheritage and geoconservation research to land use planning and new policies in the post-eruptive recovery phase of 2021 Tajogaite volcano (La Palma Island, Spain)

Juana VEGAS[1]*, Geological Survey of Spain (IGME-CSIC). Spain (j.vegas@igme.es)
Gonzalo Lozano[2], Geological Survey of Spain (Instituto Geológico y Minero de España, IGME-CSIC). Spain
David Sanz-Mangas[3], Geological Survey of Spain (Instituto Geológico y Minero de España, IGME-CSIC). Spain
Nicolás Ferrer-Valero[4], , Institute of Oceanography and Global Change. Las Palmas de Gran Canaria University (IOCAG-ULPGC). Spain
Inés Galindo[5], Geological Survey of Spain (Instituto Geológico y Minero de España, IGME-CSIC). Spain
Nieves Sánchez[6], Geological Survey of Spain (Instituto Geológico y Minero de España, IGME-CSIC). Spain

Abstract

From September 19th to December 19th in 2021, a hybrid volcanic eruption with strong fissural control and some phreatomagmatic pulses (magnitude VEI 3) occurred on the northwest slope of the Cumbre Vieja volcanic ridge on the island of La Palma (Canary Islands, Spain). More than 200 Mm3 of volcanic material was emitted through a main eruptive alignment N130ºW trend. This main fissure had more than a dozen eruptive vents, of approximately 0.5 km-length, which generated a volcanic cone with a maximum height of 200 m with respect to the pre-eruptive topography. The eruption produced tephrite-basanite lavas over more than 1200 ha, with a majority of a'ā type lavas and a minority of pāhoehoe type lavas, with an estimated maximum thickness of 70 m. The last days of the eruption also saw the opening of eruptive fissures disconnected from the main cone, with the emission of pāhoehoe lava flows. Two main lava deltas have also formed, with a subaerial surface area of 48 ha and an estimated submarine area of 21 ha. The accumulated tephra deposit ranged up to 2.7 m thick in the areas close to the main cone, reaching the whole island and even the rest of the western Canary Islands in the phases of greatest explosivity. The lava flows and accumulated tephra have had a direct impact on the most inhabited area of the island. The scientists call it an ‘urban eruption’, as it seriously affected several villages and over 3000 buildings, roads and banana and vineyards farms.

On the other hand, this latest eruption on La Palma Island in 2021 has highlighted the scientific challenge of determining the most valuable volcanic features for protection. The present work reports the methodology specially designed to identify the EVIs (Spanish acronym for Volcanic Elements of Interest) and assess their scientific and touristic value. The results have allowed to select EVIs that should be legally protected to ensure a sustainable socioeconomic development that does not endanger the conservation of the most valuable features of this volcano. The identification and mappings of EVIs have been used this methodology have been used by the Canary Islands Government (Decree Law 9/2023, of December 18), on the adoption of "territorial and urban planning measures for the economic and social recovery of the island of La Palma after

the volcanic eruption of Cumbre Vieja", where they are protected and recognised in the category of 'land for precautionary protection' as an initial procedure for their inclusion in the Cumbre Vieja Natural Park. Over this two-year period, leading up to the adoption of the Decree-Law by the Regional Government, strong damages and impacts caused irreversible loss of the most valuable volcanic elements. This fact shows the importance of quick scientific assessment of geoheritage in order to include the most valuable areas in the new territorial and urban plans to be carried out after the eruptions have ended. This is the best guarantee for geoconservation in volcanically active areas.

Keyword

Geoconservation, Geoheritage, Land use planning, urban eruption 2021, La Palma

The European Critical Raw Materials Act – How can geoscience programmes support the Act and build collaborations

Ana Luisa Luísa LAVADO[1]*, Geological Survey Ireland (analuisa.lavado@gsi.ie)
Dina Carrilho[2], Fundação para a Ciência e a Tecnologia
Koen Verbruggen[3], Geological Survey Ireland
Aoife K. Braiden[4], Geological Survey Ireland

Abstract

In 2023, the European Commission published the Critical Raw Materials (CRM) Act. This document sets the foundation to (i) strengthen the EU's capacities along all stages of the value chain by strengthening domestic supply chains, (ii) improving resilience by increasing preparedness, reducing dependencies, and promoting supply chain sustainability and circularity, and (iv) reinforcing international engagement to develop mutually beneficial partnerships. The Act also sets 2030 benchmarks for Strategic Raw Materials:

• Extraction: at least 10% of the EU's annual consumption for extraction.
• Processing: at least 40% of the EU's annual consumption for processing.
• Recycling: at least 15% of the EU's annual consumption and recycling.
• External Sources: not more that 65% of the EU's annual consumption of each strategic raw material at any relevant stage of processing from a single third country.

To effectively implement the Act and achieve the 2030 benchmarks for Strategic Raw Materials, the European Union will strengthen the uptake and deployment of breakthrough technologies in CRM by investing in research, innovation, and skills. The establishment of a large-scale European public-public partnership to provide funding and promote skills development relevant to the CRM value chain and circular economy is one important tool to be implemented. Critically, this will rely on a joint effort from Member States and non-EU countries to tackle the transnational/cross-border/international supply chains necessities, demands, and problems addressed by the Act.

To support the Act, a large scale pan-European Partnership on Raw Materials for the Green and Digital Transition will continue the successful work of the 3 ERA-MIN networks (2011-2025) as a funding instrument complementary to Horizon Europe, across all areas of the non-fuel, non-food raw materials research and value chain, which will actively contribute to the implementation and objectives of the CRM Act and to the EU Joint Research Centre Raw Materials Information System (JRC RMIS).

This presentation will summarise the contribution and efforts of European networks, including geological surveys and researchers across all sectors, and how we can support the implementation of the CRM Act while strengthening international collaborations and partnerships.

Keyword

critical raw materials, green transition, digital transition, raw materials value chain, research and innovation

Geological Survey Ireland, supporting national policy through geoscience on land and at sea.

Koen M VERBRUGGEN[1]*, GEOLOGICAL SURVEY IRELAND (koen.verbruggen@gsi.ie)
Ray Scanlon[2], GEOLOGICAL SURVEY IRELAND
Aoife Braiden[3], GEOLOGICAL SURVEY IRELAND
Monica Lee[4], GEOLOGICAL SURVEY IRELAND
Sean Cullen[5], GEOLOGICAL SURVEY IRELAND
Eoin McGrath[6], GEOLOGICAL SURVEY IRELAND
Sarah Blake[7], GEOLOGICAL SURVEY IRELAND

Abstract

Geological Survey Ireland is a division of the Irish government Department of Environment, Climate and Communications, and has typical origins as a geological survey founded to map the nation's natural resources, in 1845. In recent years it has changed focus from more traditional geological mapping activities and methods to carrying out major projects of national societal value, supporting and developing policy initiatives, many of which also support Land Use Planning. Programmes include; one of the world's largest seabed surveys INFOMAR, which is delivered jointly with the Irish Marine Institute, is supporting Offshore Renewable Energy policy and marine spatial planning; a national groundwater mapping and protection programme supporting the EU Water Framework and Drinking Water Directive and policies, which has produced maps of Aquifers, Groundwater Protection Schemes and Source Protection Zones as well as online tools use by decision makers on land use planning; modern geophysical and geochemical mapping under its Tellus programme, which is supporting agricultural soil, radiological protection and mineral development policies as well as updating the fundamental geological maps which underpin all land based products; and a minerals programme supporting construction, aggregate and mining policies, including Aggregate Potential Mapping online resources and databases of mineral occurrences. The minerals programme is also dealing with Historic Mine Site rehabilitation as a safety, water quality, remediation, and land-use issue. In addition, the survey has helped develop a new national Geothermal Roadmap and subsequent Geothermal Energy Policy and supporting scientific programme, which is working to develop deep geothermal in Ireland to support decarbonising of heating systems. Geological Survey Ireland has also developed a successful geoscience research programme, supporting international and national research policies, including those on Geoscience research supporting land use policies. By maintaining an awareness on policy development, particularly from a European Union perspective, often by working closely with EuroGeoSurvey the umbrella organisation, and focussing on stakeholder engagement, effective communication of the value of geoscience and maintaining scientific rigour, geological surveys can play a vital role in land use and marine planning and national policy.

Keyword

Geological Survey, Land Use, Ireland, Groundwater, Planning

Geoscience information in Dutch land use planning: showcase for comprehensive planning?

Rob van der KROGT[1], TNO - Geological Survey of the Netherlands
Tirza van van DAALEN[2]*, TNO Geological Survey of the Netherlands (tirza.vandaalen@tno.nl)

Abstract

In the Netherlands, knowledge about hydrology and subsoil conditions has always been supporting land use planning. But the use and content of this knowledge in planning practices shifted over time. For centuries, the Dutch gained experience with the subsoil creating new land, 'engineering' hydraulic systems (canals, ditches, wind mills) and building dykes. On the 'old' land, planning was often guided by common knowledge about local hydrology and subsurface conditions. The 20th century brought urbanization and high ambitions to create prosperity for growing populations; natural conditions regarding water and the subsurface were often ignored or 're-shaped' to enable large housing and infrastructure developments. The last few decades, spatial planning is facing new grand challenges, such as climate adaptation and the energy transition. These challenges enforce better utilisation and integration of subsurface conditions in spatial planning, for example to create (future) resilience to flooding, drought and subsidence or to enhance use of geothermal potential. This raises awareness of spatial planners and politicians that solid subsurface knowledge is (again) key for sustainable planning.

Knowledge base for the subsurface
Over many decades, geoscientific experts and organizations such as the Geological Survey of the Netherlands have created a huge knowledge base for the subsurface. Since early 90s, they invested in digitizing their paper archives. They replaced the production of geological maps by systematic digital and nationwide 3D subsurface modelling. Next, and still ongoing, they are improving data and IT-infrastructures along professional standards. Since the early 2000s serious attempts were made to connect to the spatial planning domain. This process evolved from performing advisory tasks for public boards, then providing geoscience data as public open data and concluded by the development of a key register for the subsurface: a single national database for subsurface data and information, which Dutch government bodies are obliged to use when making policies or decisions that pertain to, or can be affected by the subsurface. This key register is legally governed by a national law. And recently, the Dutch Government issued a formal policy guideline, stating that 'water and subsoil should be guiding spatial planning choices'. This unique proposition combining (legal) policies, geoscientific expertise and information management is now largely in place.

Towards more effective use of subsurface data
This proposition is not the end stage, but a starting point for the spatial planning community to develop deeper understanding how to utilize geoscience information most effectively and how to

fulfill their new role as data suppliers for the key register. On their side, the geoscience community, with the survey as its prominent party, is learning step by step how to present geoscience data for the planning domain. This involves for example rethinking or adding various data types, use and interpretation of the 3D/4D models, scale and resolution issues, and integration with aboveground data and models. Good practices can already be presented, where geoscience information contributes to more comprehensive land use planning, dealing with actual challenges related to urban development, water management, energy storage and infrastructure planning.

Keyword

Land use, Spatial planning, Subsurface data, Geoscience data, Subsurface information

OneGeology Projects: Climate Action, Geohazards and of course, the Global Geological Map

James Patrick Johnson[1], Geoscience Australia
Steve Hill[2]*, Geoscience Australia (steve.hill@ga.gov.au)
Verity Normington[3], Geoscience Australia

Abstract

OneGeology is a membership coalition that provides opportunities for collaboration between national geological survey organisations around the world. The collaborative nature of OneGeology is such that despite no official directive to work together, through strong relationships and a common goal, accessibility of geological data has been, and continues to be, improved. OneGeology is championing the adoption of new approaches and best practices are encouraged to the benefit of all. Sharing of experiences and expertise from geological surveys around the globe, allows for smaller organisations to benefit from capabilities and networks of larger organisations and, as such, programs of common interest promote common and interoperable data standards, formats and methods.

Through the OneGeology portal, geoscience information, such as geological maps, are accessible for all continents on a single platform. This portal showcases that through common standards and protocols, data can be shared and work interoperably, independent of platform. Using the lessons learned to enable the sharing of global geological maps, OneGeology is expanding the platform to share information from the member organisations regarding climate change and natural hazards.

Climate change and natural hazards affect everyone on this planet and, as such, OneGeology is endeavouring to make information accessible to all through a portal that provides direct links into organisations' webpages to provide information about a country's Climate Action scientific programs, and its Natural Hazards programs. These new examples will be a springboard for new relationships, collaborations and greater promotion of geoscience education and outreach through accessible and findable online resources.

Keyword

OneGeology, Climate, Geohazards, GeoSurveys

Public geoscience: a foundation for strategic land use decisions in Canada

Sonia TALWAR[1]*, Geological Survey of Canada (Natural Resources Canada)
(sonia.talwar@nrcan-rncan.gc.ca)
Daniel Lebel[2], [Retired] Geological Survey of Canada (Natural Resources Canada)
Philip Hill[3], Geological Survey of Canada (Natural Resources Canada)

Abstract

In Canada, public geoscience has found broad application in support of land use planning and land management by governments since the Geological Survey of Canada was established in 1842.

Here we present some recent examples where geoscience knowledge was developed to inform land decisions in Canada in a variety of national level contexts. We review geoscience programming at the Geological Survey of Canada (GSC) to highlight multiple innovative applications that were developed in response to various national policy needs regarding land management.

GSC geoscience activities have grown in applications to address national policy needs from specific land areas (such as defining new national parks), regional scale (e.g. developing northern mineral deposits and road infrastructures), to the entire Canadian offshore territory (e.g. undertaking offshore resource assessments to help define 30% of marine conservation areas by 2030).

Many of the federal level policies that drove the demand for geoscience over the last decade are derived from Canada's commitment to international conventions and treaties, namely: UNCLOS (oceans), UNCBD (biodiversity), and UNDRR (disasters). To a lesser extent, public geoscience also has been driven by UNSDGs (sustainability) and will most certainly be, by UNDRIP (Indigenous). Taken together, these federal policies and international commitments are fundamental to the new GSC Strategic Plan 2023-2028. We believe that there are potentially many lessons to be learned from a comparison of the GSC with other national geological survey organizations in how they manage domestic lands and engage in international partnerships.

However, each country varies in governance and we recognize that the Canadian experience is likely difficult to replicate elsewhere. Land management responsibilities and associated political and administrative processes between the various levels of governments is complex. From the federal to the municipal levels, each government often contends with a multitude of evolving and conflicting public and private issues and interest groups competing over the rights of use of a given land area at the surface and extending to the subsurface. In such a context, it can be a further challenge to bring the weight of scientific advice and data to bear on the decisions.

One of the more far reaching changes that has influenced land use and decision in Canada started when Canada adopted a proactive policy of Indigenous reconciliation, following a number of major judicial decisions and constitutional changes that affirmed Indigenous rights. The country fully adopted UNDRIP in 2016 after simply endorsing it in 2010. With this adoption, Canada is engaged in the work to enable Indigenous peoples to exercise their inherent rights, including the right to own, use, develop and control lands and resources within their territories. This, in turn, creates a challenge and an opportunity for geoscientists in Canada to engage with Indigenous Peoples to build capacity to manage the natural resources in line with their world view.

Keyword

Public geoscience, Policy, Land use, Decision-making, Indigenous

Navigating Extreme Landslide Events: Insights from Slovenia's August 2023 Disaster and the Role of the National Geological Survey

Miloš BAVEC[1]*, Geological Survey of Slovenia (milos.bavec@geo-zs.si)
Jernej Jež[2], Geological Survey of Slovenia
Mateja Jemec Auflič[3], Geological Survey of Slovenia
Andrej Novak[4], Geological Survey of Slovenia
Tina Peternel[5], Geological Survey of Slovenia
Ela Šegina[6], Geological Survey of Slovenia
Špela Kumelj[7], Geological Survey of Slovenia
Klemen Teran[8], Geological Survey of Slovenia
Jasna Šinigoj[9], Geological Survey of Slovenia

Abstract

In August 2023, Slovenia experienced unprecedented rainfall leading to severe floods and numerous landslides, predominantly in the Southeastern European Alps and its foothills. The Savinja, Meža, Kamniška Bistrica and Poljanska Sora valleys in northern Slovenia were particularly affected. The Geological Survey of Slovenia (GeoZS) played a crucial role in mitigating its impact.

GeoZS, the largest (public or private) geoscience organization in Slovenia, has evolved its mission from mineral resource exploration to understanding Earth's dynamics, environmental changes and issues and geohazards throughout its near 80-year history. Leveraging its expertise, GeoZS swiftly responded to the crisis.

Using MASPREM, a national landslide warning system, GeoZS collaborated with civil protection services and meteorological offices to issue timely warnings, contributing to relocate of thousands of inhabitants and prevent immediate casualties.

Immediately after the floods, GeoZS deployed landslide experts to advise intervention teams on temporary mitigation measures and relocation efforts. Additionally, GeoZS facilitated the acquisition of Copernicus Rapid Mapping results and used high-resolution orthophoto scans of affected areas, aiding in rapid damage assessment. Initial estimates suggest that approximately one-tenth of the 10,000 landslides triggered may require mitigation measures, with potential costs exceeding €1 billion.

Furthermore, GeoZS promoted the use of e-Plaz, a citizen science application, to gather data on landslide occurrences, resulting in the registration of nearly 2000 landslides by municipalities. This data serves as a valuable resource for disaster assessment and prioritizing mitigation efforts.

In response to the disaster, the government enacted the Act on Reconstruction, Development and the Provision of Financial Resources, mandating among others the creation of a centralized database for geological and geotechnical information. This marks a significant step towards proactive risk management and underscores the importance of maintaining comprehensive geological databases.

GeoZS advocates for the establishment and maintenance of such databases as a fundamental

responsibility of national geological surveys. In pursuit of its vision, GeoZS endeavors to establish practices within the geological surveys community that maximize the benefits for the public. Through initiatives like the Geological Service for Europe project (GSEU), GeoZS aims to optimize practices to ensure the public derives the greatest possible value from geological surveys, thereby enhancing disaster preparedness and response capabilities.

In conclusion, the August 2023 landslide disaster in Slovenia highlighted the indispensable role of a geological survey organizations in crisis management. By leveraging its expertise and resources, GeoZS not only facilitated immediate response efforts but also contributed to long-term risk mitigation strategies, emphasizing the importance of proactive geological data management in safeguarding communities against natural hazards.

Keyword

Geological Survey, Natural disaster, response, mitigation, geohazard

U.S. Invests in Foundational Geoscience Data Collection, Mapping, and Analysis to Inform Infrastructure Policy

David APPLEGATE[1]*, U.S. Geological Survey (applegate@usgs.gov)
William L. Cunningham[2], U.S. Geological Survey
Geoffrey S. Plumlee[3], U.S. Geological Survey

Abstract

The mission of the U.S. Geological Survey (USGS) is to deliver actionable information on complex human and natural Earth system interactions at scales and timeframes relevant to decision makers. As the science arm of the U.S. Department of the Interior, which manages one-fifth of the nation's lands, the USGS produces policy-relevant science that informs environmental, natural resource, and public safety decision.

In 2021, the Infrastructure Investment and Jobs Act provided the USGS with major investments in areas common to many geological survey organizations: geologic mapping, geophysical surveys, geochemical assessments, hyperspectral imaging, high-resolution digital elevation data, and geoscience data preservation. Several USGS programs have been enhanced through these investments: the Earth Mapping Resources Initiative (Earth MRI), the 3D Elevation Program (3DEP), and the National Geological and Geophysical Data Preservation Program (NGGDPP).

The USGS launched Earth MRI as a collaborative effort with U.S. states' geological surveys, tribal nations, and private-sector entities to modernize the surface and subsurface geologic mapping of the nation. The USGS and partners jointly identify, prioritize, and acquire new geoscience data. The primary focus is on geographic areas that have potential to host a variety of mineral resources. Such foundational data also benefits studies of energy resources, groundwater resources, natural hazards, and infrastructure planning. Earth MRI currently focuses on critical minerals and industrial minerals including construction materials. As one example, over the past 5 years, Earth MRI has conducted high-resolution airborne geophysical surveys in areas covering over 1 million square kilometers to yield an improved understanding of the Nation's critical mineral potential. The evaluation of mine waste as a potential resource for critical minerals is a unique aspect of Earth MRI. The USGS is developing a national mine waste inventory and conducting targeted research to characterize this potential resource, a potential "win-win" for mineral supplies and the environment. From all of this data collection and research, the USGS develops assessments quantifying mineral resource potential both from in-ground deposits and from mine waste.

Detailed topographic mapping provides valuable insight toward understanding geologic processes. 3DEP was created in 2016 to respond to growing needs for high-quality elevation data to inform critical decisions that are made across the USA every day, ranging from immediate safety of life, property, and environment to long-term planning for infrastructure projects. 3DEP collects lidar data nationwide with a vertical accuracy of 10 centimeters that can produce high-resolution models of ground elevation. At the end of fiscal year 2023, 94.7% of the Nation has available or

in-progress elevation data that meet 3DEP specifications for high accuracy and resolution.
The NGGDPP is providing resources that enable the USGS and U.S. state geological surveys to create more uniform physical and digital infrastructure to properly store the geological and geophysical data and samples needed to understand critical minerals, and making these data and samples available to all who need them for generations to come.
These investments are allowing the USGS and its partners to collect and synthesize data on natural resources that will inform land use planning and decision-making for generations.

Keyword

mapping, critical, minerals, data, preservation

EU International Centre of Excellence on Sustainable Resource Management in support of the United Nations Resource Management System

Meta Dobnikar[1], Geological Survey of Slovenia
Snježana Miletić[2], Geological Survey of Slovenia
Miloš BAVEC[3]*, Geological Survey of Slovenia (milos.bavec@geo-zs.si)
Zoltan Horvath[4], Supervisory Authority of Regulatory Affairs, Hungary

Abstract

Sustainable, efficient and integrated use of raw materials, needed for energy storage, power generation and the transition to climate neutrality, may be achieved by harmonization and attentive management of data on its reserves and resources. These circumstances created an opportunity to build on EU level mineral intelligence by developing a capacity building and knowledge centre in support to the sustainable resource management.

With such a motivation, the Horizon Europe project Geological Service for Europe is creating an EU International Centre of Excellence on Sustainable Resource Management (EU ICE SRM). The objective of the EU ICE SRM is promotion and capacity building of an international scheme for the classification and management of resources – the United Nations Framework Classification for Resources (UNFC), that considers the degree of confidence, technical feasibility and social-economic-environmental aspects of each project. The UNFC assists the implementation of the United Nations Resource Management System (UNRMS). UNRMS is a comprehensive resource management system for sustainable development, represented by the principles and requirements on sustainable resource management, set by the United Nations Economic Commission for Europe.

The first steps towards the creation of the EU ICE SRM have been made. Capacity building trainings on UNFC have been organized to support the implementation of the European Critical Raw Material Act, which aims to enhance the resilience of EU critical raw material supply chains. The EU ICE SRM will also further develop and maintain a European Network for UNFC experts and will tend to achieve a common understanding of UNFC, expanded to other resources, including secondary raw materials, water and energy.

By this approach the EU ICE SRM supports UNRMS through capacity building and promotion of the resources needed to accomplish the goals of the UNs 2030 Agenda for Sustainable Development. It intends to operate as a network of partners and experts to assist the decision makers and key stakeholders in resource management.

Keyword

GSEU, sustainable resource management, UNFC

Subsurface environment, a key asset for the global ecological transition

Christophe POINSSOT[1]*, BRGM (c.poinssot@brgm.fr)
Patrick D'HUGUES[2], BRGM
Francis CLARET[3], BRGM
Alain DUPUY[4], BRGM

Abstract

Global climate change is certainly one of the most challenging issue the humankind has ever faced. In order to mitigate its potential impact, reducing greenhouse gas emissions is mandatory and will require developing low-carbon technologies and societies, while preserving the biodiversity is crucial for the overall livability of earth. Although often neglected in the public debate, subsurface environment is the core of many solutions that will play a significant role either for reducing the overall impact, or for adapting to the changing environment.

On the one hand, decarbonising the economy will rely on an intensive electrification of usages that will require developing new energy infrastructures which are highly metals intensive: windmills, solar panels or electric vehicles will for instance require very large amounts of critical mineral resources such as rare earths, nickel, lithium or even copper. The anticipated explosion of the mineral demand will not be covered by the sole recycling, and extracting new metals will be mandatory. Developing new exploration programs and new mines will be needed but will have to be meet the highest environmental and social standards for being sustainable and acceptable, the so-called responsible mining.

On the other hand, low carbon heat will also have a key role to play to optimize the overall efficiency and reduce the electricity demand. Among others, geothermal heat has most likely a key role to play for meeting the demand in residential or tertiary buildings heating or geocooling. Beyond the overall reduction of electricity consumption, it will efficiently contribute to reduce peak demand which has a very strong impact on the grid dimensions. Storing fatal heat underground may also easily be implemented with such geothermal systems, paving the way for inter-seasonal heat storage. Quantitative illustration of the huge potential for decarbonization will be illustrated based on the French case.

Finally, water is both a prerequisite for human livings but also mandatory for many powerplants and industries. Example of powerplants shutdown due to summer drought is a clear illustration of the nexus between water and energy. Aquifers currently represent a very high share of the overall water used in many countries, (e.g. 40% for industries and 70% for potable water in France). Ensuring a sustainable supply of water will only be achievable by a better knowledge and management of underground water in order to compensate for the likely reducing of precipitation and the increase of intermittency.

Altogether, subsurface is at the core of many essential solutions to be implemented on our pathway towards net zero and sustainable societies. In such context, politization and governance

of subsurface environments will have to be renewed and improved based on a better knowledge of subsurface. Geosciences have never been so necessary for the future of our societies!

Keyword

energy transition, geothermal energy, mineral resources, sustainability, water

The key role of NGSOs and transnational associations in supporting policy making process for mitigating and adapting to the global climate change

Christophe POINSSOT[1]*, BRGM (c.poinssot@brgm.fr)
Philippe FREYSSINET[2], BRGM

Abstract

Global climate change is certainly one of the most challenging issue the humankind has ever faced. In order to mitigate its potential impact, reducing greenhouse gas emissions is mandatory and will require developing low-carbon technologies and societies, while preserving the biodiversity is crucial for the overall livability of earth. Although often neglected in the public debate, subsurface environment is anticipated to provide solutions that will play a significant role either for reducing the overall impact, or for adapting to the changing environment: critical mineral resources, geothermal energy, water resources, storages… Geological environments also bring risks such as eathquakes, sea level rising, erosion and landslides, clay swelling, which are for many of them sensitive to the overall climate change.

In such a context, developing and sharing a better knowledge and understanding of the subsurface is a mandatory step for an optimized usage of the underground resources and a better anticipation and prevention of the risks. It is the core mission of the National Geological Surveys association to develop such a knowledge in each country. Although invested for decades or centuries, the current knowledge is as such still far from being completed and often limited either to large scale structures or to upper subsurface. A first challenge to face is therefore to improve the subsurface knowledge and make it available to the overall societies not only by geological maps, but also by large set of databases and 3D numerical models. Essentially, geology remains an model-driven interpolation science from a huge large number of data coming from satellites, geophysical surveys, boreholes, samplings, geochemical analyses… As such, it represents a fantastic playground for model-driven AI which is typically designed for such challenges! NGSO are most likely at the eve of a new revolution to come 50 year after plate tectonics.

Supporting policy making processes and governments require providing qualified datasets and 4D models to be able to assess the usable resources while preventing the potential risks and preserving the biodiversity. However, underground has no frontiers and many issues are cross-cutting frontiers. That was one the key driver for launching in 1971 an association of all the EU NGSOs in the so-called EuroGeoSurveys non-profit association (EGS). The aim was to gather and share the subsurface knowledge, the know-how and provide EU with a large set of experts. From time to time, the core of a EU numeric platform was developed, European Geological Data Infrastructure (https://www.europe-geology.eu/) which provide EU scale maps and sets of data. EGS also developed under a dedicated EU funding, a trans-national geological service for Europe (GSEU). EGS is currently supporting the development of new and innovative EU policy for improving land planning, resources usages and risk mitigation. Key role in the i:!implementation of the Critical Raw Material Acts from 2023 is a good example.

With the anticipated increasing role of geoscience for facing the near-future issues, NGSOs and transnational organization such as EGS have a clear front-stage role to play in supporting policy making process.

Keyword

geological surveys, land planning, policy making, numeric models

The Important of Geoscience Data for Land Use Planning in Malaysia

Zamri bin RAMLI[1]*, Department of Mineral and Geoscience Malaysia (zamri@jmg.gov.my)
Amir Mizwan bin Mohd Akhir[2], Department of Mineral and Geoscience Malaysia
Abd Rahim bin Harun[3], Department of Mineral and Geoscience Malaysia

Abstract

In Malaysia, the development and adoption of mineral and geoscience data has emerged as an effective tool for providing geological information for land use planning and decision-makers. The geoscience data in land use planning is accomplished for the local agencies to develop sustainable urbanization based on environmental sensitive areas. Malaysia, alongside other nations, understands the criticality of managing mineral and geoscience data efficiently by the association values of geological hazard, natural resources, and natural heritage which is used in the evaluation of rational planning and government policy. To meet the increasing demand for accurate and up-to-date information, the Department of Mineral and Geoscience Malaysia (JMG) has developed the mineral and geoscience digital data platform since 2008 until 2024 using the system known as Mineral and Geoscience Geospatial Information System (MINGEOGIS) or with the commercial name of MyGEMS.

The development of MyGEMS encompasses all JMG's activities to produce easily accessible and shared geospatial products in compliance with the government policy and the prescribed of Geological Survey Act 1974. JMG also has separate systems such as the National Terain and Slope Geospatial System (NaTSIS), Marine Geological Database (NOSRIM), Quarry Operational Dust and Noise Pollution Index System (QPINS), National Mineral Commodity Database System (PESMIN) and Mobile Heritage Geological Site Information Application (MYGEOTAPAK). Such as NaTSIS, is developed specifically to assist local authorities and stakeholders in the process of managing landslide and slope information in the aspect of physical development and management of landslide geological disasters. There are more than 6000 number of landslides is recorded in the NatSIS system and currently used to develop landslide forecasts and landslide geological disaster notifications. Based on statistics from MyGEMS through NaTSIS in 2023, the Malaysian government has suffered economic losses of RM4 billion in 62 years (1961-2023) due to geological disasters. JMG has been appointed as the leading agency (Working Group 1) in the Inter Governmental Committee on Slope Management (ICSM) which is responsible for the aspects of Hazard Mapping and Slope Risk under the National Slope Master Plan program.

JMG is well-known as one of the External Technical Agencies in the One Stop Centre (OSC) platform by the Local Government Department under the Ministry of Housing and Local Government Malaysia, extended to all 98 Local Authorities in Peninsular Malaysia. The role and responsibility of JMG is to verify geological input and assess the risk of geological disasters for the impact of development on the environment, which coincides with the Survey Investigation Act

Earth 1974, Part IV (14). In line with geoscience information requirements, JMG is also involved in providing geoscience technical input for the Environmental Impact Assessment (EIA) Committee under the Department of Environment Malaysia. This EIA is used to identify, predict, and evaluate the impact on the environment of proposed development activity and to detail the mitigating measures prior to project approval and implementation in accordance with the requirements of the Environmental Quality Act 1974.

Keyword

geoscience data, JMG, MyGEMS, Land Use Planning in Malaysia, Local Authorities

Role of Czech Geological Survey in Siting of Deep Geological Repository of Radioactive Waste

Zdenek Venera[1]*, Czech Geological Survey (zdenek.venera@geology.cz)

Abstract

Identifying the best available site for installation of deep geological repository of radioactive waste is an issue of utmost importance for land use planning at a national scale. Czech Geological Survey (CGS) has been involved in this matter since 80-ies of the 20th century. In the Czech Government, a responsible body in this matter is Radioactive Waste Repository Authority which signed an agreement with CGS on long-term collaboration. CGS carried our research on 9 pre-selected sites in crystalline - mostly granitoid massifs based on archive data, previously produced maps, and new geophysical profiles accompanied by 1:10.000 geological mapping in zones along these profiles, and produced 3D geological models of the areas. A matrix composed of 13 characteristics of each site, including lithological homogeneity, geochemical, structural, tectonic, volcanological, seismic, geomorphological, hydrogeological, mining, and environmental aspects, was applied resulting in proposal of 4 best suitable sites to be approved by the Government. The approval in 2020 launched the next phase of research and prospecting. Current activities in 4 sites are aimed at geological and hydrogeological mapping at a scale 1:25.000 in 25 km perimeter of repository, detailed mapping at 1:10.000 of area under exploration licence (ca 30 km2), remote sensing interpretation, structural analysis comprising discrete fracture network, geophysical survey, drilling and well logging, installation of hydrogeological and seismic monitoring network, and production of detailed 3D models. Some activities can be performed only when licences are issued by the Ministry of Environment, expected by the end of this year. Current phase is planned till 2028 when 2 best suitable site should be proposed for approval of the Government: one as principal, the other as backup. That will start the final stage of exploration with even more detailed focus, drilling and geophysics. After the best site selected, repository of radioactive waste will built at a depth 500 m and shall be in operation by 2050. For decades this topic has been and will continue to be one of the major tasks of national importance for Czech Geological Survey.

Keyword

radioactive, waste, repository, geological, survey

The importance of raw materials for the Energy Transition

Teresa PONCE DE LEÃO[1]*, LNEG (teresa.leao@lneg.pt)

Abstract

Raw materials are becoming increasingly important for the competitiveness of Europe's industry, for innovation and for the transition to a low-carbon, more circular economy.
Many new enabling technologies rely on materials that are predominantly produced outside of the European Union, such as cobalt for Lithium-Ion batteries powering low-emission mobility or rare-earth elements for energy-saving electronics.
International competition for such raw materials is becoming more intense.
EU imports most of the materials it uses rather than mining them itself. It is a net importer of raw materials, in which it has had a trade deficit since 2002. Last year (2019) that trade deficit stood at €31 billion
Europe still has many resources. Europe mines more than 42 different metals and minerals, plus ornamental stones, sand and gravel and aggregates"
European Commission is now focusing on collecting information about the deposits available in Europe – not necessarily for new mines, but also to expand existing mines or use them more efficiently
End-of-life circuit boards, certain magnets in disc drives and electric vehicles, EV and other special battery types, and fluorescent lamps are among several electrical and electronic products containing critical raw materials
Recycling most of the products rich in CRMs is not commercially viable, with low and volatile CRM prices undermining efforts to improve European CRM recycling rates, which today are close to zero in most cases.
A lot of efforts are underway:
Survey data (geophysics, geochemistry, geochronology, remote sensed data) Energy Transition
Knowing and understanding the subsurface environment (MAPS)
Understanding the metallogenic processes that give rise to ore deposits (MODELS)
Inventorying the subsurface for (CRM & SRM) mineral deposits (INVENTORY)
Turning individual small data packages into large data packages (DATA HOMOGENISATION)
UNFC classification
UNMRS
These are some of the effort methodologies for a transparent and ethic way to contribute to a low-carbon, more circular economy.

Keyword

raw materials, circular economy, energy transition

Professionals in Earth Sciences in municipal administrations, a contribution to the development of the territory: a case study in Colombia, South America

Clemencia GOMEZ[1]*, Universidad Nacional de Colombia, sede Bogotá (clgomezgo@unal.edu.co)

Abstract

The geographical location, economic vulnerability of a large portion of the population, lack of teaching of Earth Sciences in schools, lack of territorial planning, illicit extraction of resources, and lack of public policies adapted to the reality of the territories are the perfect breeding ground for what is observed daily in the news: loss of lives and economic losses due to lack of harmony between public policies, knowledge, geo-hazards, and environmental degradation in the regions.

In this scenario, a legislative initiative has been proposed in Colombia that allows for the presence of a professional in Earth Sciences in the territory, who can permeate the social fabric and have a positive impact on the well-being of the population. This initiative has been accompanied by research projects at the National University of Colombia, Bogotá campus, including undergraduate theses, academic internships in a municipality, a short documentary, as well as more than 50 presentations in national and international events of different kinds, campaigns led by professional associations (Colombian Geological Society and Colombian Association of Petroleum Geologists and Geophysicists), communications and meetings with government officials and lawmakers, news coverage in national and local press, campaigns on social media, among others.

The current reality calls for ensuring the presence of professionals in Earth Sciences in municipalities, with the aim of contributing to sustainable development through the application of technical knowledge in the exercise of oversight, advisory, and validation of issues related to geo-hazards, groundwater prospecting and identification, and mining-energy resources present in the territory, supporting the development and review of territorial planning and schemes, and promoting social appropriation of knowledge in Earth Sciences. We face challenges such as climate change and its consequences for society, energy transition, carbon neutrality, and all of them have in common the knowledge acquired by geologists in their academic training.

In this sense, the initiative also seeks to generate more and better knowledge of topics related to geology and its importance for society. The lack of knowledge in Earth Sciences prevents proper and optimal territorial management, resulting in conflicts in land and subsurface use, lack of timely mitigation of potential risks in communities, and ignorance of potential water resources.

Therefore, building a country involves putting the knowledge acquired in the university at the service of society, and thus professionalizing decision-making in the territory with technical information support can lead to progress on the right path towards sustainable development.

Keyword

development, Geoscience, administration, municipal, territorial

OneGeology's impact: shaping the development of digital cartography in the Polish Geological Survey

Katarzyna JÓŹWIK[1]*, Polish Geological Institute - National Research Institute (kjoz@pgi.gov.pl)
Urszula Stępień[2], Polish Geological Institute - National Research Institute
Marcin Słodkowski[3], Polish Geological Institute - National Research Institute

Abstract

The Polish Geological Institute (PGI) was established in 1919 and has been the primary provider of geological maps in Poland ever since. According to the Polish Geological and Mining Law, the PGI acts as the Polish Geological Survey, and therefore, conducting geological mapping in the country is one of its statutory tasks.

The beginnings of digital cartography at the PGI date back to the 1990s when the first computer system (based on the Silicon Graphics Computer Systems - SGCS) for digital compilation of the Detailed Geological Map of Poland at a scale of 1:50,000 was introduced. Other digital map production systems for maps at different scales were implemented in subsequent years. The main focus of these systems was on delivering a printed map as the final outcome, and the structures of appropriate GIS databases were designed accordingly. Information on the age, lithology, and genesis of geological units was organized in a way that allowed the systems to produce complex literal and color symbols for map printouts but made spatial data analyses difficult.

Engaging in the OneGeology initiative in 2007 was a turning point for digital cartography at the Polish Geological Survey, initiating a gradual transition from printout-oriented systems to those focused on providing spatial data and services for applied geology uses.

The OneGeology initiative aimed to establish an interoperable geological distributed system for Europe and the world, utilizing the GeoSciML (Geoscience Markup Language) for data exchange. The 1:1,000,000 scale Surficial Geological Map of Poland was the first map compiled according to the OneGeology guidelines and was published by the OneGeology-Europe project in 2010. Subsequent projects, such as the Glaciotectonic Map of Poland and the Bedrock Geological Map of Poland, further reflected PGI's commitment to digital cartography. These maps, developed between 2011 and 2013, utilized the GeoSciML data model and set new standards for digital map compilation. Notable changes included improving the description and storage of information on the genesis and lithology of geological units and separating layers for surficial and bedrock units to provide a full picture of the geological structure and avoid data redundancy.

The OneGeology initiative laid the groundwork for digital geological cartography, with GeoSciML standards later forming the basis for INSPIRE schemas. Both initiatives emphasize compliance with metadata standards, such as ISO19115, ISO 19119, and ISO 19139. PGI's achievements include providing INSPIRE-consistent metadata using GeoNetwork software and offering maps compliant with the GeoSciML model. Notably, the Geological Map of Poland at a scale of 1:500,000 was fully harmonized with INSPIRE schemas using HALE software.

Currently, PGI is focused on modernizing geological maps on larger scales, such as the Detailed

Geological Map of Poland or the Geological Map of Poland at a scale of 1:200,000. The next steps will involve introducing standardized hierarchical vocabularies, enabling further harmonization and linking of data from geological maps at different scales. Finally, the Polish Geological Survey plans to use API services and AI to facilitate interaction with users through natural language queries.

Keyword

OneGeology, GeoSciML, Digital cartography, Standardized hierarchical vocabularies

PanAfGeo: A unique pan-African training programme for African Geological Surveys

Nicolas CHARLES[1]*, French Geological Survey - BRGM (n.charles@brgm.fr)
Jean-Claude GUILLANEAU[2], French Geological Survey - BRGM
Rokhaya SAMBA DIENE[3], Geological Survey of Senegal / OAGS
Julie HOLLIS[4], EuroGeoSurveys
Céline ANDRIEN[5], EuroGeoSurveys
Mosa MABUZA[6], Council for Geoscience / OAGS

Abstract

The African Mining Vision and the European Green Deal set out certain objectives that can be addressed through initiatives between the European Union and the African Union, e.g., Governance of mineral resources; Sustainable exploitation of non-energy mineral resources; Prevention and mitigation of natural and man-made disasters; and Development of local mining private sector. These goals are clearly linked to the geosciences. To help to meet these challenges, a partnership between the Organisation of the African Geological Surveys (OAGS) and its European sister-organisation, EuroGeoSurveys (EGS), was initiated in 2015, leading to the creation and implementation of a pan-African action, PanAfGeo, an initiative that has developed into a long-term strategic cooperation between African and European Geological Surveys.

PanAfGeo for “Pan-African Support to Geological Sciences and Technology Africa-EU Partnership” is a project in two three-year phases (2016-2019 and 2021-2024), training geoscientific staff from African Geological Surveys. The action is cofunded by the European Union and a consortium of 13 European Geological Surveys, coordinated by BRGM, the French Geological Survey. PanAfGeo contributes to a more sustainable management of natural resources and tackling climate change based on science and technology.

In concrete terms, PanAfGeo is an innovative training programme in different geoscientific skills, i.e. geoscientific mapping, mineral resources assessment, artisanal and small-scale mining, environmental management of mines, geohazards, geoheritage, geothermal energy, geoscientific information management; and communication and dialogue in geosciences. It aims to make the African Geological Surveys and the OAGS more effective in supporting national, regional and continental policy-making and planning. From 2016 to 2024, PanAfGeo carried out almost 60 training sessions exclusively in Africa, in English, French, and Portuguese, and thanks to the support and involvement of more than 20 host-countries. More than 1,800 geoscientists from geological surveys or similar bodies from across the African continent (54 countries) were trained, making PanAfGeo a unique pan-African geoscience-training programme. Courses were carried out by African and European experts from geological surveys, universities and also environmental authorities, such as Global Geoparks. It is noteworthy that many stakeholders are involved, including UNESCO, the Geological Society of Africa, the African Minerals Development Centre, the African Minerals and Geosciences Centre, and the Association of Women in Mining in Africa.

In the wake of this unprecedented pan-African project, a geoscientific network now exists on both

continents. This network can contribute to sustainable management of geological resources in Africa and promote EU-African partnership in geosciences and, in particular, raw materials. Looking ahead, a planned successor project aims to strengthen Africa-EU institutional partnerships on Geosciences at continental, regional and national levels; continue to strengthen African Geological Surveys and the OAGS in terms of geoscientific intelligence and national, regional and continental support to policy making and planning processes; create OAGS Expert Groups; and promote EU-Africa economic partnerships on raw materials value chains.

Keyword

Africa, Geological surveys, Geoscientific training, OAGS, EuroGeoSurveys

IGME's contribution to the Critical Raw Materials pan-European map: GSEU project

Iván MARTÍN-MÉNDEZ[1]*, IGME-CSIC (i.martin@igme.es)
Egidio Marino[2], IGME-CSIC
Concepción Fernández-Leyva[3], IGME-CSIC
Francisco Javier González[4], IGME-CSIC
Ester Boixereu[5], IGME-CSIC
Susana M. Timón-Sánchez[6], IGME-CSIC
Paula Adánez[7], IGME-CSIC
Virginia Rodríguez[8], IGME-CSIC

Abstract

The GSEU project (Horizon-CL5-2021-D3-02-14), has as its main objective to establish a Geological Survey for Europe, as an entry point to a permanent collaborative network of geological surveys and partner organizations, to provide European institutions, companies, and citizens with high-quality and up-to-date information about the earth beneath our feet and the geological resources it harbors. One of the main areas of the project is dedicated to raw materials. Its main objective is to re-evaluate both primary mineral resources - in the terrestrial and submarine domains - and mining waste, focusing on the strategic and critical raw materials needed for the energy transition, digital transformation, and sustainable development. To this end, after harmonizing the available information, a complete update of the pan-European mapping of strategic and critical mineral resources (reference of both maps) has been prepared. This mapping will serve as a starting point to assess the European potential in mineral raw materials based on known resources and resources to be known, in a harmonized and standardized way. In addition, this study has served to identify and characterize the gaps in the information at European level, which will allow proposing future lines of research, in order to strengthen the supply of critical raw materials in Europe.

The Geological Survey of Spain (IGME-CSIC) is actively contributing with the provision of its mineral resource databases (BDMIN onshore) and (GeoERA-MINDeSEA offshore) developed throughout its history and with the progress of its current mineral exploration work which is focused on the exploration of the strategic and critical materials defined by the European Union in its latest list, based on the Study on the Critical Raw Materials for the EU 2023 – Final Report.

Keyword

GSEU, Europe, critical raw materials, pan-European, Spain

What we have learned from operating OneGeology Portal

Amaya FUENZALIDA VELASCO[1]*, BRGM (a.fuenzalidavelasco@brgm.fr)
James Passmore[2], BGS
Christelle Loiselet[3], BRGM
Hajatiana Ramambazafy [4], BRGM
Valentin Raille[5], BRGM
Marcus Sen[6], BGS

Abstract

The OneGeology portal allows sharing geoscience international data via web services using common standards and protocols. Based on interoperability principles (GeoSciML). Geological services from around the world deliver map data through a standard OGC web service (WMS / WFS). The list of metadata of maps/services is collected into a catalogue of services managed centrally. Currently, 126 countries display 797 datalayers from 146 web services. The Platform code (Portal) is also an opensource facility proposed by OneGeology project, which is available from Github to be widely distributed. This free access to data and digital resources is available for anyone with internet access around the globe, and allow a unique opportunity to approach geosciences to the global community.

Working at worldwide scale is accompanied of important challenges, technical and on cooperation. In this work, we present the operational side of the One Geology functioning. That means how the international team coordinate the operational activities for make the portal work and evolve. We will present visitors statistics for the five years of the portal, such as their geographical distribution and main consulted services. We will analyze how the Covid crisis affected our portal and the main technical issues that we have need to overcome.

To finish our presentation, we will present the work perspectives for the next years in terms of technological implementation and new proposed services.

Keyword

datascience, international collaboration, web service, standards, protocols

The national geological service of Senegal : an instrument for managing geoscience data that benefits policy makers.

Raymond SAGNA[1]*, Service Géologique National du Sénégal (SGNS)
(raymond.sagna@sgns.gouv.sn)
Rokhaya SAMBA[2], Organisation Of African Geological Survey (OAGS)
Alla DIAW[3], Service Géologique National du Sénégal (SGNS)

Abstract

Since its independence, the State of Senegal has adapted its mining policy to the state of geological knowledge. This policy was implemented through mining law, the implementation of this policy resulting in action plans with activities such as improving the legislative and regulatory framework (Mining Code), knowledge of the mineral potential , etc.

Indeed, if since independence until 2000, the State has played a leading role in the mining sector because it is the main investor in the sector assisted in this by external or (FAC, KFW, FED, MRE, CRDI, UNDP, UNIDO, World Bank, IDA, etc.) internal (mining companies such as: CSPT, SSPT; PROCHIMAT, etc.) financial partners and from 2004 it is rather the mining companies which take over the acquisition of geoscientific data. However, it should be noted that the State has updated its geological infrastructure with the support of the European Union through the 9th EDF. The quantity and quality of data produced has led to an an evolution in its policy by increasingly returning to the operator in another form.

Thus, the State, through the provisions of article 114 of law n°2016-32 of November 8, 2016 relating to the Mining Code, creates a sector development fund which receives 20% of mining revenues on the one hand and on the other hand, the State has set up a public industrial and commercial establishment (EPIC) called the National Geological Service of Senegal (SGNS) whose main mission is the establishment of an efficient acquisition system, processing, interpretation and dissemination of geoscientific data by decree no. 2022-1358 of July 7, 2022.

To achieve this mission, the SGNS after several consultations is in the process of setting up a National Geological Mapping Program (PNCG). This plan, the first phase of which is devoted to the production of a general inventory of available geoscientific data, will make it possible to generate thematic maps but also a global map of the country on the one hand and on the other hand to guide the

survey campaigns data acquisition for geophysics as well as for cartography and geochemistry.

Keyword

geoscientific data, mining policy, mineral potential

SOCIAL REPORT OF THE GEOLOGICAL SERVICE OF BRAZIL, AN ESG TOOL

Patricia DURINGER Jacques[1]*, cprm (patricia.jacques@sgb.gov.br)
Ana Cláudia aguiar Accioly[2], CPRM
Ana Cristina Peixoto[3], CPRM
Samanta Bittencourt Suprani[4], CPRM
Juliano Souza Oliveira[5], CPRM

Abstract

The Geological Survey of Brazil - CPRM, is a public company, linked to the Ministry of Mines and Energy, whose mission is “to generate and disseminate geoscientific knowledge with excellence, contributing to the quality of life and sustainable development in Brazil”. To carry out its mission, CPRM receives a budget from the Federal Government through actions in the Annual Budget Law linked to State public policies, in accordance with the Federal Constitution, with its Multi-Year Plans (renewed every four years). The CPRM's Social Report aims to render accounts to society, through an accounting statement, of how much the institution's actions in the social, environmental, economic and governance axes are reflected in effective improvements for the country's population, for development sustainable and for society, highlighting the public benefits generated. It is an ESG (Environmental, Social and Governance) tool that demonstrates the social profit generated in an organized and auditable way. The first social report of CPRM is related to the base year 2021 and was published in 2022 (https://rigeo.sgb.gov.br/bitstream/doc/22837/3/balanco_social_sgb_v_final_atualizada.pdf). The methodology is based on the accounting statement using the standard table of the Brazilian Institute of Social and Economic Analysis - IBASE. Additionally, the economic impacts of projects and services carried out during the base year are evaluated and detailed. In the first social report, seven economic impacts were evaluated, which promoted a social profit of R$ 2,707,980,195.94. The projects and services that had their economic impact calculated were: hydrological alert system, studies of hydromineral sources, distribution of didactic collections of minerals and rocks, consultations with lithotheca collections, courses and training for external public, geological mapping and resource assessment minerals and mineral heritage. In the second social balance, base year 2022 (https://rigeo.cprm.gov.br/bitstream/doc/24259/1/balanco_social_2022.pdf), new products and services evaluated for their economic impacts were included, totaling 13 products, which promoted a social profit of R$ 2,051,325,816.52. The products included were: fossil workshops for children, MEV analyzes for external users, maps of geophysical anomalies, cartography for disaster prevention and the use of aerogeophysical data in theses and dissertations. Despite the inclusion of new products and services, the value of social profit recorded was lower, which is mainly explained by the decrease in the value of the iron commodity, used in one of the calculation methodologies. Fluctuation in the value of profit obtained annually is common, as it is a balance sheet. It is important to highlight to society that the document demonstrates the use of

the product or service in a given year. The future goal is to use this statement as an instrument to consolidate society's trust in the Geological Survey of Brazil, as well as to demonstrate publicly and in accessible citizen language its public value and its socio-environmental and governance performance. The geological service is preparing its third social report (base year 2023) in the expectation of being able to further expand the economic accounting of the products and services it delivers to society, in the form of public policies.

Keyword

Social Report, ESG, transparency

Geothermal energy research supporting national policy and regulation; a European case study from Ireland

Aoife K. BRAIDEN[1]*, Geological Survey Ireland / RML ltd (aoife.braiden@gsi.ie)
Sarah Blake[2], Geological Survey Ireland
Koen Verbruggen[3], Geological Survey Ireland

Abstract

Across Europe there has been a renewed focus on evidence for policy and regulation, in particular to support energy and climate adaptation strategies. For example, Geological Survey Ireland (GSI), in collaboration with partners in academia and industry, has been providing geoscience data and information for the development of new geothermal energy policy and regulations for Ireland.

New data and related products have been delivered through (a) a research funding programme established in 2015 which has been driving the research and directly supporting geoscience researchers, and (b) Geological Survey Ireland's technical staff providing open databases, collating external research outputs and developing expert knowledge. These joint activities have improved our understanding of Irish geothermal resources but have also provided essential information for decision makers for management, planning and regulation of geothermal energy in Ireland. In addition, the research has also ensured innovation and best practice through international collaborations.

A key element of the research both carried out and supported by GSI, is the delivery of open access data and products. These follow GSI, and national, open science policies and encourage the development and use of high quality national and international accessible and interoperable online databases. These databases are also the basis for planning and GIS tools currently being developed to support local and national authorities in relation to surface land use and subsurface utilisation.

In July 2023, the Irish Government published a policy statement for the development of geothermal energy in Ireland. The objective's are to support Ireland's climate action commitments by setting out;

i. the preferred approach to regulation, and

ii. the scope of a strategy to promote the sustainable development of Ireland's geothermal resources to decarbonise the heating and cooling of buildings and for industrial uses and power generation.

The development of both the regulation, further policy and the wider geothermal energy sector will require continued, bespoke research outputs and increased geological information to derisk the subsurface., and also close collaboration between academia, policy makers and expert national organisations such as geological surveys.

Keyword

Geothermal, energy, policy, research

Geoscience Policy Advocacy for the Public Good: Making an Impact through Policy!

Munira Raji[1]*, University of Plymouth, United Kingdom (munira.raji@plymouth.ac.uk)

Abstract

Geoscience research enhances our understanding of the Earth's complex systems and processes, including the atmosphere, hydrosphere, cryosphere, biosphere, and geosphere. Policy decisions and frameworks influence and shape how we manage Earth's resources, conserve environments, and assess and mitigate environmental degradation, geological hazards, climate change, and rising sea levels. However, gaps and limitations in current policies can hinder geoscientific advancement, innovation, and discovery - ultimately impacting societal well-being. This presentation highlights the integral role of geoscience policy across multiple fronts - from addressing climate change, transitioning to renewable energy from fossil fuels, implementing carbon capture mechanisms, and sustaining natural resources to building resilience against climate change, geological hazards, and environmental risks.

As experts in their field, geoscientists have some obligation and responsibility to advocate for evidence-based policies and policy reforms that support geoscience research that benefits society. The presentation will discuss why geoscientists should get involved in policy advocacy, why active engagement in policy reform is a crucial responsibility for geoscientists and how they can make a difference by doing so. Geoscientists are knowledgeable about best practices and effective methods to manage and prevent pollution, minimise the consequences of volcanic eruptions and mining activities on human well-being and the environment, and ensure sustainable exploitation of essential resources such as minerals, wind energy, geothermal energy, and groundwater in the face of rising global demand. Their input can inform policy to reduce resource overexploitation and destruction, and policies that expand funding for climate modelling research that could lead to improved predictions about the pace and impacts of climate change. In disaster management, geoscientific research on earthquakes and floods underpins policies that minimise risks and build preparedness.

By bridging the gap between the geoscience community, policy-makers, communities and other stakeholders, geoscientists can translate their technical knowledge into actionable, impactful policies that encourage sustainable extraction of natural resources, reducing community vulnerabilities, strengthening resilience to global challenges, and serving the public good.

Keyword

Geoscience Policy, policy-makers, Public Good, Geoscience and Society, Policy Advocacy

Geoscience for Sustainability – A new initiative to promote the role of geosciences in society

Jonathan ARTHUR[1]*, American Geosciences Institute (jarthur@americangeosciences.org)
Chris Keane[2], American Geosciences Institute
Ed Robeck[3], American Geosciences Institute

Abstract

The American Geosciences Institute (AGI) has embarked on the Geoscience for Sustainability (GfS) initiative as a long-term and multi-faceted project to highlight the critical role that geoscience plays in developing a sustainable world. Having begun in 2023, GfS is designed to build on the effective framing of societal issues provided by the United Nations Sustainable Development Goals (SDGs) and views the geoscience nexus with these goals as means to strengthen the global geoscience community internally and externally. Not only do geosciences bring understanding of the Earth system to enable effective stewardship, but geoscience is prominent at the intersection of the planet and humanity.

AGI envisions that the GfS initiative will empower geoscientists with the knowledge to understand how the environmental, social, and economic impacts of their geoscience work contribute to developing a sustainable world as a core ethos of the geosciences. AGI's mission in this endeavor is to build a framework of actions, tools, and programs that enable and coordinate the efforts of individuals and organizations in our professional community to support the SDGs, thereby empowering the geosciences as central to the successful development of systems that achieve sustainable development.

Importantly, GfS also responds to global concerns about the role of the geosciences, such as in terms of supporting all of society, its relevance to daily life, and the novelty of its expertise. Some elements of the public perception of the geosciences negatively impact public support for geoscience. This has many effects, including decreasing geoscience enrollments in higher education. Geoscientists fully understand these concerns are misconceptions, but they are nonetheless an indictment on the geoscience enterprise's ability to promote understanding of its role in supporting humanity.

Goals of the GfS initiative include 1) collaboratively leading the transformation of the geoscience profession into one whose members integrate sustainability into their daily work, especially with positive actions and impacts to environmental, social, and economic considerations, including people and societies affected by their work, 2) supporting awareness of sustainability as part of the daily activities of geoscientists, and 3) positioning the geoscience profession as the exemplar of a community of practice committed to developing a sustainability-focused society.

Keyword

sustainability, education, workforce, SDG, outreach

Insights on the evolution of mineral policies, acts, rules and their association with mineral targeting geosciences in India

Debkumar BHATTACHARYYA[1]*, Geological Survey of India (debkumar@gsi.gov.in)
D S JEERE[2], Geological Survey of India
K V MARUTHI[3], Geological Survey of India

Abstract

This abstract discusses the progressive efforts made to achieve economic growth in the mineral sector for non-fuel, non-atomic minerals and their association with mineral-targeting geosciences in India. The deposit discovery follows mineral block development and mining. Mines and Mineral (Development and Regulation) Act, 1957 (MMDR Act) is the main statute for the regulation of mineral sector. The Mineral Concession Rules, 1960 outline the procedures and conditions for obtaining a Prospecting Licence (PL) or Mining Lease (ML). The National Mineral Policy (NMP), 1993 and subsequent reviews undertaken in 1994, 1997, 1999 and 2000 facilitate both private and foreign investment in exploration and mining. Later, amendments to MMDR Act in 1999 introduced the concept of a Reconnaissance Permit (RP) before the PL. The RP holder has the preferential right for obtaining PL, and then ML with the required conditions. In 2008, a revised NMP mentioned the grant of RP, PL and ML transparently, seamless and easy to transferability. The private sector would be the main source of investment in RP and PL and government agencies would focus on areas where private sector investments are less. The MMDR Act amendments in 2015 brought several reforms as mandating the auction of mineral concessions to improve transparency, establishing National Mineral Exploration Trust for enhancing regional and detailed mineral exploration through funding. E-Auction was made mandatory for the grant of mineral concession to ensure a transparent method of allotments of mineral wealth.

The Government brought out a National Mineral Exploration Policy (NMEP), in 2016 to give further momentum to exploration efforts. NMEP stated a structured framework for comprehensive exploration with a judicious interplay of government support and private innovation and enterprise. It emphasised the acquisition and interpretation of baseline geoscience data for the exploration process. The policy assured that baseline geoscience data comprising geology, geochemistry, and geophysics will be generated as a public good and will be made available in the public domain for free access. National Geoscience Data Repository will be set up which will collate and make available all baseline and mineral exploration information generated by various central, state government and others.

Geological Survey of India (GSI) established in 1851, is a premier government geoscience agency involved in mineral exploration, fundamental geoscience studies and research. GSI generates a large repository of the finest quality geological database and would be responsible for allowing the data to be made freely available in the public domain and upgrading India’s geological potential

areas with new mineral exploration information. Following the NMEP 2016 and MMDR amendments, GSI is covering and disseminating the geoscience data namely., seamless geological maps on a 50K scale, geochemical data, ground gravity & magnetic data, aero geophysical and remote sensing data with priority on geological potential areas for the whole country. A significant number of potential mineral exploration blocks and the blocks with estimated mineral resources were passed on to the State Governments for auctioning as per the new MMDR Amendments of 2015, 2016, 2020 and 2021.

Keyword

Policy, Geoscience data, Mineral Targeting

Integrated geoscience mapping toward minerals and energy development: a case study for lithium prospectivity in the Northern Cape of South Africa

Taufeeq DHANSAY[1]*, Council for Geoscience (tdhansay@geoscience.org.za)

Abstract

The Council for Geoscience is mandated to undertake fundamental and applied geoscience research toward the sustainable development of South Africa. This includes development within the themes of minerals and energy, groundwater and environment, and infrastructure and land use. It aims to achieve this mandate through the collection and integration of several fundamental geoscience data and information. The Council for Geoscience has embarked on strategy to cover the country on a scale of at least 1:50,000 of various geoscience datasets. This includes geology, tectonics, geophysics, geochemistry, remote sensing, and economic geology. This strategy was initiated in 2017 and, to date, has increased South Africa's 1:50,000 scale geological coverage by 13%. Much of this increased coverage is focussed on regions that are defined to have significant mineral potential. It is envisioned that the development of these data and information may increase South Africa's share of the global exploration budget and contribute toward the country's development imperatives. This paper presents findings of how an integrated geoscience approach was applied to define lithium-bearing sequences in the Northern Cape Province of South Africa. Integration focused on the extraction of key lithological signatures from multi- and hyperspectral satellite imagery and specific geochemical indicators from regional and targeted geochemistry. These data were further corroborated and defined by field-based geological mapping and ground geophysical investigations. The integration of these findings has elaborated on the overarching tectonic evolutionary characteristics of the region and how these have enabled and controlled the emplacement of these mineralised sequences. Furthermore, this information has increased the prospective region of these sequences by at least 10,000 square kilometres. Targeted sampling has yielded lithium concentrations of up to 3-4%. Finally, mineral extractive studies were undertaken and suggest that at least 93% of the spodumene-bearing lithium can be economically liberated. It is proposed that these findings attain expression in the development of innovative mining and post-mining strategies for the region, including aspects of knowledge-driven exploration and extraction, downstream mineral beneficiation and sustainable mine closure practises.

Keyword

Exploration, Geological Mapping, Lithium, Mining, Sustainability

Communicating with Non-Scientists: A Review of Select EU Horizon Projects and their Degree of Public Transparency

Maureen Gallagher[1]*, European Federation of Geologists (maureen.gallagher@eurogeologists.eu)
Anita Stein[2], European Federation of Geologists
David Govoni[3], European Federation of Geologists

Abstract

Geology and the geosciences are the most important professional sector to safeguard the Earth and humanity's future. The changing climate, advancing technology, and human migration have all increased the need for more geologists to 1) find and extract critical raw materials for the green transition, 2) predict, prepare, and avoid natural disasters, and to 3) slow and/or reverse the effects of greenhouse gas emissions, to name a few. Yet as more are needed, fewer individuals are interested in the sector and its myriad of professions. Further, the global public has little understanding of the profession's value to society.

For more than two decades, the European Federation of Geologists (EFG) has provided expertise in the development, execution, and communication of more than two dozen European Union (EU) funded projects under the 7th Framework Programme, Horizon 2020, and Horizon Europe. These research projects span topics from critical raw materials to natural hazards, hard science to social science, and primary students to advanced career professionals. A common thread among projects is communication of results and impact. Target audiences are professionals, students and prospective students, and society (non-scientists to include policy-makers).

In 2024 the European Federation of Geologists embarked on an analysis of communication success as a means of reflection on meeting desired communication objectives for their projects and building strategies to improve communication for currently active and future EU funded projects in which EFG has involvement. In comparing ongoing projects (CRM-geothermal, CEEGS, Tripgift, TIMREX), recently closed projects (REFLECT, SUMEX, ROBOMINERS) and historic projects (INTRAW, ENGIE, CROWDGEOTHERMAL) we developed a Communication Transparency Index (CTI) to be used as a guide in maximizing transparency for our three audiences. Through these and future projects, EFG will be a leader in reversing the trend of disinterest and misunderstanding of the profession and the impact of the science for society. Maximizing our transparency is essential to meeting our objectives and promoting the value of the EU investment in these projects.

Keyword

communication, policy, transparency, geology, Policy-makers

IGCP 735 project: Rocks and the Rise of Ordovician Life

Wenhui Wang[1]*, Central South University (whwang@csu.edu.cn)
Bertrand LEFEBVRE[2], Université Lyon 1
Yves CANDELA[3], National Museums Scotland
Khadija EL HARIRI[4], Cadi Ayyad University
Mansoureh GHOBADI POUR[5], Golestan University
Elena RAEVSKAYA[6], JSC "Geologorazvedka"
Oive TINN[7], University of Tartu
Beatriz WAISFELD[8], National University of Córdoba

Abstract

Deciphering the complex interactions between climate change, biodiversity and ecosystem structuration is a major societal issue for future generations. The geological record offers the unique opportunity to document the impact of environmental changes in the biosphere in the past, and thus to provide some clues for the future. Early Palaeozoic interval embraces major evolutionary events such as the Cambrian Explosion and the Great Ordovician Biodiversification Event, but also major shifts in climate with a dramatic impact on the biosphere. Recently, the development of large-scale collaborative palaeontological databases promoted high-resolution analyses of biodiversity patterns, which could be compared using different environmental proxies. However, most available data are so far strongly biased towards some geographic areas (Europe, North America) and time intervals (lower-middle Cambrian, Middle-Upper Ordovician). Through a multidisciplinary approach, and in close collaboration with the International Subcommission on Ordovician Stratigraphy, our IGCP 735 project aims at filling the numerous knowledge gaps in most regions of the world (e.g. Africa, Asia and South America), with a special focus on less-documented time intervals (e.g. late Cambrian to early Ordovician). The IGCP 735 was approved and started in 2021. Until now, more than 220 scientists from 42 countries have participated to the project. Three annual meetings including an online meeting have been held since 2021. Three thematic volumes in the international journals Palaeogeography Palaeoclimatology Palaeoecology, Frontiers in Earth Sciences and Geobios about the scientific topic have been published in 2023. The IGCP 735 project has been very enthusiastically welcomed by the scientific community and has been acknowledged in almost two hundred publications in international journals. More details about the project can be found on our website: https://rocksnrol.wordpress.com/.

Keyword

Ordovician radiation, geological history, fossil records

Intergovernmental Action on Sustainability and the Role of Geoscience

Janice Lachance[1]*, American Geophysical Union (AGU) (jlachance@agu.org)
Lisa Graumlich[2], American Geophysical Union (AGU)
Mark Shimamoto[3], American Geophysical Union (AGU)

Abstract

In 2015, countries around the world adopted the United Nations Agenda 2030 which contains the Global Goals for Sustainable Development. 17 Goals, 169 targets, 230 indicators. Each collectively aimed at ensuring a healthier and more sustainable global society both now and into the future. While some goals explicitly align strongly with the geosciences, such as 13: Climate Action, 14: Life Below Water, and 6: Clean Water and Sanitation, the geosciences do have a role to play in all 17. AGU's strategic plan builds on the bedrock of discovery science and emphasizes the necessity of greater advancements in solution science for the benefit of humanity. It charges the community to collaborate and innovate ways their science can inform solutions to society's greatest challenges laid out in the U.N. Global Goals. This includes partnering with local communities, other disciplines of science and engineering, as well as engaging with policymakers and the public to co-produce science that ensures it moves from usable to used. This presentation will highlight how AGU through partnerships and intergovernmental outreach, is addressing knowledge co-creation and information sharing for a more sustainable and just future. Specific examples include AGU's leadership in science policy and diplomacy, open science, community science, and scientific ethics.

Keyword

science policy, global cooperation, sustainability, solution science

The Brazilian Geological Survey: Unveiling a World of Geodiversity and Scientific Expertise for Global Collaboration

Deborah MENDES[1]*, SGB/CPRM (deborah.mendes@sgb.gov.br)
Rafael Pinto DUARTE[2], SGB/CPRM

Abstract

Brazil boasts a remarkable geodiversity within its vast territory, encompassing rocks of all ages, structural features, mineral deposits, landscapes, soils, fossils, and other elements that narrate the story of our geological evolution. Unique features include the 3.65 Ga Mairi Gneissic Complex in Bahia, the oldest rocks in Brazil, and the 2.4 Ga banded iron formations of the Iron Quadrangle in Minas Gerais, one of the world's largest deposits of its kind. The Sugarloaf Mountain in Rio de Janeiro, at 560 Ma, stands as a testimony to the amalgamation of the Gondwana Supercontinent during the Neoproterozoic. The Mesozoic reactivation of the Brazilian Platform led to the formation of the Paraná-Etendeka Magmatic Province, the second largest volcanic province on the planet. Cenozoic depositional environments are found throughout the country, exemplified by the Pantanal Basin, the largest floodplain on Earth with active fluvial fan sedimentation. Given Brazil extensive geodiversity, the SGB boasts a team of highly skilled professionals in various geoscience fields, including geology, geophysics, geochemistry, mineral resources, hydrology, hydrogeology, and territorial management. Our mission is to generate and disseminate geoscientific knowledge, contributing to the improvement of the quality of life and sustainable development of Brazil. As per the 2022 Social Balance, the company generated a social profit of approximately R$2 billion, demonstrating the significance of our products and services. As a scientific research institution of the federal government, the Brazilian Geological Survey provides data and information to support decision-making by government agencies, public and private companies. Our work includes the production of Geological Risk Area Maps and Susceptibility Maps to Mass Gravitational Movements and Floods, which effectively contribute to reducing losses from natural disasters. In the agricultural sector, we highlight research on agrominerals for soil remineralization, which aims to improve soil conditions and plant health through the use of minerals and rocks, thus optimizing food production in a sustainable manner. Recognized as a Science, Technology, and Information Institution and with extensive institutional representation, the Brazilian Geological Survey has unique position among its global counterparts allows us to contribute to the generation and transfer of scientific and technological knowledge to virtually any country in the world. Therefore, our international agenda aims to simultaneously provide access to geoscientific knowledge and, through international cooperation, seek the capabilities, competencies, technologies, and expertise needed to develop our human resources and infrastructure. This paper presents the Brazilian Geological Survey internationalization strategy, highlighting consolidated geoscientific information and its relevance to the needs of other countries. We are open to partnerships that foster scientific exchange towards sustainability and rational use of natural resources worldwide, in line with the UN Sustainable Development Goals

for 2030.

Keyword

Brazilian Geological Survey, International Cooperation, Public Policy, Sustainability, COP30

East to West collaboration for a gender equality in Geosciences

Minha LEE[1]*, Kangwon National University (minha_lee@kangwon.ac.kr)
Heejung Kim[2], Kangwon National University
Lola Pereira[3], University of Salamanca

Abstract

Gender disparity is a global issue affecting every scientific fields. The disparity is higher when dealing with STEM subjects, including Geosciences. Governments are adopting several corresponding measures continuously at various times, levels, and sectors to diminish the gender gap, but all regions should collaborate because it should be common effort. For example, in South Korea, large campaigns and promotion were conducted at the national level in early 1990s to improve female enrollment in the science and technology related fields, including geoscience, as such gender disparity involved cultural aspects. Furthermore, the gender quota systems were widely encouraged and adopted in major national projects, government offices and companies. As the results, recent statistics demonstrate much improved gender equality in science and technology field at the youth level such as university admissions (50% in science, 22% in technology), new recruitments (6.5% gender disparity), and junior positions (20% in science, 10% in technology). Unfortunately, however, the number drops dramatically by age 40 and diminishes at the higher ranks. Many survey and statistical reports conclude that while the main causes of resignment at the age 30-40 are sociocultural imbalance issues (marriage, pregnancy, and childcare), after 40 the cause is mainly organizational restrictions. Thus, it is critical to connect sociocultural measures on gender disparity in households (housework and childcare) and organization reform in institutions (glass ceiling) to achieve overall gender equality in professional fields like geoscience. Previous work shows that promoting women's leadership in STEM (including Geosciences) can help in closing the gender gap in STEM, increasing the role models for female students. We will analyze successful good practices, like collaborating in developing strategies through ERASMUS+ projects with western countries like Spain and eastern countries like South Korea. Closing the gender gap in Geosciences should transcend borders, with a multilateral and international focus to build networks that will reduce the gap in academia and research fields, also in higher roles by supporting women carriers towards the new, equal paradigm in Geoscience.

Keyword

Gender disparity, STEM, equal opportunity, organizational reform, sociocultural measures

GeoLatinas: six years embracing, empowering and inspiring Latinas in Earth and Planetary Sciences

Monica Alejandra GOMEZ-CORREA[1]*, University of Hamburg & GeoLatinas – Latinas in Earth and Planetary Sciences (moagomezco@gmail.com)
Rocío Caballero-Gill[2], George Mason University & GeoLatinas – Latinas in Earth and Planetary Sciences
Daniela Navarro-Perez[3], Universidad de Magallanes & GeoLatinas – Latinas in Earth and Planetary Sciences
Sofía Barragán-Montilla[4], GeoLatinas – Latinas in Earth and Planetary Sciences & MARUM –Center for Marine Environmental Sciences, University of Bremen, Germany

Abstract

Since 2018, GeoLatinas has promoted Latina women's work and contributions to the advancement of Earth and Planetary Sciences worldwide. GeoLatinas is an international, inclusive, member-driven, circular organization that gathers students, academics and professionals in the public and private sectors. We aim to foster community and co-leadership, providing tools and opportunities to help GeoLatinas members succeed at all stages of their careers while inspiring future generations to pursue careers in Earth and Planetary Sciences.

Since its inception, our community has relied on several initiatives to translate our GeoLatinas mission and vision into actions. As such, we tackle barriers to women's advancement via representation and language barriers while promoting our community members' professional and personal growth. For example, one of GeoLatinas' first initiatives, #FridayFeatureInGeo, has been used to promote the life and work of Latinas in Earth and Planetary Sciences within all our social media platforms, enhancing their visibility and increasing representation in our fields. Beyond highlighting our members' contributions, we aim to embrace different backgrounds while decreasing the language barrier. One of the initiatives that aligns with this vision is the GeoLatinasBlog, a multilingual platform where members learn to be bloggers, editors, and translators as our writers communicate their science and perspectives. In line with this purpose, GeoTraductores is an initiative that translates science communication articles from the Eos.org platform from English to Spanish, increasing access to the Spanish-speaking audience and developing the technical skills of bilingual geoscientists. Furthermore, Conversando con GeoLatinas has been supporting the development of our members while improving their conversational English and Spanish skills.

Many of our initiatives promote our community members' professional and personal development, providing the necessary tools to thrive in their careers. This includes the Mentoring initiative, offering a variety of mentoring modes and opportunities, including a tailored pair program and resources for all members' growth within a safe space. The GeoSeminarios initiative offers a spotlight platform to showcase our research, allowing us to improve science communications

skills by focusing on a wider audience. The Impetu initiative motivates members to co-work in a supportive online community 24/7, providing ad hoc mentoring and promoting a sense of belonging. Lastly, the PERLA initiative offers webinars and workshops on technical and “soft” skills for various work sectors like industry and academia and even the transition to other career paths.

Through the labor and dedication of members in our organizational units, along with the focused initiatives above and many others, GeoLatinas has become an important online networking platform for Latinas and other demographics for which our mission and objectives resonate. At the end of 2018, GeoLatinas had 8 members in 2 countries; today, we have over 1300 members in 59 countries. This abstract summarizes 6 years of experience creating a community that works towards a more diverse and inclusive Earth and Planetary Sciences worldwide. Beyond our rapid growth in followers (over 25,600 as of February 2024) and sustainable community, our most important achievements relate to having had the privilege of supporting and mentoring each other along our journey.

Keyword

diversity, community, empowering, co-leadership, Latinas

[Keynote] Advancing Earth Science and women's equity through research, community building and professional societies

Carol FINN[1]*, US Geological Survey (cfinn@usgs.gov)
Wonsuh Song[2], Waseda University
Young-Seog Kim[3], Pukyong National University
Rie Hori[4], Ehime University
Gaku Kimura[5], JAMSTEC

Abstract

The pursuit of gender equity isn't solely the burden of women; it's a collective duty that encompasses all scientists. Research shows that the more diverse a science team, the more innovative it is. Exclusion of groups, including women who comprise ~50% of potential Earth scientists, diminishes the potential of science to serve society and promote a sustainable future. Studies show that women will study science if they see women as scientists. For example, in the US in the 1970's-1990's school children were asked to draw a scientist. At that time, only 1% drew a female scientist. Last year, 60% drew a female scientist. However, recent AI generated images of scientists are almost exclusively men. In 2019, in US science and engineering universities, women received ~50% of Bachelor's Degrees, ~45% of master's, 41% of Ph.D's, 37% of postdocs and only 29% were employed in their fields. The US ranks 18th globally in the percent of women research scientists of 34%. Korea ranked 28th with 20% and Japan 29th with 17%. Women make up ~30% of the membership of the American Geophysical Union and 32% of the Geological Society of Korea. In many places, hostile work environments, unequal opportunities and retaliation for reporting discourage women from entering and staying in Earth Science. Harassment and assault while doing field work is a serious issue as well. While the cultural change required for a more equitable and diverse workforce takes time, measures can be taken to provide the building blocks for change. An example of a building block is the Earth Science Women's Network (https://eswnonline.org/), which offers programs that pair early-career scientists with experienced professionals, organizes networking events, provides opportunities for professional development including grant writing, scientific writing and leadership skills and fosters a sense of community among women through online forums, social media groups and local chapters. Men participate in achieving the goal of scientific excellence through equity by including women in science teams, authorships on papers and principal investigator roles on grants and mentoring on how to advance in the systems, confronting wrong-doing, noting the accomplishment of women in public forums, using their voice to elevate the voices of women, telling women that they matter, and nominating them for honors, to name a few. Professional societies can play a role in advancing women through awarding honors, assigning committee appointments and leadership positions and providing resources on career advancement and overcoming barriers to advancement. For example, the American Geophysical Union, requires that elections and all committees have gender, geographic, career stage and ethnic diversity. Leadership and anti-harassment training is available for these activities. On a larger scale,

supporting research on how to advance gender equity to improve science has a large impact. The US National Science Foundation has awarded over $350M in grants to research ways to improve equity and increase participation in science. The Japan Geoscience Union has a committee on diversity management and talent pool. How will you contribute to equity, and therefore, excellence, in science? Our planet needs us all.

Keyword

Equity, Gender, Scientific Excellence, Policy

Africa-Europe: working together to close the gender gap in Geosciences.

Josefina Hamutoko[1], Geosciences, University of Namibia
Ndivhuwo Cecilia Mukosi[2], Council for Geoscience, South Africa
Lydia Olaka [3], Technical University of Kenya, Kenya
Lola PEREIRA[4]*, University of Salamanca (mdp@usal.es)
Lesego Peter[5], Botswana Geoscience Institute, Botswana
Yamirka Rojas-Agramonte[6], Institut für Geowissenschaften, Christian- Albrechts-Universität zu Kiel, Germany

Abstract

During the last International Union of Geological Sciences Executive Committee (IUGS-EC) meeting that took place in Kenya (Nairobi, 19-23 February 2024), it was clear that the gender gap is still a big problem in Geosciences. Bigger if we consider female leadership in decision-making areas. Even if there are enough female students graduating in Geosciences from the different universities, they are missing in leadership positions. By the exchange of ideas and information among African and European colleagues, it was made clear that the gap is not a geographic-limited issue. In both continents a lack of gender diversity is found where the decisions are taken. This is also a common place in other areas around the Globe, and we believe the solution is in the discussion and comparison of good practices where the gap has started to close by implementing specific policies. As a result, the colleagues that met in Kenya decided to start a network of female researchers from Africa and Europe, to study the root cause of the problem. This network will seek to establish the gender inequalities in the involved countries to start with. It will analyze the possible causes of such differences, including politics, social measures, and other tools that governments may or may not be using to close the gender gap. We will use medium-term tools to get a sustainable amount of data that can help in getting a reasonable response to our research question, including the elaboration of an ERASMUS+ proposal in the line of Capacity Building projects, in the frame of the European Union. Data for analysis will include some African Geological Surveys institutions to assess rations of graduates' intake up to leadership positions (e.g., example in Botswana). This will be the response to the demand of encouraging collaboration and action-oriented plans that was requested during the Nairobi meeting by some contributors. First, promotion of the African Geology should be a priority, helping to publish the research in high-impact journals. Also, the presence of female geologist in international conferences should be promoted, using gender quotas if needed when organizing the conference committees (a must in the IUGS-IGC meetings). Finally, promoting female researchers to be part of the editorial boards of those journals.

With these actions, a commitment to change and advance in a diverse path for geoscience will be ensured and will help female researchers to build a pipeline of young females with outstanding role models to follow in the geoscience career.

Keyword

gender gap, Africa, Europe, Geosciences

Inversion of Barcelona Basic Model Parameters for Thermo-Hydro-Mechanical Simulation of High-Level Radioactive Waste Disposal System

Yeongju KIM[1]*, Seoul National University (yzoo1008@snu.ac.kr)
Kwang-Il KIM[2], Korea Atomic Energy Research Institute
Minseop KIM[3], Korea Atomic Energy Research Institute
Changsoo LEE[4], Korea Atomic Energy Research Institute
Hoonyoung JEONG[5], Seoul National University

Abstract

For the safety and performance assessment of a high-level radioactive waste (HLW) disposal system, predicting and analyzing the coupled thermo-hydro-mechanical (THM) behaviors of bentonite, a candidate buffer material in the engineered barrier system, is crucial. The Barcelona Basic Model (BBM) is a constitutive model used to describe the geomechanical behaviors of partially saturated soils. Directly measuring BBM parameters of bentonite requires complicated tests. This study demonstrates that probable BBM parameters can be estimated by calibrating the BBM parameters to match simulation results with observed data from a simple test, the swelling pressure test, instead of the complicated direct tests.

The swelling pressure test was conducted using Gyeongju bentonite, a buffer candidate material in the improved Korean reference disposal system (KRS+). A numerical model was developed to emulate the swelling pressure test using COMSOL Multiphysics software. Optimal BBM parameters that reproduce the observed swelling pressures in hydro-mechanical simulations were determined using a particle swarm optimization method.

The optimal BBM parameters from the inversion process were used to predict the THM behaviors of the engineered barrier system (EBS) in KRS+. A numerical model was developed using TOUGH2-MP/FLAC3D software to conduct the performance assessment of coupled THM processes in KRS+. Temperature and saturation changes were evaluated at seven locations within the disposal system. Decay heat from high-level radioactive waste increases the temperature of the repository and decreases as decay heat diminishes. The maximum repository temperature reaches about 82℃ 15 to 20 years after the disposal of HLW, remaining below the maximum temperature criterion of 100℃. The saturation of the bentonite buffer near the canister decreases initially because of pore water evaporation induced by temperature increase. However, the bentonite buffer becomes saturated 100 years after the disposal of HLW, as groundwater from the surrounding rock mass flows in.

Keyword

Bentonite, Barcelona basic model, Inversion, Coupled thermo-hydro-mechanical processes, Improved Korean reference disposal system

Micro CT and NMR studies in the very compact Boda Claystone, in connection with the Hungarian HLW project

Ferenc FEDOR[1]*, Department of Geology and Meteorology, University of Pécs
(fedor.ferenc@geochem-ltd.eu)
János Geiger[2], GEOCHEM Ltd.
Péter János Koroncz[3], Doctoral School of Earth Sciences, University of Pécs
Catarina C. Castro[4], Doctoral School of Earth Sciences, University of Pécs
János Kovács[5], Department of Geology and Meteorology, University of Pécs

Abstract

The Boda Claystone Formation, which has been studied in detail since the early 1990s, is one of Hungary's target rocks of the HLW repository project. The rock is highly compact, with very low porosity and permeability, characterized primarily to nanopores and microcracks. Therefore, laboratory analysis has been challenging and has required several improvements (PPD permeameter, more accurate porosity determination, cryodesiccation, etc.). New methods that have appeared in recent years (micro CT, nano CT, NMR), complemented and calibrated with improved conventional methods, offer the possibility of gaining insight into the rock structure and understanding its behaviour under reservoir conditions. They also allow investigation of the possibility of upscaling specific rock physical properties (REV determination). From studies carried out since the second half of the 2010s, it appears that water in the nano/microstructure of rocks forms a coherent volume that is practically immobile. This water is often not bound to the surface of the clays but trapped in the nanopores. This volume of this trapped water can be several times larger than the free water recoverable from the pores. This water mass, along with the clay content, may explain the self-sealing/self-healing capacity and the extreme physical character of the rock. However, the available theoretical and modelling background is unsuitable for describing such problems and needs improvement.

Keyword

computed tomography, claystone, NMR, water content

Microbial Reactions by Bentonite Indigenous Microbes under Varied Temperatures and Irradiation Conditions

Kanghyun PARK[1]*, Korea University (parkkh831@korea.ac.kr)
Man Jae Kwon[2], Korea University

Abstract

Bentonite is a promising buffer material for engineered barrier system in deep geological repositories (DGRs) of spent nuclear fuel (SNF). With its indigenous microbes, bentonite also serves as a potential microbial source that can mediate microbial interactions with surrounding materials, which can critically impact repository stability. Over the long term, bentonite and the indigenous microbes within the repository system can be subjected to both heat and irradiation resulting from radionuclide decay. In our previous study, we investigated microbial reactions by indigenous microbes in bentonite at 18 and 50 °C under Fe(III) and sulfate reducing conditions. Building upon this foundation, we conducted two batch experiments with bentonite indigenous microbes to 1) evaluate the temperature effect under more detailed conditions, and 2) assess the microbial activity and viability under irradiation.

Microcosms comprised WRK bentonite and artificial groundwater amended with lactate as an electron donor, along with Fe(III) (in form of ferrihydrite) and sulfate as electron acceptors. To determine temperature effect, microcosms were incubated under six different temperature conditions ranging from 18 to 70 °C. For assessment of irradiation effect, microcosms were exposed to gamma-radiation at varying dose rates of 2 to 200 Gy/h for 11 days.

Under different temperature conditions, microbial lactate utilization exhibited a transition near 40 °C. At lower temperatures, lactate was metabolized to acetate and propionate via fermentation, whereas at higher temperatures transformed solely into acetate. Microbial Fe(III) reduction extent appeared higher at low temperatures (18 and 30 °C), while rapid sulfate reduction was observed at higher temperature conditions. In the irradiation experiment, abiotic lactate decomposition and Fe reduction were detected during irradiation period, which were proportional to irradiation doses. After irradiation, microbial activity was observed stepwise up to a medium dose rate (10 Gy/h) and extreme-short dose condition (200 Gy/h for 1 day). Which revealed the survivability of bentonite indigenous microbes under gamma irradiation, albeit suppressed microbial activity. However, there was no indication of microbial viability for higher dose rates. Microbial community structure and composition in both experiments will be analyzed using 16S rRNA gene sequencing and further will be correlated with the geochemical data.

Keyword

Bentonite, Indigenous microbe, Deep geological repository, Irradiation, Biogeochemistry

Investigation of Characteristics of Bentonite Samples in Natural Analogue Study Sites

Yoonah BANG[1]*, Korea Atomic Energy Research Institute (yoonahbang@kaeri.re.kr)
Ji-Hun Ryu[2], Korea Atomic Energy Research Institute

Abstract

Bentonite, primarily consisting of montmorillonite, plays an important role as an engineering barrier component in deep geological repository. Its properties, such as swelling, adsorption, ion exchange, and water retention capacities, make it an effective buffer to physically and chemically isolate high-level waste disposal facilities from the surrounding environment. This study aims to compare and analyze the fundamental characteristics of bentonite rock samples (W-B and NA-B) collected from natural analogue study sites in Jianping Xian, Chaoyang Shi, Liaoning Sheng, China, and Yeongnam, Gyeongju, Gyeongsangbuk-do, Republic of Korea. We explored the analysis methods and experimental results of bentonite, including its physical properties (color, particle size distribution, water content, density), mineralogical characteristics (mineral identification and quantification through X-ray diffraction, structure and surface properties through fourier-transform infrared and raman spectroscopy, thermogravimetric analysis, transmission electron microscopy and scanning electron microscopy), geochemical properties (chemical composition through X-ray fluorescence, total surface area, cation exchange capacity, and leaching solution), and pore water properties (pore water chemistry and anion accessible porosity). The findings of this study are expected to provide fundamental data for understanding the changes in the characteristics of bentonite under geological environment conditions, which is crucial for ensuring the safety of deep disposal systems over geological time.

Keyword

Bentonite, Montmorillonite, Natural Analogue, Deep Geological Repository

3D and 4D insights into barrier behaviour

Katherine DOBSON[1]*, University of Strathclyde (katherine.dobson@strath.ac.uk)
Zoe Shipton[2], University of Strathclyde
Andrea Kozlowski[3], University of Strathclyde
Rebecca Lindsey-Halls[4], University of Strathclyde
Joanna Renshaw[5], University of Strathclyde

Abstract

Understanding the behaviour of natural and engineered barriers for nuclear waste repositories requires us to know their properties, and more importantly how these properties evolve through time. That evolution need to include impact of the barrier on the geology and the geosystem on the barrier. Here we present a range of 3D and 4D experiments that highlight how the latest in situ imaging techniques are allowing us to investigate both the short and long-term mechanical and chemical performance of a range natural and engineered barrier materials.

We present time series x-ray computed tomography of small dimeter cores from a range of potential barrier materials. Using simulated long–term deployment conditions,we encompass the key leaching, heating and loading conditions likely to be found. We performed tomography over the duration of the experiments, and integrated the quantitative tomography data (e.g. porosity and density evolution, fracture propagation, localised shrinking and swelling) with XRD (for mineralogy), SEM analysis and a range of other analytical techniques. We will show how this combined multi-modal analysis can shed new light on the mechanical and chemical performance of potential barrier materials, and the rocks that surround them; and will discuss how these tools could be applied in the design of future repository systems and their geosphere interactions.

Keyword

barrier, geosphere, tomography, dynamics, evolution

Analysis of the Current Status of Siting Criteria and Factors for High-Level Radioactive Waste Disposal in Leading Countries

Taeyoo NA[1]*, Korea Institute of Geoscience and Mineral Resources (tyna@kigam.re.kr)
Byung-Gon Chae[2], Korea Institute of Geoscience and Mineral Resources

Abstract

The necessity of deep geological disposal for high-level radioactive waste is crucial for ensuring safe protection of human and environment from the radionuclide. It demands optimal siting criteria considering each country's specific geological conditions and societal contexts.
The current status of siting criteria and factors for deep geological disposal of high-level radioactive waste in leading countries including Sweden, Finland, Switzerland and United States was analyzed in this study. The analysis of siting criteria and factors carried out in this study has shown that all countries prioritize long-term safety and social acceptability. Specifically, they apply factors such as geological stability, groundwater flow, and environmental elements in assessing site suitability. These factors encompass various aspects including the characteristics of the bedrock, the presence of active fault zones, uplift and erosion, seismic and volcanic activity, geothermal gradient and hydraulic conductivity, pH and Eh, future climate change and natural resources, as well as transportation and costs. The analysis reveals that the detailed criteria employed by each country reflect their geological, environmental, and socio-economic characteristics. Through these varied criteria, it has been determined that each country is adopting a customized approach to ensure the safe isolation of radioactive waste and the protection of the environment.
The outcomes of this study are anticipated to set up appropriate siting criteria and factors for high-level radioactive waste disposal and will also be used to identify safe locations for deep geological disposal in Korea.

Acknowledgement

This work was supported by the Institute for Korea Spent Nuclear Fuel(iKSNF) and Korea Foundation of Nuclear Safety(KOFONS) grant funded by the Korea government(Nuclear Safety and Security Commission, NSSC)(RS-2021-KN066110)

Keyword

High-level radioactive waste, Deep geological disposal, Siting criteria, Siting factors

Characterization of Ca-type bentonite in contact with corrosion product of copper canister

Gha-Young Kim[1]*, KAERI (gkim@kaeri.re.kr)
Mihye Kong[2], Chonnam National University
Seok Yoon[3], KAERI
Jin-Seop Kim[4], KAERI

Abstract

Copper canister is one of the key components of an engineered barrier for deep geological disposal (DGD). It is the final stage of separating and isolating high-level radioactive waste from biosphere. The corrosion mechanism occurring at the surface of copper canister and the nature of associated corrosion products change as the DGD environment evolves from aerobic to anaerobic condition. The corroded copper products may present either dissolved forms or precipitates. Dissolved forms of copper corrosion product can diffuse away from the canister surface and interact with the buffer, resulting in the susceptibility of affecting the buffer performance. The purpose of this study is to understand characteristics of Ca-type bentonite (buffer material) in contact with dissolved form of copper corrosion product. In this study, we carried out the reaction experiment and evaluation of Ca-type bentonite (Bentonil-WRK) with CuCl2 (i.e., dissolved form of copper corrosion product) at room temperature. The concentration range of CuCl2 used in this study is from 0.1 uM to 0.1 M. The characteristics of CuCl2-treated bentonite such as chemical and mineral composition, element concentration, and swelling index were investigated. As a result of Ca-type bentonite treated with CuCl2, there were no significant effect on mineral alteration and no change in the swelling index in this study.

Keyword

Copper canister, Corrosion, Ca-type bentonite, Buffer, Deep geological disposal

Site Characterization and Investigation Requirements (draft) for High-Level Radioactive Waste Disposal Facilities

Hyeondong Woo[1]*, Korea Institute of Nuclear Safety (hdwoo@kins.re.kr)
Seung Gyu Hyun[2], Korea Institute of Nuclear Safety
Taekmo Shim[3], Korea Institute of Nuclear Safety
Ohsang Gwon[4], Korea Institute of Nuclear Safety

Abstract

The imminent saturation of storage for high-level radioactive waste (HLW) necessitates a critical review and reformulation of current regulatory requirements outlined in the Nuclear Safety Act of the Republic of Korea. Presently, these regulations do not fully comply with the stipulations of the IAEA SSR-5 'Disposal of Radioactive Waste'. An R&D project titled 'Development of safety criteria for site characterization and site investigation for HLW disposal facility' was conducted from 2018 to 2022 to develop a regulatory framework for this matter. The primary objective of the project is to develop a draft guideline notice for the report on site characterization of the disposal facility for high-level radioactive waste.

This study analyzes the results of site investigation and evaluation related to the characterization of deep geological conditions for high-level radioactive waste disposal facilities in other countries. Detailed requirements related to the site description model, design, construction, operation, and long-term safety of geological disposal facilities for HLW are presented to develop the draft notice for the report on site characterization for high-level radioactive waste disposal facilities.

The general guidelines of the draft notice for preparing the site characterization report for high-level radioactive waste disposal facilities were developed, along with their purpose and scope of application. Additionally, the development of the draft guideline notice for the report on site characterization for high-level radioactive waste disposal facilities and its rationale were presented, along with the site description model, design/construction/operation, and long-term safety of deep geological disposal facilities. The requirements for detailed investigations and assessments related to site characterization include:

a. Geological and geophysical characteristics
b. Hydrogeological characteristics
c. Hydrogeochemical characteristics
d. Mechanical and thermal characteristics of rock mass
e. Transport characteristics of radionuclide through groundwater
f. Characteristics of the ecosystem

Acknowledgement
This research was supported by the Korea Foundation of Nuclear Safety (NSRM 1805020-0421-CG100)

Keyword

High-level radioactive waste, Disposal facility, Site characterization

R&D of KAERI for development of base technologies for demonstration of the deep geological system

Geon Young KIM[1]*, KAERI (kimgy@kaeri.re.kr)
Jang-Soon Kwon[2], KAERI
Jin-Seop Kim[3], KAERI

Abstract

The second basic national plan of 2021 for HLW management of Korea contains important milestones of construction and operation of URL as well as phased siting process, interim storage and final disposal facility, and suggests 37 years until starting final disposal. Therefore, it is very urgent to develop demonstration technologies at the URL by the early 2030s and a new multi-ministerial 9-year R&D project (Ministry of Science and ICT, Ministry of Trade, Industry and Energy, and Nuclear Safety and Security Commission) was launched in 2021 for the development of core technologies to demonstrate the performance and safety of SNF disposal system prior to URL demonstration phase in the national SNF management program.

KAERI is carrying out two major projects in the field of deep geological disposal of the integrated governmental project. In this paper, we introduce a 'Development of base technologies for demonstration of the deep geological system' which is one of two KAERI R&D projects. The main objective of the project is development of key element technologies to identify the coupled interaction of the disposal system according to the long-term evolution and to demonstrate the performance of the disposal system at URL. The project consists 3 tasks based on the multi-barriers system components, which are development of long-term safety evaluation technology of EBS (Task 1), development of an assessment technology for the performance of long-term evolution of the natural barrier (Task 2), and development of base technologies for demonstration of the radionuclides behaviors in geological disposal environment (Task 3).

The main objective of Task 1 is to develop a long-term safety evaluation technology and in-situ validation of EBS performance in KURT and the main R&D contents are preparation of design requirement of EBS, characterisaiton of interactions of EBS components, identification of coupled THMC behaviors, and development of key technologies for in-situ demonstration of EBS performance.

The main objective of Task 2 is to develop an assessment technology for the performance of long-term evolution of the natural barrier and its demonstration methodology at URL. The main R&D contents are assessment of long-term change of geological environment, development of the long-term evolution of the natural barrier performance, development of integrated model of hydro-mechanical model and surface water-groundwater model, and development of assessment methodology on the long-term evolution of natural barrier at URL.

The main objective of Task 3 is to develop an evaluation technology of nuclide behavior within multi-barrier and conducting URL demonstration with the evolution process of disposal environment. The main R&D contents are Identification of nuclide dissolution and presentation of

dissolved chemical species in disposal environment, characterization of nuclide sorption/diffusion mechanisms within multi-barrier in disposal environment, characterization of accelerated and delayed transport of nuclide, and development of fundamental technology for on-site demonstration of nuclide behavior in disposal environment.
This project will be carried out in 3 stages for a total of 9 years and the first stage has been finished successfully in 2023.

Keyword

deep geological disposal, URL, national SNF management program, in-situ demonstration, KURT

Enhancing HLW Disposal Safety Through Global NA Study insights

HunSuk IM[1]*, KAERI (ihs95@kaeri.re.kr)
Dawoon Jeong[2], Korea Atomic Energy Research Institute
Min-Hoon Baik[3], Korea Atomic Energy Research Institute
Ji-Hun Ryu[4], Korea Atomic Energy Research Institute

Abstract

This research explores the role and strategy of Natural Analogue (NA) studies in enhancing the long-term safety and reliability of Deep Geological Disposal (DGD) systems for high-level waste (HLW) across several advanced countries, including Finland, Canada, the United States, and Spain, with a focus on their applicability to Korea's nascent NA program. NA studies utilize analogues substances and sites to investigate and analyze the long-term alteration processes of disposal system components. These investigations contribute as supplimentary data for the safety assessment (SA) of DGD systems over extensive periods.

The Finnish, leveraging the crystalline bedrock similar to that considered in Korea, is pioneering with the construction of a permanent DGD facility based on the KBS-3 concept, integrating general NA study data into its safety case. Canada's studies draw parallels between the natural uranium ore body at Cigar Lake and artificial DGR systems, using NA information on radionuclide transport behavior to refine predictive models and databases for SA. In contrast, the United States focuses on the temperature-dependent behavior relevant to HLW disposal, incorporating high-temperature studies around waste disposal containers. Spain, uniquely positioned with a state-owned nuclear policy, emphasizes comprehensive NA and SA studies, leading to the publication of extensive NA catalogs and the promotion of public understanding through simplified syntheses.

For Korea, where the HLW disposal concept remains under development, adopting a general NA study approach similar to Finland's is suggested. However, it's crucial that such studies reflect Korea's specific disposal concept and environmental conditions. This involves continuous NA studies from the development phase through to repository operation, emphasizing the need for a strategy that incorporates insights from the reviewed countries. International collaboration and domestic research organization are recommended to address diverse environmental conditions and long-term safety concerns efficiently. This strategy would benefit from engaging with global research groups and international Natural Analogue Working Groups (NAWGs).

Moreover, the study highlights the importance of interdisciplinary cooperation, particularly with archaeology, to understand the alteration processes of metal container materials and secure access to natural and archaeological analogues. Establishing a NA information system, as seen in Spain, is vital for improving social acceptance of disposal facility safety. This encompasses developing both a physical research center for tangible trust-building and a software database system for easy access to relevant NA information by facility designers and safety case developers.

This study also underscores the leadership role of nuclear regulatory agencies (e.g., CNSC, NRC,

CSN, STUK) in conducting NA studies, with operators like POSIVA and ENRESA playing key roles alongside regulatory bodies. It suggests establishing a domestic NA study system through organic cooperation among the nuclear regulatory agency, disposal facility operators, and research institutes.

In conclusion, leveraging the insights and strategies from NA studies in advanced countries can significantly inform and enhance Korea's approach to ensuring the long-term safety and reliability of its HLW disposal system, with a focus on international collaboration, interdisciplinary research, and the development of comprehensive information systems for societal engagement and regulatory support.

Keyword

Disposal System, Natural Analogues Study, Safety and Reliability, Safety Case

Integrating Advanced Technologies and Safety for a Susainable Spent Nuclear Fuel Waste management

HunSuk IM[1]*, KAERI (ihs95@kaeri.re.kr)
JungHo Hur[2], Korea Atomic Energy Research Institute
Hong Jang[3], Korea Atomic Energy Research Institute
Won Il Ko[4], Korea Atomic Energy Research Institute

Abstract

South Korea's approach to spent nuclear fuel (SNF) disposal is evolving towards a secure and environmentally responsible future, integrating advanced nuclear waste management techniques with rigorous safety protocols. The 1970s marked the inception of deep geological disposal as the paramount safe disposal method, influenced by extensive evaluations and international research spearheaded by entities like BNWL (Battle North West Laboratory). Emphasizing the critical importance of adapting to native geological conditions, South Korea, through the Korean Atomic Energy Research Institute (KAERI), has embarked on developing a domestic disposal system since 1997. This initiative encompasses the design and safety assessment of high-level radioactive waste disposal, culminating in the creation of the KAERI Underground Research Tunnel (KURT) for in-depth technological validation within granite bedrock.

Parallel to policy discussions on the High-level Radioactive Waste Special Act, technical advancements are mirroring successful international models, notably Sweden and Finland's SKB KBS-3V multi-barrier deep geological disposal system, tailored to South Korea's environmental context. Such models utilize dual protective barriers, combining engineered and natural defenses to contain and isolate SNF within deep geological formations, thereby mitigating potential ecological and human health risks. This strategy ensures the long-term decay of radioactive isotopes within the disposal canisters to levels comparable to natural uranium, despite geological evolution or container corrosion.

Despite the common adoption of deep geological disposal for spent nuclear fuel (SNF), the need for efficient disposal area use and future nuclear fuel supply considerations for advanced reactors have renewed interest in alternative disposal options. The deep borehole method, benefiting from recent technological advancements, offers potential for safe and efficient disposal by enabling tailored management of SNF. This approach involves separating SNF by radionuclide groups, processing it to fit specific disposal methods, thereby optimizing safety and minimizing disposal area. The strategy focuses on developing a disposal-coupled radionuclide management system that optimizes the radionuclide management and waste form production processes. Such a system aims for an integrated structure that facilitates rapid adaptation to process or system changes and provides strategic ease in establishing effective SNF management strategies. This is crucial for reducing environmental burdens and ensuring safety through varied and adapted disposal methods. Korean research emphasizes processing cooled SNF according to radionuclide characteristics, aiming for safer and more efficient disposal. The disposal-coupled radionuclide management

system represents a strategic approach, integrating radionuclide separation, waste form production, and disposal options to optimize SNF management, focusing on environmental impact, efficiency, and safety. This holistic method offers a pathway to improved SNF disposal, highlighting the importance of technology development and strategic integration across disposal processes.

Keyword

Disposal System, Radionucide management system, wasteform, disposal options, separation process

Investigating Measurement Methods for Grain Bulk Modulus of Sandstone: An Experimental Approach

Min-Jun KIM[1]*, Korea Institute of Geoscience and Mineral Resources (kimmj@kigam.re.kr)
Junhyung CHOI[2], Korea Institute of Geoscience and Mineral Resources
Eui-Seob PARK[3], Korea Institute of Geoscience and Mineral Resources
Byung-Gon CHAE[4], Korea Institute of Geoscience and Mineral Resources

Abstract

Grain bulk modulus is a basic property characterizing the hydraulic-mechanical coupled behavior of rock frame. It affects rock response of deep subsurface to changes in pressure, temperature, and pore fluids. In addition, as an input parameter for numerical analysis, it is significantly related to the performance of natural barrier in deep geological repository. Nevertheless, a standardized procedure or method for measuring the grain bulk modulus has not yet been suggested. This study presents a measurement method for grain bulk modulus, which is important hydraulic-mechanical properties of rock, and conducts the experiment to obtain the grain bulk modulus of sandstone. The factors affecting the grain bulk modulus were investigated, comparing volumetric characteristics of rocks with different properties. As a result of the experiment, the grain bulk modulus of Berea sandstone was determined to be 28.9 GPa, while that of Idaho sandstone was measured to be 32.8 GPa. In the case of Berea sandstone, the value was 1.2% similar to the results of previous studies, whereas for Idaho, it showed a 17.6% difference compared to the theoretical estimate. The potential causes of the discrepancy were examined, highlighting the presence of non-connected pore spaces from rock particle structure. The experimental results demonstrated that the measurement method proposed in this study can reliably predict the grain bulk modulus of sandstone.

Acknowledgement
This work was supported by the Basic Research Project of the Korea Institute of Geoscience and Mineral Resources (KIGAM, GP2020-010) funded by the Ministry of Science and ICT, Institute for Korea Spent Nuclear Fuel (iKSNF), and Korea Foundation of Nuclear Safety (KOFONS) grant funded by the Korean government (Nuclear Safety and Security Commission, NSSC) [grant number RS-2021-KN066110].

Keyword

Grain bulk modulus, Hydraulic-mechanical property, Sandstone, Natural barrier

Kinematic and Paleostress Analysis for Long-term Structural Evolution: A Preliminary Analysis in the KURT Site

Ho-Seok Choi[1]*, Pukyong National University (chlghtjr10@gmail.com)
Francois Hategekimana[2], Pukyong National University
Goeun Kim[3], Pukyong National University
Jun-Yeop Kim[4], Pukyong National University
Soolim Jung[5], Korea Atomic Energy Research Institute
Kyung-Woo Park[6], Korea Atomic Energy Research Institute
Young-Seog Kim[7], Pukyong National University

Abstract

High-level radioactive waste, containing radioactive nuclides with half-lives spanning tens to hundreds of thousands of years, requires isolation from human habitation for over 100,000 years. Selecting a geologically stable disposal site involves considering factors like topography, faults, seismic activity, and hydrological properties. Especially, brittle structures within the bedrock, such as faults, not only could serve as potential flow pathways but also significantly influence bedrock stability. However, studies on fault behavior and deformation, which is key components for site characterization, in underground are relatively scarce compared to studies at surface investigation.
This study was carried out within the KAERI Underground Research Tunnel (KURT) which is the sole experimental tunnel crucial for comprehending structural evolution and designing nuclear waste disposal sites. Before conducting a detailed geological survey, a preliminary lineament analysis was carried out through length-weighted lineament analysis, producing an overview of faulting in the study area. By inputting fault slip data encompassing strike, dip, slip direction, and slickenline into stress inversion programs, we derived the most suitable stress tensor. Further analysis of cross-cutting relationships allowed us to reconstruct the deformation history of the study area.
We identified three distinct brittle deformation stages in the study area from a strike-slip to an extensional environment, associated with the clockwise rotation of maximum horizontal stress from ENE-WSW, WNW-ESE/NW-SE to NNE-SSW. This study highlighted that the proper refinement and combination of lineament analysis, field survey, and paleostress analysis can improves previously proposed methods for the selection of deep geological repositories.

This research was supported by a grant(2022-MOIS62-001(RS-2022-ND640011)) of National Disaster Risk Analysis and Management Technology in Earthquake funded by Ministry of Interior and Safety(MOIS, Korea).

Keyword

deep geological repository, deformation history, stress inversion, cross-cutting relationship

[Keynote] Current Status and Future Outlook on IAEA Safety Standards Development and Research Regarding the Site Safety for Nuclear Facilities

Paolo CONTRI[1], International Atomic Energy Agency
Heanu LEE[2]*, International Atomic Energy Agency (H.W.Lee@iaea.org)

Abstract

Feedback by IAEA Member States (MS) from IAEA safety reviews and technical meetings recently highlighted a number of topical areas which deserve special coverage in the research community and in the IAEA activities on the development of Safety Guides and relevant technical guidelines, in order to improve the installation safety in relation to external events, in particular: refined hazard modelling, time dependent and with improved uncertainty management and event combinations, design of advanced reactor types in relation to external events, and safety assessment of nuclear installations in relation to low probability events beyond their design basis. More in detail, many projects have been launched, specifically addressing the following:

1. Hazard modelling and installation PSA: special focus will be dedicated to the challenges brought by climate change, especially in estimation of time-dependent weather-related hazards and new types of threats, including sandstorms, desertification, permafrost, biological fouling, landslides and wildfires. A large number of documents on management of uncertainties in seismic hazard and on probabilistic fault displacement hazard assessment was planned. Volcanic hazard scenarios, using tephra dispersal models, Probabilistic Safety Assessment (PSA) in relation to coastal and riverine flooding hazard, and PSA for tsunami hazards were also addressed.
2. Design and safety assessment of nuclear installations in relation to external events: the estimation of design robustness against extreme external hazards is covered by studies on the evaluation of the safety margin assessments for beyond design basis extreme events (BDBEE) of all nature. Other guidelines are in advanced stages of development on optimization of protection against external hazards for facilities other than nuclear power plants and on seismic soil liquefaction assessment. The development of a Seismic Experience Database supports the seismic qualification of systems and components by similarity, which is faster and more cost-effective compared to shaking table testing.
3. The deployment of innovative nuclear technologies raises important questions about sustainable safety approaches to site selection, evaluation, and site-specific hazard assessment for Small and Modular Reactors (SMRs), including transportable reactors, and fusion reactors. A risk informed performance-based (RIPB) approach for siting and design may well support a graded siting framework for SMRs, focused on technology-specific design features to ensure safety against both natural and human-induced hazards. The safety assessment of the so-called passive safety features of small modular reactors (SMRs) and evaluations on the Emergency Planning Zone (EPZ) size are crucial for supporting the safe and sustainable deployment of advanced reactors worldwide. A Standard Review Plan should provide specific guidelines to the regulatory bodies on the site license review process.

The improvement of the effectiveness of the IAEA SEED review service, of the capacity building programs offered by the IAEA, and the operation of the real time external event monitoring system (EENS) on earthquakes, floods, tsunamis, volcano eruptions and wildfires boost the support capabilities of the IAEA to the nuclear safety of operating and future nuclear plants.

Keyword

Nuclear safety, seismic, hazard, risk assessment, geological risk

Volcanic Tephra-Fallout Hazards and the Safety of Nuclear Installations

Hyun Woo LEE[1]*, International Atomic Energy Agency (h.w.lee@iaea.org)
Shinsaku Nishizaki[2], International Atomic Energy Agency
Paolo Contri[3], International Atomic Energy Agency

Abstract

Tephra fallout presents unusual challenges for assessing external hazards at nuclear installations. Despite some nations lacking capable volcanoes within their borders, tephra-fallout hazards can occur from eruptions outside their territories because it may reach 100s to 1000s of kilometres downwind from an erupting volcano, depending on the energy of the eruption, its volume, and the nature of the wind field. The heavy, abrasive, and corrosive nature of volcanic tephra deposits can potentially affect the performance of Structures, Systems and Components (SSCs) in nuclear installations. Although tephra fallout events are infrequent, they typically offer days-to-months of warning, facilitating timely mitigation measures. Even though tephra eruptions typically last for hours-to-days, the persistence of tephra deposits for extended periods after an eruption distinguishes tephra fallout from other natural hazards.

In this regard, to provide practical guidance for assessing volcanic tephra-fallout hazards, designing nuclear installations, and implementing operational measures, drawing from Member States' experiences and providing recommendations for mitigation, the IAEA is currently in the process of developing a technical document that focuses on the characteristics and potential effects of volcanic tephra fallout on nuclear installations, as well as considerations for mitigative design and operational actions. Major contents of the document are as follows:

1. Characteristics of Tephra Fallout. A thorough examination of volcanic tephra's essential characteristics is presented and discussed. It encompasses the diverse spectrum of particle attributes generated during volcanic eruptions, critical factors necessary for evaluating deposits from past tephra-fallout events, and the long-lasting presence of tephra-fallout deposits after an eruption. Representative eruption magnitudes and types are summarized, and relevant characteristics of active tephra eruptions and deposits are discussed.

2. Current Approaches for Tephra-Fallout Hazard Assessment. Various methodologies and approaches for assessing volcanic tephra-fallout hazards are discussed with special attention on real-world examples of recent hazard assessments, providing practical insights into the hazard evaluation processes. Discussions include details on empirical observations for the past events in site regions, overview of numerical models for calculating tephra-fallout hazards, comparisons of modelled deposits to tephra fallout, and examples of monitoring applications.

3. Considerations of Potential Effects of Hazardous Tephra Fallout on SSCs. Experiences from Member States are described to secure a concise summary of design and performance considerations aimed at mitigating volcanic tephra-fallout hazards at nuclear installations. Recognizing the shortage of specific data on this subject, the discussions also include design and performance considerations derived from industrial facilities with SSCs that are analogous to

nuclear installations.

4. Considerations for Potential Operator Mitigation Strategies. Many of the potentially adverse effects of volcanic tephra fallout can be mitigated by pre-planned operational actions. Drawing upon parallels from analogous industrial contexts and SSCs, this section offers considerations for minimizing the potential effects of tephra fallout hazards on operational safety.

In conclusion, this technical document highlights the need to assess potential tephra-fallout hazards within appropriate Member States' regulatory frameworks, given the limited operational experience with tephra fallout events, especially those hazards originating from larger-magnitude eruptions.

Keyword

volcanic, tephra, fallout, Nuclear, IAEA

Integrating multi-disciplinary data to evaluate a potential deep geological repository site

Jakub KRYL[1]*, Czech Geological Survey (jakub.kryl@geology.cz)
Ondřej Švagera[2], Czech Geological Survey
Igor Soejono[3], Czech Geological Survey
Zita Bukovská[4], Czech Geological Survey
Lenka Rukavičková[5], Czech Geological Survey
Petr Mixa[6], Czech Geological Survey
Zuzana Skácelová[7], Czech Geological Survey
Tereza Zelinková[8], Czech Geological Survey
Jan Franěk[9], Czech Geological Survey
Jan Jelínek[10], Czech Geological Survey
Lucie Mareda[11], SÚRAO
Tomáš Chabr[12], INSET Ltd
Eliška Žáčková[13], Czech Geological Survey
Jan Holeček[14], Czech Geological Survey
Iva Kůrková[15], Czech Geological Survey

Abstract

The establishment of a deep geological repository for radioactive waste requires a homogenous geological environment. An ideal location consists of granitoids unaffected by any significant fault zones or extensive brittle deformation. Evaluation of a potential repository site needs the careful integration of several geological disciplines. Here we present five main methods used to investigate the site of a potential repository in the Czech Republic – Březový potok.

The repository will be located in the Variscan granitoids of Central Bohemian Plutonic Complex, which intruded into high-grade basement of the Moldanubian.

The suitability of Březový potok as a deep geological repository site will be evaluate through: i) geological and structural mapping - to provide necessary surface information about petrological and structural configuration; ii) photogrammetry of selected outcrops (by geologists or drones), enabling the creation of 3D geological and DFN models and structural data processing using 3D software; iii) core drilling, core scanning, and borehole logging, revealing in-situ information's about the rock types and structural record, which can be analyzed by logging software; iv) geophysical methods with variable depth reach allowing for non-invasive study of the geological situation and possible comparison with core drilling and other data; and v) hydrogeological mapping, providing the information about potential fault zones with enhanced hydrogeological activity and drainage systems.

Except the methods described above we also use results of in-situ research project of Underground Research Facility Bukov, a former uranium mine, now used for scientific purposes, also located in Moldanubian Unit, Czech Republic.

The integration of these main five research approaches, alongside in-depth data from ongoing research at Bukov, which is located in the similar depth as the planned deep geological repository,

provides a unique opportunity to compare and evaluate data regarding Březový potok. This presentation aims to demonstrate how the integration of multiple approaches allows us to comprehensively study, describe, and understand the overall geological and structural situation of potential site. It facilitates the selection of safe and stable repository locations and offers insight into the complex geological and structural record at the projected depth for future underground construction.

Keyword

radioactive waste repository, structural geology, borehole, 3D modeling, photogrammetry

GeM-DB – A searchable database, linking exploration objectives and geoscientific methods for the German nuclear waste repository siting process

Thies BEILECKE[1]*, BGR (thies.beilecke@bgr.de)
Raphael Dlugosch[2], BGR
Tilo Kneuker[3], BGR
Lukas Pollok[4], BGR
Lisa Richter[5], BGR
Nicole Schubarth-Engelschall[6], BGR
Ralf Semroch[7], BGR

Abstract

The site selection procedure for a high-level radioactive waste repository in Germany is defined by a German law, the Repository Site Selection Act (StandAG, 2017), which comprises three phases. During phase 2, the implementing authority, the Federal Company for Radioactive Waste Disposal (BGE), carries out surface exploration. Based on the exploration results, the so-called further-developed preliminary safety analyses, defined requirements and criteria, and socio-economic potential analyses will be applied feeding into proposed sites for subsequent underground exploration.

Commissioned by BGE, the Federal Institute for Geosciences and Natural Resources (BGR) is contributing to this procedure with two projects. Their common goal is to develop recommendations for surface exploration of siting regions. For this purpose, BGR has developed a systematic approach that includes (1) the derivation of exploration objectives, (2) the compilation of geoscientific and geophysical exploration methods, and (3) the development of a database "GeM-DB" with an interactive web-interface. Information from an associated analysis of case studies of national and international exploration programmes for high-level radioactive waste disposal was incorporated in the database.

The exploration objectives are based on the common criteria and requirements as defined by the StandAG. The identified exploration objectives (Kneuker et al., 2020) were integrated and linked with a large number of geoscientific and geophysical exploration methods within the database GeM-DB. All exploration methods were evaluated according to their suitability and applicability for (a) the three potential host rocks in Germany (crystalline rock, claystone, rock salt) and (b) the previously defined exploration objectives.

BGR is currently developing a methodology to generate host rock specific sequences of exploration methods from the database contents and the results of the analyzed surface exploration programs. These sequences of methods provide a basis for the exploration programs to be planned by BGE.

References

Kneuker, et al. (2020): Compilation of objectives for surface exploration as specified in Section 16 of the Site Selection Act (StandAG). Federal Institute for Geosciences and Natural Resources.

Interim report; Hanover and Berlin, Deutschland.
StandAG: Gesetz zur Aufsuchung und Auswahl eines Standortes für ein Endlager für hochradioaktive Abfälle. Standortauswahlgesetz vom 5. Mai 2017 (BGBI. S. 1074) das zuletzt durch Artikel 12 Absatz 16 des Gesetzes vom 20. Juli 2017 (BGBI. S. 2808) geändert worden ist (Standortauswahlgesetz – StandAG), 2017.

Keyword

Nuclear Waste Disposal, Exploration Programs, Objectives, Exploration Methods, German Approach

Integrated analysis of deep brittle structures using borehole images and drill cores for high-level radioactive waste disposal

Ji-Min CHOI[1]*, Korea Atomic Energy Research Institute (jiminchoi@kaeri.re.kr)
Soolim Jung[2], Korea Atomic Energy Research Institute
Nak Kyu Kim[3], Korea Atomic Energy Research Institute
Kyung-Woo Park[4], Korea Atomic Energy Research Institute
Young-Seog Kim[5], Pukyong National University

Abstract

High-level radioactive waste repositories depend on multi-barrier systems, incorporating both natural and engineered barriers, to ensure long-term safety. The efficacy of natural barriers requires comprehensive evaluation through continuous field investigations and laboratory experiments. Natural barriers, categorized by lithological and structural characteristics, with a particular focus on structural features such as fracture and fault, can influence groundwater flow paths, constituting critical considerations in performance assessments. In light of the deep disposal site's location, borehole data assumes significance. Consequently, the systematization of brittle structure analysis at depth utilizing borehole data becomes imperative. The boreholes utilized in this study were drilled to an approximate depth of 200 meters and are located within the site, around KURT (KAERI Underground Research Tunnel) at KAERI (Korea Atomic Energy Research Institute). To elucidate the distribution of the deep brittle structure, we employed borehole images and physical drill cores. Borehole images were analyzed using WellCAD software to assess fracture density at various depths. Within the drill cores, samples were selectively procured to discern the distribution of fault rocks, employing techniques such as thin sections through optical characteristic analysis. Through a comprehensive approach, we jointly analyzed the data to validate the distribution and interrelation between deep fault zones and fracture zones. The findings of this study will contribute to the development of three-dimensional models for deep brittle structures within natural barriers.

Keyword

Natural barrier system, High-level radioactive waste disposal, Deep brittle structure, Borehole images, Drill cores

Geochemical and Geochronological Study of the Crystalline Rocks through Boreholes in the KURT Site: Implications for Long-term Evolution of a Deep Geological Repository

Nak Kyu KIM[1]*, Korea Atomic Energy Research Institute (kimnk@kaeri.re.kr)
Soolim JUNG[2], Korea Atomic Energy Research Institute
Ji-Min CHOI[3], Korea Atomic Energy Research Institute
Kyung-Woo PARK[4], Korea Atomic Energy Research Institute

Abstract

Countries considering or in the process of constructing high-level radioactive waste repositories are actively engaged in studying bedrock for planning the repository and safety assessment. The Korea Atomic Energy Research Institute (KAERI) has designated a research area within its premises to develop site characterization technology for high-level radioactive waste disposal, conducting extensive geological studies to comprehend the deep geological environment. The KAERI Underground Research Tunnel (KURT), completed in 2006, serves as a crucial tool for identifying the deep geological characteristics of the research area. To gain insights into the long-term evolution of the natural barrier within the repository and construct a comprehensive geological model, a thorough examination of rock distribution and bedrock in the study area is indispensable. The crystalline bedrock of KURT is known to have been derived by igneous activity associated with the continental collision between the North and South China cratons during Jurassic. While previous studies have concentrated on granitic rocks, the post-geological process and evolution of the bedrock has been inadequately explained.

In this study, we examined the lithology of the bedrock and its intrusive rock, using core rocks extracted from four boreholes (GE-1, GE-2, GE-3, and GE-4) at a depth of approximately 200 meters at the KURT site. Comprehensive geochemical composition analysis, including Sr-Nd-Pb isotopes, is conducting to explore the age and petrogenesis of the rocks. Furthermore, zircon U-Pb and whole-rock Ar-Ar geochronology techniques are planned to get the ages of the rocks. This study contributes significantly to understanding the geological evolution of the bedrock in the KURT area and can be used as a basis for the construction of a deep geological model. It is also expected to be applied as an evaluation technique for disposal performance demonstration and the long-term evolution of natural barrier.

Acknowledgements: This work was supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT, MSIT) (No.2021M2E1A1085200)

Keyword

KURT, Natural barrier, Crystalline rock, Geochemistry, Geochronology

Morphostructural analysis of the LIDAR terrain model applied in the selection of a site for the Deep Geological Repository for Radioactive Waste

Jan JELÍNEK[1]*, Czech Geological Survey (jan.jelinek@geology.cz)
Ondřej Švagera[2], Czech Geological Survey
Jakub Kryl[3], Czech Geological Survey
Zita Bukovská[4], Czech Geological Survey
Jan Franěk[5], Czech Geological Survey
Igor Soejono[6], Czech Geological Survey
Pavel Hanžl[7], Czech Geological Survey
Petr Mixa[8], Czech Geological Survey

Abstract

The energy sector of the Czech Republic relies on nuclear energy for approximately 35% of its needs, with plans for further expansion in the future. However, meeting the European Commission's regulations requires the construction of a deep repository for radioactive waste by 2050. The Czech Republic is currently in the process of identifying a suitable location, with geological conditions being a crucial criterion. Based on Swedish KBS-3 model, the crystalline rocks should provide geologically safe and stable environment for such a project.

Traditional remote sensing methods, typically successful in arid regions, prove less effective due to the characteristics of the Central Europe landscape, heavily influenced by intensive agricultural and industrial activities, vegetation cover, and weathered crystalline rocks. However, methods based on digital terrain modeling (DTM), particularly morphostructural analysis (MSA) utilizing Light Detection and Ranging (LIDAR) data, offer promising insights.

The high-resolution (1×1 meter) LIDAR-derived DTM enables the identification of morphostructures crucial for delineating of lithological boundaries, foliations, beddings, brittle deformations, and especially faults. MSA results contribute to creating detailed geological maps, providing precise information on the distribution, shape, and boundaries of lithological bodies, fault type and positions, and brittle deformation characteristics. Moreover, these findings are applicable in hydrogeological studies, aiding in locating brittle aquifer zones and validating medium-scale Discrete Fracture Network (DFN) models.

Furthermore, the integration of the morphostructural analysis with structural geological modeling enhances the understanding of the geological context, facilitating the development of accurate 3D structural geological models. These models are indispensable for subsequent hydrogeological, geotechnical, DFN, and other related analyses, ensuring comprehensive assessment and planning for the deep geological repository construction.

Keyword

morphostructural analysis, LIDAR, 3D model, deep geological repository

GPR, a fundamental tool for 3d mapping of the complex internal salt structures by investigations in drifts and boreholes

Volker Gundelach[1], BGR
Thies BEILECKE[2]*, BGR (thies.beilecke@bgr.de)

Abstract

For the exploration of salt deposits in the subsurface the method of electromagnetic reflection or ground penetrating radar (GPR) as a non-destructive measuring technique is an important tool. It can be used to detect complex geological structures in low electrically conductive rock salt by identifying the distance and the direction of reflecting objects. With this information a three dimensional model of the deposit can be created. This is essential for the exploration and appraisal of sites that are candidates for high-level nuclear waste disposal.
In mine drifts, the German Federal Institute for Geosciences and Natural Resources (BGR) mainly uses shielded antennae with center frequencies from 30 - 200 MHz to detect the distance to reflecting structures like anhydrite or clay. The measurements are carried out with two polarizations at the roof, on the floor and at the walls of a drift. Inclination measurements of 360 degrees around a drift provides information about the direction of objects using inclination, travel time and amplitude of the reflected signal. Additional, direction finding antennae like a Rhode & Schwarz antenna and an Adcock antenna can be used to gain more detailed the information about the direction of reflections. In boreholes, we use direction sensitive cross frame antennae with the center frequency of 50 MHz. Based on the spatial position of the antenna system and the comparison of amplitudes from the perpendicular frame antennae with the dipole signal allows calculating the direction of reflections around a borehole. The combined information of the distances and directions from reflections allows a spatial migration using wave front reconstruction. This provides a structural database to create three-dimensional geological models.

Keyword

GPR, Salt, Direction, Drift, Antenna

Investigation of host rocks and geotechnical barriers for the disposal of radioactive waste by means of Electrical Resistivity Tomography (ERT)

Markus Furche[1], BGR
Thies BEILECKE[2]*, BGR (thies.beilecke@bgr.de)

Abstract

DC geoelectrics (here referred to as ERT) belongs to the classical geophysical potential methods. In addition to many other fields of application, it is used in the Federal Institute for Geoscience and natural Resources (BGR) as a method of exploration of rocks and geotechnical barriers for the disposal of radioactive waste. This includes fundamental studies on rock characterization with a focus on the variability of rock properties, but also the long-term observation of processes using modern monitoring techniques. The result of ERT measurements, the spatial distribution of the electrical resistivity, cannot be unequivocally attributed to the distribution of a single parameter, but depends on different factors such as water content or lithology. For the interpretation of the measurement results, additional information from other geophysical measurements such as ground penetrating radar (GPR) or seismic methods, but also geological responses of the rock or further results from laboratory experiments on representative sample material are therefore necessary. The results of the ERT can also be used in subsequent model calculations, e. g. for security analyses.
Selected recent examples of ERT measurements at the Mont Terri rock laboratory in Switzerland are shown
a) In the so-called sandwich experiment, the effect of a specially constructed sealing structure in a semi-scale in situ experiment has been monitored by ERT measurements for several years. Here, the process of saturation of the sealing material can be mapped in three dimensions.
b) In the so-called CD-A experiment, the effect of seasonal changes in humidity on the stability of the rock mass is investigated by comparing two identical niches, however with different exposition to the atmosphere. The ERT provides decisive indications of seasonal de-saturation or re-saturation processes in a cross-section by means of long-term observations over several years.

Keyword

Nuclear Waste Disposal, DC Geoelectrics, ERT, Rock Characterization, Geophysical Monitoring

Comparison of geological and mechanical properties of crystalline and sedimentary rocks through deep drilling cases

Dae-Sung Cheon[1]*, KIGAM (cds@kigam.re.kr)
Kwangmin Jin[2], KIGAM
Won-Kyong Song[3], KIGAM
You Hong Kihm[4], KIGAM

Abstract

Crystalline rocks and sedimentary rocks are mainly considered as the host rock for geological disposal of high-level radioactive waste(HLW) around the world. In Korea's geology, crystalline rocks such as granite and gneiss occupy 60% of the country’s land area, and sedimentary rocks occupy 25%. This study compared and presented the geological and mechanical characteristics of the two rock types based on the deep drilling cases conducted in crystalline and sedimentary rock areas. Drilling for crystalline rocks was conducted at one location each in the Gyeonggi Massif, Okcheon Massif, and Yeongnam Massif, and for sedimentary rocks, drilling was conducted at three locations within the Gyeongsang Basin. From a geological perspective, the origin of the formation, lineament, and fault zone and fractures were investigated, and from a mechanical perspective, in-situ stress, uniaxial compressive strength, and elastic wave velocity were investigated. The origin of formation and lineament were investigated in a certain scale area including the deep borehole and drilled cores were used for the investigation of fault zones and fracture. In-situ stress was measured by hydraulic fracturing method in a field, and uniaxial compressive strength and elastic wave velocity were measured through laboratory test using a drilling core. It is expected that the results of this investigation through deep drilling cases will be useful in selecting a disposal site for high-level radioactive waste in Korea in the future.

Keyword

HLW, deep drilling, crystalline rock, sedimentary rock

Applying deep learning to detect fractures from GPR data

Ain LEE[1]*, Kangwon National University (dldkdls6912@kangwon.ac.kr)
Seokhoon Oh[2], Kangwon National University
Hyoung-Seok Kwon[3], Kangwon National University

Abstract

High-level radioactive waste (HLW) is disposed of in a deep geologic repository consisting of a multi-barrier system to ensure safe isolation from the ecosystem for tens of thousands of years or longer. Fracture zones in natural barriers are the primary fluid flow pathways for radionuclides, so it is essential to characterize the faults and fractures distributed in the bedrock. The distribution characteristics of fractures are investigated through various site surveys and experimental studies, and the performance of natural-barrier can be verified through fracture network modeling. Borehole image scanning methods and observation the excavation in Underground Research Laboratory (URL)s can be used to characterize the fractures in the deep underground. However, borehole imaging only provides fracture information from a specific point, and visual observation at the URL is also limited to the characterize the fractures on the excavation face. In contrast, ground penetrating radar (GPR) surveys in the URL can characterize the fractures at depths of several meters or more beyond the excavation face. During the site survey of a deep repository in Finland, a borehole radar survey was conducted to overcome the spatial limitations of borehole imaging techniques. A study on the GPR method at the Äspö Hard Rock Laboratory (HRL) in Sweden demonstrated the possibility of characterizing fractures up to a depth of approximately 8 meters inside the rock excavation. Recently, researchers have applied machine learning algorithms to extract faults and fractures from outcrop photographs or seismic profile images. This study applies the Convolutional Neural Network (CNN) technique, commonly used to extract faults from seismic data, to GPR data containing fractures. To create a CNN algorithm suitable for GPR data, it is necessary to generate training data. The study utilized GPR modeling software, GPRSIM, to generate training data and labeling data was generated based on the model data. The underground medium was set to a constant velocity similar to that of deep bedrock, and noise was added randomly to simulate field data. After applying data processing, such as gain recovery, band-pass filtering, and migration, to the modeling data, the training data was converted into images. The training data were generated under various conditions by varying the distribution of one or multiple fractures, as well as the extension, slope direction, and complexity of fractures. Using the GPR training data, we developed a CNN algorithm to identify fractures and examined the limitations of GPR method based on the fracture's distance, extension, and inclination angle. Finally, the deep learning algorithm was applied to GPR data collected in the exposed bedrock of the Daecheong Dam in Korea to assess its applicability to field data.

-Acknowledgements-
This work was supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and Korea

Foundation of Nuclear Safety(KOFONS) grant funded by the Korea government(Nuclear Safety and Security Commission, NSSC)(RS-2021-KN066110); the Basic Science Research Programme through the National Research Foundation of Korea (NRF), funded by the Ministry of Education (Grant No. 2019R1A6A1A03033167); the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIT) (No. 2022R1A2C1092301).

Keyword

Ground Penetrating Radar (GPR), Fracture zone, Deep learning, Underground Research Laboratory (URL)

Investigating Deep Groundwater Recharge Processes: A Combined Isotopic, Hydrochemical, and GIS Methodology

JAEHOON CHOI[1]*, Korea University Environmental geochemistry lab (wogns0509@korea.ac.kr)
Jeong-Hwan Lee[2], Korea Radioactive Waste Agency, Korea
Hyunsoo Seo[3], Korea University Environmental geochemistry lab
Hyun Tai Ahn[4], Korea University Environmental geochemistry lab
Seong-Taek Yun[5], Korea University Environmental geochemistry lab

Abstract

To ensure the safe disposal of radioactive waste, understanding the characteristics of deep groundwater is crucial, including its recharge processes, movement patterns at regional and local levels, and hydrochemical evolution over time. The objective of this study is to determine the residence time, recharge mechanisms, and origins of deep groundwater by utilizing environmental isotopes such as δ18O, δD, δ13C-DIC, and 14C, alongside hydrochemical parameters. To identify potential recharge areas for deep groundwater, we utilized GIS to perform DEM-based landform classification, subsequently combining this terrain analysis with residence time data (14C) and stable water isotopes (δ18O, δD) from deep groundwater for comprehensive interpretation. Through an in-depth evaluation of hydrochemical and isotopic characteristics employing GIS, we propose that a considerable volume of paleo-recharge from Mountain Block Recharge (MBR) forms the basis of deep groundwater through slow-moving regional flow. This finding highlights the necessity of not only conducting detailed studies in near-field areas to ensure the long-term safety of High-Level Waste (HLW) disposal sites but also considering the regional deep groundwater system. It is anticipated that these studies will be instrumental in delineating the management boundaries for HLW disposal facilities and in projecting the impact of future climate variations on the deep groundwater system. Acknowledgements: This study was supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and the BK Plus project in Korea.

Keyword

Deep Groundwater, Radioactive Waste Disposal, Environmental Isotopes, Mountain Block Recharge (MBR), Regional Groundwater Flow

Characteristics of radiogenic heat production rate in fractured rock mass

Yeonguk JO[1]*, Korea Institute of Geoscience and Mineral Resources (joy@kigam.re.kr)
Myungsun KIM[2], Korea Institute of Geoscience and Mineral Resources
Tae Jong LEE[3], Korea Institute of Geoscience and Mineral Resources
Changhyun LEE[4], Korea Institute of Geoscience and Mineral Resources

Abstract

This study aims to estimate the radiogenic heat production rate of a fractured subsurface rock mass using wireline logging techniques in a 1 km deep borehole. To achieve accurate heat production evaluations, natural gamma-ray logging and gamma spectrometry logging were conducted simultaneously, along with laboratory mass spectrometry analysis on drill-cores retrieved from the borehole for verification purposes. We used a well-known empirical correlation to estimate the radiogenic heat production rates using the total gamma-ray counts. Additionally, we calculated the heat productions based on the spectral gamma logs by examining the relationship between heat generation constants of major radioisotopes (uranium, thorium, potassium) and their concentrations.

The logged natural gamma-ray emissions ranged from approximately 0 to 800 API, corresponding to heat production magnitudes of 0.65 to 11 $\mu W/m^3$. However, the heat production rates estimated from natural gamma-ray logs at several intervals differed markedly from those evaluated from spectral-gamma methods. This discrepancy is likely due to the presence of natural fractures at those depths and the effects of groundwater flow and mineral alterations on heat production rate evaluations.

This study provides a comprehensive comparison of methods for estimating radiogenic heat production rates in fractured rock formations, highlighting the influence of subsurface fractures on heat production evaluations. The findings contribute valuable data for the assessment and utilization of subsurface geothermal energy resources, indicating the need for more precise heat production rate evaluations considering these variables in future studies.

Acknowledgement

This work was supported by the Institute for Korea Spent Nuclear Fuel (iKSNF) and Korea Institute of Energy Technology Evaluation and Planning (KETEP) grant funded by the Korea government (Ministry of Trade, Industry and Energy, MOTIE) (No.2021040101003A). It was also supported the iKSNF and Korea Foundation of Nuclear Safety (KOFONS) grant funded by the Korea government (Nuclear Safety and Security Commission, NSSC) (RS-2021-KN066110).

Keyword

heat production rate, natural gamma ray logging, spectral gamma logging, deep borehole, fractured rock

[Keynote] Overview of research and development (R&D) activities on radionuclide migration in Taiwan

CHUAN-PIN LEE[1]*, National Tsing Hua University (bennis6723@gmail.com)
Shih-Chin Tsai[2], National Tsing Hua University
Neng-Chuan Tien[3], National Tsing Hua University
Chi-Wen Hsieh[4], National Chung Cheng University
Kuo-Chin Hsu[5], National Cheng Kung University
Ching-Yuan Liu[6], National Central University

Abstract

The continued use of nuclear energy in Taiwan has come into question due to the difficulties in safety managing and disposing radioactive waste, and public opposition and disagreement for final repository has increased since the Fukushima nuclear disaster in March 2011. Since deep geological disposal is currently the preferred way of disposing nuclear waste, the state-run Taipoewr Company (TPC), owner of three nuclear power plants, initiated a long-term spent-fuel disposal program in the 1980s to prepare a geological repository for operation in 2050. To assess the long-term performance of this repository, it is necessary to deal with the problem of high-level radioactive waste (HLW) considering its long half-life and the associated risk of trans-porting radionuclides into the environment. Some geological investigations and research and development (R&D) efforts into radionuclide migration have been completed, and the experimental, numerical and safety assessment presented in this study are a part of this disposal program. Recently, to determine the relationship between the atomic-scale adsorption structure and the environmental behavior by using extended X-ray absorption fine structure (EXAFS) is a major and important tool, and we applied EXAFS to analyze several environmental samples including host rock and bentonite. Cesium ion adsorbed on clay minerals are dehydrated and hydrated, which are called inner-sphere (IS) and outer-sphere (OS) complexes, respectively. Cations forming OS complexes are more easily desorbed by cation exchange reaction than IS complexes. Thus, Cs+ is strongly adsorbed on clay minerals, making its extraction challenging, while other REE (i.e Eu3+) are weakly adsorbed, causing their high extraction rates by the cation exchange reaction.

Keyword

radioactive waste, disposal, repository, EXAFS, Cs

Assessment of Water-Rock Interactions of Uranium through Laboratory Batch and Column Experiments

Sung-Wook JEEN[1]*, Jeonbuk National University (sjeen@jbnu.ac.kr)
Hakyung Cho[2], Jeonbuk National University
Soyeon Lim[3], Jeonbuk National University

Abstract

Understanding uranium behavior is crucial for the deep geological disposal of high-level radioactive waste. Given that the interaction of rocks and groundwater significantly influences uranium behavior, we conducted laboratory batch and column experiments to assess water-rock interactions involving uranium. The rock samples (coaly slate) for these experiments were sourced from a natural analogue study site (Okcheon Metamorphic Belt) in Korea, and artificial groundwater simulated the compositions of the groundwater at the study site. In the batch experiments, the initial pH levels rapidly declined after the reactions started, consistently falling below 4.5. This decline was attributed to the absence of carbonate species capable of buffering the pH and the generation of hydrogen ions from the oxidation of iron sulfide. In an experiment with an initial pH of 7.9, changes in uranium concentration increased and then decreased over time. The initial increase was attributed to the dissolution of uranium minerals (uraninite and ekanite), while the subsequent decrease was considered to be caused by the adsorption or surface complexation of uranium with SiO2 and iron (hydr)oxide, such as ferrihydrite. For column experiments simulating flow-through conditions in the field, two columns were prepared: one filled with coaly slate (0.025 ~ 2 mm grain size) and another with a mixture of coaly slate and limestone (10 wt.%) to provide pH buffering. The pH in the column with coaly slate only initially exhibited the highest value at 0 cm but gradually decreased to below 4.5. This was attributed to the insufficient carbonate buffering capacity to neutralize hydrogen ions generated by the oxidation of iron sulfide in coaly slate. In the column with the mixture, in contrast, the pH remained around 8. Uranium concentration in the mixture column increased gradually with distance. Subsequently, the released uranium formed uranium aqueous complexes with dissolved F or SO4 induced by iron sulfide oxidation. This study contributes to understanding the transport and reaction characteristics of uranium in groundwater, ultimately aiding in the management of high-level radioactive waste in a deep geological disposal site.

Keyword

uranium, water-rock interaction, groundwater, deep geological disposal, natural analogue

Characterization of radionuclide mobilization using environmental tracers at natural analogue site in Boeun, South Korea

Ye Ji KIM[1]*, Seoul National University (yejikim55@snu.ac.kr)
Jaeyeon Kim[2], Seoul National University
Dugin Kaown[3], Seoul National University
Kang-Kun Lee[4], Seoul National University

Abstract

Uranium bearing geological formations can be used for natural analogue studies which can provide insight to the long-term subsurface radionuclide mobilization characteristics. Uranium within the groundwater can be a direct indicator of mobilization, but hydrogeological characteristics such as redox conditions can hinder the single use of uranium for the analyzation of migration patterns. Hence, this study aimed to characterize the transport of uranium and its daughter product within the groundwater, along with the characterization of the groundwater flow regime using groundwater age tracers. The study was conducted in Boeun, South Korea, where coaly slate and black slate are situated which contain abundant amounts of uranium. Significant amounts of radiogenic helium were only observed at the deepest sampling depth of 80 m (OB3-80). This was in correlation with the fact that this point not only showed the highest uranium concentration, but also showed the highest groundwater age evaluated by the 14C age tracer. A more specific analysis of groundwater age was conducted through a multitracing approach using 4He, 14C, and 3H, and clarified the groundwater flow regime and uranium transport mechanisms of this area. Overall, this study provided the basic flow characteristics of this area and showed the potential for He to be used as a tracer for the analyzation of uranium transport.

Acknowledgement: This work was supported by the National Research Foundation of Korea(NRF) grant funded by the Korea government(MSIP) (NRF-2021M2E1A1099413).

Keyword

Groundwater, Helium, 3H age tracer, 14C age tracer, Uranium

Methodology development for optimal remediation strategies for nuclear facility sites

In-Ho YOON[1]*, Korea Atomic Energy Research Institute (ihyoon@kaeri.re.kr)
Ilgook Kim[2], Korea Atomic Energy Research Institute
Youngho Sihn[3], Korea Atomic Energy Research Institute
Geun-Ho Kim[4], Korea Atomic Energy Research Institute
KwanSeong Jeong[5], Korea Atomic Energy Research Institute
Chan Woo Park[6], Korea Atomic Energy Research Institute

Abstract

The Leakage during the operation of nuclear facilities can result in radioactive contamination of the soil at a decommissioning site. A large amount of soil waste contaminated with Cs-137, Sr-90, Co-60, and H-3 has been generated during the decommissioning of international commercial Nuclear power plants. The geological and radionuclide transport characteristics of a nuclear facility site are known to be important factors in determining a remediation strategy. In this study, we investigate the geological characteristics and radionuclide migration of the nuclear facility site to develop a methodology for the optimal remediation strategy. We establish a methodology for the selection of strategic sampling points by horizontal or vertical points on the site. We establish the procedure for building a geological model and establish the procedure for permeability testing to investigate radionuclide migration. Based on the sampling soils, the non-radioactive isotopes of cesium (Cs), strontium (Sr) and cobalt (Co) are used as single isotope or multiple isotope to predict the isotope mobility and select the optimal remediation strategy for each isotope for the migration and desorption results through the permeability and leaching tests. This study is expected to predict isotope migration and improve the efficiency of site remediation, taking into account isotope mobility and geological characteristics in the soil and groundwater of nuclear facility sites.

Keyword

Nuclear facilities, decommissioning sites, site remediation, strategic planning

A current status of natural analogue studies in Korea for high-level radioactive waste disposal

Ji-Hun RYU[1]*, Korea Atomic Energy Research Institute (jryu@kaeri.re.kr)
Wanhyoung Cho[2], Korea Atomic Energy Research Institute
Yoonah Bang[3], Korea Atomic Energy Research Institute
HunSuk Im[4], Korea Atomic Energy Research Institute
Sanghoon Lee[5], Korea Atomic Energy Research Institute

Abstract

High-level radioactive wastes (HLW) must be isolated from the ecosystem until their radioactivity decreases to natural background radiation. Given the maximum time period of decay processes of various nuclides in spent fuel, the components of DGR (Deep geological repository) have to maintain their capabilities for the period to restrain the nuclides. To demonstrate the safety of DGR, current approaches of long-term stability of the system largely rely on short-term experiments in laboratory or engineering scaled facilities. In addition, complicated computer simulations have been developed to predict the future behaviors of DGR up to the maxium decay time covering most nuclides using various inputs from the experiments.

Due to the lack of competence in calculating the long-term processes, we try various approaches to minimize the uncertainties of simulation caused from fast laboratory experiments mimicking complexities of natural systems and low rates of processes involved. Natural analogue (NA) provides quantitative and/or qualitative information about the occurrence of various processes related to DGR to allow testing of individual processes over geologic time and space scales. Especially, for some processes such as thermal, NA study may be the only means of providing the required understanding of long-term and large-scale behavior needed to provide scientific confidence in performance assessment of DGR.

Several countries have been operating radioactive waste disposal programs to develop their own DGR and performing NA studies to have reliability of the long-term safety of the system. The Korea Atomic Energy Research Institute has launched an NA national R&D program for the first time in Korea on 2021. NA study can be an intuitive way to give reliability of the long-term safety of DGR. And the studies provide important elements or conceptual models in simulating DGR in many cases. For example, NA studies of geological systems can elicit information about the migration of nuclides in multi-barrier system of DGR.

In this study, we discussed some cases of NA studies in Korea as well as other countries for HLW disposal. We examined the differences among them and their roles in reflecting the country's own DGR. This study aims to develop the national NA program by establishing the basic concepts of NA studies.

Keyword

Deep geological repository, Natural analogue, High-level radioactive waste

Multiple sulfur and uranium isotope compositions of uraniferous slates in the Bibong Formation of the Okcheon Metamorphic Belt

Eunje OH[1]*, Seoul National University (dodosis97@snu.ac.kr)
Dong Kyun WOO[2], Seoul National University
Dongbok SHIN[3], Kongju National University
Min Sub SIM[4], Seoul National University

Abstract

Sulfur and uranium isotopes have been widely used to investigate the redox transformation of these elements in geological and biological processes, including the dissimilatory reduction of their oxyanions. Uraniferous slates in the Bibong formation of the Okcheon Metamorphic belt can be divided into black and coaly slates, of which the latter shows a higher grade of metamorphism and are usually more enriched in uranium. Although both sedimentary and metamorphic processes have been suggested to be involved in the formation of uraniferous slates, the mechanisms for uranium enrichment are not yet fully understood. In this study, we utilize the ratios of multiple sulfur isotopes (^{32}S, ^{33}S, and ^{34}S) and uranium isotopes (^{238}U and ^{235}U) to reconstruct the initial enrichment of uranium and its later alteration, coupled with changes in the biogeochemical cycle of sulfur. Samples were obtained from an outcrop (PJ Outcrop) located in Hoenam-myeon, Boeun, South Korea. The preliminary data collected from the outcrop show that the uraniferous coaly slates are enriched in ^{238}U compared to the black slates, suggesting that uranium was concentrated by reductive precipitation. Pyrite formation likely involved the reduction of seawater sulfate as a sulfur source, as indicated by the relatively high $\delta^{34}S$ values of pyrite, which range up to 14‰. In addition, the depleted $\Delta^{33}S$ values of pyrite in the uraniferous coaly slates can be attributed to the mixing of biogenic sulfide, which is strongly depleted in ^{34}S, with sulfide produced by the reduction of seawater sulfate with negligible sulfur isotope fractionation. The results of this study support the possibility that initial enrichment by microbial reduction, as well as later diagenesis and alteration, has contributed to the formation of uraniferous slates.

Keyword

uranium isotopes, multiple sulfur isotopes, uraniferous slates, Okcheon Metamorphic Belt, biogeochemical cycle

Examining Uranium Behavior Through Column Experiments Using Artificial Groundwater and Coaly Slate from a Natural Analogue Study Site in Korea

Soyeon LIM[1]*, Department of Environment and Energy, Jeonbuk National University, Jeonju-si, Jeollabuk-do, 54896, Republic of Korea (dlathdus0311@naver.com)
Hakyung CHO[2], Department of Environment and Energy, Jeonbuk National University, Jeonju-si, Jeollabuk-do, 54896, Republic of Korea
Sung-Wook JEEN[3], Department of Earth and Environmental Sciences & The Earth Environmental System Research Center, Jeonbuk National University, Jeonju-si, Jeollabuk-do, 54896, Republic of Korea

Abstract

Deep geological disposal methods are primarily employed for the management of high-level radioactive waste containing uranium. Understanding the behavior of uranium under different hydrogeochemical conditions is crucial, as any corrosion or breach of multiple barriers could lead to the potential migration of uranium into groundwater through fractures in the rock. To this end, we assessed the behavioral characteristics of uranium in the subsurface environment by analyzing temporal and spatial changes in uranium concentrations, as along with other geochemical parameters, through column experiments. Coaly slate, containing uranium minerals with a high radiation level (≥ 400 cpm), was collected from a natural analogue site of Okcheon Metamorphic Belt, Korea, and two columns (NA-PJ1 and NA-PJ2) were prepared. The columns were prepared by crushing the rock to a size of 0.025 to 2 mm and sieving it. NA-PJ1 was filled with coaly slate only, while NA-PJ2 was filled with a mixture of coaly slate and 10 wt% limestone to serve as a pH buffer. Artificial groundwater, designed to reflect the composition of the monitoring well, was injected into the column. Before the experiment, the artificial groundwater was purged with Ar gas to simulate the reducing environment. The solution was injected at a constant rate of 0.5 mL/min (720 cm/day). Temporal and spatial changes resulting from the reactions between artificial groundwater and the medium in the column were observed through profile sampling. Sampling was conducted at 0, 5, 10, 15, 20, 25, 30, 35, and 40 cm from the influent end of the column. Dissolved oxygen (DO), pH, Eh, electrical conductivity (EC), and alkalinity were measured, and cations and anions were analyzed. In both columns, DO consistently maintained a low concentration. The pH exhibited its highest value (8.5 ~ 8.93) at 0 cm in both columns. However, in NA-PJ1, it gradually decreased and fell below 4.5. This was attributed to the insufficient carbonate buffering capacity to neutralize the increased hydrogen ion concentration resulting from the oxidation reaction of iron sulfide in the coaly slate. In contrast, NA-PJ2 maintained a pH of approximately 8 at all distances. As for the uranium concentration, in NA-PJ1, it increased with distance (0.5 /L ~ 67.2 /L), primarily due to the dissolution of uranium minerals (i.e., uraninite and ekanite). Moreover, uranium formed aqueous complexes with dissolved F or SO4 generated from the oxidation reaction of iron sulfide, with the concentration gradually increasing with the flow of groundwater. Close to the column influent in NA-PJ1, uranium formed a UO2CO3(aq) complex. However, with increasing distance, uranium transitioned to form a UO2SO4(aq) complex with

SO4. The experimental results indicate that when uranium dissolves under low pH conditions, it may form complexes with other anions in the groundwater and subsequently migrate with the groundwater flow. This study can contribute to the interpretation and evaluation of uranium transport and reaction characteristics within groundwater flow systems.

Keyword

uranium, water-rock interaction, natural analogue, column experiment, groundwater

Hydrochemical Characteristics of Deep Groundwater by Depth in Granite site for Disposal of High-Level Radioactive Waste

JIWON PARK[1]*, GeoGreen21 Co., Ltd. (jwpark@geogreen21.com)
JUN-YOUNG AHN[2], GeoGreen21
SEONG-CHUN JUN[3], GeoGreen21
JEONG-YONG CHEON[4], GeoGreen21
MYEONG-JAE Yi[5], GeoGreen21

Abstract

In this study, we investigated the hydrochemical characteristics of deep groundwater at various depths in a granite area, which is one of the rock types considered for the disposal of high-level radioactive waste, to evaluate the suitability as disposal depths. The groundwater was collected at the fractured zone (281~291, 310~320, 485~495, 612~622 m bgs) of 1,000 m depth borehole installed in the KURT study area. Comparing the hydrochemical properties of groundwater collected at different depths, it was observed that as the depth increased, the pH increased while DO and ORP decreased, indicating a reducing environment with increasing depth. The EC values ranged from 50~500 uS/cm, and the concentrations of Cl- were below 10 mg/L at all depths, indicating uncontaminated groundwater such as natural. As the pH of deep groundwater increased, the dissolution of carbonate minerals occurred, increasing the concentration of HCO3- as the depth increased. The concentrations of NO3- and SO42- decreased with deeper depth, indicating a reducing environment in deep groundwater. The increase of Na+ concentration was estimated to occur as the reducing properties in groundwater became stronger as the depth increased. Conversely, the concentration of Ca2+ decreased with depth, which is presumed to be due to the formation of calcite. Based on the results of this study, it was confirmed that the underground environment at a depth more than 500 m bgs is predominant the reducing environment, which is an appropriate level for the disposal of high-level radioactive waste.

Acknowledgements
This research was supported by the National Research Foundation of Korea(NRF) under the project 'Development of Core Technologies for the Safety of Used Nuclear Fuel Storage and Disposal; NRF-2022M2E1A1052570'.

Keyword

hydrochemical characteristics, granite, deep borehole, High-Level Radioactive Waste`, deep underground disposal

Examination of Uranium Migration within Bentonite Employing the Reactive Transport Model

Won Woo YOON[1]*, Department of Earth System Sciences, Yonsei University (yysam15@yonsei.ac.kr)
Weon Shik Han[2], Department of Earth System Sciences, Yonsei University, Seoul, Republic of Korea
Jeonghwan Hwang[3], Korea Atomic Energy Research Institute, Daejeon 34057, Republic of Korea
Jung-Woo Kim[4], Korea Atomic Energy Research Institute, Daejeon 34057, Republic of Korea
Jiyong Lee[5], Department of Earth System Sciences, Yonsei University, Seoul, Republic of Korea

Abstract

The transport of uranium through bentonite buffers within high-level radioactive waste repositories under various environmental conditions is crucial, particularly due to the predominance of uranium in waste package. To simulate this complex migration process, a reactive transport model is frequently utilized which can incorporate the multi-physical processes that potentially affect uranium migration, including groundwater flow, heat flow, and geochemical reactions. In this study, a COMSOL-IPhreeqc coupled model was developed, validated, and applied to simulate the uranium migration process under diverse conditions.

Initially, the transport of uranium through a one-dimensional bentonite-granite column, without any significant environmental change was simulated to serve as a standard scenario (BG-1). This model scenario includes a column consisting of 0.5 m of bentonite and 29.5 m of granite. Uraninite was assigned at the left end of the bentonite, assuming the canister failure. Given the absence of notable environmental events, the reactions in the bentonite was induced by the porewater mixing with the adjacent granite. Subsequent simulations, BG-2 and BG-3 investigated the impacts of temperature variations due to the heat generated from the canister and seawater intrusion through fractures, respectively. These changes in temperature or porewater composition significantly altered the environmental conditions, affecting aqueous speciation, adsorption dynamics, and mineral composition within the system. Future research will further elucidate the implications of these environmental evolutions on uranium migration, providing an insight into the long-term safety of high-level radioactive waste repositories.

Keyword

HLW repository, Uranium, Reactive transport model

Investigation of geochemical evolution and radionuclide migration in engineered barrier systems using an adaptive process-based total system performance assessment framework

Jeonghwan HWANG[1]*, Korea Atomic Energy Research Institute (KAERI) (hwangjh@kaeri.re.kr)
Jung-Woo Kim[2], Korea Atomic Energy Research Institute (KAERI)

Abstract

The long-term safety of engineered barrier systems (EBS) for the disposal of high-level radioactive waste is crucial for assessing the safety performance of deep geological repositories. Developed by KAERI, an adaptive process-based total system performance assessment framework (APro) simulates the long-term geochemical evolution of repositories and its impact on radionuclide migration. APro couples COMSOL and PHREEQC through a sequential non-iterative approach for the reactive transport modeling. In addition, the inclusion of non-water hydrogen (H), non-water oxygen (O), and charge balance in the coupling process significantly improves the accuracy and stability. This setup enables a radionuclide transport model to involve detailed geochemical reactions, such as mineral dissolution/precipitation, cation exchange, surface complexation, and sorption. This study conducted APro simulations to evaluate uranium migration within the EBS, considering the effects of redox changes and seawater intrusion.

The simulations confirmed that diffusion is the dominant mechanism for the migration of uranium and other dissolved ions within the bentonite buffer due to the concentration gradient between the EBS and the host rock. Additionally, the redox condition within the EBS was changed from oxidative to reductive states due to the oxidation of pyrite, which significantly influenced uranium migration through precipitation reactions. Seawater intrusion caused significant change of geochemical condition in the EBS throughout the long-term evolution, such as the dissolution of gypsum followed by the precipitation of calcite, dolomite, and siderite, thereby altering the porewater chemistry. However, this had only a minor effect on uranium transport.

Keyword

APro, engineered barrier system, geochemical evolution, radionuclide, migration

Sorption characteristics of the cesium on the improved coal mine drainage treated sludge (CMDS) by the addition of Na and S

Soyoung JEON[1]*, Major of Earth and Environmental Sciences, Division of Earth Environmental System Science, Pukyong National University, Republic of Korea (soyoung@pukyong.ac.kr)
Soyoung PARK[2], Major of Earth and Environmental Sciences, Division of Earth Environmental System Science, Pukyong National University, Republic of Korea
Yikyeong HAN[3], Major of Environmental Geosciences, Division of Earth Environmental System Science, Pukyong National University, Republic of Korea
Minhee LEE[4], Major of Environmental Geosciences, Division of Earth Environmental System Science, Pukyong National University, Republic of Korea

Abstract

Cesium-137 (Cs), the byproduct of the uranium and plutonium fission processes, has the relatively long half-life (30 years) and the high solubility in water, making it particularly concerning for environmental pollution in the event of a leak. Although many Cs sorbents have been studied, they have disadvantages such as the high cost of sorbent materials and the low Cs removal efficiency in solution with low Cs concentration and/or high ionic strength. Additionally, the use of powdered sorbents for treating contaminated water in the real field is unrealistic because there is no convenient method to collect sorbents after treatment.

In this study, a new environmentally friendly Cs sorbent showing the high Cs sorption efficiency (named as 'Na-S-CMDS') was developed by adding sodium (Na) and sulfur (S) to the coal mine drainage treatment sludge (CMDS), which was produced during the treatment of drainage originated from abandoned coal mines. The physicochemical and mineralogical properties of the Na-S-CMDS were analyzed by various analyses including XRF, XRD, SEM/EDS, and XPS to confirm the successful Cs-sorbent development. To evaluate the Cs removal efficiency and the Cs sorption mechanisms of the Na-S-CMDS, sorption batch experiments with different Na-S-CMDS dosages, pH values, initial Cs concentration, and reaction time were duplicated. Results of sorption batch experiments indicated that the Na-S-CMDS exhibited the rapid sorption rate (< 1 hour) and the high sorption efficiency (> 90.0%) even at the low Cs concentration (< 0.5 mg/L). Additionally, the Na-S-CMDS maintained the high Cs removal efficiency (> 80.0%) across a wide pH range (pH 2 to 11). The primary sorption mechanisms of the Na-S-CMDS were attributed to the strong binding affinity of S-Cs, as proposed by the 'hard soft acid base (HSAB) theory', as well as the active ion exchange between Na+ and Cs+.

Additionally, the powdered Na-S-CMDS was synthesized into granules by using the biopolymer to facilitate the separation of the sorbent from an aqueous system. The Na-alginate was used as the biopolymer material, and batch experiments were conducted to evaluate whether the alginate-granulated Na-S-CMDS exhibits high Cs removal efficiency under the same experimental conditions or not. From this study, it was suggested that the less toxic and the low-cost Na-S-CMDS could be used as an effective sorbent for the Cs removal from radioactive wastewater with high ionic strength and at low initial Cs concentration.

*This research was supported by the Institute for Korea Spent Nuclear Fuel (IKSNF) and National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT, MSIT) (2021M2E1A1085202)

Keyword

cesium, coal mine drainage treated sludge, radioactive nuclide, sorbent, sorption

Gas and nuclide migration model study by using parameter values derived from laboratory experiments

Danu KIM[1]*, Major of Earth and Environmental Sciences, Division of Earth Environmental System Science, Pukyong National University (danu1124@pukyong.ac.kr)
Seon-ok Kim[2], Department of Energy Resources Engineering, Pukyong National University
Sookyun Wang[3], Department of Energy Resources Engineering, Pukyong National University
Minhee Lee[4], Major of Environmental Geosciences, Division of Earth Environmental System Science, Pukyong National University

Abstract

The quantitative understanding for the migration of gas and radioactive nuclide in the deep geological repository (DGR) is very important to minimize the radioactive nuclide spreading in the multi-barriers. Because gases originated from the spent nuclear fuel (SNF) disposal site are very mobile and may affect the migration of radioactive nuclides in the SNF disposal site. Thus, characteristics of gas-nuclide migration in the multi-barriers and their influences on the safety of the disposal site should be sufficiently investigated before the construction of the final SNF disposal site.

In this study, hydro-dynamic properties of gas-nuclide migration in barrier medium were investigated through laboratory experiments at the practicable SNF disposal site environment, and the numerical gas (or nuclide) migration modeling in buffer medium was performed by using input parameters acquired from experiments. For the simulation of the gas-nuclide migration in experiment and modeling, the gas-nuclide migration scenarios were classified into two stages according to the hydrogeological evolution process in the DGR: ① the migration of gas phase nuclide in the unsaturated and saturated buffer medium (only gas phase), and ② the migration of dissolved phase nuclide in the saturated buffer medium.

Hydro-dynamic and gas migration properties of the buffer material such as density, porosity, gas/water permeability, gas injection flux, gas diffusion coefficient, and gas dispersion coefficient were determined based on the experimental results. Migration properties of dissolved nuclide (Cs+ and I-) such as the average advection velocity and diffusion/dispersion/retardation coefficient at various repository conditions (injection pressure, pore pressure, confining pressure, temperature, water saturation, etc.) were also determined by experimental results including the concentration breakthrough curves. The H2 gas, Cs+ and I- were selected for the gas and the nuclide migration experiment (0.3% of H2; 132.9 ppm of Cs+; 126.9 ppm of I-).

Modeling and experimental results from this study will be more useful as the important data for the long-term modeling of radioactive nuclide-gas (multi-phase) migration, and will support idea to develop the technology, controlling radioactive nuclide migration and evaluating the safety of the SNF disposal site.

Keyword

radioactive nuclide, engineering barrier, spent nuclear fuel, deep geological repository

Characterization of Granitic Groundwater Colloids in KAERI Underground Research Tunnel for Evaluating Radionuclides Transport

Sang-Ho LEE[1]*, Korea Atomic Energy Research Institute (sangholee@kaeri.re.kr)
Jisoo Kim[2], Korea Atomic Energy Research Institute
Jin-Seok Kim[3], Korea Atomic Energy Research Institute
Seung Yeop Lee[4], Korea Atomic Energy Research Institute
Jang-Soon Kwon[5], Korea Atomic Energy Research Institute

Abstract

Groundwater colloids play a crucial role in the dynamics of colloid-facilitated radionuclide transport within deep geological repositories. Groundwater colloids include various inorganic and organic substances; thus, understanding the physicochemical properties of groundwater colloids is crucial for assessing the fate and transport of radionuclides. To investigate the role of colloidal phases in colloid-facilitated radionuclide transport, characterization of colloids for elemental composition, mineralogical characteristics, size distribution, and surface charge is required. For this purpose, samples were collected from two boreholes, DB-1 and DB-3, at the KAERI Underground Research Tunnel (KURT), representing oxidizing and reducing conditions, respectively. A Teflon-lined metal container was used to preserve the original hydrochemical condition of the groundwater. The collected samples were stabilized in a glove box system and filtered through a 0.45 μm PTFE membrane filter. Due to the low concentration of groundwater colloids, the pre-filtered samples were concentrated using a tangential-flow ultrafiltration system equipped with 3 kDa cartridges. Dynamic light scattering, particle size analysis, scanning electron microscopy, energy-dispersive X-ray analysis, and X-ray diffraction techniques were applied to characterize the groundwater colloids. The results revealed diverse colloids consisting of inorganic and organic substances, providing useful insights for understanding the potential transport of radionuclides. Therefore, the results of this study are expected to be used as one of the fundamental case studies for predicting the formation of pseudo-colloids and the migration of radionuclides in granitic environments.

Keyword

colloid, colloid-facilitated transport, radionuclide, groundwater, deep geological repository

Sorption Mechanisms and Thermodynamics of Highly Soluble Fission Products onto Ca-type Bentonil-WRK Montmorillonite

Seonggyu CHOI[1]*, KOREA ATOMIC ENERGY RESEARCH INSTITUTE (schoi21@kaeri.re.kr)
Ja-Young Goo[2], KOREA ATOMIC ENERGY RESEARCH INSTITUTE
Hyun-Kyu Lee[3], KOREA ATOMIC ENERGY RESEARCH INSTITUTE
Jae-Kwang Lee[4], KOREA ATOMIC ENERGY RESEARCH INSTITUTE
Jang-Soon Kwon[5], KOREA ATOMIC ENERGY RESEARCH INSTITUTE

Abstract

The safe management of spent nuclear fuel (SNF) and associated contaminated by-products, which are classified as high-level radioactive waste (HLW), has emerged as a serious concern in numerous countries operating nuclear power plants. In south Korea, there have been productive R&D activities and societal discussions regarding the direct disposal of HLW without reprocessing, where the concept of deep geological disposal (DGD) stands out as the most proven technological option to prevent significant release of radionuclides into biosphere and ultimately secure the long-term safety of entire disposal system. Within the DGD system, comprised of multiple engineering and natural barriers, bentonite-based buffer and backfills play the key hydrogeochemical roles in 1) suppressing the intrusion of groundwater and reactive chemical substances that may expedite the corrosion of waste canister and 2) retarding the transport of released radionuclides to biosphere by providing abundant chemisorption sites. Montmorillonite is a primary mineral component in the bentonite, and it predominates the swelling and sorption capabilities of the clay material. Therefore, in terms of reducing the uncertainty in a performance assessment of DGD system, it is crucial to comprehensively understand the mechanisms of chemical interactions between dissolved radionuclides and montmorillonite. The chemisorption of dissolved species onto mineral adsorbents has been described and quantified based on the definition of sorption-desorption distribution coefficient (Kd). However, since the simple Kd concept does not incorporate any mechanistic essence of the surficial interaction, an empirical Kd value is eventually dependent on the experimental conditions (pH, temperature, S/L, etc.) under which it was assessed. In this framework, the application of thermodynamic sorption modeling (TSM), based on the chemical principle of mass action laws, has been suggested and actively investigated to geochemically parametrize the sorption phenomena more reliably under a wide range of aquatic conditions, especially in the context of modeling radionuclide migration within the DGD environment.

In 2021, the disposal performance demonstration R&D division of Korea Atomic Energy Research Institute (KAERI) adopted a new reference Ca-type research bentonite clay, Bentonil-WRK (Clariant Korea), and we conducted experimental and modeling works on the purification of Ca-montmorillonite from Bentonil-WRK and its chemisorption behaviors with major radionuclides and other relevant substances. This presentation provides an overview of the utilization of TSM in an operation of process-based total system performance assessment framework, and the resulting reaction models and stability constants of surface Cs(I), Sr(II),

Se(IV), and I(-I) species, which are highly soluble major fission products contained in the HLW, onto the Ca-type Bentonil-WRK montmorillonite under ambient conditions were discussed.

Keyword

Radionuclide migration, Engineered barrier, Montmorillonite, Sorption, Fission product

Assessing nuclides migration across multi-barrier interfaces using reactive transport models

Heewon JUNG[1]*, Chungnam National University (hjung@cnu.ac.kr)
Sunwong Lim[2], Chungnam National University
Yehoon Kim[3], Chungnam National University

Abstract

Performance assessment of a geologic nuclear waste repository requires numerical modeling to understand the long-term migration of nuclides through engineered and natural barriers, because the timescale of interest extends well beyond the typical range of direct estimation methods. Additionally, the processes governing the long-term safety of the repository occur across various scales in space and time, often surpassing the capabilities of conventional observables. Overcoming such limitations requires a numerical approach, capable of providing insights into the intricate processes associated with conventional observables over a geologic time scale. In this regard, reactive transport models, which mathematically integrate hydrological and geochemical processes, provide unique opportunities for evaluating the long-term fate of nuclides in repository environments. Here, we focus on hydrological evolution induced by geochemical reactions at the pore-scale near a concrete-granite interface of a multi-barrier system using a novel pore-scale reactive transport modeling framework, CompLaB. Along a fracture across a concrete-granite interface, we characterize the evolution of porosity and permeability as a result of dissolution and precipitation reactions under various flow conditions. As dissolution and precipitation reactions expose new surfaces for nuclides to interact with, we also investigate the intricate nature of nuclide breakthroughs in the evolving subsurface system. This numerical study provides a building block for developing a field-scale macroscopic model that explicitly takes into account the hydrogeochemical evolution at the pore-scale.

Keyword

Pore scale, Reactive transport, Nuclides, Porosity-permeability evolution

Interrogating reactive surface distribution at the pore-scale using dual tracer breakthrough curves

Sunwong LIM[1]*, Department of Earth, Environmental & Space Sciences (Geological Sciences) Chnungnam National University (sunwong@g.cnu.ac.kr)
Heewon Jung[2], Department of Geological Sciences, Chungnam National University

Abstract

Understanding the fate of nuclides and dissolved chemicals in subsurface environments hinges on intricate interactions between transport and reaction processes at the pore scale. However, fully resolving such fine-scale phenomena in a large field system is practically infeasible. Hence, many investigations rely on field-scale observables such as breakthrough curves (BTCs) and macroscopic modeling techniques that simplify pore-scale transport and reaction processes. This simplification introduces significant uncertainties in quantitatively estimating and predicting hydrogeochemical processes in heterogeneous subsurface environments, hindering the direct application of advanced laboratory observations to field systems. To bridge the gap between pore-scale processes and macroscopic observables, this study investigates the effects of reactive surface distribution on tracer BTCs. A total of 48 simulations were conducted, injecting both conservative and reactive tracers into three simulation domains characterized by different dead-end pore volumes and reaction surface distributions, while maintaining the same porosity. The reactive tracer is consumed at predefined reactive surfaces, while the conservative tracer is used to extract reaction rate BTCs from the tracer BTCs. Analysis revealed two distinct types of peaks (Type I and Type II) in the time derivative of reaction rate BTCs, indicating advection- and diffusion-controlled surface reactions, respectively. Employing curve fitting techniques using two skewed Gaussian curves successfully reproduced the simulated reaction rate BTCs, with parameters systematically varying depending on the flow and reaction surface distribution conditions. This finding suggests a novel approach for extracting reaction surface distributions in heterogeneous subsurface environments from multi-tracer BTCs, allowing potential advancements in understanding hydrogeochemical processes in complex subsurface systems.

Keyword

multi-tracer breakthrough curve, pore-scale, reactive transport model, reactive surface distribution

Effect of gas originated from the deep geological SNF (spent nuclear fuel) repository on the sorption of Cs (I) and Sr (II) on bentonite

Daehyun SHIN[1]*, Major of Earth and Environmental Sciences, Division of Earth Environmental System Science, Pukyong National University, Republic of Korea (d3380@pukyong.ac.kr)
Sookyun WANG[2], Department of Energy Resources Engineering, Pukyong National University, Republic of Korea
Seon-ok KIM[3], Department of Energy Resources Engineering, Pukyong National University, Republic of Korea
Wonbeom HEO[4], Major of Environmental Geosciences, Division of Earth Environmental System Science, Pukyong National University, Republic of Korea
Minhee LEE[5], Major of Environmental Geosciences, Division of Earth Environmental System Science, Pukyong National University, Republic of Korea

Abstract

The deep geological repository (DGR) is regarded as a viable solution for the permanent disposal of the spent nuclear fuel (SNF). Ensuring the safe and permanent SNF disposal requires the comprehensive understanding of the hydrogeological evolution processes during the SNF disposal and of the leaked radionuclide reaction behavior in the DGR. The DGR is composed of various barrier systems and the compacted bentonite buffer is considered to be used as a crucial engineering barrier. Characterized by high swelling capacity and low permeability, the compacted bentonite buffer plays an important role in preventing groundwater infiltration and radionuclide spreading in the DGR. Throughout the hydrogeological evolution of the DGR, various gases such as H2, H2S, CO2 and He can be generated and properties of the bentonite buffer also could be influenced and modified by these gases. These transitions finally affect the behavior of released radionuclides as well as the alteration in groundwater properties.

In this study, we simulated the dissolution of active representative gases (CO2 and H2S) and the geochemical reaction in the groundwater-gas-bentonite system at the repository's oxidative (or reductive) environment. Property changes of bentonite and adsorption capacity changes of Cs (I) and Sr (II) on bentonite due to gas were mainly investigated in batch experiments. The Korean bentonite (‘Bentonil-WRK’) used in the experiment is a Ca-type bentonite intended to be used as a buffer material for the Korean SNF disposal repository. The artificial solution was prepared with the initial Cs (Sr) concentration of 20 ppm and at pH 9 for batch experiments. Powdered bentonite was mixed with solution in a sealed glass vial, and the remaining space was filled with CO2 or H2S gas. The vial was stirred at 100 rpm for 0.08, 0.5, 1, 2, 6, 12, 24, 72, 168, and 336 hours at 60℃. At the same experimental condition, the geochemical reaction modeling for the bentonite-water-gas system was performed using a program of GWB (‘Geochemist’s Workbench’) and modeling results were compared with experimental results. In this study, the effect of active gases (H2S and CO2) on the sorption property of Cs (I) and Sr (II) on the bentonite was investigated and the feasibility of the Korean bentonite (‘Bentonil-WRK’) as the buffer material to prevent the nuclide spread in the SNF disposal site was also evaluated by both of experiments and

geochemical modeling.

This research was supported by the Institute for Korea Spent Nuclear Fuel (IKSNF) and National Research Foundation of Korea (NRF) grant funded by the Korea government (Ministry of Science and ICT, MSIT) (2021M2E1A1085202)

Keyword

bentonite, sorption, radioactive nuclide, cesium, strontum

Experimental Investigation into Nuclide Diffusion on Compacted Bentonite under the Influence of Reactive Gas

Jin-Seok KIM[1]*, Disposal Performance Demonstration R&D Division, Korea Atomic Energy Research Institute (jskim84@kaeri.re.kr)
Sang-Ho Lee[2], Disposal Performance Demonstration R&D Division, Korea Atomic Energy Research Institute
Seung Yeop Lee[3], Disposal Performance Demonstration R&D Division, Korea Atomic Energy Research Institute
Jang-Soon Kwon[4], Disposal Performance Demonstration R&D Division, Korea Atomic Energy Research Institute

Abstract

Spent Nuclear Fuel (SNF) is destined for final disposal in a deep geological repository. The SNF is encapsulated within a metal canister made from cast iron insert and copper, which is designed to provide long-term containment of the radionuclides. The canister forms part of a multi-barrier disposal system that combines both engineered and natural barriers, offering a basic layer of protection to prevent the leakage of radionuclides. Radionuclides may leak from the canister at the end of its service life, with colloids and gases acting as mediators that can facilitate this process. These mediators can influence the behavior of radionuclides and accelerate their migration. Therefore, it is crucial to consider these factors when assessing the long-term stability of a deep disposal repository.

To better understand the behavior of radionuclides, an experimental setup was designed to simulate a deep geological environment. The experiment aimed to observe the diffusion of nuclide due to dissolved gas diffusion under specific temperature and pressure conditions, similar to those of a deep disposal repository. The experiment simulated gas diffusion within an engineered barrier, reflecting conditions that would be present 1000 years after the closure of the repository. The barrier material chosen for the experiment was bentonite WRK, which was compacted to a dry density of 1.61 g/cm^3. The compacted bentonite was subsequently saturated under a water pressure of 5 MPa, equivalent to the hydrostatic pressure found 500 meters underground. The evaluation of nuclide behavior, as it diffuses into bentonite along with dissolved CO2 gases, was carried out by injecting gas into saturated bentonite at a pressure of 5 MPa to balance with the hydrostatic pressure. The experiment was designed to allow nuclides to diffuse into compacted bentonite under pressures equivalent to 500 meters below ground level. Cesium iodide was used in the experiment, and diffusion reactions were conducted over periods of 10, 20, 30, and 50 days. Most of the cationic nuclides were adsorbed onto bentonite and diffused at a very slow rate. The dissolved carbon dioxide formed trace amounts of precipitated minerals and affected the porosity.

In scenarios high-pressure gas is generated at the interface of the canister and the buffer, diffusion of the dissolved gas into the buffer can occur. This can lead to cationic nuclides such as cesium and strontium adhering to the bentonite particles and becoming fixed. Additionally, the dissolved gas, dissolved elements from accessory minerals, and nuclides can form a new mineral, preventing

the migration of the radionuclide outside of the buffer. However, the high mobility and difficulty of fixation by mineralization of anions necessitate further investigation.

Keyword

Nuclide behavior, Gas diffusion, Nuclide diffusion, Bentonite,, Deep geological repository

Preliminary results of nuclide migration and retardation in engineering-scale natural fractured rock

Seonyi NAMGUNG[1]*, Korea Atomic Energy Research Institute (synamgung@kaeri.re.kr)
Ki-Jong Jang[2], Korea Atomic Energy Research Institute
Jang-Soon Kwon[3], Korea Atomic Energy Research Institute

Abstract

Ensuring the safety of managing high-level radioactive waste (HLW) in deep geological disposal sites is of paramount importance prior to the construction of the final disposal facilities. This safety assessment requires a comprehensive understanding of how radionuclides interact with geological materials and groundwater in the disposal environment. However, predicting the migration characteristics of radionuclides in the deep geological environments is challenging due to the intricate interplay among various physicochemical processes. In this study, we preliminary evaluated the nuclide behavior at an engineering-scale fractured granite rock to establish the foundational data for future field evaluations. We analyzed the mineralogy and chemical compositions of the primary and the fracture filling minerals to characterize the fractured rock. In addition, the aperture distribution of the fracture was determined based on the results of the hydraulic testing. Migration experiments were then conducted using five nonradioactive cationic and anionic nuclides (i.e., Cs, Sr, Ni, Cl, I) dissolved in deuterium water (D2O). The deuterium water was used as a criterion for evaluating the retardation factors of various nuclides based on their chemical properties. Our results showed distinct differences in the nuclides behavior with the chemical properties in this engineering-scale fractured rock. The detailed results will be presented and discussed.

Keyword

fractured rock, nuclide behaviors, migration, retardation, engineering-scale

Accelerating geochemical calculations in reactive transport simulations with an artificial neural network based surrogate model for nuclear waste repository management

Yehoon KIM[1]*, Dept. Earth, Environmental & Space Sciences, Chungnam National University (wnsla7323@naver.com)
Horim Kim[2], Korea Institute of Geosciences and Mineral Resources
Heewon Jung[3], Chungnam National University

Abstract

Reactive transport modeling is a powerful framework integrating chemical transport and geochemical reactions in subsurface environments, finding wide applications in subsurface utilization such as nuclear waste repository management. However, the applications of this modeling approach are often hindered by its substantial computational costs, a challenge that has restricted many model setups to one or two dimensions with coarse spatiotemporal discretization. The computational bottleneck resides in the geochemical reaction calculations, which typically consume approximately 90% of the total computational time. Recognizing this bottleneck, this study introduces a surrogate modeling approach that replaces the geochemical sub-process with an artificial neural network (ANN). The training data were prepared using PHREEQC considering the dissolution of carbonate minerals and surface complexation of uranium species. Preliminary ANN results demonstrate mean squared errors of less than 0.5% when compared to the full-physics PHREEQC calculations. Although this promising level of agreement suggests the potential of the proposed surrogate model in alleviating the computational burden associated with reactive transport simulations, small errors propagate in successive iterations ultimately leading to substantial deviation in surrogate model predictions and yielding unphysical results. This suggests the need for future work, a smart surrogate algorithm that is capable of identifying the error propagation and rejecting inaccurate surrogate predictions informed by full physics representation of geochemistry.

Keyword

Reactive transpot, Surrogate, ANN, Nuclides

The Basal Emsian boundary – the only pending stage issue in the Devonian stratigraphy

Ladislav SLAVÍK[1]*, Institute of Geology of the Czech Academy of Sciences (slavik@gli.cas.cz)
Hedvika Weinerová[2], Institute of Geology of the Czech Academy of Sciences
Tomáš Weiner[3], Institute of Geology of the Czech Academy of Sciences
Jindřich Hladil[4], Institute of Geology of the Czech Academy of Sciences

Abstract

The Devonian system has well defined stage boundaries. There is one exception only – the problematic lower boundary of the Emsian Stage. The current basal Emsian GSSP was defined in the Zinzil'ban Gorge (Kitab State Geological Reserve, Uzbekistan) based on the FAD of conodont Polygnathus kitabicus Yolkin et al. According to detailed correlations with Mauro-Ibero-Armorican, Rheno-Ardennan and Barrandian faunas it lies far below the base of the classical Emsian in German sense (Carls et al., 2008). At the same time, the GSSP correlates with a level in the lower part of the Praha Formation (Slavík et al., 2007; Carls et al., 2008), but the Pragian Stage has been originally devised to correspond entirely lithologically and biostratigraphically confined Praha Formation (i.e. "the original Pragian"). In 2019, the Subcommission on Devonian Stratigraphy decided to search an alternative section with stratigraphically appropriate level for the new basal Emsian GSSP. The most promising candidates are situated in the Spanish Central Pyrenees and in the Prague Synform. In the past decades, Lower Devonian successions in the Prague Synform were extensively studied for biostratigraphy and palaeontological, sedimentological, geochemical and petrophysical record. Slavík & Hladil (2020) summarized the conodont data from the Early Devonian from the Prague Synform and established conodont zonation in this area. The gracilis Event represents an alternative marker that approximately corresponds to the traditional boundary between the originally defined Pragian and Emsian stages. Our team concentrated on the Pragian-Emsian sections in the Prague Synform in order to obtain large biostratigraphical, geochemical and petrophysical datasets. The beds of the Bohemian Graptolite Event (BGE) form a correlation horizon in the upper parts of the Praha Formation. It is formed by dark grey mudstone layers alternating with carbonate beds, and characterized by close entries of conodont taxa Polygnathus excavatus excavatus Carls & Gandl and Latericriodus bilatericrescens gracilis Bultynck, which might be critical for potential definition of new basal Emsian GSSP. The data from the most promising sections with presence of the BGE with good accessibility and diverse sedimentology will be presented. The Pod Barrandovem, Mramorka Quarry and Požár 3 Quarry sections were sampled for microfacies study and faunal content, magnetic susceptibility logs, geochemical analyses (δ13C and δ18O stable isotopes, INAA, EDXRF) and GRS measurements. The most eligible section for the prospective GSSP redefinition in the Prague Synform will be presented.

The research was financed by the Czech Science Foundation (21-21829S) and was conducted within institutional support RVO 67985831 of the Institute of Geology of the Czech Academy of

Sciences.

Carls, P., Slavík, L., Valenzuela-Ríos, J.I. 2008. Comments on the GSSP for the basal Emsian stage boundary: the need for its redefinition. Bulletin of Geosciences 83(4), 383-390.
Slavík, L., Hladil, J. 2020. Early Devonian (Lochkovian – early Emsian) bioevents and conodont response in the Prague Synform (Czech Republic). Palaeogeography Palaeoclimatology Palaeoecology 549, 109-148.
Slavík, L., Valenzuela-Ríos, J.I., Hladil, J., Carls, P. 2007. Early Pragian conodont-based correlations between the Barrandian area and the Spanish Central Pyrenees. Geological Journal 42, 499-512.

Keyword

Lower Devonian, Basal Emsian GSSP, Prague Synform, Correlation proxies, Biostratigraphy

Building a numerical high-resolution geological timeline

Shuzhong SHEN[1]*, Nanjing University (szshen@nju.edu.cn)
Shuhan Zhang[2], Nanjing University
Junxuan Fan[3], Nanjing University
Xiangdong Wang[4], Nanjing University

Abstract

The Earth has a history of ~4.5 billion years and a geologic timeline is the only common language available to unravel the evolutionary history of the Earth. Since the 1960s, the International Commission on Stratigraphy (ICS) aims to establish a universal standard timeline for intercontinental and regional correlations. The ICS currently uses the Global Stratotype Section and Points (GSSP) method to define geologic time boundaries. However, we have all recognized that there are some obstacles to precisely placing the stratigraphic horizon of a GSSP. The most common challenge is that all fossil records are far from complete, and it is theoretically impossible to identify the absolute first occurrence of an index fossil species, and thus the previously defined GSSP can be frequently overthrown by subsequent earlier “first” occurrences of index fossils. In addition, the GSSPs defined by biostratigraphy commonly contradict with other physical or chemical markers (e.g., volcanic ash beds, isotope excursions, geochemical anomalies, etc.) that are of isochronous significance. All geological records have temporal and spatial properties and thus should be valuable for intercontinental and regional correlations. The 21st century has entered an era of the widespread application of big data and artificial intelligence. Building a high-resolution geological timeline based on big data of all geological records is an urgent mission for stratigraphy in the next decade. The new geological timeline we are expected should be supported by global stratigraphic databases. We could apply statistics, artificial intelligence algorithms, etc. to correct the incomplete nature of fossil records and to obtain statistically optimal solutions for the ordering of stratigraphic information and combine to use geochronology, magnetostratigraphy, chemostratigraphy and cyclostratigraphy data. The new digital timeline, once established, will greatly promote the quantitative study of the detailed timing, duration, and rate of a given event in Earth history.

Keyword

timeline, GSSP, biostratigraphy, big data, CONOP

Heterogeneous selectivity and morphological evolution during the Permian-Triassic mass extinction

Xiaokang Liu[1]*, China University of Geosciences (xkliu@cug.edu.cn)
Haijun Song[2], China University of Geosciences
Daoliang Chu[3], China University of Geosciences
Xu Dai[4], China University of Geosciences
Fengyu Wang[5], China University of Geosciences
Daniele Silvestro[6], University of Fribourg

Abstract

Morphological disparity and taxonomic diversity are distinct measures of biodiversity, typically expected to evolve synergistically. However, evidence from mass extinctions indicates they can be decoupled. Mass extinctions lead to a drastic loss of diversity, but their impact on disparity remains unclear. Here, we evaluate the dynamics of morphological disparity and extinction selectivity across the Permian-Triassic mass extinction (PTME). We developed a new approach based on the extraction of morphological features from fossil images using a deep learning model (DeepMorph) and applied it to a high-resolution temporal dataset encompassing 599 genera across six marine clades. While five clades experienced strong taxonomic losses, we detected different patterns and magnitudes of morphological change during the PTME, including evidence of selective extinction of specialized forms in some clades. The presence and intensity of morphological selectivity likely reflect the variations in environmental tolerance thresholds among different clades. In clades affected by selective extinctions, the intensity of diversity loss promoted the loss of morphological disparity. Conversely, in clades experiencing non-selective extinctions, the magnitude of diversity loss had a negligible impact on disparity. Our results highlight that the PTME had heterogeneous morphological selective impacts across clades, offering new insights into how mass extinctions can reshape biodiversity and ecosystem structure.

Keyword

Morphological evolution, Disparity, Deep learning, Selectivity, Permian-Triassic mass extinction

A Deep Learning Approach to Synthesizing Phanerozoic Paleoclimate and Biogeochemical Cycles

Dongyu ZHENG[1]*, Chengdu University of Technology (zhengdongyu@cdut.edu.cn)
Andrew S Merdith[2], University of Adelaide
Yves Goddéris[3], CNRS–Université de Toulouse III
Yannick Donnadieu[4], Aix Marseille Univ
Khushboo Gurung[5], University of Leeds
Benjamin J.W. Mills[6], University of Leeds

Abstract

Databases of 3D paleoclimate simulations are increasingly integral to global biogeochemical models across the Phanerozoic Eon, enhancing the accuracy of surface process representations. However, the method's utility is constrained by the limited availability of comprehensive paleoclimate simulations across various pCO2 levels and continental configurations. Our study introduces the application of the Frame Interpolation for Large Motion (FILM) Deep Learning technique to enhance the temporal resolution of paleoclimate model simulations from an interval of approximately 25 million years to every 1 million year (Myr).

Our methodology's efficacy was validated through tests on a set of continental configurations with a 5 Myr time resolution, accurately reconstructing intermediate frames over periods up to 40 Myrs. Applying this technique, we successfully refined the temporal granularity of the paleoclimate data within the SCION climate-biogeochemical model. This refinement enabled the SCION model to predict previously undetected climate shifts, overcoming the limitations imposed by sparse datasets and simplistic linear interpolations previously employed.

We posit that a ~10 Myr resolution might be optimal for exploring the long-term carbon cycle, with Deep Learning playing a pivotal role in achieving this resolution efficiently. Furthermore, these methods open avenues for developing continuous models for 3D continental processes like species distribution over geological timescales. However, the heterogeneous nature of runoff distribution poses challenges to Deep Learning's interpolation accuracy, underscoring the necessity of validating interpolated climates with dedicated paleoclimate model runs for rigorous scientific conclusions.

Keyword

Paleoclimate, Biogeochemistry, Deep Learning, Phanerozoic

[Invited] Reconstructing High-Resolution Biodiversity Patterns in Deep Time: Innovations, Challenges, and Future Directions

Junxuan FAN[1]*, Nanjing University (jxfan@nju.edu.cn)
Shuzhong Shen[2], Nanjing University

Abstract

One crucial aspect of studying the Earth's life history is the reconstruction of deep-time biodiversity patterns. With the emergence of large databases such as the Paleobiology Database (PBDB), the massive compilation of paleontological data has enabled the statistical analysis of fossil records at various hierarchical levels, including family, genus, or species, over continuous time intervals. This approach has been widely adopted, offering an important means of inferring long-term biodiversity history. However, in long-term, large-scale studies, the temporal resolution is often on the order of millions to tens of millions of years, limiting our understanding of rapid, significant events affecting the evolution of life. Over the past decade, we have explored non-traditional methods, such as using the CONOP approach of quantitative stratigraphy, coupled with artificial intelligence and parallel computing, to construct higher temporal resolution marine biodiversity history. With the continued accumulation of data from large stratigraphic databases such as the Geobiodiversity Database (GBDB) and OneStratigraphy, we have investigated several significant biotic events during the Phanerozoic. Future developments focus on two main directions. First, we will try to apply this methodology to the terrestrial fossil records to construct high-resolution biodiversity curves for terrestrial life and to compare them accurately with marine curves. Second, as sedimentary geochemical databases continue to improve, high-resolution time series data of key environmental proxies will emerge, allowing more reliable mechanisms of environment-life interactions to be established in deep time.

Keyword

Paleobiodiversity, PBDB, OneStratigraphy, CONOP, Deep-time

[Keynote] Mesozoic origin and evolution of coccolithophores documented by their biodiversity and calcification

ELISABETTA ERBA[1]*, University of Milan, Dept. Earth Sciences (elisabetta.erba@unimi.it)

Abstract

Paleoclimate episodes preserved in the geological record are valuable sources of information about how ecosystems and species functioned in much warmer conditions than today. Paleontological data, thus, inform us about the impacts of global changes on the biosphere and ecosystem dynamics. Long-term time-series can be used to derive the tempo and mode of biota adaptation and recovery.

Calcareous nannofossils include the coccoliths/nannoliths produced by coccolithophores and nannoliths of unknown provenance. They are the low-Mg calcite remains of calcareous nannoplankton that have populated the oceans since Triassic times. The rise of coccolithogenesis is one of the most profound ecological innovations in the oceanic ecosystem, and Early Triassic nannofossils from South China are important for delineating the circumstances that prompted (or allowed) a group of phytoplankton to mineralize calcite, effectively dating the birth of the modern ocean. The origination of coccolithophores in the aftermath of Earth's most catastrophic mass extinction at the end of the Permian imposed a reset of marine ecosystems and forced biota to adapt to, and perhaps take advantage of, extreme climatic and chemical conditions in the ocean and novel niches.

The origin of coccolithophore biocalcification—a spectacular example of the intimate coupling between geological processes and life evolution—began to change oceanic ecosystem dynamics, biochemical processes, and sedimentation in the oceans. The onset of coccolithogenesis marked the beginning of the long and successful evolutionary history of coccolithophores. The Mesozoic evolution of calcareous nannoplankton is characterized by a general increase in diversity, punctuated by speciations, mass extinctions, and turnovers. Times of accelerated rates and/or drops in nannofossil diversity partly correlate with global changes in the geosphere, hydrosphere, and atmosphere, suggesting that the evolutionary patterns are linked to environmental modifications that are interconnected with and determined by processes operating inside the Earth.

During the Mesozoic, calcareous nannoplankton diversification led to the development of 25 coccolith/nannolith families and 5 groups Incertae sedis. In Late Cretaceous times, nannofossil diversity reached a total of 149 species and 115 genera. At a broad scale, nannofossil diversity does not show a clear relationship with climate changes or paleoenvironmental perturbations.

The long-term trends in biodiversity and abundance/calcification of coccolithophores allow for the analysis of their resilience and resistance. In terms of resilience, the biodiversity of calcareous nannoplankton during the Jurassic and Cretaceous shows high resilience, as they were able to maintain their diversity and recover to their pre-perturbation state after disturbances. Possibly, nannofossil diversity is not a suitable parameter for measuring resilience or resistance. Instead, nannoplankton calcification patterns provide valuable insights into their ecological resilience and

resistance. Indeed, based on coccolithophore abundance and calcification, their resilience was more moderate, and different taxa displayed varying levels of sensitivity and resistance.

Keyword

BIODIVERSITY, MESOZOIC, COCCOLITHOPHORES, RESILIENCE

Unraveling Marine Biodiversity Dynamics in North China during the Middle-Late Cambrian: Insights from a High-resolution Species-level Richness Analysis

Yujie Shi[1]*, Nanjing University (yujieshi795@outlook.com)
Yukun Shi[2], Nanjing University
Aihua Yang[3], Nanjing University
Hanhui Huang[4], University of Oxford
Zhengbo Lu[5], Nanjing University
Yiying Deng[6], Hefei University of Technology
Xiaofang Teng[7], Nanjing University
Junxuan Fan[8], Nanjing University

Abstract

The Cambrian represents a significant milestone in Earth's evolutionary history, marked by pivotal changes in biology and the environment. Despite this, marine biodiversity during the Middle to Late Cambrian remains poorly understood, with dynamic patterns still subject to debate. North China, existing as an independent tectonic plate during the Cambrian, possesses a unique geological background and biota from that time, making it crucial for unraveling deep-time biodiversity history.

In this study, we compiled a dataset based on published biostratigraphic sections of the Middle-Late Cambrian in North China, sourced from the OneStratigraphy database (http://onestratigraphy.ddeworld.org/). Utilizing a constrained optimization algorithm, a high-resolution, multi-phyla, species-level marine richness curve was constructed. This curve reveals richness patterns among different fossil groups and life modes, shedding light on the evolutionary events of marine animals in North China. These events include evolutionary radiation from the Wuliuan to the Guzhangian, extinction events in the early Guzhangian and late Guzhangian to early Paibian, and recoveries in the late Guzhangian and Paibian to Stage 10.

Our detailed analysis reveals that fossil groups with different life modes, such as benthic and nektonic groups, exhibited diverse patterns during these events. Trilobites, the best-recorded marine group from this period, underwent detailed analysis, with richness curves constructed for distinct taxonomic orders. Further investigations unveiled shifts in trilobite dominance across stages and compared these with those of South China to reveal diverse responses under different geological backgrounds. By decomposing fauna composition and turnovers in these bio-events, we explored potential biotic drivers. Proxies of marine physical environments, including carbon isotopes, strontium isotopes, I/Ca ratio, and others, were scrutinized to elucidate their relationships with biodiversity dynamics.

Overall, this study enhances our understanding of Cambrian marine fauna biodiversity dynamics

in the North China Block. It offers preliminary insights into the intricate relationships between biotic and abiotic factors during this pivotal period in Earth's history.

Keyword

Cambrian, Biodiversity, North China, CONOP

An enigmatic macrofossil from the terminal Ediacaran Liuchapo Formation in South China

Qing TANG[1]*, Nanjing University (qingt@nju.edu.cn)
Lang Xue[2], Nanjing University
Haizhou Wang[3], China University of Petroleum (Beijing)
Bin Wan[4], Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences
Ke Pang[5], Nanjing Institute of Geology and Paleontology, Chinese Academy of Sciences

Abstract

The terminal Ediacaran is key for the rise of modern ecological system that featured by complex eukaryotes, including animals. Molecular clock data suggest that major groups of metazoans diverged in the Ediacaran or even earlier. However, among the many complex macrofossils reported in the Ediacaran, only a few are arguably metazoans. To achieve a better understanding on the diversity of complex eukaryotes in the Ediacaran, here we report a new group of enigmatic macrofossils from the terminal Ediacaran Liuchapo Formation in Changde city, Hunan Province, South China. Our investigation, using reflected light microscopy, scanning electron microscopy, energy-dispersive X-ray spectroscopy, and micro-CT, reveals that the Liuchapo specimens are preserved as domal casts and molds. Their morphology varies from round or polygonal to starlike in line with their size growth. A pyritized membrane is usually preserved on outer margin of the specimens, occasionally accompanied with pyrite clusters and organic particles within the body. Moreover, multiple concentric spherical structures are occasionally observed within the specimens. Collectively, these observations indicate a biogenetic origin for the Liuchapo specimens, likely presenting a novel Ediacara-type macrofossil and morphologically similar to some Phanerozoic medusae. Although the metazoan interpretation of the Liuchapo specimens requires future studies with more robust evidence, their discovery contributes to the growing diversity of complex eukaryotes in the terminal Ediacaran ecosystem.

Keyword

terminal Ediacaran, Liuchapo Formation, Ediacara-type macrofossil, complex eukaryote, South China

Palaeo-environmental insights into late Ediacaran "mass extinctions"

Brennan O'Connell[1]*, University of Cambridge (bo295@cam.ac.uk)
William J. McMahon[2], University of Cambridge
Catherine E. Boddy[3], University of Cambridge
Alex G. Liu[4], University of Cambridge

Abstract

Observed shifts in taxonomic diversity between three biotic assemblages of the Ediacaran biota–the Avalon (~575–560 Ma), White Sea (~560–550 Ma), and Nama (~550-539 Ma)–strongly influence current understanding of early animal evolution and are considered to evidence trends of diversification and extinction. However, the influence of local palaeo-environmental controls on Ediacaran taxonomic diversity is not adequately accounted for in existing datasets. Brief or highly generalised palaeo-environmental descriptions for key localities, limited study of non-fossiliferous units, and differences in interpretation of strata by various research teams complicate palaeo-environmental reconstructions and global site comparisons. Here, we apply consistent, field-based sedimentological and stratigraphic methods to reconstruct the palaeo-environmental context of key sites representing each Ediacaran biotic assemblage (from Australia, Canada, and Namibia), considering both fossiliferous and non-fossiliferous intervals. Our approach permits direct comparison of similar palaeo-environments between assemblages and through time, permitting recognition of potential palaeo-environmental controls on the observed distribution of Ediacaran macrobiota. Preliminary findings suggest broad overlap in palaeo-environments between key sites, with deltaic, shoreface, and offshore shelves represented in all studied basins. However, subtle but important differences between sites have the potential to influence interpretation of true organism diversity and community structure. For example, a higher prevalence of transported biota in the Nama assemblage compared to the White Sea or Avalon assemblages, and far more extensive deltaic deposits in the Avalon (100s of meters thick) than in the White Sea or Nama (10s of meters thick) may account for some variation in community composition, ecosystem maturity, and organism size. Comparisons of taxonomic diversity through time that rely on comparisons between biotic assemblages must account for facies-scale palaeo-environmental variability, to distinguish ecological or environmental controls from evolutionary patterns. Macrofossils are strongly facies- and environment-dependant in all studied sections, with implications for the magnitude of proposed late Ediacaran extinction events.

Keyword

Ediacaran, mass extinctions, white sea, nama, avalon

Morphological complexity as a potential predictive indicator of evolutionary rates in ammonoids

Luyi Miao[1]*, State Key Laboratory of Biogeology and Environmental Geology, School of Earth Sciences, China University of Geosciences, Wuhan 430074, China. (miaoluyi@cug.edu.cn)
Arnaud Brayard[2], Biogéosciences, UMR 6282, CNRS, Université de Bourgogne
Dieter Korn[3], Museum für Naturkunde, Leibniz-Institut für Evolutions- und Biodiversitätsforschung
Xu Dai[4], State Key Laboratory of Biogeology and Environmental Geology, School of Earth Sciences, China University of Geosciences
Haijun Song[5], State Key Laboratory of Biogeology and Environmental Geology, School of Earth Sciences, China University of Geosciences

Abstract

The heterogeneity of evolutionary rates is a key issue in the field of macroevolution. The origination and extinction rates are controlled by abiotic factors such as climate and geography, as well as biotic factors such as species diversity and competitive interactions. However, the possible relationship between morphological complexity and evolutionary rates is largely unknown.

To explore the link between morphological complexity and evolutionary rates in ammonoids, we propose a new method, the Ornamentation Index (OI), for quantitatively describing the ornamentation complexity of ammonoids through 3D models. This new approach was applied at the genus- and species-levels on 462 Cretaceous genera and 212 Early Pliensbachian species and. The results show that ammonoids with a high complexity (strongest and more complex ornamentation) have generally a short longevity, whereas those with a simpler or less pronounced ornamentation persist over longer periods. In addition, ammonoids with a more complex ornamentation tend to exhibit higher origination and extinction rates compared to those with a simpler morphology.

As the development of ornamentation in shelled animals is often related to ecological habits, and affect functions such as hydrodynamic properties, anti-predation, shell building, sensory function, it may also indirectly influence the ecological niche of organisms. The potentially increased energy requirements of strongly ornamented groups may favor their presence in ecosystems with a higher species richness and a greater energy availability, which in turn may facilitate a more rapid pace of evolution within these niches . Additionally, for the Cretaceous case studies, the analyse of the relationship between the ammonoid ornamentation complexity and their latitudinal distribution shows that low paleolatitudes contained more strongly ornamented forms, whereas higher paleolatitudes tend to harbour species exhibiting a weaker shell ornamentation. Furthermore, complex species possess greater phenotypic plasticity and a broader range of variation, which can have led to possible more rapid morphological divergences and thus, to a higher propensity for speciation for some ammonoid groups.

Keyword

morphological complexity, ammonites, morphological macroevolution, origination and extinction rates

Recognition and timing of Early-Middle Devonian extinction events in South Polar regions

Cameron Roy PENN-CLARKE[1]*, Evolutionary Studies Institute, University of the Witwatersrand, Johannesburg (Cameron.Penn-Clarke@wits.ac.za)
David Harper[2], Palaeoecosystems Group, Department of Earth Sciences, Durham University, Durham, UK
Clarisa Vorster[3], PPM Research Group, Department of Geology, University of Johannesburg, Johannesburg, South Africa

Abstract

Multiple biocrises are recognised throughout the Devonian, of which those from the Late Devonian are perhaps most well-studied. Biocrises from the Early-Midde Devonian have received comparatively less attention. Growing evidence suggests that a number of these biocrises, namely the “Kačák” (terminal Eifelian) and “Taghanic” (middle Givetian), were of such severity that both rank in the 10 largest mass extinction events of the Phanerozoic and are part of a long-term declining biodiversity trend which culminated in the Late Devonian mass extinctions. Eifelian and Givetian biocrises are noteworthy in that they are associated with the collapse of endemic bioregions and a shift towards cosmopolitan faunas, typified by the progressive invasion of warmer-water taxa into higher latitudes, termed the “Great Devonian Interchange”. The extent of Eifelian and Givetian biocrises has recently been recognised at south polar regions, making them global phenomena. Here, these events are suspected to be associated with the collapse of the Malvinoxhosan bioregion and extinction of its endemic biotas. In South Africa the extinction of the Malvinoxhosan biotas show a stepped decline in biodiversity correlated with changes in local base-level at varying orders of magnitude, with high survivorship among cosmopolitan taxa. Although changes in sea-level seems to be responsible, there is no appreciable change in overall environment suggesting a complex extinction mechanism at play.

Detrital zircons from the Devonian System in South Africa have been utilised to link changes in base-level with tectonic activity and constrain maximum ages for biotic turnover events. At least two proximal detrital sources are identified, the Neoproterozoic-Cambrian Pan-African Belts and post Pan-African Cambrian-Ordovician supracrustals, with distal sourcing from the Cambrian-Ordovician Famatinian Belt and Silurian-Devonian aged Patagonian massifs. Zircons from Famatinian and Patagonian sources show a trend of younging and increasing frequency and are almost always associated with the stratigraphic range of the Malvinoxhosan biotas, peaking in frequency during major transgressive phases. Maximum ages from youngest zircons from strata associated with biotic turnovers returned maximum depositional ages of 405±14 Ma, 394±5 Ma, and are in range of the Zlichov, Daleje, and Choteč events whilst the final appearance of the Malvinoxhosan biotas is associated with of 387±7 Ma and 382±15 Ma zircons, in range of the Kačák and Taghanic events. Following the extinction of Malvinoxhosan biotas, detrital zircons are almost always exclusively from Pan-African sources. This further coincides with an overall regressive stacking pattern into the overlying Witteberg Group. Time-sliced palaeogeographic

reconstructions further show reorganisation of basin morphology, notably shifts in palaeoshoreline orientation, coincident with base-level changes suggesting lithospheric flexure. Collectively the convergence of Patagonia with Gondwana affected tectonics, palaeogeography and allocyclicity in the Cape Basin (and associated West Gondwana depocentres). Such changes in tectonics and palaeogeography suggest that the convergence of Patagonia with Gondwana might have also broken-down allopatric barriers to speciation, such as circumpolar currents, perhaps influencing extinctions at a global scale.

Keyword

Devonian, Mass extinctions, Turnover, Malvinoxhosan, Biodiversity

Early Palaeozoic biodiversifications: Plus ça change

David A.T. HARPER[1]*, Durham University (david.harper@durham.ac.uk)
Bertrand LEFEBVRE[2], CNRS, Universite de Lyon1
Thomas SERVAIS[3], CNRS, Universite de Lille

Abstract

Life has diversified on Earth during the past four billion years. 19th Century savants presented models for the gradual increase in diversity and complexity of animals during the Phanerozoic, punctuated by some mass extinctions. More recently views have diverged from those espousing gradual change to those focused on sudden, rapid diversity pulses, based on the interrogation of large databases. The new generation of data capture and evaluation relies on big data and sophisticated analytical techniques. Results, however, are not consistent in all the available big databases; each database is not truly global. The origins and early diversifications of groups of animals are diachronous in both time and space, whereas large hikes in biodiversity in some groups are due to intensive study of a number of key continents, mainly North America and Europe, especially Scandinavia, with large numbers of palaeontologists involved. For example new data from China demonstrate there is no Furongian Gap in the late Cambrian, that artificially separated the Cambrian and Ordovician radiations. Instead increasing diversity segues seamlessly through the Cambrian – Ordovician boundary; high-latitude Early Ordovician biotas contain significant numbers of exceptionally-preserved faunas, some more typical of Cambrian Lagerstätten. We are far from de-colonizing our data: much data especially from the global south may continue to change our perception of biodiversity change and continue to fill in gaps in the fossil record. Interestingly, there is another approach that may be more robust. A recent compilation of the first occurrences of higher taxa such as phyla indicates that most were already present in the late Proterozoic and the early Cambrian, corresponding to the concept of the Cambrian Explosion. The cumulative arrival of orders, families, genera show a gradual and long-term increase during the entire Ordovician. As biases are mitigated and new data added, a vision emerges of a single long-term radiation of Early Paleozoic animal diversity following its initiation in the Proterozoic and earliest Phanerozoic, a view not that different from that of our 19th Century pioneers. Plus ça change.

Keyword

Cambrian, Ordovician, palaeobiodiversity, palaeobiogeography

Foraminiferal biodiversity changes to interpret the paleoenvironmental perturbation across the Late Cretaceous Oceanic Anoxic Event 2 at southern high latitudes (IODP Sites U1513 and U1516, SE Indian Ocean)

Maria Rose PETRIZZO[1]*, University of Milan, Department of Earth Sciences (mrose.petrizzo@unimi.it)
Giulia Amaglio[2], University of Milan, Department of Earth Sciences
Erik Wolfgring[3], University of Vienna, Department of Palaeontology

Abstract

Oceanic Anoxic Event 2 (OAE 2), at the Cenomanian/Turonian boundary (93.9 Ma), was an episode of major perturbation in the global C cycle with a delta13C excursion of 2-3‰ documented worldwide. The boundary interval is also accompanied by warming of the ocean with surface-ocean temperatures that reached 36°C at low latitudes and equator-to-pole sea surface temperature gradients reduced to 5°C.

To investigate the pattern of response of biota to the environmental perturbation at high latitudes, we present microfossils and geochemical data from Integrated Ocean Discovery Program (IODP) Sites U1513 and U1516 drilled in the Mentelle Basin (NE Indian Ocean; paleolatitude 60° S in the Late Cretaceous).

The lithology is composed of alternating sequences of gray and black nannofossil-rich claystone with carbonate content ranging from 0.6 to 70 % gradually increasing from the base to the top except for an interval in the middle part of OAE 2 composed by siliceous and organic matter-rich sediments and lacking carbonate that spans most of the delta13C positive excursion.

The assemblage composition, distribution and variations in abundance of planktonic and benthic foraminifera, radiolaria, and calcipheres are examined in light of their known paleoecological preferences to understand changes in biodiversity related to the OAE 2 perturbations in surface and bottom waters.

Below and in the lower part of OAE 2, planktonic foraminifera are dominated by small-sized (125-38 micronm) opportunistic species of *Microhedbergella*, and *Muricohedbergella*. This interval coincides with a dominantly eutrophic regime in the surface waters. Benthic foraminifera illustrate a depauperate community with the dominance of *Gavelinella*, *Gyroidinoides* and *Stensioeina*. Opportunistic agglutinated *Glomospira* and *Ammodiscus* occur at both sites indicating low oxygen conditions and low organic flux at the seafloor.

The middle part of OAE 2 (plateau phase of the delta13C profile) is masked by absence of carbonate, by the highest TOC values, and dominance of radiolaria indicating this interval corresponded to a time of highly stressed eutrophic conditions with possible shoaling of the Carbonate Compensation Depth. In this interval planktonic foraminifera and calcareous benthic foraminifera are almost absent.

Conditions moderate after this extreme environmental perturbation as reflected by the planktonic

foraminiferal assemblages that show changes in composition. Species occupying relatively deep ecological niches as *Dicarinella* and *Praeglobotruncana* appear, and the overall increase in diversity and abundance indicates a more stable and stratified water column. The higher taxonomic diversity and higher number of low oxygen tolerant benthic foraminifera as *Gavelinella* and *Conorboides* reflects the repopulation of bottom waters, likewise the agglutinated and infaunal foraminifera show an increase in abundance, particularly *Clavulinoides* and *Spiroplectammina*, that was mostly influenced by food supply rather than fluctuations in the oxygen availability.
Overall, this study provides a complete record of the foraminiferal biodiversity across the OAE 2 at high latitudes allowing to understand their evolution that seems to vary among species and proceed at different paces, resulting in the establishment of novel communities that differ from those existing before the environmental change.

Keyword

Oceanic Anoxic Event 2, Late Cretaceous, Foraminifera, paleoenvironmental changes

Pioneering Data-Driven Discoveries from DeepBone.org

Zhaohui PAN[1]*, Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences (panzhaohui@ivpp.ac.cn)
Haohan Wang[2], Qujing Normal University
Min Zhu[3], Institute of Vertebrate Paleontology and Paleoanthropology, Chinese Academy of Sciences

Abstract

DeepBone.org has solidified its role as a crucial resource in vertebrate paleontology, presenting extensive datasets that catalyze data-driven research across several major clades, including Antiarcha, Agnatha, and Proboscidea. Beyond the datasets already published or under review, our efforts to continuously expand and refine data collections across other taxa are unwavering. This initiative is revolutionizing the methodologies employed in studying the paleobiogeographic evolution and biodiversity changes through deep time in vertebrates, shedding light on the dynamics sculpting vertebrate history. By integrating detailed specimen-based datasets with sophisticated quantitative analyses, DeepBone.org facilitates in-depth examinations of vertebrate spatial and temporal distribution patterns, thus elucidating the complex interplay of factors influencing biodiversity and evolutionary patterns.

To demonstrate the significant impact of DeepBone.org, we highlight a series of case studies, including the biogeographic networks and taxonomic revisions of Antiarcha, alongside the investigation into Proboscidea's diversity through different epochs. These instances emphasize the database's essential role in addressing critical questions within vertebrate paleontology, such as resolving contentious taxonomic units, refining character matrices for specific clades, variations in species distributions, paleogeographic dynamics, and the effects of climatic and environmental transformations on vertebrate populations over geological time intervals. New advances augment our comprehension of vertebrate evolution and showcase the importance of adopting deep-time perspectives in conservation biology strategies.

Leveraging DeepBone's exhaustive dataset, we have meticulously compiled and analyzed the last decade of literature in vertebrate paleontology. This bibliometric analysis reveals an increase in vertebrate paleontology research activity and publications. Key contributions stem from resource-rich countries and those with robust research infrastructures. Significantly, the study identifies the rise of new research areas such as Biodiversity Conservation, Biochemistry, and Molecular Biology, marking a shift towards broader and more varied research interests. These areas now emerge as notable trends in vertebrate paleontology, reflecting the expansion of the field into more diverse scientific domains.

In conclusion, DeepBone.org marks a pivotal shift towards a data-centric paradigm in vertebrate paleontology, transforming the study of Earth's vertebrate history. This platform enhances our understanding of vertebrate diversity and its future trends and exemplifies the integration of traditional paleontological methods with advanced data analysis techniques. Our work highlights DeepBone.org's essential role in advancing vertebrate evolution studies, laying a solid

groundwork for future data-driven research. By utilizing its extensive datasets and analytical tools, researchers are empowered to test new hypotheses, refine theories, and engage in interdisciplinary collaborations. DeepBone.org is unlocking unprecedented insights into the complex evolution of vertebrates, fostering research that extends beyond academic curiosity to address vital biodiversity conservation and environmental management challenges.

Keyword

DeepBone.org, Vertebrate Paleontology, Data-Driven Peleontology, Quantitative Analyses

Latitudinal Shift Patterns of Taxa Through the Phanerozoic

Shuhan Zhang[1]*, Nanjing University (shuhanzhang@smail.nju.edu.cn)
Shuzhong Shen[2], Nanjing University

Abstract

The fossil record documents climate-induced range shifts in taxa, but the nature and scale of these dynamics remain unknown. Numerous genera have shifted their distributions at different scales and magnitudes in response to various environmental changes. In this study, we utilized global fossil data to quantitatively analyze latitudinal shifts (LS) for taxa throughout the Phanerozoic. Employing a variety of indices, we quantified LS, and subjecting the data to rigorous quality control and subsampling techniques to assess the robustness of the results. Furthermore, we employed network analyses to unearth the spatial and temporal intricacies of the LS throughout the Phanerozoic, and the Coverage Cross Mapping method was employed to detect causal relationships between the LS and environmental changes. Our study revealed several intervals characterized by elevated taxon shifts, and the Permian, late Triassic, and late Cenozoic showed most significant signals. These intervals with active biotic shifts were associated with transitions between icehouse and greenhouse climates and large fluctuations in global average sea surface temperature and pCO2. Shifts were concentrated at more southerly latitudes early in the Phanerozoic and more northerly latitudes later in the Phanerozoic. This long-term, northward movement in where shift hotspots occur was likely caused by continental migration northward. We conclude that frequent drastic changes in climate and persistent continental movements are the driving forces behind the magnitude and scale of LS dynamics. These results inform our understanding on how species will respond and move under ongoing rapid anthropogenic change.

Keyword

latitudinal shifts, Phanerozoic, evolution, environmental changes, biotic dispersal

Dynamic Linking of Progressive Exhumation to Mendocino Triple Junction Migration

yudan SI[1]*, china university of geoscience (beijing) (sydancugb@gmail.com)
shaofeng liu[2], china university of geoscience (beijing)

Abstract

Deciphering exhumation processes at Earth's surface provide insight into tectonic processes, long-term climate change, and paleoenvironmental conditions. An intriguing study area is the California Coast Ranges and the San Andreas Fault strike-slip system, influenced by the subduction of the Pacific-Farallon Ridge beneath the North American plate around 30 Ma. Understanding the temporal and spatial variations in exhumation rates and their connection to crustal deformation and deep mantle flow remains a challenge. We employ a novel approach that combines age-elevation relationships and multiple thermochronometric systems with different closure temperatures to estimate the exhumation history along the San Andreas Fault since 32 Ma. Our analysis of 731 published thermochronometric ages reveals consistently low and non-uniformly distributed exhumation rates (0.05-0.2 km/Myr) until approximately 4 Ma, coinciding with a period of intensified global glacial erosion. Notably, non-simultaneous rapid exhumation events (0.2 km/Myr) occur in different regions and propagate northwestward, showing consistency with the migration of the Mendocino Triple Junction (MTJ) as indicated by global plate reconstructions. Moreover, we observe hysteresis in the migrating pioneer belts of the rapid exhumation zone compared to the time-dependent position of the MTJ over a considerable distance.

Our findings indicate that climate only significantly influences the erosion process from 4 to 0 Ma, during the period of increased global erosion rates, putatively due to enhanced glacial processes. However, overall progressive rapid exhumation is primarily controlled by tectonic factors rather than climate. The crustal uplift inferred suggests a response to the upwelling of the asthenosphere in the slab gap during the MTJ migration, and the pioneer belts of the rapid exhumation zone can be interpreted as the northern boundary of the slab window. The observed hysteresis in the pioneer belts implies the tearing of the subducting plate towards the north during slab detachment. This model emphasizes the intricate coupling between lithosphere evolution, asthenosphere upwelling, and the constraints on the process of slab tearing, shedding light on the complex interplay of tectonic and climatic forces in shaping the California Coast Ranges and the San Andreas Fault system.

Keyword

Mendocino Triple Junction, progressive exhumation, slab window, California coast

[Invited] Toward a "best-fit" tectonic reconstruction for the Caroline Plate: Oceanic plateau-subduction zone interaction as a driver for plate boundary reorganization?

Samuel MARTIN[1]*, University of British Columbia (smartin@eoas.ubc.ca)
Nicholas Ellis[2], University of Michigan
Jolante van Wijk[3], Los Alamos National Laboratory
Jonny Wu[4], University of Arizona

Abstract

The Caroline Plate is located at the complex junction of the Pacific, Philippine Sea, and Indo-Australian Plates, where there is significant uncertainty regarding how late Eocene to recent Pacific-Philippine Sea Plate convergence was accommodated. At the Caroline Plate's western boundary with the Philippine Sea Plate, arc-affinity rocks suggest late Eocene through early Miocene subduction; however, subsequent seafloor spreading in the Ayu Trough seems to preclude later convergence at this boundary. The plate's poorly-studied eastern boundary with the Pacific Plate could have accommodated the remaining convergence, but seafloor morphology and geophysical observations do not suggest a significant subduction history. Despite this ambiguity, previous plate reconstructions have generally coupled the Caroline Plate to either the Pacific or the Philippine Sea Plate, requiring all convergence to occur at the plate's western or eastern boundary, respectively.

At the northern Caroline Plate-Pacific Plate boundary, a transtensional rift (the Sorol Trough) bisects the Caroline Ridge, an oceanic plateau/large igneous province. Several researchers have suggested an early Miocene collision between the plateau and the Caroline-Philippine Sea Plate boundary jammed the subduction zone and possibly led to the Sorol Trough's development, but implications of this event for the Caroline Plate's other boundaries have not been thoroughly considered. To better constrain the plateau's emplacement age, we used a probabilistic approach to obtain quantitative age estimates from microfossil assemblages cored at four Deep Sea Drilling Program sites on the plateau, three of which reached basaltic substrate. These depositional ages (~25-26 Ma) are generally consistent with radiometric ages of underlying basalts and suggest a ~4-5 Myr time gap between the plateau's emplacement and its collision with the trench.

We present a new tectonic reconstruction for the Caroline Plate, aiming to elucidate the subset of possible models which should contain the best-fit solution to geologic evidence for past relative motions. Considering the Pacific-coupled and Philippine Sea-coupled models as end members, we modified regional reconstructions to test a simple intermediate model in which the Caroline Plate was fully coupled to the Pacific Plate until 20 Ma, the approximate age of plateau-trench collision. Due to subduction zone jamming, the Caroline Plate was then fully coupled to the Philippine Sea Plate from 20 to 0 Ma, requiring active boundaries to develop between the Caroline and Pacific

Plates, including the Sorol Trough. Advantages of this model include its compatibility with both pre-20 Ma arc volcanism and later seafloor spreading at the Caroline Plate's western boundary, and less total convergence required at the plate's eastern boundary compared to the Philippine Sea Plate-coupled model. However, ~700-900 km of post-20 Ma Pacific-Caroline convergence and left-lateral slip along the Sorol Trough are still required, far greater than observation-based estimates. The amount of required convergence would be lower if the Caroline-Philippine Sea Plate coupling was incomplete or of shorter duration. Thus, the best modeling solution likely lies between the Pacific-coupled and intermediate models. Improved understanding of Pacific-Philippine Sea relative motions may also help resolve apparent discrepancies between observational constraints on the Caroline Plate's tectonic evolution.

Keyword

plate reconstruction, subduction, large igneous province, western Pacific, island arc

[Keynote] Topography and deformation of the Polar regions measured with thermochronometry

Matthew College Fox[1]*, University College London (m.fox@ucl.ac.uk)

Abstract

Earth's surface is shaped by tectonic processes and erosion. Knowledge of the evolution of Earth's surface is required across all aspects of the Earth Sciences. In the Polar regions, in particular, the topography hosts ice sheets which control global sea level. In turn, changes in the topography change the potential to support large ice sheets. Furthermore, changes in ice sheet extent may not always be due to climatic variability, but due to evolving topography. Therefore it is crucial to measure topographic evolution across the Polar regions. One method that has been used to measure topographic change is low-temperature thermochronometry. The basis of this approach is that as valleys incise, rocks at the base of the valleys are brought to Earth's surface and cool. It is this cooling that can be measured with thermochronometry. Traditional approaches, where bedrock is accessible, rely on the potential to measure differences in cooling rates, and timings, between valley bottoms compared to surrounding peaks. In the Polar regions, this is not possible because the valley bottoms are covered by ice. Detrital methods exploit the processes of glacial erosion and sediment transport to gain indirect access to samples from below the ice. Using this approach, we can build three dimensional thermal models to constrain likely topographic evolution. I highlight this approach for areas in Antartica and Greenland, and show the unique potential of this method.

Keyword

Thermochronometry, Ice sheets, Heat flow, Inverse methods

Non-cylindrical Slab Subduction and Tearing beneath Southern Iberia

Pengfei MA[1]*, Taiyuan University of Technology (mapengfei@tyut.edu.cn)

Abstract

Oroclines emerge from subduction processes governed by the negative buoyancy of descending slabs. This system becomes particularly complex in the constrained oceanic basins nestled between continental landmasses, where the irregularity at the boundary between continents and oceans exacerbates the intricacies of subduction dynamics. A prime example of such geological complexity is observed in the Betic-Rif orogenic system, which effectively seals off the Western Mediterranean. This system is characterized by an asymmetric orocline, intricately associated with the dynamics of the Gibraltar subduction zone. Despite the critical geological insights it offers, our comprehension of the interactions between the plate and mantle during the Betic-Rif orogeny remains incomplete, especially concerning the mechanisms of trench retreat, the formation of the non-cylindrical Gibraltar slab, and the connection between the deformation of the Iberian lithosphere and slab subduction.

To bridge these knowledge gaps, we have developed advanced four-dimensional thermo-mechanical models grounded in detailed plate reconstructions. These models aim to elucidate the evolution of plate-mantle interactions in the Western Mediterranean region since the Oligocene epoch. Our research findings are strongly supported by seismic tomography and the broader context of regional tectonics, validating the crucial influence exerted by the unique rotational and rollback motions of the Gibraltar slab on its distinctive non-cylindrical shape. Moreover, through meticulously designed control experiments, we have uncovered how changes in the strength of the continental margin can significantly interfere with the tearing of the Gibraltar slab. Such variations also lead to a delayed decoupling between the slab and the Iberian lithosphere, subsequently impacting the migration patterns of the trench. These revelations shine a light on the complex and multifaceted interactions that occur between subduction zones, the mantle, and the lithosphere in the assymetric subduction zone system.

Keyword

Betic-Rif orogeny, Geodynamic simulation, plate-mantle interplay

High-elevation Tibetan Plateau before India–Eurasia collision recorded by triple oxygen isotopes

Xiangrui Liu[1]*, China university of geosciences Beijing (lxr_1129@163.com)
Jingen Dai[2], China university of geosciences Beijing

Abstract

The timing and magnitude of the early Cenozoic surface uplift of the Tibetan Plateau pose a challenge due to the limited availability of unaltered terrestrial sediments crucial for paleoaltimetry methods. Nevertheless, this data is pivotal for elucidating the geodynamic and paleoclimatic evolution of the Indian and Eurasian landmasses, as well as for interpreting global climatic patterns, biodiversity trends, and biogeochemical cycles since the Cenozoic era. Our analysis reveals a significant uplift occurring by 63 to 61 million years ago, predating the collision between the Indian and Eurasian continental plates. This inference is drawn from a comparison of triple oxygen isotopes in contemporary meteoric waters with those found in quartz veins containing epithermal Ag–Pb–Zn deposits from the Palaeocene Gangdese Arc in southern Lhasa. The observed low $\delta^{18}O$ and $\delta^{17}O$ values in the quartz indicate precipitation from meteoric waters influenced by substantial topographic rainout effects. Our findings indicate that by 63 to 61 million years ago, the Gangdese Arc had attained an elevation of approximately 3.5 km, suggesting that it had achieved over 60% of its present height prior to the collision between continents. This uplift likely resulted from crustal shortening in response to the shallow-angle subduction of the Neo-Tethyan oceanic lithosphere. This early estimation of high paleoelevation for the Himalaya–Tibetan system challenges previous assumptions suggesting that the uplift of southern Tibet necessitated continent–continent collision for substantial topographic formation.

Keyword

Tibetan Plateau, Paleoaltimetry, Triple oxygen isotopes, Gangdese Arc, India-Eurasia collision

Tectonic and topographic evolution of the Eastern Himalayan Syntaxis

Zhicheng Yu[1]*, China University of GeosciencesBeijing (yuzhicheng_cugb@163.com)
Jingen Dai[2], China University of GeosciencesBeijing

Abstract

The Eastern Himalayan Syntaxis (EHS), one of the most tectonically active regions on Earth, offers a unique opportunity to explore the intricate relationship between tectonics and surface exhumation processes. Dominated by the imposing Namche Barwa (7782 m) and Gyala Peri (7294 m) mountain groups, separated by the deep Yalung–Tsangpo river gorge, the EHS holds significant implications for understanding the uplift of the Tibetan Plateau and its broader impacts on climate and the interactions among tectonics, erosion, and climate. The tectonic evolution of the Namche Barwa massif is pivotal in unraveling the complex uplift history of the region. Trigger mechanisms for the rapid exhumation of the Namche Barwa massif remain subject to debate, with at least seven models proposed to analyze the geodynamic evolution of the EHS. Central to these debates are the contrasting models of a stationary or localized "tectonic aneurysm" versus a northeasterly "migrating crustal antiform." Given the formidable challenges of sampling at Namche Barwa Peak, researchers often rely on samples from surrounding areas and the foreland basin to infer the exhumation history of the core. Synthesizing data from thermochronology, thermal-kinematic models, seismicity, and structural geology reveals complex temporal and spatial patterns in age distribution and exhumation history. However, discrepancies arising from differences in sampling locations and methodologies continue to fuel controversies surrounding the mechanism and timing of rapid exhumation in the eastern syntaxis. Previous studies have employed multidisciplinary approaches to constrain the exhumation history across various time scales. Initially, it was proposed that coupling between crustal rock advection and surface erosion commenced in the late Miocene (8–10 Ma). However, subsequent research challenges this view, suggesting a Quaternary onset of rapid exhumation primarily driven by tectonic mechanisms. Recent research findings propose a three-stage history that reconciles seemingly contradictory evidence regarding the timing of rapid exhumation since the late Miocene. The rapid exhumation of Namche Barwa is influenced by a myriad of factors, including tectonic uplift, high river power, relief, glacial activity, and megafloods erosion. Quantifying the individual contributions of these factors to rapid exhumation poses a significant and ongoing challenge in the field.

Keyword

Eastern Himalayan Syntaxis, Geodynamic evolution, Exhumation history

The crustal and uppermost mantle Vs structure of the middle and lower reaches of the Yangtze River Metallogenic Belt: implications for metallogenic process

Yingjie YANG[1]*, Southern University of Science and Technology (yangyj@sustech.edu.cn)
Yongqian Zhang[2], Chinese Academy of Geological Sciences
Qingtian Lü [3], Chinese Academy of Geological Sciences

Abstract

The Middle and Lower Reaches of the Yangtze River metallogenic belt (MLYMB) is one of the most important Fe-Cu polymetallic belts in China. However, the mechanism and deep geodynamical process for the formation of this belt are still controversial. Here, we obtain the crustal and the uppermost mantle structures using ambient noise data from a dense seismic profile. A low velocity zone (LVZ) is revealed beneath the Moho of MLYMB, interpreted as the source of the deep mineralization materials. In addition, a low velocity layer (LVL) and a high velocity layer (HVL) are observed in the crust of the southern segment of the profile. The LVL is interpreted as a tectonic detachment layer between the upper and the lower crust, and the HVL is interpreted as the aggregation zone for mineralizing melts or crystallized magma chambers. Based on the observed velocity features, we propose a three-stage model for the formation of ore deposits in MLYMB. Our model suggests that an upwelling of asthenosphere triggered by the delamination of a previously thickened lithosphere leads to the partial melting of upper mantle rocks, which eventually ponders under the Moho. The magma then infiltrates through the ductile lower crust and reaches a depth of ~7-13 km, forming a minerals-enriched magma chamber. Minerals-rich hot fluids originating from the magma chamber continue to move upward along the pre-existent faults and the minerals finally precipitate in dense veinlets when reaching shallow depths, forming the ore deposits in and around the MLYMB.

Keyword

Middle and Lower Reaches of the Yangtze River, Metallogenic belt, Ambient noise tomography, Shear wave velocity, Metallogenic model

[Keynote] Archean lithospheric mantle beneath Neoproterozoic Central Asia Orogenic Belt: significance of Archean lithosphere in the evolution of younger terranes

Kuo-Lung WANG[1]*, Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan (kwang@earth.sinica.edu.tw)
Suzanne Y. O'Reilly[2], GEMOC/CCFS Key Centre, School of Natural Sciences, Macquarie University, Sydney, Australia
Victor Kovach[3], Institute of Precambrian Geology and Geochronology, Russian Academy of Sciences, St. Petersburg, Russia
Sergei Dril[4], Institute of Geochemistry, Siberian Branch of Russian Academy of Sciences, Irkutsk, Russia
MIkhail I. Kuzmin[5], Institute of Geochemistry, Siberian Branch of Russian Academy of Sciences, Irkutsk, Russia
Vladimir Yarmolyuk[6], IGEM, Russian Academy of Sciences, Moscow, Russia
Vladimir Prikhodko[7], bInstitute of Tectonics and Geophysics, Far Eastern Branch, Russian Academy of Sciences, Khabarovsk, Russia
Yoshiyuki Iizuka[8], Institute of Earth Sciences, Academia Sinica, Taipei, Taiwan
William Griffin[9], GEMOC/CCFS Key Centre, School of Natural Sciences, Macquarie University, Sydney, Australia
Norman Pearson[10], GEMOC/CCFS Key Centre, School of Natural Sciences, Macquarie University, Sydney, Australia

Abstract

Earth's continents are underlain by "roots"- 100-250 km thick of depleted mantle rocks, and the properties and history of these roots affect the long-term stability of the continents. Recent studies have demonstrated that Os model-age spectra from mantle xenoliths commonly show age peaks corresponding to the ages of thermal/tectonic events in the overlying crust. These deep-seated events are generally mirrored in the crust suggesting strong linkages between crust and mantle. The Central Asian Orogenic Belt (CAOB) is proposed as the largest area of crustal growth in the Phanerozoic with ca. 50-60 % juvenile crust (Şengör et al., 1993; Jahn, 2004). Processes for deriving juvenile material from the mantle and accreting vertically are expected to have affected the subcontinental lithospheric mantle (SCLM) beneath. Cenozoic alkali basalts occur throughout Central and East Asia encompassing southern Siberia, central and southern Mongolia, NE China and the Russian Far East. Some basalts carry fragments of mantle rocks that provide direct evidence on the nature and composition of the deep lithosphere and contain a record of mantle processes. In this study, we summarize in-situ Os model ages on sulfides in peridotitic xenoliths from off-cratonic settings (in the basalts from Tariat (1.5 Ma), Mongolia; Vitim (14 and 0.65 Ma), Khamar Daban Range (KDR; 17 Ma) and Sviyaginsky volcano (12 Ma), Russia) in the CAOB to examine SCLM formation. Mantle xenoliths collected from these volcanic fields are mainly spinel lherzolites, with garnet- and spinel-garnet lherzolites only found in Vitim. Geochemical evidence suggests these lherzolites represent residual SCLM, some of which is quite refractory and may be ancient. Most of both their Os TMA from the least-disturbed sulfides ($^{187}Re/^{188}Os<0.07$) and

TRD from higher Re/Os sulfides without later introduction/loss of Os, yield model ages ranging from 0.3 to 3.0 Ga, with peaks around 1.7-1.4, 1.2-0.9 and 0.7-0.5 Ga (Wang et al., 2013; 2015). These ages suggest that the certain proportions of the SCLM beneath the CAOB formed at least by the Proterozoic time, and that some domains are Archean. Younger sulfide Os ages (1.2-0.9 and 0.7-0.5 Ga) may mark the commencement of the Central Asia Orogeny since the Neoproterozoic and involvement of the mantle as suggested by Jahn (2004). These sulfide Os ages, recording formation of the SCLM and subsequent metasomatism by juvenile crustal-growth events, are consistent with the thermotectonic events recorded in the overlying crust of the ancient microcontinents where the sampled volcanic fields locate. All geochemical characteristics of these peridotites reveal that ancient, refractory Archean-Proterozoic lithospheric mantle is embedded in the younger, fertile post-Archean lithospheric mantle beneath the CAOB. The ancient Archean-Proterozoic mantle domain has survived but may have been subjected to metasomatic re-enrichment during Central Asia Orogeny since the Neoproterozoic and the Cenozoic extension with intraplate volcanism in this region. Comparing the lithospheric mantle domains from the above regions as revealed by Os model ages, with ancient microcontinents at least Mesoproterozoic in age and predating formation of the CAOB significantly diminishes the volume of new juvenile crust generated during the orogeny (Kroner et al., 2017).

Keyword

lithospheric mantle, mantle xenoliths, Os isotope, Archean, Proterozoic

Crustal architecture of the Newfoundland Appalachians and its control on metallogeny

Chaoyang WANG[1]*, 1. SinoProbe Laboratory, CAGS, Beijing, 100094, China (wangcags@126.com)
Tao WANG[2], 1. SinoProbe Laboratory, CAGS, Beijing, 100094, China; 2. Beijing SHRIMP Center, Institute of Geology, CAGS, Beijing 100037, China
Cees VAN STAAL[3], 3. Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, Ontario, Canada;
Zengqian HOU[4], 1. SinoProbe Laboratory, CAGS, Beijing, 100094, China;
Shoufa LIN[5], 3. Department of Earth and Environmental Sciences, University of Waterloo, Waterloo, Ontario, Canada;
Jianjun ZHANG[6], 1. SinoProbe Laboratory, CAGS, Beijing, 100094, China

Abstract

The Newfoundland Appalachians preserves one of the most complete and best exposed cross-sections through the Appalachian Mountain's belt.

This study presents the whole-rock Nd isotope mapping of felsic-intermediate igneous rocks from the Newfoundland Appalachians using datasets of 418 Sm-Nd data with ages, including 71 new analyses. The results show that the Humber Belt, the Notre Dame Subzone, the Exploits Subzone, the Gander Belt, and the Avalon Belt have the different Nd Isotopic characteristics. The juvenile crust (εNd(t) value > 0), accounting for 40% of the isotope-mapped area, is mainly distributed on both sides of the suture line (Beothuk Lake Line) between the Notre Dame subzone and the Exploits subzone, as well as in the Avalon Belt. Additionally, although the Exploits subzone and the Gander subzone have different compositions, there is similarity in the central part, and we considered that both of them belong to the same micro-continent (Ganderia). It is also consistent with the geophysical results. The juvenile crustal provinces in the Notre Dame and Exploits subzones control the volcanic-type Cu-Zu deposits. Various types of Au ores are mainly distributed in the old crustal province within the Gander Belt. The distribution of porphyry Cu ores is more inclined towards the juvenile crustal province (Avalon Zone). Our research shows that the isotopic mapping of the deep material composition can provide direct evidence for the delineation of the tectonic units and their control on metallogeny.

Keyword

juvenile crust, Nd isotopic mapping, Newfoundland Appalachians, metallogeny

Continental growth and orogenic typesBig data of magmatic rocks

TAO WANG[1]*, 1. Beijing SHRIMP Center, Institute of Geology, CAGS, Beijing 100037, China; 2. SinoProbe Laboratory, CAGS, Beijing, 100094, China (taowang@pku.edu.cn)
He HUANG[2], 2. SinoProbe Laboratory, CAGS, Beijing, 100094, China
Chaoyang Wang[3], 2. SinoProbe Laboratory, CAGS, Beijing, 100094, China
Ying TONG[4], 1. Beijing SHRIMP Center, Institute of Geology, CAGS, Beijing 100037, China; 2. SinoProbe Laboratory, CAGS, Beijing, 100094, China
Lei GUO[5], 2. SinoProbe Laboratory, CAGS, Beijing, 100094, China
Jianjun ZHANG[6], 2. SinoProbe Laboratory, CAGS, Beijing, 100094, China

Abstract

The continental crust distinguishes Earth from other planets and records its unique evolutionary history characterized by its assembly and growth during orogenesis. Many issues are still not known well, including whether voluminous Phanerozoic growth occurs or not, what are the relationships of the continental crustal growth to orogeny, and how to quantitatively evaluate them.

The study presents the results of our recent research on these issues based on big data of igneous rocks. Nd-isotopic mapping of felsic and intermediate igneous rocks from eight representative and well-studied Phanerozoic orogens characterizes their architecture and crustal growth. The maps illustrate the distribution of isotopic domains that reflect the compositional architecture of the orogens. The results demonstrate that the proportions of juvenile crust decrease from typical accretionary (>59%, e.g., the Central Asian Orogenic Belt or Altaids) to general accretionary (50%–30%, e.g., the Newfoundland Appalachians and the Lachlan Orogen), to accretionary–collisional (30–10%), and to collisional orogens (<10%; e.g., the Tethyan Tibet, Caledonides, Variscides, and the Qinling-Dabie Orogen). This study also confirms voluminous (>50%) Phanerozoic crustal growth. Here, we propose a new method to estimate crustal growth areas or volumes and their percentages of a whole orogen based on isotopic provinces. In this way, we can quantitatively estimate the extent of crustal growth and characterize orogen types as well as their relationships through isotope mapping.

Keyword

Magmatic rocks, isotopic mapping, crustal growth, orogeny

Water Reservoirs and Speciation in the Lithospheric Mantle

Halimulati ANANUER[1]*, Macquarie University (halimulati.ananuer@mq.edu.au)
Olivier Alard[2], Australian National University
Sylvie Demouchy[3], Université Clermont Auvergne
Suzanne Y O'Reilly[4], Macquarie University

Abstract

The distribution and speciation of water in the mantle play a crucial role in mantle geodynamics, including large-scale mineralization. Concepts related to water storage in the mantle have undergone significant evolution over the past two decades.

Indeed, it has been shown that the dominant mantle minerals (olivine and pyroxenes), traditionally known as anhydrous "dry" minerals or NAM (nominally anhydrous minerals), contain a few **µ**g•g-1 of hydrogen locked in point defects. Due to the significance of this discovery, the "water" (detected as H and/or OH-) content in the mantle over the last 20 years has been almost exclusively considered through the NAM's H budget, with little attention given to co-existing hydrous minerals (micas, amphibole) and their role in water storage in the mantle.

Furthermore, most mantle "water" assessments have primarily focused on measuring "water" concentration in mineral crystal lattices, while completely ignoring any Grain Boundary Interstitial Components (GBIC). However, GBIC has been recurrently proposed as a likely major reservoir for incompatible trace elements such as LREE, U, Th, and Ba. Given that H is also an incompatible element, therefore, the contribution of GBIC to the water mantle budget should be considered.

This study has measured the water abundance in the sub-continental lithospheric mantle by studying 22 mantle-derived peridotite xenoliths (spinel facies) hosted in alkali basalts from worldwide occurrences. To ensure a comprehensive perspective on water abundance in the mantle, measurements were made on in-situ analyses using Fourier transform infrared spectroscopy (FTIR) for NAMs and simultaneous thermal analyzer coupled with quadrupole mass spectrometer (STA/QMS) for the whole-rock and mineral fraction (including melt/fluid inclusions).

This unique integrated data set sheds some novel light on the distribution of "water" throughout mantle bulk-rock assemblages and reveals counter-intuitive relationships between NAMs, hydrous phases and GBIC. These include (i) the concentration of hydrogen in NAMs does not depend on the occurrence or the volumetric abundance of hydrous phases; (ii) GBIC is the repository for a significant amount of "water"; (iii) hydrous metasomatic phases compete with GBIC for the storage of volatile elements. In summary, our results indicate that H ("water") abundance in the sub-continental lithospheric mantle has been significantly underestimated and that we need to consider more than NAMs for robust assessment of the budget and behaviour of H and, likely other volatile elements, in the Earth's mantle.

Keyword

Mantle water, Grain Boundary Interstitial Components, Hydrous minerals, Nominally anhydrous minerals, STA/QMS

Crustal modification influenced by multiple convergent systems: Insights from Mesozoic magmatism in northeastern China

He HUANG[1]*, Institute of Geology, Chinese Academy of Geological Sciences (huanghecugb@126.com)
Tao Wang[2], Institute of Geology, Chinese Academy of Geological Sciences
Lei Guo[3], Institute of Geology, Chinese Academy of Geological Sciences
Jiyuan Yin[4], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

Convergent continental margins are the major sites for the formation, differentiation, preservation, and destruction of continental crust. This article focuses on the Mesozoic crustal modification history of northeastern China from a magmatic perspective. During Mesozoic times, NE China was influenced by three convergent systems, namely the Paleo-Asian Ocean (PAO) regime to the south, the Mongol-Okhotsk Ocean (MOO) regime to the northwest, and the Paleo-Pacific Ocean (PPO) regime to the east. This study comprehensively synthesizes information on Early Triassic to Early Cretaceous magmatic rocks. We unravel the spatiotemporal effects of the above-mentioned convergent regimes by evaluating the migration of major magmatic belts and other geological and geophysical evidence. The PAO regime is confined to the southernmost part of NE China and exerted influence during pre-late Late Triassic times. The MOO regime-related magmatism lasted until the early Early Cretaceous and occurred throughout the Great Xing'an Range and adjacent regions. The spatial effect of the PPO did not exceed the eastern margin of the Songliao Basin until the Early Jurassic; low-angle to flat subduction of the PPO slab led to the westward migration of continental arc front in the Middle Jurassic and the waning of PPO regime-related magmatism in the Late Jurassic. Since the earliest Cretaceous, the rollback and retreat of the PPO slab became the predominant geodynamic control in NE China, but the superposition of the MOO regime played a role during the early Early Cretaceous. Employing whole-rock Nd and zircon Hf isotope spatial imaging, this study elucidates that, although the pre-Mesozoic lithospheric heterogeneity provides first-order control, the Mesozoic crustal architecture of NE China was further carved by Mesozoic tectonics. Retreating subduction (slab rollback) and post-collisional lithospheric delamination resulted in the prolonged extensional background and crustal growth (rejuvenation); on the contrary, low-angle subduction and syn-collisional compression could cause transient periods of ancient crust reworking. Our results also estimate the high altitude of the Great Xing'an Range and adjacent regions in the Early Cretaceous. This study opens new possibilities to explicitly document crustal modification processes in fossil orogens from a magmatic perspective.

Keyword

Multiple convergent continental margins, Crustal modification, Magmatic rock, Mesozoic, NE China

[Invited] Kinematics, Tectonic Events and Orogens

Manuel Pubellier[1]*, CNRS-UMR8538 Paris Sorbonne U. (manupub.pubellier@gmail.com)
Camille François[2], Africa Museum, Tervuren & CGMW

Abstract

Continental growth is mostly made of crustal morphostructures docked at active margins, but also accreted material scrapped off the downgoing plate, as well magmatic material injected in the upper plate. The process of continental plates drifting is nevertheless continuous and only punctuated by relatively short-lived deformation events. Since the early stages in the Proterozoic, plates have moved, agglomerated to each other, and then parted to drift again. This implies that the normal process is oceanic crust formation and subduction which generate moderate deformation if the subducting slab is not too flat. In contrast, orogens are deformation events which jam former oceans but also smaller crustal slivers rifted from the mainland and carrying volcanic arcs. This is spectacular during the Phanerozoic in Eurasia, where large belts have been accreted from the core of Siberia to the present active boundary of the Alpine-Himalayan Belt and associated subduction of relics of oceanic Tethyan crust. The large scale view illustrates how the successive belts were formed at specific orogenies, as large continental slivers were docking to Laurasia at the expense of the shrinking Gondwana. To go deeper in understanding the process of continental growth, detailed dating is necessary in recent and well documented examples, such as opening and closure of marginal basins and Neogene to Present docking of morphostructures. Opening of smaller basins (marginal seas) is almost never cylindrical and display a V-shape geometry implying a diachronism of a migrating breakup. Similarly the closure of these basins also migrates, and results in diachronous unconformities. The paired system of South China Sea and Proto South China Sea coeval opening and closure is a good example to illustrate the discrepancies in the correlation of events. In addition the convergence between two plates is rarely frontal. Late Neogene examples in the Philippines, Indonesia or the Caribbean, illustrate how oblique collision also migrates along the deformation front. These oblique cases allow us to refine the time of shortening and the associate subduction jump. It is shown that the shortening occurs during short lived (<2Myrs) tectonic events. This suggests that the duration of the subduction reversal or jump is extremely fast, and that the whole of the plate convergence has to be accommodated during this time laps by deformation of the crust; faults, folds and metamorphism. In this view, large less understood orogens may actually have integrated several of these short-lived tectonic events.

Keyword

Tectonic event, Suture, Continental Growth, plate Convergence

Geochronology and geochemistry of metamorphic rocks in the Khutag Uul block of the Khatanbulag Massif, South Mongolian Orogenic Belt: Timing of formation and metamorphism and tectonic implications

Narantsetseg TSERENDASH[1]*, Institute of Geology of Mongolian Academy of Sciences (geodyn2018@gmail.com)
Enkhdalai Batkhuyag[2], Institute of Geology of MAS
Lei Guo[3], Institute of Geology of CAGS
Ying Tong[4], Institute of Geology of CAGS

Abstract

Metamorphic complexes, including the Khutag-Uul and Tseel Formations, are scattered in the Khutag Uul Block of SE Mongolia and have long been interpreted to represent the Precambrian basement of the Khatanbulag Massif of the South Mongolian Orogenic Belt; however, reliable evidence is very poor. Here we present new results of petrological, geochemical, and zircon U-Pb age data of schist and gneiss samples from these complexes, with the aim of constraining the depositional and metamorphic ages and the tectonic affinity of the Block.

LA-ICP-MS zircon U-Pb dating results of 5 samples of garnet-bearing quartz-muscovite and chlorite-muscovite schists and quartz-mica orthogneisses suggest the maximum depositional ages of protoliths of the Khutag-Uul and Tseel Formations are 1548 Ma and 1242 Ma, respectively, and strata were subjected to a high-grade metamorphism around 1010–942 Ma. In addition, the zircon U-Pb ages of one quartz-mica orthogneiss sample indicate that the lower and upper intercept ages are 1658±64 Ma and 852±91 Ma, respectively. All of these data indicate that the reasonable Late Paleoproterozoic–Lower Mesoproterozoic and Middle Mesoproterozoic ages for the Khutag-Uul and Tseel Formations, respectively. These new results, in combination with published data, demonstrate that Precambrian basement rocks that were subjected to an early Neoproterozoic magmatic event exist in the so-called Khutag Uul Block of the Khatanbulag Massif, South Mongolian Orogenic Belt.

Whole-rock major and trace element contents of the Paleoproterozoic to Mesoproterozoic paraschists and orthogneisses are representative for the upper continental crust, with Rb, K, Th, U, Pb, Zr, Hf, and LREE enrichment and Nb, Ta, Sr, P, and Ti depletion, and suggest a continental arc setting. In general, the nature and timing of geological events recorded in the metamorphic rocks from Khutag Uul Block support their affinity to the Tarim Block.

Keyword

Precambrian basement, protolith, geochronology, geochemistry

Comparative Orotomy of the Archean Superior, North China, and Phanerozoic Altaid orogenic systems

Tim Kusky[1]*, China University of Geosciences, Wuhan (tkusky@gmail.com)
Celal Sengor[2], Istanbul Technical University

Abstract

Geological maps encode vast amounts of data about the rock types, ages, chemistry, and deep-time history or different tectonic units, yet this is often difficult to extract because of the way that different geologists artistically portray their results in maps and cross sections at various scales. Comparative orotomy is the science of dissecting the structure and history of mountain ranges in comparison with one another, against a background of fundamental processes of orogeny, and testing how this structure and inferred processes may have changed through deep time. Currently, this science is just entering the big data Deep-time Digital Earth era, so here we present a preliminary comparative orotomy of a few of the world's best-documented Phanerozoic and Archean accretionary orogens. We compare and contrast the materials and mechanisms of continental crustal growth in the largest preserved regions of Phanerozoic and Archean juvenile additions to the crust, to test for similarities or differences in the formation of continents through time. We accomplish this through a comparison of map patterns, lithological contents, structural and metamorphic evolution, of the Phanerozoic Altaid orogenic system of Asia, with the Archean Superior Province of the North American Craton, and the Archean-Paleoproterozoic North China Block. All three orogenic systems consist of collages of curvilinear belts of eroded arcs, some older continental slivers, vast tracts of former subduction/accretionary complexes, containing numerous shreds of portions of the ophiolite suite, slivers of island and continental arcs, accreted oceanic plateaux, all intruded by multiple magmatic suites during or between multiple deformation events, then sliced by large transcurrent fault systems. The Altaids and parts of the Superior are bent into large oroclinal structures. We make this comparison because the Superior Province, and North China Block, are both typical Archean accretionary orogens that, in the Paleoproterozoic, were incorporated into larger supercontinents (e.g., Kenorland, Nuna, which then formed the core of Columbia, Rodinia, Laurentia, and Pangea). Since the Superior is the largest single fragment of Archean continental cratonic lithosphere preserved on Earth, the Superior Province is widely regarded as a testing ground about how Earth's continental crust was formed. Likewise, the Altaids encompass the largest region of crustal growth for the Phanerozoic. The North China Block is smaller, but preserves similar features. Our comparison of these ancient cratonic fragments with the Altaids is needed, as in recent years many myths about how the planet may have responded to higher heat production and flow in the Archean have emerged, because of trends in the science where the regional geology is ignored in favor of numerical models, isotopic proxies for assumed models of chemical behavior for crust-forming or tectonic processes, or comparisons with other-worldly bodies that bear little resemblance to our hydrous Earth. Thus, we return to the geological record, and here describe the map patterns, lithological associations,

structural patterns, and evolution of the Altaids, Superior Province, and North China, showing how comparative tectonics, orotomy, is useful in the absence of meaningful paleomagnetic or biostratigraphic data. The obvious next stage in this science is making our

Keyword

Archean, tectonics, big data, geological maps, orotomy

[Invited] Dense passive source seismic array reveals detailed shallow lithospheric structures: a case study from Western Australia

Huaiyu YUAN[1]*, Macquarie University (huaiyu.yuan@uwa.edu.au)

Abstract

Dense passive source seismic arrays offer unparalleled insights into the lithospheric structures of cratons, ancient geological entities with rich and complex evolutionary histories. Dating back to the early Archean, the formation of the West Australian Craton (WAC) was initiated by processes such as magma upwelling, crustal material differentiation and gravitational sorting, culminating in the accumulation of the earliest continental crust nuclei. These nuclei have endured through prolonged tectonic activity, preserving invaluable clues about Earth's early geological processes. Over billions of years, the WAC has been subjected to a multitude of tectonic events, including late Archean rifting, Proterozoic orogenies, and Mesozoic rifting during successive supercontinental cycles. These dynamic processes have profoundly influenced the craton's geological architecture, resulting in a mosaic of crustal features and lithospheric structural complexities, which have played a pivotal role in the formation of world-renowned mineral deposits. With the aim of establishing a comprehensive regional background model for the recently initiated 10-year WA Array lithospheric mapping project, we integrate datasets and models from previous dense deployments to unravel the intricate details of the WAC's shallow lithosphere. Our objective is to build a comprehensive understanding of the WAC's evolution, drawing on insights from the 'pre-WA Array' era, and to elucidate the factors governing the distribution of its mineral deposits.

Keyword

Craton, Lithosphere, Tectonics, Lithospheric architecture, Seismic imaging

Lithospheric thermochemical structure beneath the southwestern Central Asian Orogenic Belt from joint inversion

Xuewei BAO[1]*, Zhejiang university (xwbao@zju.edu.cn)
Yingkai Wu[2], Zhejiang university

Abstract

Located at the southwestern Central Asian Orogenic Belt, the lithospheric interaction and deformation of the Tarim craton, Tian Shan and Junggar lithosphere are important to understand the complicated tectonic activities in this region. We here obtain the thermal and compositional structure of the upper mantle beneath this unique place by probabilistic joint inversion of the newly processed Rayleigh-wave dispersion data, surface heat flow, geoid anomalies and absolute elevation. The Junggar and Tarim Basins are dominated by a thick lithospheric root of more than 240 km, determined from the 1250 ℃ isotherm. Meanwhile, the spatial variation of the magnesium number shows relatively fertile lithospheric mantle beneath the Junggar and Tarim Basins. Specially, the lower crust and uppermost mantle beneath the Junggar Basin are characterized by high velocities, in agreement with previous models which suggests the existence of fossil oceanic lithosphere. Furthermore, the lithospheric structure beneath the western and eastern Tian Shan show distinct geophysical and geochemical properties, feature by thin lithosphere, high temperature, low density, low velocity and thick lithosphere, low temperature, high density, high velocity, respectively. These observations indicate that while the lithospheric structure beneath the western Tian Shan is significantly affected by mantle upwelling, the lithosphere beneath the eastern Tian Shan is mainly thickened by southward underthrusting of Junggar lithosphere and northward underthrusting of Tarim lithosphere.

Keyword

Lithospheric thermochemical structure, Tian Shan, Junggar Basin, Tarim Basin, joint inversion

Petrogenesis of late Carboniferous garnet-bearing, strongly-peraluminous granites in the West Junggar oceanic arc, NW China: implication for crustal maturation and rapid supracrustal recycling

Jiyuan Yin[1]*, Institute of Geology, Chinese Academy of Geological Sciences (yinjiyuan1983@163.com)
Tao Wang[2], Institute of Geology, Chinese Academy of Geological Sciences
Min Sun[3], University of Hong Kong

Abstract

Subduction and melting of supracrustal materials have been postulated to play an essential role in crustal maturation of oceanic arcs. However, the direct observation and sampling of sediment melt within the base of crust are great challenge so that it has been difficult to constrain the timeframe and magnitude of supracrustal recycling. Here we show geochemical results for the garnet-bearing, strongly-peraluminous and garnet-free peraluminous granitoids in the West Junggar. These rocks are emplaced in a late Carboniferous (~307–301 Ma) intra-oceanic arc setting in southern Central Asian Orogenic Belt (CAOB), and are characterized by high Sr/Y ratio (52 – 100) and strong depletion in heavy rare earth elements (HREE, La/YbN = 32 – 115). Zircon from these rocks have depleted Hf isotopes (+11.1 to +13.5), but elevated δ18O (8.5‰ – 9.8‰), implying subduction and remelting of juvenile greywacke sediments at ~50 – 60 km. In contrast, the youngest inherited zircon cores are dated at ~316 Ma and show low δ18OZrn (4.3‰ – 5.0‰), implying contribution of hydrothermally altered crust to the sedimentary source. Our results reveal that crustal maturation in the West Junggar during the late Paleozoic time most likely involved repeated crustal remelting and rapid (~15 Myr) supracrustal recycling in subduction zones.

Keyword

supracrustal recycling, subduction zones, West Junggar oceanic arc, crustal maturation

Formation, Preservation, and Metallogenic Fertility of Juvenile Crust in the Eastern Tethyan Collisional Orogen

Zengqian HOU[1]*, 1. Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China (houzengqian@126.com)
Changming WANG[2], 2. State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Beijing, 100083
Hongrui ZHANG[3], 1. Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China
Yongjun LU[4], 3. Geological Survey of Western Australia, 100 Plain Street, East Perth, WA 6004, Australia
Tao WANG[5], 1. Institute of Geology, Chinese Academy of Geological Sciences, Beijing 100037, China

Abstract

Genesis and the growth of continental crust are fundamental to maintaining life and supplying resources to our society. It is widely accepted that continental collision zones are favored locations of crustal preservation, yet it remains unclear when and how continental collision generates juvenile crust and maintains net crustal growth. Here we carry out hafnium isotopic mapping of three collisional orogens with distinct maturity in the Tethyan domain, i.e., the Zagros, Himalaya, and Qinling, to reveal the evolution of juvenile crust in collisional zones. Our results indicate that the amount of juvenile crust generated and preserved in collisional orogens far exceeds previous estimates. The pre-collisional juvenile crust generated by arc magmatism was mostly preserved in Zagros, slightly reworked in Himalaya, and partly lost in the Qinling orogen. In growing orogens such as Zagros and Himalaya, the collision produces juvenile crust and leads to net crustal growth by the input of juvenile mafic magmas derived from partial melting of both subduction–modified lithospheric mantle and asthenosphere. In decayed orogen such as Qinling, there is little juvenile crust produced during a collision due to limited mantle melting. The juvenile lower crust is fertilized in ore-forming components, which can be released into hydrous felsic magmas during later remelting, and thus plays a significant role in the genesis of magmatic–hydrothermal ore deposits in collision zones.

Keyword

Juvenile crust, Crustal growth, Collisional orogen, Tethyan domain

Geophysical data constraint on the nature of the basement of the Junggar Basin, the southwestern Central Asian Orogenic Belt

XIAOSAN ZHU[1]*, Institute of Geology, Chinese Academy of Geological Sciences (zhuxiaosan129@outlook.com)
Tao Wang[2], Institute of Geology, Chinese Academy of Geological Sciences
Yusen Huang[3], Institute of Geology, Chinese Academy of Geological Sciences
Xiaofei Chen[4], Southern University of Science and Technology
He Huang[5], Institute of Geology, Chinese Academy of Geological Sciences
Ying Tong[6], Institute of Geology, Chinese Academy of Geological Sciences
Hongwei Zheng[7], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The nature of the basement in Mesozoic–Cenozoic basins, such as the Junggar Basin in China, is key to understanding the Central Asian Orogenic Belt. In this study, we investigated the geophysical anomalies and identified the structure of the deep crust and upper mantle in the Junggar Basin and its adjacent areas including the West Junggar and Tianshan orogen based on Bouguer gravity, magnetic, and broadband seismic data. The Junggar Basin is characterized by low Bouguer and high magnetic anomalies, and the pattern of the anomalies only changes slightly with increasing depth. The Junggar Basin has deep Curie point depths (~30–42 km) in its centre and shallow depths in its western and eastern parts and northern margin, and it has a crustal thickness of ~40 km. There is a near-vertical area of high shear-wave velocity (Vs > 4.5 km/s) with a horizontal width of nearly 80 km at a depth of 70–75 km in the northwestern margin of the Junggar basin. Low-velocity (Vs < 3.0 km/s) and high-velocity (Vs > 4.5 km/s) areas occur at depths of 15–45 and 60–80 km in the Junggar Basin, respectively. Near-vertical subducted oceanic plates and partially molten lithosphere may coexist in the West Junggar Orogen and western Junggar Basin areas. The basement of the Junggar Basin consists mainly of juvenile oceanic crustal materials based on all observations. Our findings provide important insights into the lithospheric structures of the southwestern Central Asian Orogenic Belt.

Keyword

Junggar Basin, Bouguer gravity anomaly, magnetic anomaly, shear-wave velocity, Central Asian Orogenic Belt

Early Mesozoic architecture and processes of the Qinling orogen, central China: Nd-Hf isotope mapping

Xiaoxia WANG[1]*, Institute of Mineral Resources,Chinese Academy of Geological Sciences (xiaoxiawang@hotmail.com)
Tao WANG[2], SinoProbe Laboratory, Chinese Academy of Geological Sciences; Beijing SHRIMP Center, Institute of Geology, Chinese Academy of Geological Sciences
Changhui KE[3], Institute of Mineral Resources,Chinese Academy of Geological Sciences
Yang YANG[4], Chang'an University
Yongfei TIAN[5], Northwest University

Abstract

The Qinling orogen, one of the most important orogens in Asia, belongs to the northeastern part of the Tethyan orogen. The orogenic architecture and processes of the Qinling orogen remain controversial. In this study, we present new zircon U–Pb ages, whole-rock geochemical and Sm-Nd isotopic data, and zircon Lu-Hf isotopic data for early Mesozoic felsic-intermediate igneous rocks in this orogen, combined with data from literature, to delineate the Mesozoic crustal architecture and processes of this orogen. A total of 181 zircon U–Pb ages show three phases (252–230, 230–198, and190–185 Ma) of the igneous rocks. The first-phase igneous rocks occur mainly in the westernmost segment of the orogen and formed in a subduction setting during the closure of the Mianlue Ocean (a northern branch of the Paleo-Tethyan Ocean). The second and third-phase igneous rocks, distributed in the middle to eastern parts of the Qinling orogen, were generated in late syn-collisional and post-collisional tectonic settings, respectively. Whole-rock Nd isotope mapping of these igneous rocks yield six isotope provinces and zircon Hf isotope mapping yield seven isotope provinces. These provinces display that the southern margin of the North China Block and the northern margin of the Yangzi Block are dominated by ancient deep crust, that is, early Paleoproterozoic (2.3–1.8Ga) and late Paleoproterozoic (ca.1.7 Ga) components, respectively. The North Qinling and South Qinling contains different basement, the former basement is younger (TDM(Nd)= 1.4–1.0 Ga) than the latter (TDM(Nd)=1.6–1.2 Ga), suggesting that the North Qinling is an independent terrane different from the North China Block and South Qinling. The isotopic tracing also reveals a deep-seated NNE–SSW-trending zoned architecture that is approximately perpendicular to the WNW–ENE-trending of the orogen. This provides new evidence for the “Spaghetti Junction model” for the Qinling orogen. The old Nd (2.2–1.0 Ga, mostly 2.0–1.2 Ga) and Hf (2.3–0.8 Ga, mostly 2.0–1.2 Ga) model ages indicate that the continental growth in this orogen occurred mainly during the Paleoproterozoic and Mesoproterozoic, with only minor amounts of juvenile (TDM = 0.1 Ga) continental growth (or preservation) along the Shangdan and Mianlue sutures. These characteristics suggest that the Qinling orogen is dominantly formed by the collision of ancient continental blocks, distinct from some typical accretionary orogens, such as the Central Asian Orogenic Belt with voluminous juvenile crust.

Keyword

Nd-Hf isotope, crustal architecture, granitoids, Paleo-Tethys, Qinling orogen

Evolution of the Proto-Tethys Ocean in the West Kunlun Orogenic Belt, Northwestern Tibet: Insights from the Sub-Arc Crust and Lithospheric Mantle Modification

Zaili TAO[1]*, Institute of Geology, Chinese Academy of Geological Sciences (Taozaili96@163.com)
Jiyuan Yin[2], Institute of Geology, Chinese Academy of Geological Sciences
Mike Fowler[3], School of the Environment, Geography and Geosciences, University of Portsmouth

Abstract

Radiogenic isotopes serve as a crucial tool for investigating crustal evolution, playing a pivotal role in revealing magma sources and petrogenesis. However, they can be ineffective in distinguishing distinct magmatic sources with similar radiogenic isotopic compositions, a common occurrence in nature. This paper addresses this challenge in the Ordovician igneous rocks from the West Kunlun orogenic belt (WKOB), to distinguish between two potential magmatic sources (i.e., Tarim Craton vs. Tianshuihai terrane) with similar isotopic compositions, by using appropriate thermodynamic and geochemical modeling. Zircon U–Pb dating yields ages of 484 ± 4 Ma, 469 ± 2 Ma, and 461 ± 2 Ma for the Duwa gabbros, Datong monzogranites and syenites, respectively. The Duwa gabbros exhibit low SiO2 (47.4–49.1 wt. %), high MgO (5.45–6.85 wt. %), high large ion lithophile elements (LILEs) and low high field-strength elements (HFSEs), which suggest an origin in subduction-modified mantle. They display high zircon δ18O values (7.6–7.9 ‰) and enriched zircon Hf isotopic compositions (εHf(t)= -5.3 to -7.7), consistent with 1-5% subducted sediments in an enriched mantle source. Trace element models further confirm that the gabbros are most likely derived from low-degree (~8 %) partial melting of subduction-modified Tarim mantle in the spinel-garnet facies, rather than the Tianshuihai mantle. The Datong syenite samples belong to the shoshonitic series and are characterized by medium SiO2 (59.5–61.4 wt.%), relatively low MgO (0.88–1.19 wt.%) and Mg# (37–42), enrichment in LILEs and depletion in HFSEs. They have high whole-rock (87Sr/86Sr)i ratios (0.7103 to 0.7105) and negative whole-rock εNd(t) values (-3.8 to -4.3), plus negative to slightly positive zircon εHf(t) values (–3.8 to +2.6), similar to the coeval mafic rocks. Thermodynamic and geochemical modeling suggests that the Datong shoshonitic rocks likely originated via crystal fractionation of the shoshonitic basaltic magmas in the SW Tarim Craton. The Datong monzogranites have high SiO2 (69.7–72.6 wt.%), low MgO (0.59–0.66 wt.%) and demonstrate a typical enrichment in alkalis, Zr and Nb with depletion in Sr, P and Ti, consistent with A-type granites. They are characterized by high whole-rock (87Sr/86Sr)i ratios (0.7321 to 0.7323), negative whole-rock εNd(t) (-11.3 to -11.8), negative zircon εHf(t) (-11.0 to -16.5) and high zircon δ18O (7.2–8.0 ‰), indicating derivation from the remelting of ancient crustal source. Thermodynamic, major and trace element modeling suggest that their parent magma may have been generated by water-deficient (ca. 2 wt.%) partial melting of ancient crustal material beneath the SW Tarim Craton rather than that of the Tianshuihai terrane, under high temperature (T > ~900 ℃), low-pressure (P= 5–8 kbar) conditions.

Considering the tectonic framework of the WKOB, we propose that the original mantle and crust beneath the southern Kunlun terrane may have been modified by that beneath the SW Tarim Craton during the Ordovician. Since these conclusions all favor Tarim-derived magmatism, they indicate that the Ordovician magmatism in the southern Kunlun terrane is most consistent with episodic northward subduction of the Proto-Tethys Ocean, commencing at ~485 Ma.

Keyword

West Kunlun orogenic belt, Thermodynamic modeling, Magmatic sources, Proto-Tethys Ocean, Northward subduction

Linking the past to the future of tide-domianted estuarine changes under human activities and climate changes, case study at the Pearl River Estuary

Junjie DENG[1]*, School of Marine Sciences, Sun Yat-sen University (dengjj6@mail.sysu.edu.cn)

Abstract

Over the past century, intensive human activities have disrupted the natural dynamic equilibrium of sediment transport and deposition in the coastal region. Under the combined influence of human activities and climate change forcing, the evolution of the coastal zone exhibits complexity and uncertainty. With the aim to study if the tide-dominated estuary will attain an equilibrium state or will be infilled until it became a river, this paper adopts the data-driven and process-based approaches to link the past to the future. Based on the historical data of bathymetric changes, relative sea-level changes, and riverine sediment discharge and so on, this paper utilizes a data-driven model called Bayesian Network to train and verify the estuary filling evolution over the past century. This model is then used to predict future changes based on different scenarios such as sea level rise and riverine sediment supply. The data-driven modeling approach will be compared with a validated long-term process-based morphodynamic model and historical measurements. Both models' results indicate that sediment discharge is the most significant factor influencing volume changes in Lingding Bay, while sea-level rise has minimal impact in the past. Various scenarios will be conducted to evaluate the possible source of uncertainties of future evolution. Process-based modelling will be used to study the equilibrium conditions, which represents the certainty of the future evolution. The Bayes Network modelling can reveal the uncertainties of the future projection, which cannot be reflected by the process-based model. A global comparison with different tide-dominated estuarine evolution will help understand the estuarine responses to external forcings from the prospective of dynamic equilibrium.

Keyword

Estuarine evolution, dynamic equilibrium, Bayes Network, climate change, human activities

[Keynote] Competing Natural and Anthropogenic Influences on Sediment Supply to the Global Ocean

Peter Dominic Clift[1]*, University College London (peter.clift@ucl.ac.uk)

Abstract

Sediment transport in modern river systems is modulated over million-year timescales by tectonic forces and rock uplift during mountain building. On shorter, orbital timescales, source erosion, and the speed of transport are controlled by intensity and seasonality of precipitation that focuses erosion in certain parts of the source mountains, while discharge controls the speed at which different grain sizes are transported to the ocean. In Asian systems this primarily reflects monsoon intensity, but similar patterns are noted in the Mississippi basin linked to deglaciation. While muddy and silty sediments may be transported almost geologically instantaneously to the sea, denser sandy material may take thousands of years to reach the ocean. Sea level variability may then buffer the sediment on the continental shelf during high stands. Sandy sediment may only reach deep-water depo-centres after a complete glacial cycle, especially if the shelf is wide and sediment supply rates are moderate. In general, times of stronger precipitation and warmer temperatures result in faster rate of chemical weathering, but more importantly, greater degrees of sediment recycling out of floodplains and river terraces, resulting in both faster rates of sediment supply, but also deposition of more strongly chemically, weathered sediments. A similar effect can be produced by enhanced erosion of weathered soil by human activities, particularly deforestation and the spread of agriculture. This is seen ~4-5 ka in the Indus River and ~2.5 ka in the Pearl River. Some of the effect of this reworking may not be observed offshore because of preferential sedimentation of sands and also smectite clays in the coastal zone. Resolving the impact of climate change on fluvial systems from that caused by human activities can be problematic and require a number of proxies that uniquely characterize human activities, such as heavy metals related to the smelting of metals by early societies.

Keyword

Sediment, Climate, anthropogenic, river

THE 4F NUMERICAL MODEL – a solution for past reconstructions of coastal and glacial dynamics and future simulations

Jerzy Jan FRYDEL[1]*, Polish Geological Institute - National Research Institute
(jerzy.frydel@pgi.gov.pl)

Abstract

Climate change, melting glaciers and rising global ocean levels, the development of mass wasting processes (including landslides) on exposed coastal cliffs, and the increasing impact of storms on urbanised areas located in the coastal zone of the seas and oceans should be recognised as key issues whose identification is a challenge for coastal researchers in the 21st century. During the Holocene, the level of the Baltic Sea was subject to major shifts caused by eustatic sea-level changes and glacio-isostasy, resulting in transgression and/or regression of the coastline. The aim of the study was to develop a universal method for reconstructing and projecting future shoreline changes in the southern Baltic Sea using numerical modelling. The postulated approach allows the reconstruction of geological processes including: ice sheet retreat/advance, marine regression/transgression and erosion/accumulation within the coastline. Reconstructions and simulations of the dynamics of the indicated processes, expressed by changes in shoreline position (or glacier extent), were recognised through application of the 4F MODEL developed for this purpose. The model combines time, space and dynamics in its matrix, being the basis for multiscale analyses performed in a homogeneous spatio-temporal environment, enabling both past reconstructions and future scenarios. The 4F (form and function of the Frydel factor) model uses mathematical formulas (functional programming) derived from the equation of coastal and glacial dynamics, by Frydel (2022), which is variable-based, therefore functions can be universally applied in reconstructions and simulations across different regions and spatial and temporal scales (depending on the provided data range). The approach utilises high-level polynomial regression, followed by integral calculus (on the fly) of successive functions using the formulas (Frydel et al., 2017, Frydel, 2022). As a result, the palaeogeographic relationships from the primary matrix become transformed into a nested matrix, in a way expressing palaeodynamics in a function of time. The reconstruction, in the Desmos environment, of the extent of individual glacial phases and coastlines (input data) subject to high-order polynomial regression (or mapping with any other functions) is accurate (coefficient of determination, R^2 ~ 0.9), thus providing reliable data for further application in the process of integral calculus and modelling of development dynamics. The importance of the strategy used lies in its direct applicability both for determining the extent and dynamics of geological processes in the past and for forecasting purposes, including coastal spatial planning requirements, based on hypsometry and sea levels projected from RCP emission scenarios (Oppenheimer et al., 2019; Golledge et al., 2020). The time scales considered in the 4F model include the late Pleistocene, Holocene and Anthropocene (geological, long-term and short-term scales). The 4F model, constructed in the Desmos environment, was validated in the GIS environment achieving <92.6%, 99.9%> compliance for reconstructions and <46.6%, 82.7%> for

prognostic purposes. These results obtained from the palaeogeographic and palaeodynamic analyses and simulations were linked to past changes in the southern Baltic Sea level (Uścinowicz, 1995, 2004, 2006) and palaeogeographic reconstructions (Marks, 2002; Marks et al., 2016), adding a new dimension to palaeoclimatic studies, as described by Frydel (2022).

Keyword

glacial dynamics, coastal dynamics, Baltic Sea, functional programming, polynomial regression

Regional Relative Sea Level Changes Influenced by Geological Settings: Insights from InSAR Analysis

Zhaoquan Huang[1]*, Xiamen University (hzq@xmu.edu.cn)
Fengling Yu[2], Xiamen University
Yongxiang Huang[3], Xiamen University

Abstract

As the global climate continues to experience ongoing warming, understanding the spatial variation of relative sea level becomes increasingly crucial for studying regional coastal evolution and ensuring local coastal safety. Recognizing vertical land motion at high spatial resolution is now acknowledged as pivotal in analyzing relative sea level changes in regional or local scale. However, obtaining detailed spatial information on regional relative sea level changes from tide gauge stations is challenging due to their sparse distribution. In recent years, high-resolution land motion detected by InSAR have emerged as significant inputs for analyzing relative sea level changes. Yet, most sea level studies tend to overlook the varying influence of geological environments on land motion, potentially leading to an underestimation of the true magnitude of effects on relative sea level in certain areas.

In this study, our focus is on the Xiamen-Kinmen coast, where we employ GPS-calibrated InSAR to extract regional vertical land motion at a high spatial resolution. By incorporating geological background data, we discern the vertical land motion across different geological settings. Subsequently, we examine the correlation between relative sea level changes and geological factors. Our analysis unveils significant fluctuations in relative sea level along the coast, influenced by diverse geological environments, on a spatial scale of several kilometers. It is different from previous conclusions using a single tide gauge station to study sea level changes in this area. This study enhances the spatial resolution of sea level change risk analysis in coastal regions, offering valuable insights into the dynamic interplay between vertical land motion and sea level changes.

Keyword

Relative Sea Level Changes, Geological Settings, InSAR, vertical land motion

A Marine Spatial Data Infrastructure for the Adriatic Sea: Managing Multidisciplinary, Heterogeneous, and Fragmented Geodata with a FAIR Approach to Support Research Life Cycle Management

Federica FOGLINI[1]*, CNR ISMAR (federica.foglini@ismar.cnr.it)
Valentina Grande[2], CNR ISMAR

Abstract

Facilitating wider access and reuse of research data in Earth Sciences has rapidly gained traction because of the need for research integrity, reproducibility, and accountability as well as new opportunities for large-scale data analysis and reanalysis. Adhering to the FAIR principles is crucial for fostering interoperability with European and international marine data management infrastructures, facilitating the handling and exchange of multidisciplinary data.

The Institute of Marine Sciences (ISMAR) and the Institute of Polar Sciences (ISP) of the Italian National Research Council (CNR) have collected diverse geodata from the Adriatic Sea over the years, spanning geological, oceanographic, biological, and anthropogenic aspects, as well as their interactions, using various methodologies and for multiple purposes.

To address the challenges posed by the heterogeneity and fragmentation of these datasets, a Marine Spatial Data Infrastructure (MSDI) has been established. Its purpose is to integrate and preserve geodata, promote their reuse (such as generating scenarios for geological past and future developments using numerical models), and ensure a high level of FAIRness (Findable, Accessible, Interoperable, and Reusable). The MSDI comprises a Spatial Relational Database Management System (RDBMS) built on specific data models partly aligned with the INSPIRE Directive specifications, a WebGIS, a metadata catalogue, and a cloud system. This paper demonstrates the capabilities of the MSDI, discussing its key implementation steps, constituent elements, achieved level of FAIRness, factors enhancing FAIRness, and areas requiring further development.

This study also introduce and demonstrate recent tools and service implemented to manage the entire Earth Science research life cycle through the “Research Object” paradigm. Research Objects are virtual aggregations of resources that bring together data, methods, results and people to document scientific investigations, according to Open Science principles.

This study showcases the importance of integrating and harmonizing these diverse datasets, as it facilitates interoperability with other marine data management infrastructures. This interoperability enables the efficient handling and exchange of a wide range of multidisciplinary data, such as with the European Marine Observation and Data Network (EMODnet) and the Deep-Time Digital Earth (DDE) .

The Adriatic Marine Spatial Data Infrastructure (MSDI) serves as a valuable model or blueprint for other marginal seas worldwide, as it represents the interface between continents and oceans. Marginal seas, such as the Adriatic Sea, play a crucial role in global ocean dynamics and are important for various reasons, including ecological, economic, and strategic considerations. Such

infrastructures facilitates informed decision-making processes related to marine resource management, conservation efforts, maritime transportation, and sustainable development.

Keyword

Adriatic, Geodata, FAIR

Numerical paleogeographic modeling of marginal seas – Holocene evolution of Baltic Sea as a case study

Jakub Miluch[1]*, University of Szczecin (Poland) (jakub.miluch@usz.edu.pl)
Peter Arlinghaus[2], Helmholtz-Zentrum Hereon
Andreas Groh[3], Technical University Dresden
Jan Harff[4], University of Szczecin
Wenyan Zhang[5], Helmholtz-Zentrum Hereon

Abstract

Paleogeographic reconstructions of subpolar and polar marginal seas' evolution require a specified set of input data: Digital Elevation Model (DEM), eustatic climate-controlled sea level change, vertical crust movement (isostatic and tectonic) rate and sediment budget. We applied a conceptual model integrating these parameters for the generation of paleo-DEMs describing the evolution of the Baltic Sea since the beginning of the Holocene (11.7 cal BP). Backstripping of the Holocene sediment cover and adjusting the DEM to the time 11.7 cal BP according to the effect of the Fennoscandian iceshield's load at the beginning of the Holocene (Glacio-Isostatic Adjustment - GIA) and sea level variations allowed to reconstruct the starting condition for the application of the forward modelling procedure to generate a sequence of paleo-Digital Elevation Models (paleo-DEMs) of any time resolution. For our case study the first challenge consisted of the generation of a thickness model of Holocene sediments in the Baltic Sea basin to be backstripped before starting the forward modelling procedure. This generation of regional sediment thickness model of the Baltic Sea required a synthesis of various local-scale datasets. Gathered sub-datasets covered majority of the Baltic Sea basin with the thickness grid. Data were extrapolated to undersampled areas by application of co-kriging as well as Random Forest Machine Learning methods. To model the Glacio-Isostatic Adjustment (GIA) the Sea-Level Equation (SLE) after Peltier using the well accepted regional parameters was applied. The specific geological history of Baltic Sea, involved shifting from sea to lake phases by, either eustatically or istostatically-driven, disconnections of the Baltic Basin from the global ocean. When Baltic was decoupled from the global ocean, the eustatic component corresponded to the level of the Ancylus freshwater lake. In this case, the areas of the "outer coast" of Fennoscandia: North Sea, Norwegian Sea and Barents Sea were modelled separately from the Baltic lake basin. For our case study we selected a time resolution of 500 years, having led to 24 paleogeographic scenarios. We used previous reconstructions of Baltic Sea paleogeography derived from mapping of paleocoastlines based on proxy field-born data for plausibility tests of our numerical model results. These tests validate our method to be generally applicable for the paleogeographic marginal seas reconstruction as parts of glacial, periglacial to postglacial paleo-landscapes in polar to subpolar regions. Further positive validation of obtained paleo-DEMs may support generation of future projections.

Keyword

paleogegraphic reconstruction, numerical modeling, marginal seas

Towards a Marginal Seas Taxonomy

Jan HARFF[1]*, University of Szczecin, Institute of Marine and Environmental Sciences (jan.harff@io-warnemuende.de)
Hayley Cawthra[2], Council for Geoscience, Cape Town, South Africa
Peter Clift[3], Department of Earth Sciences, University College London, UK
Herbert Gary Greene[4], Moss Landing Marine Laboratories, San José State University, USA
Marcus Reckermann[5], International Baltic Earth Secretariat, Helmholtz-Zentrum Hereon, Geesthacht, Germany

Abstract

Marginal seas, as transition areas between continents and oceans, with their highly sensitive ecosystems are particularly threatened by climate change and increasingly human impacts. Their protection requires new holistic strategies that comprehensively describe the management of marginal marine systems, including coasts and catchment areas. We are looking for solutions that abstract from the comprehensive diversity of marginal seas and assign appropriate task-related functional models to classes of these seas. The task, therefore, is to initially develop a marginal sea taxonomy, the systematization of which, in addition to natural parameters and functioning, increasingly considers the interaction with resource users and anthropogenic drivers. The spatial framework is formed by the shelf seas, their coastal zones, and catchment areas. The time frame is determined by the last glacial cycle, but especially by the Holocene and Anthropocene. Influencing factors are determined by the dynamics of climate, geosystems, and ecosystems, as well as from increasingly socio-economic developments. On the one hand, the question of variables and their values (data) is historically determined by developments in measurement and monitoring techniques. On the other hand, the long-term development (trends) of marginal seas' environment requires proxy data – mainly from sedimentary records. In addition to numerical functional models, Artificial Intelligence (AI) and Machine Learning (ML) methods are also available for the complex evaluation and interpretation of these data. To describe our concept, we compare examples of marginal seas based on the dominance of their influencing factors. We compare the glacio-isostatically controlled Baltic Sea and western Greenland shelf with the isostatically stable South African shelf (Agulhas Bank), South Asian marginal seas influenced by the Asian monsoons, and the geo-hazardous threatened Salish Sea on the northwestern American coast. The development of a marginal seas taxonomy requires direct collaboration between scientists (e.g., geological, physical, environmental, ecological, humanities, IT/data), modelers, industrialists, and governments.

Keyword

marginal seas, classification, modelling, management

Classification of the morphodynamics of the coast - how we can improve projections of the coastline changes

Joanna DUDZINSKA-NOWAK[1]*, University of Szczecin (joanna.dudzinska-nowak@usz.edu.pl)

Abstract

The Morphodynamic of the southern Baltic Sea coasts is determined by a complex interplay of the geological setting, eustatic sea-level change, glacio-isostatic adjustment, wave-driven sediment dynamics, storm surges, and aeolian processes acting in various temporal and spatial scales from millennia to hours and in spatial scale from kilometers to centimeters. In terms of presently occurring climate changes, observed an increased number and intensity of storm events, which pose a threat to the infrastructure, the determination of the future scenario of coastline development is of particular importance for broadly defined coastal safety.

This study presents the method of the classification of the morphodynamics of the coast which can be useful for more accurate prediction of the coastal changes as well as a tool for other marginal seas comparison. To be a complex, the scientific classification of the coast should meet the following conditions: (1) cover all morphological types of the coasts, (2) take into account the processes and factors determining the type of shore development, and reflect the relationships between different types of shore and (3) it should reflect the contemporary dynamics of the shore as fully as possible. The use of high-resolution remote sensing data allows us to indicate precisely the characteristic features of the terrain's morphology, which if repeated, can be treated as indicators of the changes. The presented research shows the methodology and results of the conducted classification of the coastal dynamics of the southern Baltic Sea, focusing not only on the direction of movement and rate of change but also on the dynamic of change in different time scales. The main criterion for this classification is the determination of two numerical indicators for each examined section of the coast, synthesizing the image of registered changes in the dune/cliff base line.

The spatial distribution of individual classes of shore dynamics indicates a great diversity and variability of morphodynamic processes along the entire studied section. Changes with medium and high dynamics of both accumulation and erosion processes dominate. The sections with low dynamics of the processes taking place constitute only less than 20% of the studied area. The coast in dynamic equilibrium covers less than 10%. The spatial distribution of individual classes of shore dynamics proves a large diversity and space and time variability of morphodynamic processes along the entire investigated section of the shore, which may substantially bias future scenarios. The presented classification can be treated as an open classification, making it possible to complete the picture of the contemporary dynamics of the coast of any non-tidal marginal seas and any time intervals. The location of specific dynamic shore classes may change over time depending on the variability of hydro-meteorological conditions.

Keyword

coastal morphodynamic, remote sensing, classification, Baltic Sea, future projections

Characteristics and origin of Quaternary mass transport deposits in the Qiongdongnan basin, northern South China Sea

Tao JIANG[1]*, China University of Geoscieces (taojiang@cug.edu.cn)

Abstract

Mass transport deposits in the northern South China Sea have been extensively studied over the past decade due to their potential as hydrocarbon reservoirs and seals, as well as their role in marine geohazards. Several boreholes have cored the mass transport deposits. The chronological framework is established by Optically Simulated Luminescence dating, AMS 14C dating and 18O date. By integrating core-log-seismic data, this study examines the characteristics, distribution and origins of multiple mass transport deposits in the Qiongdongnan basin. The results reveal the presence of more than ten phases of Quaternary mass transport deposits developed in the Qiongdongnan basin, which have obvious soft deformation structure in the cores and show chaotic reflectors in the seismic date. Those mass transport deposits may have been triggered by factors such as high sedimentation rates, increased slope gradients, fault reactivation, earthquakes, and sea level fluctuations. Among these triggers, earthquakes and rapid sea level fluctuations are considered the most significant. Additionally, the mass transport deposits serve as hydrocarbon seals, facilitating the accumulation of shallow gas reservoirs and gas hydrates within the Quaternary strata. It is important for multidisciplinary scientists to conduct further integrated research to better understand mass transport deposits and related tsunamis, which pose significant marine geohazards.

Keyword

mass transport deposits, Qiongdongnan basin, South China Sea, sea level changes, earthquake

Analyzing the impacts of spatiotemporal coastline changes on sustainable development in the Pearl River Estuary and Hong Kong of northern South China Sea

Yingying LIU[1]*, Nanjing University of Information Science and Technology
(liuyingying415@163.com)
Jiajun Feng[2], Nanjing University of Information Science and Technology
Teng Xiao[3], Nanjing University of Information Science and Technology
Qiuming Cheng[4], China University of Geosciences Beijing
Jin Yeu Tsou[5], City University of Hong Kong
Yuanzhi Zhang[6], Nanjing University of Information Science and Technology

Abstract

Changes in coastlines and coastal zones reflect human activities and global changes. Using Landsat imagery from 1998 to 2021, the temporal and spatial variation characteristics of coastlines and coastal zone land use/land cover changes in the Pearl River Estuary and Hong Kong (PRE_HK) of northern South China Sea were studied during this period, followed by an analysis of how human activity affects them, in an attempt to provide a basis for decision-making in coastal zone management. Our results show that the PRE_HK coastline expanded outward, demonstrating an obvious trend that featured increasing length. The PRE_HK coastal zone was observed to primarily comprise construction land and cultivated land, of which the construction land displayed significant growth in contrast to the woodland's decreasing trend, indicating that the PRE_HK coastline was changing from natural to artificial in character. Human activity in the PRE_HK coastal zone had a significantly positive impact on the coastline length. While the amount of coastline in all PRE_HK sub-regions has increased overall, the coastline length in Guangzhou-Dongguan, in particular, exhibited the greatest growth. During analysis, a positive correlation emerged between coastline length and fractal dimension, in particular, the correlation between Shenzhen coastline length and fractal dimension demonstrated the highest level among the four sub-regions studied. With the exception of Hong Kong, construction land increased significantly in all PRE_HK coastal zones and encroached on other types of land, such as cultivated land, woodland, and water area. Additionally, except for Hong Kong, human disturbance in the PRE_HK coastal zone increased. Among all study areas, Shenzhen revealed a significant increase in human disturbance over the period of interest, exhibiting the highest level of this factor among the sub-regions in the study. These findings could potentially facilitate effective coastal zone management to achieve sustainable development in coastal zones.

Keyword

Coastline length, Coastal zone management, Fractal dimension, Human disturbance, Pearl River Estuary and Hong Kong

Mapping the sedimentary change in South China Sea over Last Glacial Cycle and Holocene

Jinpeng ZHANG[1]*, 1 Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China. 2 Institute of Marine and Environmental Sciences, University of Szczecin, 16 Adama Mickiewicza, 70-383 Szczecin, Poland. (jinpenggmgs@sina.com)
Pingyuan Li[2], Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China
Yufeng Wang[3], Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China
Jianmei Hou[4], Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China
Qiao Xue[5], Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China
Lei Jia[6], Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China

Abstract

The South China Sea is the largest marginal sea between Eurasian continent and Pacific Ocean, with relative wide continental shelf and series of large rivers discharge in the Asian Monsoon realm. Following the global ice volume and sea-level change in the orbital scale, the paleogeography and paleomorphology were shaped frequently in the South China Sea, and overlapping with regional climate change force. To model the sedimentary processes and reconstruction the paleoenvironment is one of important conjunct demands in marine geosciences. Under the time of big data and data driving, a collaboration work is operating to integrate geological survey's data, international joint cruise' results and published data in journals, in order to expose the change of sediments thickness and map the regional depositional history, especially in the Late Pleistocene and Holocene.

Though multi-sources data analysis from hundreds of sedimentary cores in the South China Sea, covering the coast, shelf, slope and deep basin, our study offers the opportunity to describe marine sediments and paleogeography change, particularly in isopachous and isochronic level, following the marine oxygen isotope stage alternation. As a relative sufficient investigation area in the northern of South China Sea, the available single channel seismic data and drilling cores' materials make the regional mapping work more reliable on the shelf and in coast zone. As an on-going work, the geological modelling research is approaching to shelf construction, delta formation, estuary change, making sense to understand the global change impact on this big marginal sea between Eurasian continent and Pacific Ocean, and offering an exemplary for

worldwide marginal seas research as well.

Acknowledgement

This work is partly supported by the international collaboration project between Guangzhou Marine Geological Survey, CGS, China and University of Szczecin, Poland. Part of work is involved into the DDE Marginal Sea R&D project “Morphological evolution of coastal seas – Past and Future”. Part of the communication was supported by the Guangdong Basic and Applied Basic Research Foundation, China (No. 2021A1515011746), and by the State Key Laboratory of Palaeobiology and Stratigraphy, China (No. 183130).

Keyword

South China Sea, Glacial-interglacial cycle, Sedimentology, Morphology, Sea-level change

Huatung Basin in West Pacific Marginal Seas: a linkage of West Philippine Sea and South China Sea

Hongfang GAO[1]*, Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China. (promap@163.com)
Jinpeng Zhang[2], Guangzhou Marine Geological Survey, China Geological Survey/Key Laboratory of Marine Mineral Resources, Ministry of Natural Resources, 1133 Haibin Rd., 511458 Guangzhou, China.

Abstract

The Huatung Basin, east off Taiwan Island, is an intersection of the Pacific Plate and Eurasian Plate, and the convergence point of multiple tectonic movements of subduction, collision and uplift, which records the tectonic activity processes of subduction and collision of geographical units, including the island arc of Ryukyu-Taiwan, marginal sea basins of South China Sea and West Philippine Sea. Based on most recent geophysical data and drilling data in adjacent areas, we found new geological phenomena to benefit the solution of Huatung Basin genesis debate, in term of Mesonic or Cenozoic puzzle.

The results include, (1) Gravity inversion and magnetic anomaly data show that the crustal properties of Huatung Basin, Gagua Ridge and West Philippine Basin are similar; (2) The deep reflection seismic profile shows that the deep crust and upper mantle have folded and deformation, which is consistent with the basement relief of Huatung Basin-Gagua Ridge and West Philippine Basin; (3) Eocene sedimentary strata developed in the upper part of Gagua Ridge; (4) The largest unconformity T7 in Huatung Basin and West Philippine Basin coincides with the Puli movement in Taiwan Island and Ryukyu Islands, during the Late Eocene-Middle Oligocene (35-30 Ma); (5) Huatung Basin and West Philippine Basin on both sides of Gagua Ridge, developed consistent sequences since the Early Miocene, with relatively stable structure and small stratigraphic deformation.

The research conclusions are,

(1) Huatung Basin and Gagua Ridge have similar properties to the West Philippine Basin. Gagua Ridge and its adjacent low uplift are formed by crust- upper mantle folding and deformation. During the folding and deformation process, ridge formed by rock strata bend, anticlinal part arch upward and crust thickens. In the syncline part, basin and trough formed by stretched and thinner rock strata to create a larger accommodating space with number of sediments preservation.

(2) Huatung Basin is not a Mesozoic basin, but like the West Philippine Basin to expand during the Late Paleocene-Early Eocene (60-35 Ma), and then to enter regional uplift and drift period. The regional unconformity T7 records the complete closure and regional uplift and drift of the Huatung and Philippine Basin.

(3) During the northwestward drift of Philippine Sea Plate and Luzon Island Arc, and the eastward subsidence of Manila Trench in South China Sea, Huatung Basin, Gagua Ridge and East Trough of Gagua Ridge were obstructed by the Eurasian Plate with regional flexural folding and

deformation. Large accommodation space was offered in Huatung Basin and East Trough of Gagua Ridge. With the continuous collision between the Philippine Sea Plate and Eurasian Plate in Neogene, Taiwan Island was uplifted, and a large number of matters flooded into the Huatung Basin, and be transported to East Trough of Gagua Ridge through the Ryukyu Trench, forming obvious thick Neogene-Quaternary sedimentary sequence.

Keyword

Huatung Basin, Gagua Ridge, South China Sea, Crustal folding and deformation, West Philippine Basin

Origin of rapid sedimentation since Late Miocene in the western continental margins of South China Sea

Xinong XIE[1]*, China University of Geosciences (xnxie@cug.edu.cn)
Yunliu YANG[2], Hubei Key Laboratory of Marine Geological Resources, China University of Geosciences
Li ZHANG[3], Guangzhou Marine Geological Survey
Hui CHEN[4], School of Marine Sciences, Sun Yat-sen University
Ming SU[5], School of Marine Sciences, Sun Yat-sen University

Abstract

The South China Sea (SCS) is one of the most active tectonic zones in the world. The massive information on sedimentary infilling in the SCS provided by marine surveys and offshore oil and gas exploration has made the SCS as the best place and natural laboratory for comprehensive research on "climate-tectonics-sedimentation". A large number of seismic and drilling data show that a series of multi-stage progradational wedges have developed along the strike-slip fault zone in the western SCS since the Late Miocene, indicating the characteristics of rapid subsidence and rapid sedimentation. There are developed not only large deltas rapidly propelling progradational wedges, such as the Rajang Delta of the Zengmu basin and the delta of the Wan'an basin, but also rapidly advancing continental clinoforms, such as the seaward migration of the shelf break at the intersection of the Yinggehai and Qiongdongnan basins for nearly 200 km, and similarly the rapid seaward migration of the continental slopes in both the Zhongjiannan and the Wan'an basins.

A plentiful of clastic provenance systems occur in the western continental margins of the SCS, which include multi-directional sediment supply from the Red River, Mekong River, Hainan Island, Indochina Peninsula and eastern Vietnam. Since the Late Miocene, abundant supply of terrigenous detritus and rapid sedimentation occur in the western margins of the SCS. Of them, the uplift of the Tibetan Plateau and the East Asian summer monsoon are likely to be the two key factors controlling the flux of river sediments. Primary reason for abundant supply of terrigenous detritus is due to homochromous regional tectonics, especially rapid uplift in drainage area. According to the study of geological historical records and the uplift history of the Tibetan Plateau, the strong uplift and denudation of the Tibetan Plateau during the Late Miocene and Pliocene provided sufficient clastic materials for the Red River and the Mekong River, and the sediments were further transported to the western continental margins of the SCS through the rivers, resulting in a dramatic increase in the sedimentation rate since the Late Miocene. Second reason is the strengthening of the East Asian monsoon and the strong weathering and denudation in the source area. The strengthening of the monsoon brings about strong rain, while the weathering and erosion of terrestrial materials increases. Therefore, the supply and rapid sedimentation of abundant terrigenous clastics since the Late Miocene in the western margins of the SCS are closely related to regional tectonic events during the same period, such as the rapid uplift of the Tibetan Plateau, and also related to the strengthening of the East Asian monsoon and the strong weathering and denudation in the source area.

Keyword

western margins of South China Sea, rapid sedimentation, East Asian monsoon

Study on changes of coastline morphology and submarine geomorphology in Caofeidian Area, the North Bohai Sea

Wenqin JIANG[1]*, Yantai Center of Coastal Zone Geological Survey
(3001200041@email.cugb.edu.cn)
Hongxian Chu[2], Yantai Center of Coastal Zone Geological Survey
Minghui Zhu[3], Yantai Center of Coastal Zone Geological Survey
Wenliang Liu[4], Yantai Center of Coastal Zone Geological Survey
Binghui Feng[5], Yantai Center of Coastal Zone Geological Survey
Jidong Yuan[6], Yantai Center of Coastal Zone Geological Survey
Huijie Shi[7], Qingdao Institute of Marine Geology
Dapeng Bai[8], Yantai Center of Coastal Zone Geological Survey

Abstract

Land reclamation projects typically alter the natural coastline morphology and submarine topography, affecting the conditions of coastal erosion and deposition, thereby influencing the topography of the seabed. Using the Caofeidian land reclamation project in the Bohai Sea as a case study, this research employs multi-phase nearshore remote sensing data, submarine topography measurements and sub-bottom profiles since 2001. It combines tidal currents, the types of seabed sediments and suspended particle concentration data to discover that there has been a gradual decrease in the rate of coastline change. The land reclamation efforts in Caofeidian have successfully preserved the geomorphic features of the Caofeidian Cape. The strong tidal flow within the deep trough generates shear stress greater than the critical erosional shear stress of the surface sediment, resulting in the removal of surface sediment and the continual erosion in the deep trough. Consequently, new underwater landslides and eroded basins have emerged in the marine area of the deep trough. While this helps to maintain the depth of the deep trough, attention should be given to whether the underwater landslides are advancing towards the front edge of the Caofeidian headland. In order to address this issue, timely measures should be implemented, such as reinforcing submarine slope engineering in Caofeidian and enhancing monitoring and early warning systems for marine geological hazards in the deep trough marine area. The research findings will provide valuable technical support for the management of natural resources and the protection and restoration of coastal areas.

Keyword

geomorphology, erosion, remote sensing, marine deep trough, Caofeidian

An expansive Ediacaran lagoon: clay mineralogy and geochemistry evidences for the spatiotemporal extent of evaporitic conditions in the Doushantuo Formation

Shujun HAN[1]*, Research Institute of Petroleum Exploration and Development, PetroChina (hansj2022@petrochina.com.cn)
Stefan Carlos Loehr[2], University of Adelaide
April Nicole Abbott[3], Coastal Carolina University
Andre Baldermann[4], Graz University of Technology
Graham Shields[5], University College London
Huan Cui[6], Mississippi State University
Alan Jay Kaufman[7], University of Maryland
Bo Chen[8], Nanjing Institute of Geology and Palaeontology, Chinese Academy of Sciences
Bingsong Yu[9], China University of Geosciences (Beijing)

Abstract

The Ediacaran Doushantuo Formation (ca. 635–551 Ma) in South China has yielded a broad array of microfossil and isotope proxy records which underpin much of our understanding of the Earth System and biospheric evolution during a critical time period, while the depositional environment is still debated. Abundant authigenic Mg-rich saponite clay has been reported in the Yangtze Gorges Area as a proxy for local restricted, evaporitic lagoon setting (1), while the spatiotemporal extent of restricted, evaporitic conditions across the Yangtze Block remains largely unexplored. Here we use mineralogical and petrographic approaches to systematically document spatiotemporal variations of clay mineralogy in the Yangtze Block, providing new constraints for depositional environments and further implication on early earth system.

Our results find that the open marine slope and basin settings do not contain Mg-rich clays and are dominated by illite clay, consistent with previous work which suggests that formation of Mg-rich clays require evaporitic, restricted conditions. In contrast, Mg-rich clays persistently occur in all shelf settings studied, including saponite, talc, sepiolite and palygorksite, implying that evaporitic restricted conditions were much more expansive than previous assumed. In addition to this spatial pattern, we identify a clear stratigraphic progression where the basal and uppermost Doushantuo Formation contains illite but Mg-rich clays appear in between, shortly above the cap carbonate. The results suggest an extensive carbonate rimmed, evaporitic lagoon developed on the Yangtze shelf shortly after the deposition of the cap carbonate, consistent with existing paleographic reconstructions (2). Open marine conditions on the shelf only became re-established following erosion of the carbonate rim, most likely during the Gaskiers glaciation, and subsequent marine transgression.

Interestingly, we found the intervals containing authigenic Mg-rich clay show more positive carbonate carbon isotope values and elevated carbonate Sr concentration, which could have been impacted by local restriction and evaporation. Compilation of published carbon isotope data in more sections spreading across the Yangtze Block show that shelfal sections usually show positive carbon isotope values in the middle of the Doushantuo (632.5 ± 0.5 Ma to 579.3 ± 0.8 Ma)

between the global-comparable negative excursion in cap carbonate and the Shuram excursion, while the time-equivalent record of slope to basinal section are mostly negative. The geochemical variations are correlated to our clay mineralogical results, indicating different water chemistry between lagoon and the open ocean. In this case, coupled mineralogical and geochemical proxies can contribute to detailed paleogeographic reconstruction. Moreover, cautions are required when interpreting proxy records derived from shallow, shelfal sections, as these may record local lagoon conditions rather than a ‘global ocean’ signal, and more geochemical proxies can be revisited under the spatiotemperal environment model constrained by clay mineralogy.

References:

1. Han, S. et al. Authigenic clay mineral evidence for restricted, evaporitic conditions during the emergence of the Ediacaran Doushantuo Biota. Commun. Earth Environ. 3, 165 (2022).

2. Han, S. et al. Authigenic clay mineral constraints on spatiotemporal evolution of restricted, evaporitic conditions during deposition of the Ediacaran Doushantuo Formation. Earth Planet. Sci. Lett. 626, 118524 (2024).

Keyword

authigenic clay, Ediacaran Doushantuo Formation, restricted lagoon, evaporitic condition

(Withdrawn) Evolutionary dynamics of redox-sensitive minerals

ziyi zhuang[1]*, Peking University (ziyi_zhuang@pku.edu.cn)
Yannan Zhang[2], Beihang University
Yan Li[3], Peking University
Rongzhang Yin[4], Peking University
Chunjiang Li[5], Peking University
Anhuai Lu[6], Peking University
Yong Lai[7], Peking University
Xiangzhi Bai[8], Beihang University

Abstract

There are many geological and geochemical proxies used for tracing Earth’s atmospheric O2 level (pO2) evolution, but they always had distinct response dynamics to pO2 fluctuations. This was ascribed to their different sensitivities to changes in O2 fugacity and the lack of their continuous and complete geological records. In this study, a global-scale mineralogical dataset was established, including 30,918 samples of minerals containing manganese (Mn), molybdenum (Mo), chromium (Cr), cerium (Ce), phosphorus (P) and carbon (C) minerals. The tempo and rhythm of valence evolution of Mn, Mo, Cr and Ce can be well fitted a third-order trigonometric Fourier series expansion of a periodic function. Furtherly, we quantified the time lag between variation in pO2 and the corresponding response in these minerals’ evolution through evolutionary dynamic model. According to the results of analysis, it was found that the evolutionary time lag sequence of high-valent Mn, Ce, Mo and Cr minerals after 2.4 Ga followed MnIV>CeIV>MoVI>CrVI, that is, Mn and Ce minerals displaying the most rapid dynamic response, followed by Mo and Cr minerals, which aligns with the thermodynamic sequence of oxidation reactions. All minerals maintained high depositing frequency over the period of orogenic quiescence (1.8-0.8 Ga), while there are two depositional discontinuities or slowdown during the Great Oxidation Event (the GOE) and the Neoproterozoic Oxygenation Event (the NOE) in the evolution of these minerals. Our findings support that Earth's surface environment is actually a dynamic process of continuous oxidation during orogenic quiescence. These two discontinuities of mineral depositional records related to mineral phase conversion or dissolution during the GOE and/or the NOE, which revealed the quick change of the Earth's internal and external environment. The analysis results show that Mn and P minerals have similar evolutionary processes, which may help to explore the origin of Earth oxygenation, for example, whether Mn or P is the limiting element of early atmospheric oxygen level.

Keyword

Mineral evolutionary dynamics, time lag, atmospheric oxygen level

[Keynote] Characterizing early earth environment and searching for signs of life: Data-driven methods to answer questions about Earth and other planets

Anirudh Prabhu[1]*, Carnegie Institution for Science (aprabhu@carnegiescience.edu)
Robert M Hazen[2], Carnegie Institution for Science
Shaunna M Morrison[3], Carnegie Institution for Science
Henderson J Cleaves[4], Howard University
Michael L Wong[5], Carnegie Institution for Science
Grethe Hystad[6], Purdue University Northwest
George Cody[7], Carnegie Institution for Science

Abstract

Data-driven approaches have been at the center of many recent scientific discoveries and have opened up new frontiers in these areas of inquiry. Most prior efforts on biosignature detection has been focused on the identification of key “smoking gun” biomolecules, such as lipids, hopanoids, and other species that are presumed to be exclusively biotic in origins. Such methods rely on teasing out a few specific analytical peaks from a noisy background.
We adopt a different and powerful new informatics approach in studying early earth and other planetary environments using data-driven methods.

In this presentation, we will go through some of the most recent and exciting discoveries made using machine learning methods we have developed. We look at our work on data-driven biosignature detection from 2 perspectives (1) where we use network science in order to characterize mineralogy of a planet, and to eventually from planetary scale biosignatures and (2) where we combine pyrolysis-gas chromatography-mass spectrometry and machine learning to build a predictive model to detect agnostic molecular biosignatures. We will also take a detailed look at how these descriptive and predictive models can used to characterize early environments through the study of highly degraded biotic samples, even when no single molecular fragment is by itself diagnostic.

Keyword

Artificial Intelligence, Mineralogy, Biosignatures, Early Earth, Data science

[Keynote] Data-Driven Discoveries in Mineralogy

Robert M HAZEN[1]*, Carnegie Institution for Science (rhazen@ciw.edu)

Abstract

The story of Earth is a 4.5-billion-year saga of dramatic transformations, driven by physical, chemical, and biological processes. The co-evolution of life and rocks unfolded in an irreversible sequence of evolutionary stages. Each stage re-sculpted our planet's surface, while introducing new planetary processes and phenomena. This grand and intertwined tale of Earth's living and non-living spheres is coming into ever-sharper focus, thanks to advances in "mineral informatics"—a field that employs large and growing mineral data resources to tell the deep-time stories of our evolving planet. Minerals are remarkably information rich, holding dozens of trace and minor elements, scores of stable isotopes, solid and fluid inclusions, chemical zoning, twinning, exsolution, countless defects, and a host of optical, magnetic, electrical, and other properties. Every mineral specimen is a time capsule waiting to be opened—waiting to tell its story.

This lecture will explore some of the advanced data analytical and visualization methods that are shining new light on the old field of mineralogy by exploiting large and growing mineral data resources. Examples include distribution analysis, cluster analysis, association analysis, and network analysis. These approaches advance our understanding of the changing diversity and distribution of minerals through Earth history, the co-evolution of the geosphere and biosphere, new approaches to predicting critical mineral occurrences, and ways to compare Earth with other planets and moons.

Mineral informatics also points to a new approach to classifying minerals--an approach that complements the current protocols of the International Mineralogical Association. This evolutionary system of mineralogy attempts to use the information-rich attributes of minerals to arrange them according the age a process by which they form.

Keyword

Mineral evolution, Network analysis, Mineral classification

Optimizing the infrared radiation performance of tourmaline under γ−ray irradiation

Ming GUO[1]*, Southwest University of Science and Technology (806897163@qq.com)
Faqin Dong[2], Southwest University of Science and Technology
Wei Zhang[3], Southwest University of Science and Technology
Lin Zhou[4], Southwest University of Science and Technology
Leonid Kotov[5], Syktyvkar State University
Elena Kotova[6], St. Petersburg Mining

Abstract

Three natural tourmalines - dravite, elbaite, and schorl - were irradiated by using gamma rays. The results indicate that the far-infrared radiation performance of these tourmalines improved with different irradiation doses. Schorl exhibited the highest far-infrared radiation performance at an irradiation dose of 1500 kGy, with a total emissivity of 94.16% and a maximum emissivity of 99.11%. The structural changes of tourmaline before vs. after irradiation were studied through X-Ray Diffraction (XRD), Fourier Transform Infrared Spectroscopy (FITR), and UV-Vis-Diffuser-Reflectance (UV-Vis-DRS) technologies. The inherent dipole moment and cell volume changes of tourmaline before vs. after irradiation were calculated through X-ray single crystal diffraction refinement results and were studied per the mechanism of the effect of γ-ray irradiation on the far-infrared emission performance of tourmaline. The main factor that improves the far-infrared emission performance of tourmaline is the effect of γ-ray irradiation on the valence state of the Fe element and the consequent decrease in the band gap. However, the spontaneous polarization characteristics of tourmaline can lead to agglomeration, which reduces the specific surface areas and may result in unsatisfactory experimental outcomes.

This study aims to enhance the far-infrared radiation performance of tourmaline by using γ-ray irradiation, and investigate the mechanism behind the influence of γ-ray irradiation on the far-infrared emission performance of various types of tourmaline. Simultaneously, it introduces a promising new method to enhance the efficiency of far-infrared emitting health materials. It investigates how modifications in the composition and structure of tourmaline affect its performance, providing insights for the development of functional mineral materials containing tourmaline.

Keyword

Tourmaline, γ-ray irradiation, Far-infrared emissivity, Spontaneous polarization

Control mechanism of iron speciation on spontaneous polarization of tourmaline containing Fe

Lin ZHOU[1]*, Southwest University of Science and Technology (zhoulin_5189@163.com)
Elena Leonidovna Kotova[2], St. Petersburg Mining University
Faqin Dong[3], Southwest University of Science and Technology
Leonid Nafanailovichd Kotov [4], Syktyvkar State University
Wei Zhang[5], Southwest University of Science and Technology
Ming Guo[6], Southwest University of Science and Technology

Abstract

Tourmalines have great application potential because of its natural spontaneous polarization, but there are few researches on its properties at present. In the study, the spontaneous polarization as crucial characteristic of tourmaline was focused on, and common iron-containing tourmaline was selected as the object. The total composition, end element occupancy, crystal microstructure and characteristic properties of tourmalines with different Fe content were analyzing to reveal the effect and control path among composition-microstructure-characteristic property. The results showed that for schorl, the cell volume increased with the increase of magnesium content, and the polyhedron distortion of tourmaline and the intrinsic electric dipole moment increased with the increase of Fe2+ content and iron atom in Z site; for dravite, the cell volume increased with the increase of Fe content, the structural distortion and the intrinsic electric dipole moment decreased with the increase of Fe content, and increased with the increase of Fe2+ content; for elbaite, the cell volume increased with the increase of lithium and iron content, and the polyhedron distortion and intrinsic electric dipole moment increased with the increase of Fe2+ content. By analyzing the variation trend of intrinsic electric dipole moment under the dominance of Y-end element occupancy, the configuration structure-performance relationship of tourmaline with Fe as the main factor was revealed: When the Mg/Fe ratio was less than 1, the performance of tourmaline decreased with the decrease of Fe content; when the Mg/Fe ratio was greater than 1, the performance of tourmaline increased with the decrease of Fe content. According to the results, based on the actual reported composition data of tourmaline, the optimal tourmaline configuration with the best performance were proposed.

Keyword

Tourmaline, spontaneous polarization, iron speciation, gamma irradiation

Co-evolving N-Fe redox processes controlled iron minerals in banded iron formation

LIUQIN HUANG[1]*, China University of Geosciences, Wuhan (huanglq@cug.edu.cn)
Yanlong Dong[2], China University of Geosciences, Wuhan
Hailiang Dong[3], China University of Geosciences, Beijing
Hongchen Jiang[4], China University of Geosciences, Wuhan

Abstract

The early Precambrian ocean, especially during Archean to Paleoproterozoic, was characterized by low oxygen, rich reductants, and probably warm-hot temperature (>50 ℃, probably higher than 70 ℃) conditions, but irreversibly evolved into oxic and temperate conditions in the late Neoproterozoic. Although many details remain controversial about the evolutionary history of the ocean, there is no doubt that large environmental changes, especially the gradual cooling and stepwise oxygenation of the ocean, fundamentally shaped the physiochemical structure (e.g., ferruginous to stratified euxinic to oxic) of the oceans and the microbial world (e.g., thermophilic anaerobes evolving into mesophilic aerobes). Biogeochemical cycles in the Precambrian ocean responded to the co-evolution of biosphere and the physicochemical structure of the ocean, which closely link to the enigma of banded iron formations (BIFs) that primarily triggered by massive Fe(II) oxidation under anoxic-hypoxic condition for two-billon years (~3.8-1.8 Ga). The current Fe(II) oxidation models, however, rarely consider the effects of the evolution of coupled biogeochemical cycles on secular succession (shifting from magnetite to hematite) of dominant iron minerals in BIFs. Here, we investigated the evolution of coupled Fe-N redox processes under the simulated Precambrian ocean conditions, and propose a dynamic model for the origin of iron mineral succession in BIFs: During the early-mid Archean, NO2- was mainly produced by nitrification in the oceans of warm-hot temperatures (>50-60 oC), which favored the primary precipitation of Fe(II)-Fe(III) oxides (magnetite) and silicates (cronstedtite) in the early BIFs. Subsequently, the cooling and oxygenation of paleo-ocean near the GOE promoted the input of both NO2- and NO3-, resulting in co-precipitation of an increasing amount of Fe(III) minerals (goethite and lepidocrocite as precursors of hematite). This dynamic N-Fe coupling model explains the observed secular transition of iron mineral phases in BIF deposition.

Keyword

Precambrian ocean, Banded iron formation, co-evolution, N-Fe biogeochemical coupling, iron minerals

[Invited] New phenomena in high-pressure chemistry, and implications for planetary interiors

Artem R. OGANOV[1]*, Skolkovo Institute of Science and Technology (a.kisil@skoltech.ru)

Abstract

High-pressure chemistry shows many surprising phenomena, such as:
1. The formation of unusual stoichiometries, e.g. Na3Cl and NaCl7 [1]. Many of such compounds possess unusual physical and chemical properties, e.g. high-temperature superconductivity (with Tc up to 253 K in (La,Y)H10 [2]) and may exist in planetary interiors (e.g., novel oxides of Mg and Si and magnesium silicates [e.g., 3,4]).
2. Much more common (compared with normal conditions) formation of electrides [e.g., 5-7], where electrons localized in interstitial voids serve as anions.
3. The destruction of molecular states (e.g., [8]) – with molecules giving way to atomic or polymeric solids or liquids. This has consequences for chemistry of giant planets Uranus and Neptune [8].
4. Stabilization of exotic oxidation states, in particular in anomalously high valence – such as Cs5+ in CsF5 [e.g., 9].
To explain these and many other chemical phenomena, we turn to electronegativities and chemical hardnesses of atoms, which are expected to depend strongly on pressure. We have extended the concept of Mulliken electronegativities to high pressure [10] – which required modification of the definition and gave a new scale. The new electronegativity is defined as minus the chemical potential of the electron in an atom relative to homogeneous electron gas at the same pressure. We have tabulated electronegativities and chemical hardnesses of all elements up to Cm (#96) at pressures up to 500 GPa, and shown that they explain many unusual chemical phenomena known at high pressure [10]. I shall also discuss our recent hypothesis [11] on the origin of oceanic water, which is based on stability of Mg2SiO5H2, probably present in the early Earth.
[1] Zhang W.W., Oganov A.R., Goncharov A.F. et al., (2013). Unexpected stoichiometries of stable sodium chlorides. Science 342, 1502-1505. [2] Semenok D.V., Troyan I.A., Ivanova A.G., et al (2021). Superconductivity at 253 K in lanthanum–yttrium ternary hydrides. Materials Today 48, 18-28. [3] Zhu Q., Oganov A.R., Lyakhov A.O. (2013). Novel stable compounds in the Mg-O system under high pressure. Phys. Chem. Chem. Phys. 15, 7696-7700.
[4] Niu H.Y., Oganov A.R., Chen X.Q., Li D.Z. (2015). Novel stable compounds in the Mg-Si-O system under exoplanet pressures. Sci. Rep. 5, 18347. [5] Huang H.-M., Zhu Q., Blatov V.A., Oganov A.R., et al (2023). Novel topological motifs and superconductivity in Li-Cs system. Nano Lett. 23, 5012-5018.
[6] Dong X., Oganov A.R., Goncharov A.F., et al (2017). A stable compound of helium and sodium at high pressure. Nature Chemistry 9, 440-445. [7] Ma Y., Eremets M.I., Oganov A.R., et al (2009). Transparent dense sodium. Nature 458, 182-185. [8] Naumova A.S., Lepeshkin S.V., Bushlanov P.V., Oganov A.R. (2021). Unusual chemistry of the C-H-N-O system under pressure

and implications for giant planets. J. Phys. Chem. A125, 3936-3942. [9] Zhu Q., Oganov A. R., Zeng Q. F. (2015). Formation of stoichiometric CsFn compounds. [10] Dong X., Oganov A.R., Cui H., Zhou X.-F., Wang H.-T. (2022). Electronegativity and chemical hardness of the elements under pressure. [11] Li H.F., Oganov A.R.,Cui H., Zhou X.-F.,). Ultrahigh-pressure magnesium hydrosilicates.

Keyword

High-pressure, Unusual stoichiometries, Superconductivity, Electronegativity, Earth

AI for minerals: Electron transfer rules under pressure informed by machine learning

Yanzhang LI[1]*, Peking University (yzlee@pku.edu.cn)
Hongyu Wang[2], Beihang University
Yuxuan Hu[3], Beihang University
Anhuai Lu[4], Peking University
Xiangzhi Bai[5], Beihang University
Yan Li[6], Peking University

Abstract

Electron transfer, though the most basic process in nature, is infrequently applied to high-pressure environments, such as those found deep within the Earth. In this study, we introduce a deep learning model to determine the electronegativity of 96 elements across various pressures in 0-500 GPa. Additionally, we've developed a unified formula to quantify the relationship between electronegativity, pressure, and electronic configuration. Morevoer, the electronegativity value under high pressure is obtained by our developed AI-based tool named AI4Min-PE, which can further predict work function, bond energy, formation energy, and chemical affinity of compounds with any given chemical formula. AI4Min-PE can serve as a handy AI-based tool in geoscience and help researchers get insight into basic rules about the interaction of materials in the deep Earth before time-consuming calculations and difficult-to-operate experiments. By analyzing the relative work function of minerals, we observe a decreasing trend with increasing pressure due to pressure-induced electron delocalization. Using the work function as a proxy, we find that the force driving directional electron transfer is enhanced by the increasing work function difference between compounds under pressure. This finding provides a plausible explanation for the observed high-conductivity anomalies and sheds light on the redox reactivity between widespread Fe(II)-bearing minerals and water during subduction. Our results offer valuable insights into the fundamental physicochemical properties of elements and their compounds under pressure.

Keyword

AI for minerals, Electronegativity, Machine learning, Electron transfer, Deep Earth

Endolithic microbes catalyze aragonite dolomitization

Geng WU[1]*, China University of Geosciences (wugeng@cug.edu.cn)
Deng LIU[2], China University of Geosciences
Hongchen JIANG[3], China University of Geosciences

Abstract

Dolomite, a calcium-magnesium carbonate mineral, exhibits prevalence in Archean and Proterozoic marine microbialites but has exhibited rarity during the Phanerozoic, perplexing geologists for over a century. Kim et al. (2023) elucidated the crystal growth of dolomite under ambient conditions, drawing upon laboratory experiments and theoretical simulations within a crystal growth framework. Despite extensive study, the mechanisms governing dolomitization in Earth's surface conditions remain inadequately understood, with a dearth of evidence illustrating the evolution of microbially mediated mineral phases into the ordered dolomite observed in the geological record. This investigation focuses on terrestrial geothermal travertine in western Tibet, wherein endolithic microbes have colonized the substrate. Through the application of LA-ICP-MS, SEM-EDS, and FIB-TEM technologies, the presence of ordered dolomite in the endolithic colonization zone of aragonite travertine is confirmed. The outcomes of mineralogical, microbial ecological, and geochemical analyses suggest that endolithic microbes play a catalytic role in aragonite dolomitization within terrestrial geothermal travertine. The involvement of endolithic microbes in the dolomite formation observed in this study signifies a potential biosignature. The identified microbial participation in the formation of ordered dolomite in the current investigation not only contributes substantively to our understanding of terrestrial geothermal areas but also holds implications for recognizing past and present biosignatures, particularly in subsurface regions on Mars. This is particularly relevant within Mars' locales exhibiting geothermal travertine, emphasizing the importance of our findings in advancing the identification of biosignatures on the Martian surface.

Keyword

ordered Dolomite, endolithic microbes, aragonite, geothermal travertine

Advent of different Iron mineral corresponding to the Eh evolving of Precambrian sea water

Yuanfeng CAI[1]*, Nanjing University (caiyf@nju.edu.cn)
Zhou Fang[2], Nanjing University
Siyi Huang[3], Nanjing University

Abstract

The Eh evolving during the later Archean and Early Paleoproterozoic could be recorded and retrospected by the mineral species. Banded iron formation (BIF) was considered as most typical representatives of changing of Eh of Precambrian sea water which now was thought of a potential example of co-evolving with microbes. Known iron minerals include magnetite, hematite, goethite, lepidocrocite, siderite, ankerite etc. These iron minerals were constituted by different valence of iron, and can be used to indicate different degree of Ehs. With the increase of Ehs, iron minerals might follow in the order of siderite and ankerite, magnetite, glauconite, goethite or lepidocrocite, hematite. Different iron oxide assemblages were found in BIF with different age of formation. For example, Magnetite-martite-specularite assemblages was found in BIF outcropped in Koolyanobbing and Marda greenstone belt with the formation age ca.2.8-2.6 Ga. Martite-microplaty hematite assemblages was found in Mt. Whaleback, Mt. Tom Price and Paraburdoo deposit with the formation age younger than ca.2.2 Ga (Hagemann et al., 2016). In general, magnetite and hematite was the major iron oxide in Archean and Paleoproterozoic BIF, respectively. BIFs present in the Badampahar greenstone belt (3.3–3.1 Ga), East Indian Shield had distinctly negative Ce anomalies which might indicate Fe2+ oxidation in an oxygenated hydrosphere and derivation of free oxygen from microbial photosynthesis (Ghosh and Baidya, 2017). The precipitation of iron formation recorded directly the Eh condition of local seawater and thus useful to restore the paleoenvironmental information. In summary, it is important to explore the first advent of iron minerals one by one and evaluate its forming Eh according to published data in literature.

Keyword

Iron minerals, Eh, BIF, Precambrian

A preliminary study on the evolution and ecology of arsenic minerals

Minghao TANG[1]*, tianjin university (2021231017@tju.edu.cn)
Xiangyu Zhu[2], tianjin university
Hui henry Teng[3], tianjin university

Abstract

Various information pertaining the evolution of the Earth can be recorded by minerals through their structural characteristics and chemical compositions, such as valence state, isotope composition, and trace element concentration. This recorded information contributes to the discovery of many major geological events. However, the traditional way of leveraging mineral information is low dimensional and always neglects the relevance of multiple data and their dynamic change through deep time, and thus could not be satisfied with the fact that massive and multidimensional mineral data are emerging. Fortunately, not long ago, Hazen introduced the ideal of “mineral evolution and ecology”, which focused on the diversity and distribution of mineral assemblages and stressed their evolutional behavior over time due to a range of physical, chemical, and biological processes. Propped up by such a concept, combined with big data analytics and its relevant technological means, mineral diversity can be used as a carrier to integrate vast and multidimensional mineral information through deep time. Arsenic has a low abundance in the earth system, but approximately 770 arsenic minerals have been recorded to date, indicating that arsenic minerals may be a potential proxy for changing environmental conditions. Moreover, arsenic pollution in essence is the evolution of arsenic minerals that entails the dissolution of primary minerals and formation of secondary As-bearing phases. In the present work, we investigate the evolution of arsenic minerals through deep time, predict the most probable sites for discovering new arsenic minerals, and estimate the number of arsenic mineral species that may currently exist in the Earth’s crust on the basis of existing arsenic mineral locality data. The results reveal that the diversification of geochemical conditions and activation of arsenic associated with supercontinent collisions and the great oxygenation events (GOE) confer the geological environment the ability to innovate arsenic minerals. The arsenic mineral distribution data reveal that most arsenic minerals are rare and are only concentrated in a few mines. This phenomenon can be attributed not only to past hydrothermal events that led to the formation of various arsenic minerals but also to the fact that these mines often contain rare elements or possess unique geochemical conditions. As such, these locales present an abundance of arsenic minerals as well as promising opportunities for discovering new ones.

Keyword

arsenic minerals, mineral evolution, mineral ecology, mineral diversity

Mineralogical and Fe Isotopic Constraints on the Origin of the Banded Iron Formations: A Case Study of the Kuruman Formation in South Africa

He Zhang[1]*, Nanjing University (zhanghemineral@163.com)
Zhou Fang[2], Nanjing University
Chang Liu[3], Nanjing University
Siyi Huang[4], Nanjing University
Huan Liu[5], Nanjing University
Guangyi Wei[6], Nanjing University
Shichao An[7], Nanjing University
Xianglong Luo[8], Nanjing University
Weiqiang Li[9], Nanjing University
Yuanfeng Cai[10], Nanjing University
Jiarun Liu[11], Nanjing University
Xiancai Lu[12], Nanjing University

Abstract

The Paleoproterozoic Era was a critical geological interval involving redox evolution of Earth's oceans and rapid production of banded iron formations (BIF). However, little is still known about the dynamic input and output of Fe in response to oceanic physicochemical evolution. One key variable is the BIF alternating layers that record the fluctuating oceanic physicochemical conditions. Here, we performed analyses of Fe isotopes and Fe-bearing species on samples from the Kuruman BIF ores in South Africa and presented an outline of compositional and textural evolution for BIF alternating layers. The resulting data suggest that these samples feature alternating layers due to varying ratios of goethite to hematite/magnetite. The goethite is interpreted as a secondary phase as a result of weathering of pre-existing Fe oxides. Most yellow goethite-rich layers are characterized by negative δ56Fe values, but grey hematite/magnetite-rich layers by positive δ56Fe values. Such isotopic fractionation is expected to involve the preferential precipitation of heavy Fe isotopes, which would make seawater enriched in light Fe isotopes for precipitation of Fe oxides with negative δ56Fe values. The rhythmic compositional and textural variations within BIF ores might be attributed to pulsed input of Fe into the oceans, but more likely resulted from episodic loss of Fe compositions through oxidation from upper photic zones in closed ocean systems.

Keyword

Paleoproterozoic, Banded iron formation, Fe isotope, Fe oxide, Kuruman

Mineralogical phases and redox evolution of manganese in Precambrian manganese deposit: Implications for diagenesis

Huan LIU[1]*, Nanjing University (liuhuan@nju.edu.cn)
Xiangjie Cui[2], Nanjing University
Yuanfeng Cai[3], Nanjing University
Xiancai Lu[4], Nanjing University

Abstract

Precambrian manganese (Mn) deposits that occur in south China are closely related to the environmental change between the Sturtian and Marinoan glaciations. The formation of manganese deposits is generally related to a high concentration of oxygen in Earth's surface environments, revealing the evolution of Mn-bearing mineral phases which may be related to the microbial function. However, to our knowledge, the redox evolution of manganese and the metallogenic mechanism are still in debate. In this study, mineralogical observations were conducted for the Datangpo-type manganese deposit, which is located in Tongren, Guizhou Province. Mineralogical compositions were identified by using X-ray diffraction and Raman analyses. Synchrotron-based μ-XRF and X-ray absorption spectroscopic analyses coupled to electron microscopy were used to investigate the oxidation states and mineral phases, demonstrating that Mn exists in the carbonate phases, including kutnohorite and rhodochrosite. Elemental maps of Mn, Fe, Ca, and Mg indicated an evolution route as dolomite, kutnohorite, and then Fe-bearing rhodochrosite. The increase in Fe contents indicated a late stage of microbial Fe reduction after Mn. The Mn-bearing carbonates could be derived from the reduction of Mn oxides during the diagenesis process. A metallogenesis model was proposed that microbial activities could play key roles in mediating the reduction of oxidized manganese species, coupling with the oxidation of organic matter. These mineralogical observations provide new insights into the redox evolution of manganese oxidation states and Mn-bearing mineral phases in ancient sediments.

Keyword

Manganese, Redox evolution, Microbial reduction

Photoinduced ring-opening of native sulfur in driving synthesis of prebiotic building blocks

Huan YE[1]*, Peking university (yehuan1998@126.com)
Yanzhang Li[2], Peking university
Rongzhang Yin[3], Peking university
Zhaoyang Hu[4], Peking university
Yan Li[5], Peking university
Anhuai Lu[6], Peking university

Abstract

Native sulfur (denoted as S0) has been regarded as the crucial species in the biogeochemical cycle of sulfur, and the opening of its eight-membered rings is critical to its activation. By combining optical measurements, theoretical calculations, and photochemical experiments, we investigate the external (incident optical energy) and internal factors (impurity elements) that trigger the opening of S0 ring. Synchrotron radiation in situ X-ray absorption near edge spectra confirms that S0 can undergo ring-opening reactions under light irradiation below ~575 nm, which results from electron transition via indirect bandgap. Density functional theory calculations and ab initio nonadiabatic molecular dynamics reveal that photo-assisted electron transition evokes ring opening in the femtosecond scale, resulting in a new chain-like molecular configuration with changed charge density and electronic structure. Compared with the ring-like structure, the ring cleavage can provide two unpaired electrons on the terminal S atoms as reactive sites, and induce the thermodynamic spontaneous for reducing CO2 to HCOOH.

In the field of impurity elements, we find the room-temperature bandgap of four S0 samples with different substituting concentrations (mainly As and Se, up to 282.0 and 19.3 μg/g, respectively) decreases linearly with the increase of doping amount. It confirms that As and Se can add 4p orbitals into the S 3p-dominated valence and conduction band of S0, thus reducing the energy required for electron transition and promoting the ring-opening reaction. With the increasing of As content, S0 sample with high concentrations of As would produce much less HCOOH from carbonates compared with the few-As sample, attributed to the new three bonds of As with only one active unpaired electron left after ring opening. This research contributes to the excited state of native sulfur under the induction of light energy and can catalyze the efficient synthesis of substances such as inorganic carbon to organic carbon, which provides a new way for the gentle synthesis and accumulation of basic small organic molecules in the abiogenesis.

Keyword

Native sulfur, Ring-opening, Photochemical reactions, Impurity elements, Theoretical calculation

(Withdrawn) The co-evolution of Earth and life: biosignatures in Earth's mineral networks

Shaunna MORRISON[1]*, Carnegie Institution for Science (smorrison@ciw.edu)
Anirudh Prabhu[2], Carnegie Institution for Science
Robert Hazen[3], Carnegie Institution for Science
Michael Wong[4], Carnegie Institution for Science
Ahmed Eleish[5], Carnegie Institution for Science

Abstract

Determining the habitability of planets remains a fundamental question in science and society. In this study, we harness network theory to explore the unique patterns exhibited by minerals and their mineralizing environments in both biotic and abiotic contexts throughout the evolution of Earth and other terrestrial bodies in our solar system [1-. By examining mineralogical networks across diverse planetary systems, including early solar system bodies, the early Hadean Earth (closely related to modern-day Mars), plate tectonics, and modern Earth, we gain valuable insights into Earth's history and the factors that have shaped the development and sustainability of life. Our investigation reveals distinct characteristics within biotic networks, setting them apart from their abiotic counterparts.

Figure 1. A network representation of the relationships between all known mineral species and their modes of formation in our solar system. Brown nodes represent mineral species. Colored nodes represent paragenetic modes (modes of mineralization). Links demonstrate that a mineral is known to form in the linked paragenetic mode.

This research significantly advances our understanding of the intricate interplay between Earth and life. Network analysis offers deeper insights into the connections between minerals and living systems, providing invaluable perspectives on the emergence and co-evolution of life on our planet. Moreover, our findings contribute to identifying and characterizing planetary biosignatures, essential for the search for extraterrestrial life. Recognizing these unique patterns within biotic networks lays the groundwork for developing targeted exploration strategies for detecting potential biosignatures and interpreting the complexities of planetary environments.

Our innovative network analysis of minerals and mineralizing environments sheds new light on the relationships between Earth and life. By delving into the intricate connections within biotic and abiotic systems, we deepen our understanding of Earth's dynamic history and enhance our knowledge of potential habitats for life beyond our planet.

References:

[1] Morrison SM, Liu C, Eleish A, Prabhu A, Li C, Ralph J, Downs RT, Golden JJ, Fox P,

Hummer DR, Meyer MB, Hazen RM (2017) Network analysis of mineralogical systems. American Mineralogist, 102, 1588-1596, https://doi.org/10.2138/am-2017-6104CCBYNCND
[2] Morrison SM, Prabhu A, Hazen RM (2023) Exploration of the Biological Influence in Earth's Mineralogical Networks, Geological Society of America Abstracts with Programs. Vol. 55, No. 6, 2023, doi: 10.1130/abs/2023AM-394193
[3] Morrison, S.M., Prabhu, A. and Hazen, R. (2023) Is Earth's biological influence recorded in its mineralogical networks? AGU23.

Keyword

Mineralogy, data science, network, geobio, mineral evolution

Phyllosilicates-based nanozymatic microsystems and their significance in geological processes

Shiyong SUN[1]*, Southwest University of Science and Technology (shiysun@163.com)
Ke WANG[2], Southwest University of Science and Technology

Abstract

Enzymes are a group of biological macromolecules, generally referred to as proteins with high catalytic activity, selectivity and specificity. In living organisms, enzymes act as extremely effective catalysts for thousands of specific reactions in the metabolic processes that sustain life. However, the application of enzymes is often hampered owing to their lack of stability in organic solvents and at high temperatures. In addition, the recovery and reuse of enzymes are difficult in a liquid system. Enzyme immobilization is an efficient route to solve these problems, thereby permitting the catalysis under harsh reaction conditions at an industrial scale. The nanobiocatalyst is an emerging innovation that synergistically integrates advanced nanotechnology with biotechnology for improving enzyme activity, stability, capability and engineering performances. Recently, the construction of phyllosilicates-based nanozymatic microsystems by immobilizing enzymes on phyllosilicates has attracted widespread attention, as phyllosilicates have advantages such as natural nanoscale, swelling lamellar nanostructure, exchangeable interlayer cations, high specific surface area, biocompatibility and easy surface functionalization.

In our recent work, phyllosilicates (i.e. montmorillonite, halloysite, nontronite) as enzyme immobilization support, constructing a series of phyllosilicates-based nanozymatic microsystems based on different immobilization strategies. The effects of the nanostructures of phyllosilicates and their interfacial reactivity on the adsorption kinetics, adsorption capacity, enzyme orientation, and conformation of enzymes at the surface and interface were explored. Besides, the methods of mineralogy such as directional structural modification and surface functionalization on the microstructure of phyllosilicates/enzymes complex structure on its catalytic performance was also studied. The results indicates that the phyllosilicates-based nanozymatic microsystems showed enhanced enzymatic activity, better catalytic stability, reusability and storage stability than free enzymes. Our work has provided a promising way for screening, optimizing and rational design of efficient phyllosilicates-based nanozymatic microsystems.

Keyword

Phyllosilicate, Nanozymatic microsystems, Origin of life, Enzyme immobilization, Biocatalysis

Organic minerals: definition, classification and characteristics

Xiangping Gu[1], Guanghua Institute of Gemology and Mineral Resources, Jiangxi University of Applied Science and Technology, Nanchang 330100, China
Guanghua Liu[2]*, Jiangxi University of Applied Science and Technology (gstone1698@gmail.com)
Hexiong Yang[3], Department of Geosciences, University of Arizona, 1040 E. 4th Street, Tucson, AZ 85721-0077, USA
Bin Lian[4], College of Marine Science and Engineering, Nanjing Normal University, Nanjing, Jiangsu, China

Abstract

Organic minerals: definition, classification and characteristics
Xiangping Gu (1,4), Hexiong Yang(2), Bin Lian(3), and Guanghua Liu(1*)
(1) Guanghua Institute of Gemology and Mineral Resources, Jiangxi University of Applied Science and Technology, Nanchang 330100, China
(2) Department of Geosciences, University of Arizona, 1040 E. 4th Street, Tucson, AZ 85721-0077, USA
(3) College of Marine Science and Engineering, Nanjing Normal University, Nanjing, Jiangsu, China.
(4)School of Geosciences and Info-Physics, Central South University, Changsha, Hunan 410083, China

*Correspondence: gstone1698@gmail.com

Abstract: Organic minerals are crystalline substaneces with C—C, C—H and/or C—N bonds formed from geological processes in nature, specfically including natural crystalline organic compounds, salts of organic acids and metal-organic complexes. According to the current mineral list of the International Mineral Association (IMA) update to November 2023, there are 83 organic minerals (81 approved) in 407 localities, including 50 organic acid salts in 272 localities, 13 hydrocarbons in 44 localities, and 20 miscellaneous organic minerals in 91 localities. Organic minerals are classified into twenty-two types according to the types of organic groups, among which oxalate (35) arene (12), glycolate (4), uric acid (4) and acetate (3) are the most abundant. The organic minerals may be crystallized in all seven crystal systems with monoclinic (42), orthorhombic (17) and triclinic (9) being the dominant. Depending on the linkage among organic anion groups and metal polyhedra through covalent and ionic bonds, organic minerals can be structurally classified as types of isolated molecules (34 minerals), chain (16 minerals), layer (14 minerals) and framework (18 minerals). Genetically, organic minerals may be formed with relations to guano substance (21), taphonomic and petrified organic materials (6), coal or oilfields (21), or as supergene minerals (27) in various host rocks in metal mines, as well as in caves (4), marine sediments (2) and Antarctic area (2).

Keyword

organic mineral, biomineral definition, biomineral classfication, crystal chemistry

Mineralogical Differences of Ooids and Evolution of Water Environment in Xuanlong-type Iron Ore.

Ganyu TANG[1]*, School of Earth and Space Sciences, Peking University
(2101110630@pku.edu.cn)
Yong LAI[2], School of Earth and Space Sciences, Peking University
Ziyi ZHUANG[3], School of Earth and Space Sciences, Peking University
Sai CHEN[4], School of Earth and Space Sciences, Peking University

Abstract

Xuanlong-type iron ore was the most important type of sedimentary iron ore in North China and has played a crucial role in China's mining and industrial development. In order to further explore the mineralogical differences of Fe-ooids in Xuanlong type iron ore and the changes in water environment during the evolutionary processes, this study collected samples of Xuanlong-type hematite from the Chuanlinggou Formation of the North China Block. Through observation and analysis under the optical microscopy and Environmental Scanning Electron Microscopy (ESEM), the oolitic hematite was divided into seven types according to three aspects: main mineral composition, core minerals of ooid formation, and degree of recrystallization. The various types of oolites exhibited differences in the evolutionary process, including environmental phases of oolitic formation, diagenesis and later-stage reworking processes. Through X-ray diffraction (XRD) analysis, it was found that samples from different layers had similar mineral compositions, such as quartz, hematite, siderite, reflecting the stability of the environment during the period of orogenic quiescence. The main valence states of the variable valence elements Fe and Mn in samples at different layers were determined through X-ray absorption spectroscopy (XAS) analysis, where Fe mainly exists in the form of Fe(III), and Mn mainly exists in the form of Mn(II). It suggested that the gradual increase in environmental reducibility during the transgression. The Energy Dispersive Spectroscopy (EDS) and Tescan Integrated Mineral Analyzer (TIMA) data showed the precise distribution pattern of elements up to the ooid layer. Incomplete and thin chamosite layers alternated between fine hematite layers, which demonstrating the oscillatory evolutionary process of the ooid forming water environment in a relative equilibrium system. Based on evidence such as microbial mats, the discovery of primary self-formed apatite in the oolitic hematite deposit for the first time indicated the P-rich environmental phase after microbial involvement in mineralization. The mineral phase coexisting with siderite and apatite limited the composition and state of the ancient water environment. The evolutionary environment of Xuanlong-type iron ore was influenced by the superposition of two opposing factors, namely the transgressive sequence and the increase in oxygen fugacity, which is the result of the interplay between physical and chemical equilibrium and microbial involvement.

Keyword

Xuanlong-type iron ore, oolitic hematite, oolitic siderite, evolution of water environment,

microbial involvement

Online databases of the geologic formations of Asia and Africa with display onto plate reconstructions

Wen Du[1]*, IUGS Deep-time Digital Earth (619154536@qq.com)
James G Ogg[2], Key Lab of Deep-time Geography and Environment Reconstruction, Institute of Sedimentary Geology, Chengdu University of Technology
Aditya Sivathanu[3], Electrical and Computer Engineering, Purdue University, West Lafayette, IN 47907
Sabrina Chang[4], J.P. Morgan, Seattle and New York City, USA
Suyash Mishra[5], J.P. Morgan, Seattle and New York City, USA
Sabin Zahirovic[6], EarthByte Group, School of Geosciences, The University of Sydney, Sydney, NSW 2006, Australia
Aaron Ault[7], Electrical and Computer Engineering, Purdue University, West Lafayette, IN 47907
O'Neil Mamallapalli[8], IUGS Deep-Time Digital Earth, Rajahmundry, India
Haipeng Li[9], Deep-time Digital Earth Research Center of Excellence (Suzhou), International Union of Geological Sciences, Kunshan (Jiangsu), China
Mingcai Hou[10], Key Lab of Deep-time Geography and Environment Reconstruction, Institute of Sedimentary Geology, Chengdu University of Technology, Chengdu, Sichuan, 610059, China
Gabriele Ogg[11], Geologic TimeScale Foundation, 1224 N Salisbury St., West Lafayette, IN 47906

Abstract

Building paleogeographic maps that are projected onto different tectonic plate reconstruction models requires team efforts to compile extensive interlinked databases of regional sedimentary and volcanic facies, data sharing standards, and computer projection methods. Two goals of the Deep-Time Digital Earth (DDE) program of the International Union of Geological Sciences (IUGS) Paleogeography Working Group are: (1) to interconnect online national databases for all geologic formations, and to compile these online "lexicons" for countries that currently lack these; (2) to project the combined paleogeographic output of these distributed databases for any time interval onto appropriate plate tectonic reconstructions.

Therefore, we have worked with regional experts to compile and interlink cloud-based lexicons for different regions of the world that are enhanced by graphic user-interfaces. Online lexicons with map-based and stratigraphic-column navigation are currently completed for the Indian Plate (ca. 800 formations), China (ca. 3200), Vietnam-Thailand-Malaysia (ca. 600), and all major basins in Africa (ca. 700) and in the Middle East (ca. 700 formations). These will soon be joined by Japan (ca. 600 formations) and basins in South America (ca. 700 formations). A multi-database search system (age, region, lithology keywords, etc.) enables all returned entries be displayed by-age or in alphabetical order. The genera in the "fossil" field are auto-linked to their entries and images in the online Treatise of Invertebrate Paleontology. With a single click, a user can plot the original extent of the geologic formation (or an array of regional formations of a specified age) onto different plate reconstruction models with the polygon(s) filled with the appropriate lithologic facies pattern(s). Our team collaborated with the Macrostrat team at Univ. Wisconsin (Madison) to interlink with their extensive regional facies-time compilations for North America and the ocean basins to enable a near-global coverage. Following the lead of Macrostrat's ROCKD

app, this project is in partnership with UNESCO's Commission for the Geologic Map of the World and other geological surveys to enable linking online geologic map units for direct access to the lexicon details on that geologic formation and its former paleogeographic setting. Essentially, goal is to create a view of the sediments and volcanics that were accumulating onto the Earth's surface at any time in the past.
The main website (https://geolex.org) has links to the growing array of regional lexicons.

Keyword

Online database, Geologic formations, Plate reconstruction, DDE

TimeScale Creator and the TSC Online for Visualizing Earth History

Jaehyuk Lee[1]*, Purdue University (lee3952@purdue.edu)
James Ogg[2], Purdue University; IUGS Deep-time Digital Earth
Paolo Gumasing[3], Purdue University
Gabi Ogg[4], Geologic TimeScale Foundation
Aaron Ault[5], College of Engineering, Purdue University
Abdullah Khan Zehady[6], Cisco, Inc.
Jason Bobick[7], W. Lafayette, Indiana, USA
Earth History Visualization Team VIP[8], College of Engineering, Purdue University

Abstract

The global, public, and geoscience community has a need for easily visualizing and exploring relationships between geological events throughout Earth's history. TimeScale Creator, a free JAVA package, enables you to explore and create charts of any portion of the geologic time scale from an extensive suite of global and regional events in Earth History. The internal database suite encompasses over 20,000 biologic, geomagnetic, sea-level, stable isotope, and other events. Users can append external data packs ranging from British Isles geology to microfossil ranges with images to create charts with regional information that's not provided in the internal dataset. All datasets are calibrated to the age models of Geologic Timescale 2020 (Gradstein et al., 2020, Elsevier)

Some of the functions of the TimeScale Creator Java version include popup windows displaying details on events, adjusting the display format of columns, saving the generated chart in PDF or SVG, map interfaces for regional datasets that also includes a slider to display facies-with-time in that region, search-and-display, depth-age cross-plots and simple data-mining.

In order to increase the public accessibility of TimeScale Creator, TSC Online brings it to the internet via the cloud. TSC Online enables anyone with a browser to use the functionalities of TimeScale Creator. The current TSC Online (Feb, 2024) has all the basic functions and it will be progressively enhanced until it has all the capabilities of the TimeScale Creator.

Keyword

Data Visualization, Earth History, Geologic Time Scale

Application of explainable machine learning to geophysical data

JIACHUN YOU[1]*, Chengdu University of Technology (youjiachun@cdut.edu.cn)
Mingcai HOU[2], Chengdu University of Technology
Anqing CHEN[3], Chengdu University of Technology

Abstract

With the rapid development and increasingly widespread application of machine learning (ML) technologies, their contribution to enhancing the efficiency, accuracy, and automation level of target tasks across various fields are undeniable. However, as we enjoy the conveniences brought by ML, the issue of its internal operating mechanisms being opaque, often referred to as the "black box" problem, has gradually come to the fore. In recent years, an increasing number of researchers have recognized this issue and, as a result, have proposed numerous explainable machine learning (EML) methods. Among these, Shapley Additive Explanations (SHAP), an advanced interpretability tool, visualizes the decision-making process of models by quantifying the contribution of each feature to the target based on the game-theoretic Shapley values. Due to the advantages of SHAP in universality and flexibility, it has been widely applied to the explanation of different tasks (such as regression and classification) and a variety of ML models. Building on this, our research aims to visualize and analyze the decision-making process of Convolutional Neural Networks (CNN) for seismic sedimentary facies classification and the prediction process of Extreme Gradient Boosting Decision Trees (XGBoost) for well-log curve regression through the SHAP tool: (1) For the task of classifying seismic sedimentary facies, we presented the distribution of SHAP values for two-dimensional images, created by stitching together various seismic attributes, in the form of heatmaps. These distributions of SHAP values illustrate the level of contribution of each attribute within the CNN model towards the target sedimentary facies. Based on the importance ranking of these seismic attributes formed by their contribution levels, we trained and obtained an improved CNN model after removing irrelevant attributes. The results indicate that the SHAP-enhanced CNN model has a higher classification accuracy compared to the original CNN model. (2) For the regression task of well-log curve prediction, by calculating the SHAP values of each feature in the XGBoost model, we obtained the importance ranking of various well-log parameters regarding shear-wave velocity (Vs) and the specific contribution of each parameter to a certain predicted value of Vs. The prediction of Vs, provided through the form of addition and subtraction of SHAP values, not only to a certain extent delineates the nonlinear relationships among various geophysical parameters in the actual subsurface but also further reveals the relationships between these parameters and Vs that are distinct from general statistical norms (e.g., Pearson correlation coefficient).

The application of the SHAP tool, based on EML, in sedimentary facies classification and well-log curve prediction has revealed how ML models depend on different features for their respective tasks. This not only increases the transparency of the model decision-making process but also provides valuable insights for further model optimization. In this way, SHAP offers an effective

tool for addressing the "black box" problem in ML, contributing to the advancement and broader application of ML technologies in more fields.

Keyword

CNN, explainable machine learning, Shapley Additive Explanations, XGBoost, black box

[Keynote] Orogenic Deformation and Kinematic Reconstructions; Is there a good match?

Camille FRANÇOIS[1]*, Africa Museum, Commission for the Geological Map of the World & Belgian National Committee for Geological Sciences (camille.francois@africamuseum.be)
Manuel PUBELLIER[2], CGMW, CNRS, Ecole Normale Supérieure de Paris, France
Christian ROBERT[3], Ecole Normale Supérieure de Paris, France
Sabin ZAHIROVIC[4], The University of Sydney, School of Geosciences, EarthByte Group, Autralia
Marc ST-ONGE [5], Geological Survey of Canada, Canada & CGMW, France
Randall ORNDORFF[6], U.S. Geological Survey, USA & CGMW, France
Mercer PARKER [7], U.S. Geological Survey, USA
Dixon PORTER [8], CGMW, France
Roland OBERHÄNSLI [9], Potsdam University, Institute of Geosciences, Germany
Jorge GÓMEZ TAPIAS[10], Colombian Geological Survey, Colombia & CGMW, France
Daniela MATEUS ZABALA [11], Colombian Geological Survey, Colombia
Damien DELVAUX[12], Africa Museum, Belgium
Joseph AKAME[13], Université Libre de Bruxelles, G-Time, Belgium
Siti Nur Fathiyah JAMALUDIN[14], Universiti Teknologi Petronas, Malaysia
Julie TUGEND [15], CGMW, France
Benjamin SAUTTER[16], Geo-Ocean UMR CNRS 6538, Université Bretagne Sud, France
IGCP 667 Team[17], CGMW, France

Abstract

The geometric properties of the Earth's magnetic field and its capture in the rock record make possible to track the position of ancestral continents and oceans, and therefore to study the history and the dynamics of plates from the Precambrian to the Present. However, too few well-constrained paleomagnetic data are available for Precambrian rocks, making it difficult to generate a rigorous model for the ancient Earth. In addition, some continental blocks (Kaapvaal, Zimbabwe, West Africa, East Antarctica, South China, Tarim, Amazonia) are almost devoid of any paleomagnetic data, yet they are commonly represented in Nuna (Columbia) reconstructions.
Among the tools available for plate reconstructions, fossils and stratigraphic series are utilized to establish the extent of orogens through time, thereby documenting the zones of deformation related to the collision of crustal blocks. In addition, reconstructions can also use the evolutionary record inherent to oceanic crust, at least during the Phanerozoic. This project is part of IGCP 667 “World Map of Orogens (WMO)”, in which the main objective is to construct a map at a scale of 1:35 000 000 documenting the distribution of ancient to modern orogens and associated markers throughout Earth history. Such a compilation requires careful consideration of both the various types of global-scale compressional tectonic regimes and the best means of portraying the associated tectonic elements or attributes on a map. Consideration of pre-plate tectonic (ca. 2.5 Gyr ago), early Earth crustal deformation processes and features also becomes necessary.
Our objective is to overlay the WMO on established reconstructions (e.g. GPlates, PaleoMap) and document misfits, regardless of whether these are derived from assumptions associated with the reconstruction(s), or due to the lack of geological data. Therefore, we anticipate our map will help

refine reconstructions particularly for the Precambrian or for continental blocks such as those in Africa where paleogeographic data are scarce. The WMO allows us to better visualize misfits between paleogeographic reconstructions and deformation as observed directly in orogens through geological observations. Conversely, paleogeographic reconstructions may also help us to reconsider areas where geological observations could be dated more accurately and/or reassessed.

Keyword

Orogen, plate tectonic reconstructions, Evolution of geodynamics

Deep Time Geography of the McArthur-Yanliao Gulf—New ways of looking at a frontier resource-rich basin.

Alan S. COLLINS[1]*, The University of Adelaide (alan.collins@adelaide.edu.au)
Morgan L. Blades[2], The University of Adelaide
Juraj Farkas[3], The University of Adelaide
Darwinaji Subarkah[4], The University of Adelaide
Angus Nixon[5], The University of Adelaide
Bo Yang[6], Chinese Unviersity of Geosciences, Beijing
Simon Holford[7], The University of Adelaide
Rosalind King[8], The University of Adelaide
Carl Spandler[9], The University of Adelaide
Sarah Gilbert[10], The University of Adelaide
Ananyaa Deepak[11], The University of Adelaide
Johann Soares[12], The University of Adelaide
Yaser Madavan[13], The University of Adelaide
Dana Imbrogno[14], The University of Adelaide
Lesley Edwards[15], The University of Adelaide
Ruoheng Li[16], The University of Adelaide
Amber Jarrett[17], Northern Territory Geological Survey
Tim Munson[18], Northern Territory Geological Survey
Xianzhi Cao[19], Ocean University of China, Qingdao
Nicolas Flament[20], The University of Wollongong
Derrick Hasterok[21], The University of Adelaide
Dietmar Muller[22], The University of Sydney
Sergei Pisarevsky[23], Curtin University, Perth
Sanzhong Li[24], Ocean University of China, Qingdao
Samantha R. Walker[25], Copenhagen University
Robert Frei[26], Copenhagen University

Abstract

The north Australian part of the McArthur-Yanliao Gulf is a vast frontier exploration province for basin-hosted resources, both hydrocarbons (oil and natural gas) and metals (critical metals [e.g. rare earth elements, Co], Cu, Pb, Zn and Au). This basin system covers much of northern Australia and extends as the Yanliao Basin across much of North China, which lay off northern Australia when the basin formed—ca. 1820–1325 Ma. Hydrocarbon and metal deposits in the basin are largely controlled by host sediment composition and ‘redox traps’ related to ancient water chemistry, which, in-turn, are modulated by biological activity, tectonism and relative sea level change. None of these controls are fully understood or constrained throughout the basin.

In order to better understand the basin evolution we follow a number of approaches, including:

1. Developing new techniques to date shales, rapidly and economically, to assist with intra-basinal correlation, thermal and hydrothermal overprint history, and to help build a basin chronostratigraphic framework.

Innovations in laser mass spectrometry have been used to date shales and carbonates from the

McArthur Basin and triage the resulting data to separate ages interpreted as dating deposition or early diagenesis, from those reflecting later hydrothermal overprints. These are coupled with campaign-style detrital mineral geochronology and targeted high-precision U–Pb thermal ionisation mass spectrometry to build a basin chronostratigraphy.

2. Chracterizing the source areas for the basin system through detrital petrochronology and shale geochemistry.

Detrital minerals (zircon, rutile, muscovite) from the main ‘packages’ in the greater McArthur Basin have been dated and their trace element compositions determined to build a spatial and temporal database of source material that has been interpreted based on the tectonic evolution of the basement terranes around the greater McArthur Basin during the amalgamation of the Australian continents within Nuna/Columbia.

3. Investigating the ancient basin water chemistry through chemical proxies that relate to bio-productivity, salinity/restriction, and redox—temporally and spatially.

Proterozoic basin waters were extremely heterogeneous in dissolved oxygen. We are developing and building basin-wide elemental (e.g. U, V, Cu, Co, Mo, Fe, organic geochemistry) and isotopic (Cr, Cd) proxies for the reconstruction of paleoredox and paleobioproductivity conditions at different sites in the ambient water columns. These will be coupled with elemental and isotopic proxies for restriction/salinity (including coupled 87Sr/86Sr and 88Sr/86Sr datasets from carbonates) and proxies for biological activity (e.g. Cr/Cd, as well as C and N isotopes). These are being interpreted in a sequence stratigraphic framework to understand the dynamics between basin water chemistry, tectonics and basin water level variations.

4. Building a reconstruction of the basin, and of the tectonic geography of the basin and its environs through the ca. 1.8–1.32 Ga history of its existence. This has been facilitated by constructing a full-plate tectonic reconstruction for the Proterozoic.

Here we present a full-plate tectonic reconstruction from 1.8 Ga to present, focussed on the region of the Australian continental lithosphere. The greater McArthur Basin is considered as part of the McArthur-Yanliao Gulf of Nuna/Columbia and the nature of the basin will be addressed at different times/places.

Keyword

Proterozoic, Basin Analysis, Deep Time Reconstruction, McArthur, Yanliao

[Keynote] A dynamic evolution of Earth history over the past two billion year

Zheng-Xiang Li[1]*, Curtin University (z.li@curtin.edu.au)
Yebo Liu[2], Earth Dynamics Research Group, Curtin University, Australia

Abstract

Earth's evolution since 2 Ga has been dominated by the cyclic occurrence of three successive supercontinents Nuna (1600–1300 Ma), Rodinia (900–720 Ma), and Pangea (320–170 Ma) and related geodynamic, atmospheric and biological events. This occurred after a billion years of early plate tectonics dominated by continental and cratonic growth, and smaller-scale mantle convection. The start-up of the supercontinent cycle led to the beginning of stable hemisphere-scale (long-wavelength) degree-1 and degree-2 mantle structures. Through the recognition of geodynamicly-defined type-1 and type-2 inertia interchange true polar wander (IITPW) events during the past three supercontinent cycles, together with LLSVP-related global mantle plume events, we are able to hypothesize an evolution history of first-order global mantle structure over the past 2 billion years and establish possible paleolongitudes of continents and supercontinents back to ca. 2 Ga. We argue that Nuna assembled at about the same longitude as the latest supercontinent Pangea over a degree-2 mantle structure that started to exist from ca. 1700 Ma; Rodinia formed through introversion over the legacy Nuna subduction girdle either ca. 90° to the west (a preferred model) or to the east of Nuna's longitude before the migrated subduction girdle surrounding it generated its own degree-2 mantle structure by ca. 800–780 Ma; Pangea assembled through extroversion over the legacy Rodinian mantle structure by closing a long-lived superocean, with the present-day degree-2 mantle structure (including the two antipodal Pacific and African LLSVPs) only started to exist not long before 250 Ma. Recent geodynamic modeling work by the Curtin team further predicts that the future supercontinent (Amasia) could only form through extroversion, i.e., by the closure of the Pacific Ocean — residual of the Panthalassa Superocean.

Keyword

Supercontinent cycle, Geodynamics, Earth evolution, Superocean, True polar wander

Models, mysteries and mayhem: Tectonic reconstructions at the dawn of animal life

Marissa J BETTS[1]*, University of New England (marissa.betts@une.edu.au)
Sabin Zahirovic[2], The University of Sydney
Elizabeth M Dowding[3], Friedrich-Alexander-Universität
Mathew Domeier[4], University of Oslo
Andrew Merdith[5], University of Adelaide
Bethany J Allen[6], ETH Zürich
Thomas W Wong Hearing[7], Leicester University
Alexander G Liu[8], University of Cambridge
Luke Strotz[9], Northwest University
Timothy P Topper[10], Swedish Museum of Natural History
Sarah M Jacquet[11], University of Missouri
Chloe M Marcilly[12], University of Oslo
Rose Gates[13], University of New England

Abstract

The ‘Cambrian Explosion’ is one of the most important biological events in Earth’s history, and the Ediacaran–Cambrian transition remains one of the most fundamental and enduring research frontiers in Earth science. Plate tectonics has been linked to early animal evolution, though exactly how it may have contributed has remained difficult to establish. Development of a robust tectonic model for the Ediacaran–Cambrian interval (635–485 Ma) is fundamental to resolving how positions and movements of continental plates impacted the first animals and their ecosystems. Global tectonic plate reconstructions are generally underpinned by base models built with palaeomagnetic data. However, Ediacaran–early Cambrian palaeomagnetic data are challenging to interpret, and difficulties reconciling relative plate positions have resulted in a wide variety of differing models for this interval. The Ediacaran and Cambrian both have unratified stage boundaries, hence temporal resolution for this interval also remains relatively poor. For end-users—particularly those interested in scrutinising palaeobiological or palaeobiogeographic patterns—applying these tectonic models becomes a process fraught with uncertainty, with impacts on scientific outcomes that are difficult to quantify.

Comprehensive assessment of other proxies used for plate tectonic reconstructions in the Ediacaran–Cambrian is therefore essential. This is particularly important in the context of leveraging the fossil and sedimentary rock record to compare and evaluate the viability of pre-existing models, mindful of pitfalls associated with circular logic that may confound their application down the line (e.g. testing of fossil distributions with models built with fossil assemblage patterns). Databases such as the Palaeobiology Database (PBDB), and Geobiodiversity Database are essential for generating the statistical power necessary to address fundamental issues both at the model-development and at the model-application stages. How these data are collated, curated, cleaned and distributed is therefore of great importance, and must

follow the FAIR (findable, accessible, interoperable, reusable) and Open Science principles. This work will review the challenges for Ediacaran–Cambrian tectonic models, the mayhem caused by low resolution or difficult to interpret data, and explore pathways toward how best to reconstruct the Ediacaran–Cambrian world.

Keyword

palaeobiogeography, chronostratigraphy, tectonostratigraphy, palaeocontinent, radiation

Palaeogeography of salt deposition prior to the opening of the Central Atlantic Ocean

Julie TUGEND[1]*, CCGM/CGMW (julie.tugend@gmail.com)
Geoffroy MOHN[2], GEC, CY Cergy Paris Université, France
Nick KUSZNIR[3], Department of Earth, Ocean and Ecological Sciences, University of Liverpool, Liverpool L693GP, UK
Mark DEPTUCK[4], Canada-Nova Scotia Offshore Petroleum Board – CNSOPB, Canada
Kristopher KENDELL[5], Canada-Nova Scotia Offshore Petroleum Board – CNSOPB, Canada
Fraser D. KEPPIE[6], Nova Scotia Department of Natural Resources and Renewables – NRR, Canada
Natasha MACADAM[7], Nova Scotia Department of Natural Resources and Renewables – NRR, Canada

Abstract

Providing information on the palaeobathymetric evolution of sedimentary basins is essential to propose reliable paleogeographic models of rift systems prior to the onset of oceanic accretion. Constraining palaeobathymetries can however be quite challenging and trigger debates, notably in the case of salt deposition during continental breakup.

Here we investigate the palaeobathymetric evolution of the conjugate Nova Scotian and Moroccan rifted margin during the early stages of the opening of the Central Atlantic Ocean. Breakup of Pangea during the Triassic and Early Jurassic generated a series of rift basins filled by continental deposits passing up-section into evaporites and carbonates. Although first order plate motions are understood, the segmentation of salt basins and tectonic context of salt deposition (pre- or syn-kinematic) prior to the opening of the Central Atlantic remains to be constrained.

We use a flexural backstripping technique, which incorporates decompaction and post-breakup reverse thermal subsidence modelling to predict the palaeobathymetry and palaeostructure through the Jurassic down to the Late Triassic base salt. Quantitative analyses of seismic reflection and gravity anomaly data have also been used to determine crustal thickness variations and along strike variability in breakup related magmatism in the ocean-continent-transition, both controlling the isostatic response.

The palaeobathymetry of base salt determined from reverse post-breakup subsidence modelling exceeds 2 km in the distal parts of the rifted margins where the continental crust is highly thinned (<10km). In contrast in proximal domains where the continental crust was only slightly thinned during rifting, the base salt horizon restores near sea level at breakup time. Our interpretation of this difference is that while the proximal salt underwent post-rift thermal subsidence only, the distal salt was deposited during the latest stage of rifting and underwent tectonic subsidence from crustal thinning in addition to post-rift thermal subsidence. A period of basin isolation most likely occurred during the latest Triassic to Middle Jurassic in the early stage of the Central Atlantic opening, however, this does not seem to be the main parameter controlling the basin bathymetry during salt deposition. Integrating these results into larger scale paleogeographic models enables us to show how the Late Triassic to Early Jurassic salt basins connected and evolved into open

marine conditions in the Middle to Late Jurassic in relation with the opening of the Central Atlantic and Western Tethys.

Keyword

Paleobathymetry, Central Atlantic, Rifting, Salt

Sedimentary Geochemistry of Major Metal Hosting sub-basins within the Palaeoproterozoic Batten Fault Zone, McArthur Basin, Australia

Dana IMBROGNO[1]*, University of Adelaide (dana.imbrogno@adelaide.edu.au)
Alan S. Collins[2], University of Adelaide
Darwinaji Subarkah[3], University of Adelaide
Carl Spandler[4], University of Adelaide
Morgan L. Blades[5], University of Adelaide
Grace Bubner[6], University of Adelaide
Robert Klaebe[7], University of Adelaide
Tony Hall[8], University of Adelaide
Sam Spinks[9], Teck Australia Pty Ltd
Nicola Cawood[10], Teck Australia Pty Ltd

Abstract

The greater McArthur Basin covers much of the Northern Territory, Australia, and comprises multiple stacked siliciclastic and carbonate sedimentary sequences of Proterozoic age. Despite being labelled as 'the boring billion' due to the perceived stability of Earth systems, this period actually exhibits significant and geochemically traceable fluctuations in water chemistry. These rocks are also of interest for research purposes due to their hosting of economically significant hydrocarbon and mineral resources.

The Batten Fault Zone within the McArthur Basin is a broad structurally complex corridor with structural depocenters and sub-basins. This study uses litho-stratigraphy, geochronology, and sedimentary geochemistry over four of these sub-basins to correlate depositional sequences and highlight post-depositional alteration characteristics. Shale and carbonate geochemical data collected for this project focuses on the middle McArthur Group (ca. 1650-1630 Ma) stratigraphy, aiming to fill gaps in literature surrounding Earth systems and tectonic processes during this time of little preservation of life and productivity.

These rocks in the middle McArthur Group have predominantly been deposited under deep subtidal to slope conditions, and the combination of carbonate and siliciclastic samples sequence has produced Total Organic Carbon (TOC), δ13Corg, and δ13Ccarb profiles for sub-basins in the central and northern Batten Fault Zone. Notable trends observed in these profiles, such as the ~+2.0 ‰ δ13Ccarb excursion transitioning from the Barney Creek Formation into the overlying Reward Dolostone, are valuable tools for local and regional stratigraphic correlation. Major and trace element data further enhance correlations between sub-basins while revealing geochemical changes associated with redox conditions, alteration processes, and paleoenvironmental factors during and after deposition. The combined data set provides a solid framework for the sedimentological, environmental, hydrological, and structural evolution of each sub-basin, which, in the scope of the "mineral systems framework" can then be used to examine models for Pb-Zn-Ag ore mineral formation processes in the McArthur Basin.

Keyword

Proterozoic, Carbon Isotopes, McArthur Basin, Mineralisation

[Keynote] A web-based and data-driven approach to paleogeographic reconstructions: Application to Asian Cenozoic evolution

Guillaume Dupont-Nivet[1]*, CNRS Geosciences Rennes (guillaume.dupont-nivet@univ-rennes1.fr)
Jovid Aminov[2], University of Central Asia, 155 Imatshoev Street, 736000, Khorog, Tajikistan
Fernando Poblete[3], Universidad de Chile, Departamento de Geología, Facultad de Ciencias Físicas y Matemáticas, Santiago, Chile
Diego Ruiz[4], niversität Potsdam, Institute of Geoscience, 14476 Potsdam, Germany
Haipeng Li[5], Deep-time Digital Earth Research Center of Excellence (Zhejiang), Hangzhou, China

Abstract

The ability to reconstruct the geologic evolution of the Earth as a system including the geosphere, atmosphere and biosphere interactions, is essential to understand the fate of our environment in the context of the Climate, Life and Energy crises of the new Anthropocene era. Scientists of tomorrow working on environmental changes require ever more detailed databases and maps to access and correlate the overwhelming mass of information stemming from the ongoing surge of environmental data and models. Earth System reconstructions are fundamental assets to assess potential sources and locations of key geo-resources that are now vital for the energy transition (e.g. raw materials, rare earth elements, subsurface storage, geothermal sites). Earth System reconstructions are also the best means to communicate past and future Life and Environmental evolutions, while providing consciousness of our role and situation in the immensity of Time and Nature. They convey these essential lessons in a didactic fashion for teachers and students, museums, or for governments and NGOs to make decisions and promote public awareness. Although Earth System reconstructions have long been recognized as essential, they have yet to deliver their full breakthrough potential combining various booming disciplines. A number of software programs and computer algorithms have been developed in the past three decades to reconstruct either the past positions of continents and oceans or their elevation and depth. The next step is to develop a comprehensive and integrated solution easily accessible on the web that can automate most of the steps involved in reconstructing past plate configurations and topography. We present here a web application that we are developing for the creation of digital paleogeographic maps. As part of a large project over Asia, we review here the case of the intensely studied, yet still extremely controversial India-Asia collision with major implications on regional environmental, depositional and global climate transitions. Ongoing debates argue for radically different end-member models of the collision timing and its configuration, and of associated topographic growth in the collision zone. We present here new Asian paleogeographic reconstructions integrating various end-members models of the India-Asia collision and associated topographic patterns and land-sea masks with implications on the locus, source and generation of resources. Results are provided in various model-relevant formats with associated database and discussion forums to comment an contribute to the amelioration of these maps and databases.

Keyword

Paleogeography, Software, Geodata, Cenozoic, Asia

The influence of Earth's thermal cycles on instigating significant geological activities

Chun'an TANG[1]*, Dalian University of Technology (tca@mail.neu.edu.cn)
Bin GONG[2], Brunel University London

Abstract

The Earth's history unfolds in a rhythmic dance of warming and cooling periods, each choreographed with dynamic or tranquil phases of geological activity. When the Earth basks in warmth, expansive geological processes, like the formation of large igneous provinces, come to life. Conversely, during colder spells, geological activity adopts a more subdued tempo. However, amidst this symphony of Earth's thermal cycles and episodic geological phenomena, consensus on their fundamental relationship remains elusive, despite the plethora of models seeking to elucidate their triggers. In this study, we propose a thermodynamic equilibrium equation as a framework to decode the Earth's thermal cycles. We hypothesize that these cycles serve as the driving force behind the planet's evolution, orchestrating the periodicity of geological events such as supercontinental cycles, orogenies, glacial epochs, and biological extinctions. Building upon this premise, we present a comprehensive Wall Chart, synthesizing global data and evidence from geological events spanning Earth's history, to unravel the intricate interplay between these events and the planet's thermal rhythms. Our analysis reveals a compelling nexus between the Earth's thermal fluctuations and the genesis of key geological events, including the formation of evaporites, red beds, and large igneous provinces. Notably, our Wall Chart prompts a thought-provoking inquiry: what links the two Great Oxidation Events to the two Snowball Earth episodes? Through meticulous examination of empirical data, our study unveils the intricate relationship between thermal cycles and pivotal geological milestones throughout Earth's history. This deeper understanding not only enriches our knowledge of Earth's evolutionary journey but also offers insights into the evolution of rocky planets within our Solar System and beyond.

Keyword

Earth’s thermal cycle, great geologic event, triggering mechanism

African geologic formation databases with visualizations onto plate reconstructions

James G OGG[1]*, IUGS Deep-time Digital Earth (jogg@purdue.edu)
Wen Du[2], IUGS Deep-time Digital Earth
Rebecca Bobick[3], Dept. Earth, Atmos. & Planet. Sci., Purdue University, West Lafayette, IN, USA
Gabriele Ogg[4], Geologic TimeScale Foundation, West Lafayette, IN, USA
Jacques LeBlanc[5], International Consulting Geologist, Alberta, Canada
Monica Juvane[6], Empresa Moçambicama de Hidrocarbonetos, Maputo, Mozambique
Dércio Levy José[7], Empresa Moçambicama de Hidrocarbonetos, Maputo, Mozambique
Aditya Sivathanu[8], Dept. Computer Engineering, Purdue University, West Lafayette, IN, USA
Sabrina Chang[9], JP Morgan Chase and Co., Seattle office, Seattle, USA
Suyash Mishra[10], JP Morgan Chase and Co., New York office, New York, USA
Yuzheng Qian[11], Amazon.com Services LLC, Seattle, USA
Aaron Ault[12], Dept. Computer Engineering, Purdue University, West Lafayette, IN, USA
Haipeng Li[13], IUGS Deep-time Digital Earth

Abstract

It is a challenge to obtain information about the geologic formations and their succession in Africa due to lack of on-line lexicons for most regions. Therefore, we established AfricaLex as a free public online database that includes details on the geologic formations in all major basins of Africa, both onshore and offshore. The entries for each formation contain details on the type sections, lithology, contacts, regional distribution, fossils, age range interpretation and associated images.

AfricaLex (https://africalex.geolex.org/) and NigerLex (https://nigerlex.geolex.org) offer search for geologic formations in the database by standard search criteria (name, partial name, age, region, lithology keywords, or any combination), and a map-based user interface with stratigraphic-column navigation. The returned entries can be displayed by-age or in alphabetical order with the link to each formation shown as color-coded based on its geologic age. Regional extents are also digitized in GeoJSON format to enable plotting of the individual formations or as time-slices of all formations across Africa of a user-selected age onto any of three proposed plate reconstruction models with a single click. The plotted regional extents are filled with appropriate lithologic facies pattern for each formation.

The aim is to make information on Africa geology and its component geologic formations more to accessible to geologists and the general public from the world and for improving paleogeographic maps. Users can obtain a view of the sediments and volcanics that were accumulating at any time across the ancient land of Africa. These lexicon systems will be interlinked to other stratigraphic and paleogeographic databases through the lUGS Deep-Time Digital Earth platform.

Keyword

Africa, database, DDE, geologic formations, plate reconstruction

China and southeast Asia geologic formation databases with visualizations onto plate reconstructions

Gabriele OGG[1]*, Geologic TimeScale Foundation, West Lafayette, IN, USA (gabiogg@hotmail.com)
Hongfei Hou[2], Chinese Acad. Geological Sciences, Beijing, China
James Ogg[3], IUGS Deep-Time Digital Earth
Wen Du[4], IUGS Deep-Time Digital Earth
Haipeng Li[5], IUGS Deep-Time Digital Earth
Mingcai Hou[6], Institute of Sedimentary Geology, Chengdu Univ. Technology, Chengdu, Sichuan, China
Bui Dong[7], Vietnam National University of Science, Hanoi, Viet Nam
Masahiko Makino[8], Geological Survey of Japan, AIST, Tsukuba, Japan
Nikolas Ogg[9], Dept. Computer Sci., Purdue Univ., West Lafayette, IN, USA

Abstract

In a successful collaboration with numerous regional experts on the stratigraphy of China and Southeast Asia, our international team developed cloud-based stratigraphic lexicons with graphical user-interfaces. These databases currently consist of over 4000 onshore and offshore sedimentary and volcanic formations spanning the Proterozoic through Neogene across China, Thailand, Vietnam, Malaysia and Japan regions (chinalex.geolex.org; thailex.geolex.org; vietlex.geolex.org; malaylex.geolex.org; japanlex.geolex.org). The entries for each formation contain details on the type sections, lithology, contacts, regional distribution, fossils, age range interpretation and associated images. APIs enable easy access and integration with other applications. The cloud-based databases and websites can be explored through user-friendly map and stratigraphic-column interfaces generated from the TimeScale Creator software. A comprehensive search system allows users to retrieve information on all geologic formations for a specific date or geologic stage from multiple databases.

Regional extents of each formation are also given in a GeoJSON format that enables visualization as facies-pattern-filled polygons. These can be projected onto three proposed plate reconstructions of its corresponding time interval; or as time slices of regional paleogeography.

These lexicon systems will be interlinked to other stratigraphic and paleogeographic databases through the lUGS Deep-Time Digital Earth platform. This comprehensive approach allows one to explore deep-time dynamics and the evolution of the different regions of our planet Earth.

Keyword

Asia, database, geologic formations, paleogeography, DDE

Indian Plate and Middle East geologic formation databases with visualizations onto plate reconstructions

O'Neil MAMALLAPALLI[1]*, IUGS Deep-Time Digital Earth, Rajahmundry, India (oneil.rhylet@gmail.com)
Raju DSN Datla[2], Oil and Natural Gas Corporation, Dehradun, India
Nallapa Reddy Addula[3], Oil and Natural Gas Corporation, Chennai, India
Nusrat Kamal Siddiqui[4], University of the Punjab, Institute of Geology, Lahore, Pakistan
Bhargava N Om[5], Indian National Science Academy, Panchkula, India
Birendra P Singh[6], Panjab University, Center of Advanced Study in Geology, Chandigarh
Cecilia Shafer[7], Halliburton, Houston, Texas
Bruno Granier[8], University of Brest, France
Jacques LeBlanc[9], University of Quebec, Chicoutimi, Alberta, Canada
James Ogg[10], Deep-time Digital Earth Research Center of Excellence (Suzhou), International Union of Geological Sciences, Kunshan (Jiangsu), China
Gabriele Ogg[11], Geologic TimeScale Foundation
Sabrina Chang[12], Purdue University, Electrical and Computer Engineering, West Lafayette
Suyash Mishra[13], Purdue University, Electrical and Computer Engineering, West Lafayette
Yuzheng Qian[14], Carnegie Mellon University, Electrical and Computer Engineering, Pittsburgh
Aaron Ault[15], Purdue University, Electrical and Computer Engineering, West Lafayette

Abstract

In a successful collaboration with numerous regional experts on the stratigraphy of the Indian Plate and the Middle East, our international team developed cloud-based stratigraphic lexicons with graphical user-interfaces. These databases consist of the Indian Plate (*indplex.geolex.org*) of nearly 1000 onshore and offshore sedimentary and volcanic formations across India, Pakistan, Nepal, Bhutan, Sri Lanka, Bangladesh, and Myanmar and of Middle East regions (*mideastlex.geolex.org*; *qatarlex.geolex.org*). The entries for each formation contain details on the succession of lithology, as well as the fossils present, age range, regional distribution and associated images. APIs enable easy access and integration with other applications. A comprehensive search system allows users to retrieve information on all geologic formations for a specific date or geologic stage from multiple databases. The cloud-based databases and websites can be explored through user-friendly map and stratigraphic-column interfaces generated from the *TimeScale Creator* software.

Regional extents of each formation in a GeoJSON format enables visualization as facies-pattern-filled polygons projected onto three proposed plate reconstructions of its corresponding time interval; or as time slices of regional paleogeography. These lexicon systems will be interlinked to other stratigraphic and paleogeographic databases through the lUGS Deep-Time Digital Earth platform. This comprehensive approach allows one better comprehend deep-time dynamics and gain valuable insights into the evolution of the different regions of our planet Earth.

Keyword

India, Middle East, database, geologic formations, plate reconstruction, DDE

New Permian Tethyan Paleogeographic Reconstruction and its implication to the collapse of the Late Paleozoic Ice Age

Qiang Ren[1]*, Chengdu University of Technology (renqiang@cdut.edu.cn)
Mingcai Hou[2], Chengdu University of Technology
Anqing Chen[3], Chengdu University of Technology

Abstract

The Late Paleozoic Ice Age (LPIA) is an extreme cold climate event with the longest duration and largest ice sheet area since Phanerozoic. “How the LPIA ended” is an unknown scientific question. Some scientists have studied from the perspective of exhaust of the large igneous provinces and the weakening of chemical weathering of rocks, but they have not been able to explain the sudden reduction of global ice sheet in the early Early Permian and the subsequent multiple glacial-interglacial cycles. It is well known that plate tectonics plays an important role in the evolution of climate and biology, and the existing tectonic features show that the global plate has undergone several variable shifts since the Permian period, represented by the northward convergence of the Tethys tectonic domain. However, whether the plate subduction and volcanic exhaust caused by the convergence played a key role in the extinction of the LPIA has not been answered. This study used a large language model to mine and compile relevant data such as the Permian paleomagnetic and arc magmatic rocks required for full-plate reconstruction, simulated and calculated the subduction flux of global converging plates, determined the causal relationship between subduction flux and arc magmatic rocks through in-depth analysis, and further explored its impact on global climate change (atmospheric CO2 concentration is a climate substitute index). It is revealed that the change of global plate subduction is an important factor driving the final disappearance of the LPIA.

Keyword

Permian, Paleogeographic reconstruction, Late Paleozoic Ice Age, Full-plate, subduction

Leveraging Large Language Models for Sedimentary Environmental Interpretation: A New Approach To Addressing The Non-Uniqueness Problem In Paleogeography

Haipeng LI[1]*, Deep-time Digital Earth Research Center of Excellence (haipeng.geo@gmail.com)
Luoqi Wang[2], Zhejiang University
Linshu Hu[3], Zhejiang University
Mingcai Hou[4], Chengdu University of Technology

Abstract

The interpretation of the sedimentary rock record is fundamental for reconstructing paleogeography. However, the inherent non-uniqueness in such interpretations often poses significant challenges, which are further amplified by the exponential increase in scholarly publications. Traditional expert systems, while providing a potential solution, demand substantial contributions from specialists across various sub-disciplines, making them labor-intensive and less adaptive to the incorporation of newly published studies.

In light of these challenges, we propose a novel approach that leverages the advancements in Large Language Models (LLMs), such as GPT-4 and retrieval augmented generation, to process and interpret the vast corpus of publications. By integrating these technologies and fine-tuning them with domain-specific text, we have developed a system capable of providing multiple, probabilistically weighted paleoenvironmental interpretations, each substantiated with specific references.

Our preliminary results suggest that this integrative approach holds significant potential in aiding the interpretation of sedimentary environments and addressing the non-uniqueness problem by harnessing the wealth of knowledge embedded in published literature. This innovative methodology could pave the way for more accurate, comprehensive, and holistic interpretations of the rock record, thereby enhancing our ability to reconstruct paleogeography. We extend an invitation to the broader paleoenvironmental research community to collaborate in refining and applying this promising approach.

Keyword

large language model, nonunique interpretation, paleogeography, expert system

Plate Tectonics & Paleogeography during the Last 1.5 Billion Years

Christopher Robert SCOTESE[1]*, Northwestern University (cscotese@gmail.com)

Abstract

Paleogeography is the study of the changing surface of the Earth through time. Driven by plate tectonics, the configuration of the continents and ocean basins has been in constant flux. Plate tectonics pushes the land surface upwards or pulls it apart causing its collapse. All the while, the unrelenting forces of climate and weather slowly reduce mountains to sand and mud and redistribute these sediments to the sea. The following presentation reviews the changing paleogeography of the last 1.5 billion years. It describes with maps and animations the broad patterns of Neoproterozoic and Phanerozoic paleogeography and as well as many of the specific paleogeographic events that have shaped the modern continents and ocean basins. The focus of this discussion is on the changing latitudinal distribution of the continents, changes in sea level, the opening and closing of oceanic seaways, mountain building, and how these paleogeographic changes have affected global climate, ocean circulation, and the evolution of life.

In this review, we present an atlas of 110 paleogeographic maps and a series of animations that illustrates how the surface of the Earth has evolved during the last 1.5 billion years. During that time interval, the Earth has witnessed the formation and breakup of three supercontinents: Rodinia, Pannotia, and Pangea. The continents have been transformed from low-lying flooded platforms to high-standing land areas crisscrossed by the scars of past continental collisions. Oceans have opened and closed, and then opened again in a seemingly never-ending cycle.

Keyword

plate tectonics, paleogeography, Neoproterozoic, Phanerozoic, supercontinent

Critical depths of the vertical transition zone between modern infiltration water and fossil groundwater in China

Ying YU[1]*, China University of Geosciences (yuying@cug.edu.cn)
Chuanyu Feng[2], State Key Laboratory of Environmental Aquatic Chemistry, Research Center for Eco-Environmental Sciences, Chinese Academy of Sciences, Beijing, 100085, China
Jianmei Cheng[3], School of Environmental Studies, China University of Geosciences, Wuhan, 430074, China
Shanbin Liu[4], School of Computer Science, China University of Geosciences, Wuhan, 430074, China
Hong Yao[5], School of Computer Science, China University of Geosciences, Wuhan, 430074, China
Yanxin Wang[6], School of Environmental Studies, China University of Geosciences, Wuhan, 430074, China

Abstract

Older groundwater is generally more susceptible to overdraft and also more difficult to recover once contaminated. To understand the prevalence and vulnerability of fossil groundwater that infiltrated before the Holocene, a global assessment has been conducted recently, but the analysis results for China have been limited by the collection of data. In this study, we combined the groundwater isotope data from the literature databases of CNKI (China National Knowledge Infrastructure) and SCIE (Science citation expanded) and established the groundwater age dataset of China by virtue of the water samples from 1441 wells. By reconstructing the historical precipitation 3H records of China and using the late-Quaternary atmospheric 14C, the fractions of the modern groundwater that infiltrated after the year 1953 and the fossil groundwater that infiltrated before 12,000 years ago in the groundwater samples have been calculated based on the straight-forward mixing models. Then we evaluated the extent and depths of the modern and fossil groundwater in the major 16 groundwater-supply areas of China. The results show that the exploitation of deep groundwater mainly occurs in northern China, such as in the Ordos Basin, the North China Plain, the Hexi corridor, etc. The average critical depth of the vertical transition zone between modern infiltration water and fossil groundwater in China is about 300 m, beneath which more than half of the water samples are dominated by fossil groundwater. Meanwhile, when deeper than 600 m, the groundwater barely can be recharged by the modern precipitation. It is also found that for the uppermost 600 m of the crust in China, the modern and fossil groundwater, respectively, dominates the total groundwater storage at 32% and 51%. Besides, 3H can be detected in half of the water samples containing fossil groundwater. It indicates that the construction of deep wells might have already made the fossil groundwater polluted by modern contaminants.

Keyword

Fossil groundwater, Groundwater age, Carbon isotope, Tritium, Groundwater renewability

Heterogeneity in spatiotemporal evolution of groundwater storage in the North China Plain and its driving mechanisms

Xiaowei ZHAO[1]*, China University of Geosciences, Wuhan (2573968770@qq.com)
Ying Yu[2], China University of Geosciences, Wuhan
Jianmei Cheng[3], China University of Geosciences, Wuhan
Kuiyuan DING[4], China University of Geosciences, Wuhan
Yiming LUO[5], China University of Geosciences, Wuhan
Kun ZHENG[6], China University of Geosciences, Wuhan
Yang XIAN[7], China University of Geosciences, Wuhan
Yihang LIN[8], China University of Geosciences, Wuhan

Abstract

Groundwater is the most important freshwater resource on Earth, playing a critical role in agricultural irrigation and industrial production. As overexploitation-induced groundwater depletion is a common issue in many areas around the world, the spatial-temporal evolution characteristics of groundwater storage (GWS) and its underlying mechanisms are widely studied for the effective conduction of groundwater management. However, the spatiotemporal evolution mechanism of the GWS is still entirely unrevealed, for which objective division of GWS evolution periods and the statistical description of GWS's spatial heterogeneity is a key issue. This study aims to establish a new framework to analyze the spatiotemporal evolution of GWS in the North China Plain (NCP) and its heterogeneity. The Mann-Kendall mutation test and sliding t-test are applied to objectively split the evolution periods of GWS and used the BIRCH clustering algorithm to statistically describe GWS's spatial heterogeneity. The GWS in the NCP during 2002-2021 is estimated based on the Gravity Recovery and Climate Experiment (GRACE) datasets and Global Land Data Assimilation System (GLDAS) models and verified by in-situ groundwater. Results show that reduction rates of GWS in the three stages are -5.87 m/yr (Stage I, April 2002 to December 2009), -12.95 mm/yr (Stage II, January 2010 to December 2013), and -29.11 mm/yr (Stage III, January 2014 to December 2021), respectively. This means that groundwater depletion in the NCP is still worsening. Due to the hydrogeological settings, the most serious reduction of GWS has been shifted from the shallow aquifers in the piedmont alluvial plain to the deep aquifers in the east-central alluvial plain. The significantly different evolution of groundwater storage between the northern and southern regions is highly related to precipitation. Besides, the water diversion projects and the modernization of irrigated areas promote the recovery of shallow GWS in the NCP and even mitigate the reduction rates of deep GWS in certain regions.

Keyword

Groundwater storage, Gravity Recovery and Climate Experiment, Spatiotemporal evolution, North China Plain

Web GPlates: The Next-Generation Research Platform of Paleogeographic Reconstruction

Han CHENG[1]*, Deep-time Digital Earth (cheng.han@ddeworld.org)
Haipeng Li[2], Deep-time Digital Earth Research Center of Excellence (Suzhou)
Sabin Zahirovic[3], The University of Sydney, Sydney, NSW, Australia
Yisa Wang[4], Deep-time Digital Earth Research Center of Excellence (Suzhou)

Abstract

Paleogeographic reconstruction studies Earth's surface evolution, including tectonic processes, terrestrial and marine patterns, climate, and biological diversity through geological time. This complex field requires analyzing data across geology, geophysics, and geochemistry. Traditional paleogeographic maps, despite their abundance, often suffer from limitations due to their static nature, inconsistent map projections, varied time intervals, and differing plate tectonic models. These constraints challenge the dynamic update and effective management of paleogeographic data. To address these challenges, we introduce Web GPlates (https://dplanet.deep-time.org/DPlanet/), a cloud-based research platform specifically designed for paleogeographic reconstruction. Built upon the Web Assembly and Unity framework to ensure exceptional performance in web browsers, Web GPlates leverages a C# reconstruction of GPlates' plate rotation algorithms, which enables deep-time visualization of plate reconstruction models and data attached to plate models. The platform's user-friendly interface facilitates the management of paleogeographic reconstruction data, allowing for database searches, uploading, visualization, and interpretive analysis of such data. Moreover, by adopting a project-based approach to work, not only can the process of paleogeographic reconstruction be documented, but users can also create dynamic and interactive paleogeographic maps. These maps generated by Web GPlates can illustrate the intricate relationships between paleogeographic reconstruction outcomes and their underlying data, enhancing the depth, dissemination paleogeographic research.

Keyword

Paleogeographic Reconstruction, Cloud-Based Research Platform, Deep-Time Visualization, Web GPlates, Interactive Maps

Provenance Evolution Across the North Australian Craton from 1.8 to 1.3 Ga: Basin Analysis and Plate Tectonic Evolution.

Morgan L. BLADES[1]*, The University of Adelaide (morgan.blades@adelaide.edu.au)
Ananyaa Deepak[2], The University of Adelaide
Bo Yang[3], Chinese University of Geosciences, Beijing
Alicia De Groot[4], The University Adelaide
Darwinaji Subarkah[5], The University Adelaide
Tim Munson[6], Northern Territory Geological Survey
Alan S. Collins[7], The University of Adelaide

Abstract

The ca. 1.82 to 1.32 Ga north Australian Proterozoic greater McArthur Basin is a part of the larger McArthur-Yanliao Gulf that flooded a large part of Nuna and included much of North China and, at times, may have included the Laurentian Belt Basin. Rocks within the greater McArthur Basin were deposited/erupted in five first-order sequences that have been subdivided as 'packages'. These broadly match up with the 'superbasins' of the Mount Isa region of Queensland. The greater McArthur Basin packages are (from oldest to youngest) the: Redback, Goyder, Glyde, Favenc and Wilton Packages. These rocks preserve some of the eukaryote cell fossils and include chemical biomarkers thought to be produced by eukaryote stem-groups. The basin system also contains the oldest commercial hydrocarbons and extensive sedimentary-hosted metal mineralisation.

Here we present spatially and temporally extensive detrital zircon data (UPb, Hf) and selected additional detrital phases (e.g. rutile, muscovite) from the Redbank Package, Glybe Package, Favenc Package and Wilton Package from five constituent parts of the greater McArthur Basin (McArthur Basin sensu stricto, Beetaloo Sub-basin, Birrindudu Basin, Tomkinson Province and South Nicholson Basin) spanning the Northern Territory of Australia. (The Goyder Package has a limited spatial distribution and is not discussed.) These data constrain the basin evolution, the nature of detritus fluxing into the basin, and reveal the tumultuous plate-tectonic events occurring around all margins of the basin over this half-billion-year time range.

Together the data tell the story of initial Palaeoproterozoic accretionary orogens to the south and east (present directions relative to modern north Australia) that ended in the east by the collision of the North Australian Craton (NAC: the continent in which the greater McArthur Basin overlies) with Laurentia, forming the Isan Orogeny. This major continent-continent orogeny was the last major Nuna-forming collision and the supercontinent reached a maximum size by ca. 1600 Ma. Subsequent rifting led to oceanic separation of Laurentia and isolated a continent formed by North China, the NAC, the South Australia Craton (SAC) and a large part of East Antarctica before this continent collided with the West Australian Craton (WAC) at ca. 1350 Ma. Extension related to the ca. 1325 to 1310 Ma Derim-Derim Large Igneous Province led to ocean-crust formation north of the NAC/NChina and related uplift of northern Australia terminated the half-billion-year history of the greater McArthur Basin.

Keyword

McArthur Basin, U-Pb detrital zircon, Provenance, North Australia Craton, Proterozoic

The progress and perspective of digital intelligence paleogeographic reconstruction

MINGCAI HOU[1]*, CHENGDU UNIVERSITY OF TECHNOLOGY (houmc@cdut.edu.cn)
ANQING CHEN[2], CHENGDU UNIVERSITY OF TECHNOLOGY
QIANG REN[3], CHENGDU UNIVERSITY OF TECHNOLOGY
HANTING ZHONG[4], CHENGDU UNIVERSITY OF TECHNOLOGY

Abstract

The paleogeographic reconstruction is a comprehensive study of the surface tectonic processes, the sea-land pattern, and geomorphic environmental characteristics in geological history. This field is represented by the creation of maps that depict the ancient contours of oceans and continents, as well as important topographic and surface environment characteristics. It serves as a fundamental process for restoring Earth evolutionary history, predicting the distribution of energy and mineral resources, and understanding life and climate evolution. The advent of the era of big data has facilitated the application of digital methods in updating and presenting paleogeographic maps in a rapid and user-friendly manner. To now, several groups published digital global paleogeographic reconstruction models and related data and methods, including Earthbyte, PaleoMap, UNIL, Deep-Time Maps, and other teams. As the concept of data-knowledge-model-driven paleogeography reconstruction proposed by the Deep-time Digital Earth (DDE) International Science Program, this study summarizes and presents a new process for updating global paleogeography maps via developing digital methods. According to interdisciplinary innovation, several technologies, encompassing knowledge-graph-based and machine-learning-based, for paleo-environmental interpretation from geo-data were developed. Here, the Permian-Middle Triassic paleogeography reconstruction for the East Tethys domain is conducted as a case. Firstly, we reconstructed the plate-motion tectonic framework using GPlates. Then the pre-existing lithofacies paleogeography maps were by employed to generate topographic and geomorphic maps automatically by machine-learning-based method with manual fine adjustment. Ultimately, a digital comprehensive paleogeography reconstruction of the Middle Permian-Middle Triassic East Tethys domain was formed through layer superposition. This case is significantly enhancing mapping efficiency, data abundance, traceability, and model accuracy, which could be more timely offering new constraints and insight for understanding co-evolution among landform, ocean anoxia, biological mass extinction, and so on.

Keyword

Deep-time Digital Earth, paleogeography, big data, machine learning, reconstruction model

"Paleotopographic Mapping": A Tool for Creating New Paleotopographic Models

Fan SHU[1]*, School of Earth Sciences, Zhejiang University (22338023@zju.edu.cn)
Haipeng LI[2], Deep-time Digital Earth Research Center of ExcellenceZhijiang
Jin QI[3], School of Earth Sciences, Zhejiang University
Linshu HU[4], School of Earth Sciences, Zhejiang University
Sensen WU[5], School of Earth Sciences, Zhejiang University
Zhenhong DU[6], School of Earth Sciences, Zhejiang University

Abstract

Paleotopographic reconstruction is a comprehensive research field that provides fundamental support for understanding Earth's evolutionary history, essential for paleoclimate, landscape evolution, and biodiversity modeling. However, various methods exist for paleotopographic reconstruction, and different approaches may yield varying interpretations of the same geological period. To facilitate interdisciplinary collaboration and enable experts to create new paleotopographic models based on their specialized knowledge, the DDE platform has introduced the "Paleotopographic Mapping" tool. The "Paleotopographic Mapping" tool is an online mapping tool developed to create new paleotopographic models based on existing ones. The tool links existing paleogeographic data, serving as references for subject-matter experts. Using the "Paleotopographic Mapping" tool, experts can create a project, select an existing paleotopographic model as the basis and use their specialized knowledge to edit it and generate a new paleotopographic model. This tool supports bulk edit and annotations so that experts can edit models conveniently and explain the reasons of doing so. Additionally, the "Paleotopographic Mapping" tool supports features such as "edit history", "paleogeographic rotation" and "model comparisons". Further more, with detailed tips and references, even non-experts can experience creating new paleotopographic models. The DDE platform aims to leverage this tool to create more paleotopographic models, offering researchers more choices for related studies.

Keyword

Paleogeography, Paleotopographic Model, Paleotopographic Reconstruction, Online Mapping, Deep-time Digital Earth

Construction of a fluvial facies knowledge graph and its application in sedimentary facies identification

Lei ZHANG[1]*, 19980873969 (1054359427@qq.com)
cai ming HOU[2], 15982309825

Abstract

Lithofacies paleogeography is a data-intensive discipline that uses lithofacies analysis to reconstruct depositional environments and sedimentary facies, and studies the distribution, formation, and evolution of sedimentary facies. Traditional sedimentary facies analysis and identification are labor-intensive tasks, unstructured knowledge, unstandardized terminology, and the process of sedimentary facies analysis and interpretation are complex. A standardized, structured, and systematic knowledge base coupled with an efficient, fast, and automatic sedimentary facies identification system is necessary. To this end, this study constructed the knowledge system of fluvial facies and carried out knowledge representation. On this basis, we created the domain knowledge graph of fluvial facies and realized visualization, query, and retrieval on the graph database platform. Based on tree logic hierarchical knowledge structure and data mining clustering algorithm, a novel data mining clustering algorithm model suitable for sedimentary facies reasoning was designed, and developed a new sedimentary facies identification and knowledge reasoning system, which provides effective decision support for sedimentary facies identification based on expert experience knowledge. 17 sets of known sedimentary facies data from classical sedimentological literature were applied to the model, compared, and validated. The reasoning results show that the interpretation accordant rate is up to 90%. The model and algorithm provide an efficient and automated reasoning technology, which provides a new approach and route for the rapid and intelligent identification of sedimentary facies in the geology field. Knowledge collection, summary and induction of expert experience knowledge is an effective method for intelligent systems to automatically acquire knowledge from literature data. Combined with the knowledge of palaeogeography, the methods, techniques and processes used to construct knowledge graph and sedimentary facies identification will be extended to the identification, reasoning, and prediction of other sedimentary facies.

Keyword

Fluvial facies knowledge graph, Domain ontology, Knowledge reasoning, Sedimentary facies identification, Data-intensive science

Physics-based Machine Learning Model for Predicting Geothermal Heat Flow in Henan Province, China

Jifu He[1], China University of Geosciences, Beijing
Kewen LI[2]*, China University of Geosciences, Beijing (likewen@cugb.edu.cn)

Abstract

Geothermal heat flow (GHF) emerges as a critical parameter for pinpointing geothermal energy-rich areas and decrypting the Earth's inner thermal dynamics. Remarkably, almost half of the world's measured GHF data clusters within the United States and Europe, leaving vast stretches globally grappling with a scarcity and patchy distribution of GHF measurements. To bridge this knowledge gap and map the GHF distribution accurately across these underrepresented regions, the development of a sophisticated prediction model is imperative. In this arena, machine learning techniques stand out, surpassing traditional interpolation or analytical methods in accuracy. Yet, the exploration of machine learning for GHF prediction remains nascent, predominantly leaning on data-driven paradigms. This study develops a novel approach by introducing a physics-based GHF prediction model, which integrates analytical solutions directly into its framework. We have meticulously selected two analytical solutions for this purpose: one derived from merging the Curie point depth with a one-dimensional heat conduction model, and another hailing from the interplay between the Moho surface depth and elevation, processed through a thermal equilibrium model. This innovative model not only enhances the accuracy but significantly bolsters the interpretability over conventional data-driven models, such as those based on Gradient Boosting Regression Trees (GBRT). Employing this groundbreaking model, we have crafted the most up-to-date GHF map for Henan Province, China, unveiling the intricate distribution of the geothermal fields. This cutting-edge research not only paves the way for a deeper understanding of geothermal resources but also showcases the potential of integrating physics-informed mechanisms with machine learning to revolutionize the GHF prediction at a global scale.

Keyword

Machine learning, Interpolation methods, Geothermal heat flux, Sweet spots, Henan Province in China

Heat extraction performance and seismic potential estimation of horizontal well doublets in enhanced geothermal systems: insights from coupled thermo-hydro-mechanical modeling

Wei JIANG[1]*, State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu, China (472666563@qq.com)
Chuan yin Jiang[2], HydroSciences Montpellier (HSM), University of Montpellier, CNRS, IRD, Montpellier, France
Xiao guang Wang[3], State Key Laboratory of Oil and Gas Reservoir Geology and Exploitation, Chengdu University of Technology, Chengdu, China

Abstract

In the long-term injection and production process of deep fractured geothermal reservoirs, fractures gradually open under combined effects of thermal stress and pore fluid pressure. In an anisotropic stress condition, localized stress disturbances may cause normal closure, shear sliding, and shear dilation of fractures, further impacting the local flow and heat transfer behaviors. Understanding this coupled mechanism is crucial for interpreting the evolution behavior of fracture networks and predicting and controlling the heat extraction performance of thermal reservoirs. In this study, we developed a coupled thermo-hydro-mechanical (THM) model based on the discrete fracture network approach to investigate the joint effects of thermal perturbation and in-situ stress on the development of deep fractured geothermal reservoirs during horizontal well development. This model captures important processes, including normal closure, shear dilation, and shear sliding of fractures, thermal expansion of rocks, fluid flow and heat convection/conduction in both fractures and rocks. We quantitatively analyzed the effects of different in-situ stresses, initial reservoir temperatures, wellbore direction, for both vertical and horizontal wells. We quantitatively compute and compare the evolutional behavior of fracture aperture, fluid flow, and heat transfer for the two well types. The results show that, in addition to reducing the normal closure of fractures, the transient cooling effect of the thermal front may trigger shear dilation under anisotropic in-situ stress conditions. The maximum principal stress in the x direction tends to open 30° fractures while closing 110° fractures. A larger angle between horizontal wells and 30° fractures leads to a faster thermal breakthrough but less and smaller induced seismic events. Under the same injection rate, horizontal wells have a larger heat extraction rate but a faster thermal breakthrough than vertical wells. Our research results provide important implications for optimizing the heat extraction efficiency of geothermal reservoirs and managing seismic hazards during fluid injection and production processes.

Keyword

Heat extraction, Induced seismicity, Horizontal well, Enhanced Geothermal Systems, Discrete fracture network

[Keynote] A Global Energy Outlook: Implications for Geothermal Energy

Richard J Chuchla[1]*, DDE (Deep-time Digital Earth (rchuchla@aol.com)

Abstract

The world's insatiable appetite for energy and the inescapable consequences of global warming due to fossil fuel combustion create an imperative for rapid deployment of carbon-free energy sources. On an annual basis, we currently consume 175,000 TWh of primary energy. From that, we generate approximately 29,000 TWh/yr of electricity. Decarbonized electricity is a foundational element of the energy transition. Over the past four decades electricity demand has almost tripled and will likely increase by another 50% by 2050. Simultaneously solving the complex equations of technology, finance and policy are absolutely required to enable the transition. Global warming provides a critically important additional parameter, which further challenges solutions. The disparity in energy needs and financial capacity between developed and developing economies make clear the need for solutions tailored to local needs.

In exactly this context, we will explore the unique potential and challenges of geothermal energy. Today this energy source fulfills approximately 0.3% of power demand. The dynamic earth, from plate motion to related subduction, mountain building and rifting is driven by a heat engine. However, the lithosphere creates an insulating blanket which only allows higher heat flow where the blanket is torn (plate boundaries) or stretched (rifts). While power generation is localized where hydrothermal systems develop along the hot active plate margins or internal rifts, district heating draws on a much more widely distributed potential resource and, in places, (China, Europe) can tap existing infrastructure. We are already seeing the potential for repurposing existing oil and gas infrastructure and leveraging basic oil and gas technology and workforce knowledge and skills. Hydrothermal systems that produce energy also produce ore deposits and co-production of elements critical to the energy transition are already in the planning stages. All of these factors will be important to growth-to-scale, wide application and cost reduction of geothermal energy.

Keyword

geothermal, energy, power, electricity, climate

A fast approach predicting geothermal play fairways using machine learning to multidisciplinary big data-Case studies in Africa and China

Shu JIANG[1]*, China University of Geosciences (jiangsu@cug.edu.cn)

Abstract

Fast and accurate prediction of geothermal play fairways is crucial for efficient exploration, development and utilization of renewable geothermal energy. This study employs spatial analysis of big data and machine learning to predict potential geothermal plays in Africa and China. The multidisciplinary data include regional geology, geophysics, geochemistry, petrophysics, earthquake, volcano, faults, geothermal heat flow, hot springs, groundwater, terrain, and drilled wells. For the geothermal play fairways in data-scare mega regions, we populate the data using Kriging interpolation and Euclidean distance. fuzzy analytic hierarchy process are random forest are used for feature analysis, prediction, and grading of favorable geothermal play areas. Findings indicate high-grade geothermal resources are mainly in regions like Ethiopia, Kenya, northern and southern Tanzania, Uganda, Rwanda, Burundi and Malawi, mostly distributed along structural belts like the East African Rift. For the potential sedimentary-hosted geothermal reservoirs in the Bohai Bay Basin and South China Sea, typical well logs and seismic attributes were firstly correlated with porosity, permeability, water saturation, and temperature of a facies, neural network and genetic inversion were then employed to predict the geothermal reservoirs with higher porosity, permeability, water saturation, and temperature and quickly build a 3D geothermal reservoir model. These predictions have been validated by the existing geothermal power plants and high temperature reservoirs previously drilled.

Keyword

geothermal play fairway, machine learning, big data, geothermal reservoir

Target Optimization for Hot Dry Rock Resources in the Jizhong Depression

XIAOXUE JIANG[1]*, National Key Laboratory of Petroleum Resources and Engineering&China university of petroleumBeijing (jiangxiaoxue135@163.com)
chuanqing zhu[2], National Key Laboratory of Petroleum Resources and Engineering&China university of petroleum (Beijing)
Xie Fang[3], National Key Laboratory of Petroleum Resources and Engineering&China university of petroleum (Beijing)
Jiaqi Zhang[4], National Key Laboratory of Petroleum Resources and Engineering&China university of petroleum (Beijing)

Abstract

The Jizhong Depression in the Bohai Bay Basin has enormous potential for geothermal resource development. Previous studies have systematically researched the hydrothermal geothermal resources in the Jizhong Depression, but research on deep-seated hot dry rock resources remains unclear. Based on the data of geology, geothermal geological conditions, and rock thermal properties, this study analyzes the characteristics and controlling factors of shallow and deep geothermal fields in the research area. It also identifies favorable targets for hot dry rock resources. According to the calculated geothermal gradients from temperature data, significant differences exist in the shallow and deep formation geothermal gradients in the uplifted area of the Jizhong Depression. The shallow layer exhibits a high geothermal gradient of 41.79°C/km, while the deep layer shows a lower gradient of 30.73°C/km. In the depression area, the geothermal gradient remains relatively constant with depth, averaging at 28.9°C/km. Additionally, there are noticeable differences in heat flow distribution between the uplifted and depression areas. The heat flow in the raised area is between 70-110 mW/m2, indicating a higher thermal background, while adjacent depression areas generally exhibit heat flow below 60 mW/m2. The characteristics of the geothermal field are mainly influenced by rock thermal conductivity, basement structural undulations, and groundwater activity. The tectonic morphology in the uplifted and depression areas of the Jizhong Depression leads to differences in rock thermal conductivity in horizontal and vertical directions. That causes thermal flow refraction and redistribution, and makes the surface heat flow distribution characteristics correspond to the relief of the basement. Thermal convection is occurring within highly permeable dolomite layers which are widely distributed at the shallow end of the raised zone, causing rapid upward heat transfer from the deeper formations of the region and increasing temperatures in the shallower strata. In contrast, deep formations in the uplifted area are less influenced by thermal convection, primarily transferring heat through conduction. Under the effect of conduction-convection complex heat transfer, there are large differences in the temperature distribution characteristics of shallow and deep formations between the raised and depressed areas. Under the effect of conduction-convection complex heat transfer, there are large differences in the temperature distribution characteristics of shallow and deep formations between the raised and depressed areas. Using measured data to calculate the temperature of different buried layers in the study area, it is observed that the uplifted area

exhibits high temperatures in the shallow layers but lower temperatures in the deep formations, while the depression area shows lower temperatures in the shallow layers but higher temperatures in the deep layers. Consequently, the Jizhong Depression is characterized by high-temperature geothermal resources mainly distributed in the deep-seated areas within 5000 m, with temperatures reaching 190°C, which is a favorable target for hot dry rock exploration. This study deepens the understanding of the genesis and distribution patterns of deep-seated high-temperature geothermal fields in the Jizhong Depression, providing valuable reference and guidance for the development of hot dry rock geothermal resources.

Keyword

Geothermal field, Heat refraction, Hot dry rock, Geothermal resources, The Jizhong depression

Characterization of structurally controlled geothermal systems

Gemma Mitjanas[1]*, Sustainable Minerals Institute (Univ of Queensland)
(g.mitjanascolls@uq.edu.au)
John Walsh[2], University College Dublin
Gemma Alías[3], Universitat de Barcelona
Pilar Queralt[4], Universitat de Barcelona
Juanjo Ledo[5], Universidad Complutense de Madrid

Abstract

Faults have long been known to significantly influence the migration of fluids within the crust, often acting as the principal conduits and traps for groundwater, and therefore, also having a key role in fault-controlled geothermal systems. This duality of flow behaviour underneath the importance of the characterization of main structures and the parameters that might affect their role.

Recent studies in the Catalan Coastal Ranges (NE Spain) have evidenced the significance of structural complexity in conditioning the role of faults in the circulation of fluids (1). Details of the geometry and nature of fault intersections, splays, relays, and associated damage-related fractures have been considered together in flow localization. And, the integration of geophysical methods, have been proven to be key in their characterization (2).

The Vallès-Penedès fault in the Catalan Coastal Ranges, host hot springs (60-70°C) along its fault trace, which limits a Palaeozoic metamorphic and granodioritic horst from the Miocene sediments that fill the graben. We have integrated geological and geophysical exploration methods, including fracture characterization, gravity, passive seismic, and magnetotellurics, to characterize the main structures and identify the characteristics that allow the presence of hot springs only in specific parts of the fault.

Results show how the geothermal flow is primarily concentrated in the intersection of the Valles-Penedes fault zone with a Palaeozoic thrust sheet, enhanced by fault-related fracturing. The resulting structural complexities, which include the development of a relay ramp and high fracture density, together with the characteristics of the host rock and the flow direction, have been identified as key factors in the localization of the currently active hot springs.

Keyword

Exploration, Fault Zones, Geophysics

Project InnerSpace's GeoMapTM: Unlocking Geothermal Potential Worldwide

Jamie BEARD[1]*, Project InnerSpace (jackson@projectinnerspace.org)
Dani MERINO-GARCIA[2], Project InnerSpace
Higinia TORREGROSA[3], Project InnerSpace

Abstract

In the quest for sustainable and clean energy sources, geothermal energy has emerged as a promising contender. The Earth's internal heat can be harnessed to power and heat our homes, industries, and communities. However, realizing this potential requires a deep understanding of the Earth's subsurface and surface characteristics. Project InnerSpace's GeoMapTM: has been designed to provide a free platform where various stakeholders can access this data. The GeoMapTM body of work consists of surface and subsurface modules, a suitability analysis tool, and a Techno-Economic Sensitivity Tool ("TEST"), all of which work together to provide outputs to user inquiries about geothermal resources and development potential.

With funding allocated to nine different research projects, including seven focused on the subsurface and two on the surface, Project InnerSpace has brought together over 85 scientists from around the globe to consolidate fragmented datasets, increase their spatial resolution, improve their metadata, and enhance data quality. Through an exciting partnership with Google, GeoMapTM will leverage vast and powerful datasets from Google's Earth Engine to form the backbone of the project's surface suitability assessment. This high-resolution satellite data and building information will help the tool understand heat and electricity demand, a vital aspect of geothermal energy planning.

GeoMapTM aims to serve a diverse range of stakeholders: large industrial corporations looking to harness geothermal energy, geothermal sector companies, governments seeking to highlight their country's potential, and investors with the resources to fund innovative projects. Moreover, the project has gained attention from networks specializing in critical minerals and natural hydrogen. The data generated isn't just valuable for geothermal energy; it has applications across various fields and disciplines, which will help to expand its reach and impact.

The first rendition of GeoMapTM focused on the African continent, with a surface-level heat demand analysis completed for the city of Lagos, Nigeria, the most populous urban area in Africa. In future renditions of GeoMapTM, we will be expanding east to incorporate the Asian continent and are eager to discover synergies with experts in the field from throughout the region.

In conclusion, Project InnerSpace's GeoMapTM is an endeavor that unites global expertise and cutting-edge technology to unlock the potential of geothermal energy. The goal is clear: to create a comprehensive and accessible resource that empowers stakeholders to make informed decisions

about geothermal potential worldwide

Keyword

Surface and Subsurface Modules, Suitability Analysis Tool, Techno-Economic Sensitivity Tool, Stakeholder Education, Geothermal

Prediction of heat flow distribution in North China, based on digital geomorphic and multi-geophysical data

Chuanqing ZHU[1]*, China University of Petroleum (Beijing) (zhucq@cup.edu.cn)
Nansheng Qiu[2], China University of Petroleum (Beijing)
Yaorong Shen[3], China University of Petroleum (Beijing)

Abstract

Terrestrial heat flow is a comprehensive geothermal parameter reflecting the regional thermal background. The terrestrial heat flow data are of great significance to understanding the thermal state and activity of the crust, the thermal structure of the lithosphere, and the evaluation of geothermal, oil and gas resources. Due to the limitations of the distribution of boreholes and rock coring, the spatial distribution of measured terrestrial heat flow data in China is uneven, and there is a large blank area of heat flow data outside sedimentary basins. The surface heat flow is closely related to the thickness of the lithosphere, the buried depth of Curie surface, and the geomorphology and the age of geological events. This study takes North China craton as the research area, uses the neural network method and the GEOGPT large language model, and tries to establish the internal logical correlation between multiple types of parameters and heat flow based on the analysis and summary of multiple geological and geophysical parameters such as digital geomorphology, thermal tectonic events, geological units, and buried depth of geological interfaces. The high-density grid was used to fill the blank area of measured heat flow, and the local heat flow prediction was more consistent with the regional structure-thermal background.

Keyword

GEOGPT large model, Digital geomorphology, Multiple geophysical data, Heat flow, North China

Integrations of geothermal exploration techniques in the Guguan geothermal potential area, Taiwan

Rou-Fei CHEN[1]*, National Taipei University of Technology (roufei@mail.ntut.edu.tw)
Yi-Chung CHEN[2], National Taipei University of Technology
Bing-Sheng YU[3], National Taipei University of Technology
Chia-Chi CHIU[4], National Taipei University of Technology
Mien-Ming CHEN[5], Geological Survey and Mining Management Agency, MOEA
Chi-Hsuan CHEN[6], Geological Survey and Mining Management Agency, MOEA
Wan-Chi CHIANG[7], Geological Survey and Mining Management Agency, MOEA
Ming-Fang YU[8], National Taipei University of Technology
Wen-Shan CHEN[9], Green Energy & Environment Research Laboratories (GEL), Industrial Technology Research Institute (ITRI)

Abstract

Taiwan Island located in the Circum-Pacific Volcanic Belt (Ring of Fire), an active orogenic zone with abundant volcanic and tectonic activities, and rich geothermal resources in the earth's crust. However, geological exploration is uncertain and risky in the preliminary survey stage of geothermal resource development, which is often difficult and discouraging. Based on the above concepts, this project has selected the geothermal potential area in Guguan, Taichung City to, with the use of multiple multi-scale geothermal surface exploration methods and subsurface exploration techniques, obtain comprehensive geothermal geological information and further develop a subsurface three-dimensional geological model to rationally assess the size and distribution of geothermal energy reserves. The said data may be used as a reference for the exploitation of geothermal resources and facilitate the development of geothermal potential areas. The work items of project include: (1) geothermal geological survey; (2) geophysical exploration; (3) geochemical analysis; (4) drilling and well testing; (5) 3D geothermal geological modeling; and (6) administrative assistance. First, we will compile geothermal geological data in the study area and select a key exploration area of 30 km2 to, supplemented by a 0.5-meter resolution airborne LiDAR derived DEM, carry out field surveys and the production of a 1:10,000 geothermal geological map production; and then, together with a 0.2-m resolution UAV LiDAR-derived DEM and a 0.1-m resolution GB LiDAR derived DSM, measure the nodal fracture of key outcrops and carry out a stress analysis accordingly. Second, geomagnetic and georesistance profiles are planned to follow in accordance with the regional geological architecture to obtain deep geothermal geological data such as subsurface lithology, geological structures, fracture zones, and hydrothermal fluids. In addition, a geochemical analysis of surface water, hot spring water, and rock samples will be conducted in the key exploration areas; and the results will be used to evaluate the chemical properties, hydrothermal sources, and temperature of thermal fluids in the region to estimate the temperature of deep geothermal reservoirs. Finally, based on the aforesaid geological, physical, and geochemical analysis results, drilling sites will be selected to verify the subsurface geological structure via drilling, probing and well testing; and three-dimensional

geothermal model will also be constructed accordingly to make clear the potential and distribution of geothermal resources. The three-dimensional geothermal model, which also incorporates all technological results, will be verified with field surveys and statistically modified by rolling parameters. In the meanwhile, we will integrate all results into the geothermal exploration database and determinate potential geothermal resources in the study area. It is estimated that the research results of this project will be integrated into CGS' Geothermal Exploration Information Platform, through which the geothermal development industry can facilitate their exploitation of thermal resources and the government can refer to for their renewable energy policy.

Keyword

Geothermal exploration, multi-scale LiDAR technology, Magnetotellurics (MT) Surveys, three-dimensional geothermal model, Guguan geothermal potential area

[Keynote] Deep-time Digital Earth: an overview of progress since 2019, and a look into the future

Michael H Stephenson[1]*, Stephenson Geoscience Consulting Ltd (mikepalyno@me.com)

Abstract

The Deep-time Digital Earth program was initiated in February 2019 at the Fragrant Hills Hotel in Beijing, China, where seventy international geologists and geoscience data specialists gathered alongside representatives of the International Union of Geological Sciences (IUGS). DDE follows the vision of the IUGS which is to promote development of the Earth sciences through the support of broad-based scientific studies relevant to the entire Earth system. Founding members include the International Commission on Stratigraphy, International Association of Palaeontology, International Association of Sedimentologists, Society for Sedimentary Geology, American Association of Petroleum Geologists, and the International Association for Mathematical Geosciences. Major geological surveys, institutes and commissions are also involved including the China Geological Survey, the Geological Survey of India, the Commission for Geological Map of the World, and the Commission on the Management and Application of Geoscience Information. DDE will operate the full FAIR data concept (Findable, Accessible, Interoperable, and Re-usable), and link to desktop systems for geoscientists all over the world as well as to students and teachers in classrooms and on the internet.

In the past four years progress has been astonishing, despite the interjection of the covid pandemic, with projects on geological mapping, geological lexicons, interoperability and standards, marginal seas, geological timelines and national computing nodes. Highlights include the development of the DDE modelling and data platform now with over 1000 datasets, and the ability to offer an advanced modelling environment through ordinary computing equipment (a simple laptop), and the DDE Outcrop 3D visualisation system which already offers an unprecedented 120 high resolution dm to km images of some of the most spectacular and important geological sites on the Earth.

A challenge into the future will be continuing to develop collaboration in an increasingly fractured world with strong geopolitical divides, but DDE's avowed commitment to non-alignment and to science will maximise its ability to work with scientist throughout the world whatever their origin. Another challenge will be to continue to make DDE science relevant to societal problems, including climate change and resources, and to the UNs sustainable development goals (SDGs), but DDE's structure of Task and Working Groups and roots in the Global South will help to keep DDE's science useful and relevant.

In the future DDE will continue to make geological data more Findable, Accessible, Interoperable, and Re-usable so that geological data will begin to resemble the more open and creative scientific environments of bioscience, astronomy and physics, and so that machine learning and artificial intelligence will be more applicable, ushering in a bright future for the Earth sciences into the 2030s.

Keyword

Deeptime, Digital, geoscience, data, IUGS

Unlocking the Deep-time Earth with Open Keys: Collaboration, Platform and Research projects.

Chao LI[1]*, Deep-time Digital Earth (li.chao@ddeworld.org)
Zheng Tong[2], Deep-time Digital Earth

Abstract

The incompleteness of the evidence for Earth's evolution and the difficulty of integrating existing data are inevitable difficulties for geoscientists who are trying to understand the past and the future. A wealth of deep-time earth data and models exist in archives and publications, which are not readily accessible and reusable to scientists.

The most intuitive solution is to collaborate with all geoscientists to build a geoscience cyberinfrastructure, essentially a dynamically updated data network. A collaborative distributed protocol with time-space frameworks, terminology standards, and even multi-jurisdictional intellectual property rules should be developed to enable secure access to and efficient use of geoscience resources on a global scale. Furthermore, an online work platform website should be developed and serves as a user interface.

Case studies could demonstrate the effectiveness of the mechanism. From life to matter, from climate to geography, scientists are conducting ambitious, integrated studies that carefully put global-scale data and advanced models together. It's time to put these separate studies on a unified platform, and enable more studies by the platform, so that more accumulated data yields more value.

This oral will showcase some of the ideas, practices and experiences in building and using the cyberinfrastructure aiming solve Deep-time issues, as well as the great value of global cooperation for promoting discoveries about the deep-time earth.

Keyword

deep-time, collaboration, platform, network

Data-driven Hydrogeology Research Hatched by the OneGroundwater Platform

Jianmei Cheng[1]*, School of Environmental Studies, China University of Geosciences, Wuhan, 430074, China (jmcheng@cug.edu.cn)
Kun Zheng[2], School of Geography and Information Engineering, China University of Geosciences, Wuhan, 430074, China
Hong Yao[3], School of Computer Science, China University of Geosciences, Wuhan, 430074, China
Ying Yu[4], School of Environmental Studies, China University of Geosciences, Wuhan, 430074, China
Yanxin Wang[5], School of Environmental Studies, China University of Geosciences, Wuhan, 430074, China

Abstract

Either groundwater's sustainable management or its deep hydrogeological process research, relies on the support of massive multi-source heterogenous data. But presently the accessibility and systematisms of groundwater data are quite insufficient. Large amounts of hydrogeological information are still scattered in numerous documents in different forms, and simultaneously, very limited data on the properties and migration characteristics of deep groundwater can be found. Here we aimed to develop the techniques of knowledge extraction and graph data organization for the automatic acquisition of hydrogeological information in literature databases and the construction of the hydrogeology knowledge graph. Then, by establishing the hydrogeological base service platform, OneGroundwater, we can efficiently store and manage the acquired multi-source heterogeneous groundwater data with the knowledge-based intelligent retrieval function in the real-time service computing framework. So far, our hydrogeological mapping team has preliminarily completed the preparation of the African hydrogeological map and uploaded it to the platform for display. Simultaneously, we have conducted the study of groundwater storage in Africa. In terms of thematic dataset construction, data collection, database design, database construction, and database application promotion have been jointly promoted. A large amount of data has been collected for the databases of global spring water, saline water, high-arsenic and high fluorine groundwater. These data have been uploaded on the OneGroundwater platform. In terms of knowledge system construction, a large number of triples and entities have been obtained through work such as data crawlers, entity recognition and relationship extraction, and manual review. Using these triples and entities, a knowledge graph of water containing fluid inclusions has been successfully constructed and visualized. Moreover, for the OneGroundwater platform, the functionality, knowledge system visualization, database optimization and spatiotemporal data analysis tools, user access, and other aspects have been continuously improved and improved. Next, with the increase of the thematic databases in the platform, the data-driven hydrogeological research will be further promoted.

Keyword

Hydrogeology, data-driven groundwater science, hydrogeological base service platform

DDE OneSediment: a comprehensive sedimentological and palaeogeographic database and research platform

Xiumian Hu[1]*, NANJING UNIVERSITY (huxm@nju.edu.cn)
Chengshan Wang[2], China University of Geosciences, Beijing
Jitao Chen[3], Nanjing Institute of Geology and Palaeontology, CAS
Jianghai Yang[4], China University of Geosciences, Wuhan
Jingxin Jiang[5], Nanjing University
Mingcai Hou[6], Chengdu University of Technology
Data Team DDE[7], Hangzhou DDE Centre
Platform Team DDE[8], Hangzhou DDE Centre
Sedimentology Working Group[9], Hangzhou DDE Centre
Palaeogeography Working Group[10], Hangzhou DDE Centre

Abstract

OneSediment is a disciplinary data product planned by the Deep-Time Digital Earth (DDE) international big science program, which aims to integrate sedimentological data scattered all over the world, of different sources (journals, books, reports) and of different categories (analyzing data, text, images, etc.).

The construction of OneSediment is based on the knowledge system of sedimentology and paleogeography, covering the whole sedimentological area; The construction method is shared by using cloud technology, big data and other technologies to meet the globally needs of data building and sharing; The formation of a dynamic database with unified standards and platforms, in line with the principles of FAIR (Findable, Accessible, Interpretable, Reusable), promote the informatization and standardization of sedimentological data, and provide sedimentological information services for the public. By way of thematic database construction to interested scientists, OneSediment will integrate databases of different scales and forms, and realize data interoperability and interconnection, and to provide a one-stop scientific data serves for calculations, statistics, figuring, mapping and simulations.

Up to now, 25 thematic databases have been constructed under the joint efforts of the DDE Sedimentology and the Paleogeography working groups. For example, the ocean sediment database (OSD) is under construction, including eight core data categories related to sediment composition (macroscopic, microscopic, clay minerals), sedimentary geochemistry (organic geochemistry, inorganic geochemistry, pore water chemistry), physical properties (moisture and density, diffuse reflectance color), stratigraphic event data for age-depth models, with 2,247 sedimentary boreholes and a total of more than 1,630,000 data entries. The incoming data were standardized by subject experts, and there are 583 standard fields.

Another example is the global detrital zircon database with approximately 600,000 U-Pb age data mainly from China, Iran, Turkey and Cyprus has been developed, which had been published recently as a special collection in Geoscience Data Journal, together with the global deep-time sandstone detrital component database, modern river sediment composition database, global chert

database. Chinese Sedimentological Microscopic Images database was constructed and published in special issues of Chinese Science Data.

Keyword

Geological data, Sedimentology, Palaeogeography, Data Science

[Keynote] The Deep-time Digital Earth Program in the Evolving Global Research Data Landscape

Kerstin Annette Lehnert[1]*, Columbia University (lehnert@ldeo.columbia.edu)
Lesley Wyborn[2], Australian National University

Abstract

Modern-day Geoscientists increasingly want to and need to use Big Data and data analytics to solve the large-scale and urgent questions that they address in their research for both discovery science and applied science. The Deep-time Digital Earth (DDE) Program therefore is a highly relevant, promising, and welcome effort to pursue the challenging but promising goal of moving the Geosciences into a new era of Big Data. DDE was created with the vision to utilize modern and cutting-edge computational paradigms, internet cloud computing, data mining, machine learning and AI to extract knowledge from the massive volumes of data that have been and are generated world-wide to understand the Earth's evolution and contribute to achieving the sustainable development goals." DDE's mission is to "harmonize global deep-time Earth data and share global geoscience knowledge", setting itself an ambitious goal considering the complexity of the global data ecosystem and its continuing evolution and expansion. Since DDE was inaugurated in 2019, new scientific paradigms and new technologies for data storage, description, identification, interoperability, and analytics have emerged and new principles and policies for data management and open and ethical data sharing have been developed and put in place by funders, publishers in many countries to ensure preservation and FAIRness of data (Findable, Accessible, Interoperable, Reusable).

The development of data standards and their implementation as community best practices face many challenges. The biggest ones are not technical, but legal, political, social, or cultural in nature (Edwards et al. 2007; Wittenberg & Strawn 2018). Over the past decade, new initiatives have been launched through international organizations such as CODATA, Research Data Alliance, the World Data System and the IUGS to advance cross-disciplinary and international communication, coordination, and collaboration, helping to build consensus on best practices and standards for the sharing and re-use of digital research data. DDE's progress and success depend on its ability to leverage and complement those initiatives. DDE's move to connect with CODATA and the WorldFAIR project is an important step to advance collaboration with relevant standard developments such as the OneGeochemistry case study in WorldFAIR. Such collaborations are critical to converge on standards and broaden their adoption, particularly in the Long Tail Geosciences communities that are heterogeneous and fragmented.

DDE has shown itself capable of generating tools that will enable analysis of global datasets, but so far, those tools work on DDE-compiled datasets. They will not necessarily work on datasets generated by other regional or international groups, and require adaptation of the tools to these

datasets, and or the conversion of these existing datasets to DDE standards.

The best option for success and long-term impact of the DDE program is for DDE to work with the IUGS, CODATA, RDA and other international initiatives to jointly develop the global standards required to enable machine readability of geoscience data in compliance with the FAIR, CARE and TRUST principles, respecting diversity and inclusion; incorporating ideas, concepts and knowledges from the Global North, Global South, and indigenous communities; and ensuring consistent and sustained data infrastructure.

Keyword

Deep-time Digital Earth; data standards; international collaboration; FAIR principles, data standards, big data, FAIR, international collaboration

Building the Earth System History Machine: A Dynamic Simulation of Plate Tectonics, Paleogeography, Paleoclimate and Paleobiogeography.

Christopher Robert SCOTESE[1]*, Northwestern University (cscotese@gmail.com)

Abstract

Since the time of Nicholas Steno, more than 350 years ago, field geologists, paleontologists, stratigraphers, and geophysicists have fastidiously and painstakingly described and mapped the surficial and buried layers of the Earth's crust, revealing its detailed and exquisite history. This story emerged slowly at first, then accelerated as Earth Historians were able to calibrate their correlations using absolute radiometric age-dating. Using this robust chronometric framework, we now can tell the exciting story of the Earth, in all of its interwoven tectonic, geographic, oceanographic, atmospheric, geochemical, climatic, and biologic complexity. During the last 30 years, Energy companies and national geological surveys have compiled 3D exploration databases and have built 3D stratigraphic models covering the globe. An immense amount of high-resolution, digital stratigraphic data are now in-hand. So what does the future hold? The task before us is two-fold: first, a new Earth System History "Library of Alexandria" must be built from this great volume of digital Earth System History data to preserve it for future generations and, more importantly, to create a comprehensive, coherent and authoritative digital data source for the emerging artificial intelligence systems (e.g., GPT5). The second task, though daunting, is to use this Earth System History database, along with important geophysical data bases, to build an "Earth System History Machine". This Earth System History Machine will dynamically simulate the plate tectonic, paleogeographic, sedimentologic, paleoceanographic, geochemical, paleoclimatic evolution of the Earth since its beginnings, through to the present, and forward into the future Anthropocene. Numerous researchers, who span the globe, are now actively working towards this lofty goal They include researchers and students at the PALEOMAP Project (Northwestern University), EarthByte (University of Sydney), CEED (Norway), University of Geneva, University of Chicago, Leeds University, Chronosphere Project (Erlangen), University of Bristol, Texas A&M University, NMNH, DDE Project, Purdue University, Chinese Academy of Sciences, Peking University, University of Geosciences (Wuhan), Nanjing University, Paleobiology Database, Macrostrat (University of Wisconsin), Utrecht University, University of Western Australia, CNRS, ETH, University of Lisbon, and others.

Keyword

AI, Earth System History, Plate Tectonics, Paleogeography, Paleoclimate

DDE scholar report: a new open and Ai frontier and innovative reflect for solid earth

Meng WANG[1]*, Xiniang institute of Ecology and Geography, Chinese Academy of Sciences (yeswangmeng@gmail.com)
Yu Zhao[2], School of Earth Sciences and Resources, China University of Geosciences (Beijing)
Li Cheng[3], Journal Center, China University of Geosciences (Beijing)
Chengshan Wang[4], School of Earth Sciences and Resources, China University of Geosciences (Beijing)
Hans Thybo[5], University of Copenhagen
Patricio Guillermo Villafañe[6], Instituto Superior de Correlación Geológica (INSUGEO)

Abstract

The Deep-Time Digital Earth (DDE) program was initiated by the International Union of Geological Sciences (IUGS) and is being developed in cooperation with national geological surveys, professional associations, academic institutions and scientists around the world. Following the FAIR (findable, accessible, interoperable and reusable) and TRUST (Transparency, Responsibility, User focus, Sustainability and Technology) principles, DDE aims to link and harmonize global deep-time Earth data and share global geoscience knowledge with the goal of stimulating data-driven discoveries in the study of Earth's evolution through deep time.

In order to release DDE's expert knowledge bonus, data bonus and platform bonus, and help scientists deal with the challenges of earth science research based on their needs, DDE plans to launch a series of annual thematic, scholarly reports. Through in-depth analysis and interpretation of global research trends, it will help scientists understand major research breakthroughs in the field of solid earth sciences, and understand research methods, solutions to major scientific problems and highlight key topics and themes for future research.

The first DDE report is due to be released in 2023. DDE Report will use the theory and methods from bibliometric and altimetric research and release the “hot” topics and development of earth science research in solid earth science. The report will explore the deep reason behind trends and become the barometer of earth science research publications and outputs. DDE report aims to help scientists on determining the future research focus and innovation, and finally, to guide future earth science research trends.

Keyword

DDE, Public goods, solid earth science, hot topics, Deep-Time Digital Earth

IMMERSIVE VIRTUAL EXPERIENCE: A NEW “LOOK UP” TO THE GSSPs

Simonetta Monechi[1]*, Dipartimento Scienze della Terra, University of Florence, Italy (simonetta.monechi@unifi.it)
Laia Alegret[2], ept. Ciencias de la Tierra Universidad de Zaragoza, Spain
Aitor Payros[3], Department of Geology, University of the Basque Country, Bilbao, Spain
Claudia Agnini[4], Dipartimento di Geoscienze, Università di Padova, Padova, Italy
Gabriele Scaduto[5], Dipartimento Scienze della Terra, Università degli Studi di Firenze, Italy
Bruno Fanini[6], Institute of Heritage Science of the Italian National Research Council (CNR ISPC), Rome, Italy

Abstract

In recent years, three-dimensional digital models have rapidly developed providing diverse and important data that has great potential for innovative information technologies and scientific research in geoscience. The acquisition and digitization of the geological outcrops and in particular of the GSSPs and geo-heritage sites allowed the International Subcommission on Paleogene Stratigraphy (ISPS) to enhance and give visibility to the scientific community and the general public of the most important Paleogene sections (see the ISPS website https://www.paleogene.org/).

The acquisition of these data utilized photogrammetry and Lidar modeling techniques with mobile phone.

The models have been enhanced to create an immersive virtual experience of the geosites. The utilization of ATON, an open-source framework developed by the Institute of Heritage Science of the Italian National Research Council (CNR ISPC), allows the exploration of large, massive 3D datasets using HMDs (i.e. Oculus Quest) directly through a web brouser, without requiring any installation. Such a modular framework offers advanced functionalities like visual immersive analytics and integration with complex multimedia content. Users virtually immerse in the outcrop enabling rea-time querying of all geometries, annotations and measurement functionalities (e.g. examinining 3D fossils and other material or associated information).

This innovative approach offers an incredible opportunity for saving temporary outcrops, geological features or fossils in virtual environments, and will contribute to research, to promote and disseminate geo-education.

Keyword

3D models, immersive visual presentation, Geosites, GSSP, digitization

[Invited] Building Stacked Relative Paleointensity Records for Chron C18: Insights into the Geodynamo Characteristics Over Extended Timescales

Yuhji YAMAMOTO[1]*, Kochi University (y.yamamoto@kochi-u.ac.jp)
Hiroto FUKAMI[2], Kochi University; Sanyo Techno Marine Co. Ltd
Peter C. LIPPERT[3], University of Utah

Abstract

Knowledge of variations in intensity of paleomagnetic field (paleointensity) can be inferred from volcanic materials and marine sediments. The former allows for the estimation by absolute values, and related data have been reported as old as 4.2 Ga, though their quality is variable and their temporal coverage is sporadic (Bono et al., 2022). The latter could provide estimates in a more continuous form in relative values, i.e., relative paleointensity (RPI), but the temporal coverage had been limited to ~2-3 Ma in the case of stacked records. Deep-sea drilling, such as the Integrated Ocean Drilling Program (IODP), can recover sediments without disturbance to depths of ~200 meters below the seafloor, thus building up stacked RPI records back in time as longer time series. Records of RPI older than ~2-3 Ma began to be reported from sediments recovered by the IODP, primarily in the 2010s: it is possible to build an RPI stack based on these records if they cover the same period and are from different regions. For the period of ~38.5-41.1 Ma, corresponding to the interval of Chron C18, RPI records were reported from two regions 9000 km apart, the equatorial Pacific (Yamamoto et al., 2014) and the northwest Atlantic (Yamamoto et al., 2022). The stacked RPI record for Chron 18, named PIS-C18, is constructed (visually aligned) from these records and it is the oldest stack record to date (Yamamoto et al., 2022). It exhibits general characteristics such that RPI minima always occur at chron boundaries and RPI fluctuates between highs and lows within each chron. In more detail, RPI is generally high with no prominent lows during Chron C18n.2n, whereas it is not as high and has several prominent lows almost equivalent to the RPI minima at the chron boundaries during Chrons C18n.1n and C18r. It is implied that there is a higher probability for a prominent low intensity event such as a geomagnetic excursion during a longer polarity interval than during a shorter polarity interval. Also, a histogram of PIS-C18 RPI is slightly skewed to the right, and the ratio of the standard deviation to the mean paleointensity is 0.38: these are similar to characteristics observed in the PISO-1500 RPI histogram (Channell et al., 2009). It is suggested that all of these features are characteristic of the geodynamo over timescales of 10^4 – 10^6 years which has been unchanged at least since the Eocene.

Keyword

relative paleointensity, Chron C18, equatorial Pacific, northwest Atlantic

The reliability of Cretaceous redbed paleomagnetic datasets from the Tibetan Plateau

Jiahui MA[1]*, China University of Geosciences (Beijing) (3001200098@email.cugb.edu.cn)
Tianshui Yang[2], China University of Geosciences (Beijing)

Abstract

Sedimentary rocks, particularly redbeds, which can record nearly continuous geomagnetic fields and provide definitely paleohorizontal relative to volcanic rocks, have always been the most extensively collected material for paleomagnetic studies in the Tibetan Plateau and its adjacent areas. However, Cretaceous paleomagnetic datasets obtained from the coeval redbeds and volcanic rocks of the Lhasa terrane have significantly different inclinations. Considering that the factors that caused the inclination discrepancies in redbeds are controversial, it is extremely urgent to clarify the reliability of the characteristic remanent magnetization (ChRM) of redbeds in the Tibetan Plateau. Here, we performed a new paleomagnetic study on the Upper Cretaceous Abushan Formation (Fm) redbeds in the Anduo area of the central Tibetan Plateau. A detrital zircon U-Pb dating result from the bottom of the sampled Abushan Fm redbeds yielded the youngest zircon age of 89.1 ± 0.9 Ma, which, combined with Cretaceous Normal Polarity Superchron interval (ca. 121.4−83.6 Ma), dated the sampled redbeds with 89.1−83.6 Ma. The tilt-corrected site mean direction for 37 sites is Ds = 0.9°, Is = +36.4°, k = 43.6 with α95 = 3.6°, corresponding to a paleopole at 78.2°N, 266.8°E with A95=3.6° and a paleolatitude of 20.5 ± 3.6°N for the study area (32.3°N, 91.4°E). This paleomagnetic dataset passes both McElhinny (1964) and McFadden (1990) fold tests at the 99% confidence level and the conglomerate test at 99% and 95% confidence levels. But the mean inclination obtained from the southwest dipping limb (Is = +44.2°) is steeper than that from the north dipping limb (Is = +34.2°). The fold and conglomerate tests, combined with the rock-magnetic results, microscopic observations, and credible demagnetization curves indicate that the ChRM directions are the primary DRMs carried by detrital hematite and do not experience obvious distortional strains. Both the elongation/inclination (E/I) and anisotropy-based correction methods suggest that the inclination shallowing is insignificant in sampling sections. Finally, considering that the site-mean inclination of the southwest dipping strata (Ic1 = +41.2°) is consistent with that of the north dipping strata (Ic2 = +40.9°) after syntectonic-sedimentation-correction, the invalid inclination discrepancy should result from unidentified syntectonic growth strata. Furthermore, the mean inclination acquired from two limbs of folds is basically consistent before and after syntectonic-sedimentation-correction, which indicates that the redbed paleomagnetic datasets obtained from two limbs of folds are still reliable.

Keyword

Tibetan Plateau, Paleomagnetism, Redbeds, Reliability

The Balanced Billion

Ross N MITCHELL[1]*, Chinese Academy of Sciences (ross.mitchell@mail.iggcas.cn.cn)
David` AD Evans[2], Yale University

Abstract

A mid-Proterozoic stretch of Earth's history (roughly 1.8–0.8 Ga) has been called, non-affectionately, the "boring billion". The moniker was first inspired several decades ago by the apparent absence of any significant carbon isotope anomalies and was linked to the relatively dull interval between Earth's broadly two-step pattern in atmospheric oxygenation. Other datasets from Earth's surficial environment during this time have been shown to be equally peculiar, including: the disappearance of iron formation and notable absences of any large oxygenation events, phosphorites, or glacial and manganese deposits, and a billion-year lag between the oldest known Paleoproterozoic eukaryote fossils versus pronounced mid-Neoproterozoic eukaryotic diversity and ecological importance.

Oddities of this billion years come not only from records of surface evolution and palaeoenvironment, but also the solid Earth, including metamorphic style (a paucity of high-pressure conditions) and either absences (ophiolites) or abundances (anorthosites) of specific igneous rock suites. Recently, the mid-Proterozoic anomaly has even been suggested to be expressed as deep as mantle convection and as far flung as the Earth–Moon system: with the billion years suggested to respectively represent the transition between bottom-up to top-down mantle convection as well as a remarkable flat-lining of Earth's rotational history at a constant ~19 hours per day. Anomalies can be recognized as deep as Earth's core, because measured palaeomagnetic inclinations (which convert to palaeolatitude assuming a geomagnetic field model) deviate significantly from the expectation of a geocentric axial dipole.

However, Earth's mid-Proterozoic tectonic record is anything but stagnant. The Grenvillian super-orogen is globally widespread and anomalously deeply eroded. Regardless of whether individual components of that orogenic system involve collisions between continents as part of Rodinia assembly or are produced by long-lived tectonic accretion, the attractive temporal correlations between silicate rock weathering and paleoclimate variability in Phanerozoic time might predict profound atmospheric CO2 drawdown and glaciation during the Grenvillian interval at ca. 1000 Ma, as well as changes to atmospheric oxygen from pyrite weathering and burial. Instead, climatic stability through the Meso-Neoproterozoic transition highlights the important geochemical flux balances and restorative feedbacks that must have existed around the rock cycle encompassing magmatism, weathering, sedimentation, and metamorphism. Profound and rapid changes in Rodinia's paleolatitude could contribute to repetitive episodic activation of such feedbacks.

In light of (i) the original evidence coming from a relatively stable carbon cycles, (ii) the souring over time of the unflattering term "boring billion" and (iii) more recent additional clues coming from the deep Earth, we suggest a rebranding of the 1.8-0.8 Ga interval to the "Balanced Billion". An important benefit of this renaming is that it may inspire better recognition and quantification of

mid-Proterozoic Earth system feedbacks—in not only the balanced paleoenvironment, but also balanced mantle convection and a constant daylength due to balanced solar and lunar tidal torques. Whether these variegated processes are directly related is a frontier for understanding the interconnectedness of the deep-time Earth system, and may lead to a better understanding of the long-delayed fuse in the rise of animals.

Keyword

boring billion, balanced billion, Mesoproterozoic, Rodinia, Columbia

Closing the Unimos Ocean and assembling Rodinia

Nicholas SWANSON-HYSELL[1]*, University of Minnesota (nicks-h@umn.edu)
Yiming Zhang[2], UC Berkeley
Eben Blake Hodgin[3], Brown University
Anthony Fuentes[4], UC Berkeley
Tadesse Alemu[5], Colby College

Abstract

The continent-continent collision of the Grenvillian orogeny that initiated in the latest Mesoproterozoic was a major event in the formation of the supercontinent Rodinia. Leading up to the onset of collisional orogenesis, there was rapid plate motion of Laurentia associated with the closure of the Unimos Ocean. This rapid motion has come into further clarity with new geochronology and paleomagnetic data from the Southwestern Laurentia large igneous province. These data add to the rich well-calibrated record from volcanics and intrusions of the North American Midcontinent Rift known as the Keweenawan Track. New temporal constraints and paleomagnetic data from sedimentary rocks deposited following rift volcanism show plate motion to have dramatically slowed following ca. 1080 Ma. This slow-down is contemporaneous with the onset of collision recorded in the Grenvillian orogeny. Slow rates of continental motion were then sustained throughout the orogeny. These data support the interpretation that the previous rapid motion recorded in the Keweenawan Track is dominantly the result of differential plate motion. We illustrate how site level data can be assigned ages and associated uncertainties within probabilistic frameworks rather than being assigned single ages. Additionally, we can account for the variability associated with processes such as inclination shallowing, enabling us to both utilize the richness of the available data and accurately reflect its inherent uncertainties. Overall, our new constraints show that the position of Laurentia, and associated land masses within the supercontinent Rodinia, at the start of the Neoproterozoic Era differs from current reconstructions that rely on the ages that are currently assigned to paleomagnetic poles of the Grenville loop. These data highlight continued opportunities for the development of new paleomagnetic and geochronologic data to enable substantive progress in deep time paleogeography.

Keyword

Rodinia, Paleogeography, Geochronology, Tectonics

Neoarchean plate mobilism: constraints from paleomagnetic results of Wyoming and Superior

Jikai Ding[1]*, China University of Geosciences Beijing (djikai@126.com)
Chris Rogers[2], Department of Earth Sciences, Carleton University, Ottawa, ON, Canada
Ulf Söderlund[3], Department of Geology, Lund University, Sölvegatan 12, SE-223 62 Lund, Sweden
David A.D. Evans[4], Department of Earth & Planetary Sciences, Yale University, New Haven, CT 06520, USA
Zheng Gong[5], Department of Earth & Planetary Sciences, Yale University, New Haven, CT 06520, USA
Richard E. Ernst[6], Department of Earth Sciences, Carleton University, Ottawa, ON, Canada
Kevin Chamberlain[7], Department of Geology & Geophysics, University of Wyoming, Laramie WY, USA
Taylor Kilian[8], KoBold Metals, Berkeley, California 94704, USA

Abstract

How far back in time plate tectonics has operated is one of the largest questions in Earth sciences. Existing estimates for the onset of plate tectonics range from the Hadean to Cambrian based on diverse constraints from geology, geochemistry, paleomagnetism and numerical models. One of the most robust arguments for plate tectonics is Paleomagnetism, which could tell us if two cratons have experienced relative horizontal motions in the geologic past (Evans and Pisarevsky, 2008). At present, the most reliable paleomagnetic data suggested the relative cratonic motion occurred during 2.7–2.17 Ga. In this study, a new paleomagnetic pole was reported from the ca. 2480 Ma mafic dikes from the Wyoming craton. It will provide constraint on the assembly time of Wyoming and Superior, and constrain the oldest relative motion in earth's history at present.

The ca. 2480 Ma mafic dikes appear to be wide-spread in the Stillwater complex in the the Beartooth mountains of the Wyoming craton. The ca. 2480 Ma mafic dikes intruded into the Stillwater complex and the basement. The dikes are NW-trending or NE-trending diabase or gabbro. In this study, a total of 46 sites were collected including 27 sites from dikes, as well as 19 sites from the host rocks. After stepwise thermal demagnetization, 12 dikes hold a consistent high temperature component (HTC) which directs south-southeast and down with moderate inclination. Two tentatively positive baked-contact tests demonstrate that the HTC can be interpreted as primary in origin. The pole was achieved by averaging 12 VGPs from 12 mafic dikes.

By matching the new pole with the poles from the ca. 2505 Ma Ptarmigan-Mistassini dikes and the ca. 2466-2446 Ma Matachewan dikes (Evans and Halls, 2010), while also matching the ca. 2160 Ma poles from the Rabbit Creek dikes and the Biscotasing dikes (Evans and Halls, 2010; Kilian, 2015), the aggregate dataset demonstrates Wyoming and Superior assembled before ca. 2500 Ma. Our preferred reconstruction is based on broad alignment of paleo-magnetic poles as well as geological similarities such as Huronian and Snowy Pass Supergroup juxtaposition and consideration of mafic dike trends within and between the two cratons (Roscoe and Card, 1993).

the ca. 2.71 Ga poles from the Wyoming craton and the Abitibi subprovince of Superior are substantially separated from each other, suggesting Neoarchean relative lateral motion between cratons.

Evans, D.A.D., Pisarevsky, S.A., 2008. Plate tectonics on early Earth? Weighing the paleomagnetic evidence[J]. When did plate tectonics begin on planet Earth, 440: 249-263.
Evans, D. A. D. and Halls, H. C., 2010. Restoring Proterozoic deformation within the Superior craton. Precambrian Research, v. 183, p. 474 – 489
Kilian TM. Precambrian paleomagnetism of mafic dike swarms and the Wyoming craton: implications for an Archean supercontinent. Yale University, 2015.
Roscoe, S.M. and Card, K. D. 1993. The reappearance of the Huronian in Wyoming: rifting and drifting of ancient continents. Canadian Journal of Earth Sciences, v. 30, p. 2475–2480.

Keyword

Neoarchean, plate mobilism, Wyoming, Superior, Mafic dike

Combined paleomagnetic and geochronological data from the ca. 1240 Ma mafic dikes in the North China Craton (NCC) and its implications

Jikai Ding[1]*, China University of Geosciences Beijing (djikai@126.com)
Shihong Zhang[2], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China
Hanqing Zhao[3], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China
David A.D. Evans[4], Department of Earth & Planetary Sciences, Yale University, New Haven, Connecticut 06520, USA
Kevin Chamberlain[5], Department of Geology & Geophysics, University of Wyoming, Laramie WY, USA
Haiyan Li[6], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China
Tianshui Yang[7], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China
Huaichun Wu[8], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China

Abstract

A combined paleomagnetic and geochronological study is carried out on the mafic dykes from Shandong Province in the North China Craton (NCC). CA-ID-TIMS baddeleyite dating results from one dike suggest it emplaced at ca. 1240 Ma. Rock magnetic results show the main magnetic carriers in the samples from the dikes are PSD magnetite. After stepwise thermal demagnetization, most samples from the dikes yielded consistent high-temperature component (HC), which directs east and down with steep inclination. The primary origin of the HC is bolstered by positive baked-contact tests and a reversal test. Combined with previous results, a paleomagnetic pole is obtained from 32 virtual geomagnetic poles and it averaged out the paleo-secular variation. The pole is different from any younger paleomagnetic poles of the NCC and it is considered as a key pole of ca. 1240 Ma for the NCC.

The new ca. 1240 Ma pole places the NCC in a moderate paleolatitudinal region. The ca. 1780–780 Ma apparent polar wander paths from Laurentia and NCC (Zhang et al., 2012; Ding et al., 2021; Evans et al., 2021) suggest Nuna broke up during 1450– 1320 Ma; from ca. 1240 to 1110 Ma the two cratons reassembled to be an integrated landmass and had a long-lived connection until the breakup of Rodinia.

Reference

Ding, J.K., Zhang, S.H., Evans, D.A.D., Yang, T.S., Li, H.Y., Wu, H.C., and Chen, J.P., 2021, North China craton: The conjugate margin for northwestern Laurentia in Rodinia: Geology, v. 49, p. 773–778.
Evans, D.A.D., Pesonen, L.J., Eglington, B.M., Elming, S.Å., Gong, Z., Li, Z.X., McCausland,

P.J., Meert, J.G., Mertanen, S., Pisarevsky, S.A., Pivarunas, A.F., Salminen, J., Swanson-Hysell, N.L., Torsvik, T.H., Trindade, R.I.F., Veikkolainen, T., and Zhang, S.H., 2021. Chapter 19: An expanding list of reliable paleomagnetic poles for Precambrian tectonic reconstructions. In: Pesonen, L.J., Evans, D.A.D., Elming, S.Å., Salminen, J. M., Veikkolainen, T. (Eds.), Ancient Supercontinents and the Paleogeography of Earth. Elsevier, pp. 605–639.
Zhang, S., Li, Z., Evans, D.A.D., Wu, H., Li, H., Dong, J., 2012. Pre-Rodinia superconti-nent Nuna shaping up: a global synthesis with new paleomagnetic results from North China. Earth Planet. Sci. Lett.353–354, 145–155.

Keyword

North China Craton, Ca. 1240 Ma mafic dike, Paleomagnetism, Nuna, Rodinia

Analyzing the paleosecular variation of Earth's geomagnetic field 1.1 billion years ago and its implications for understanding ancient field morphology

Hanqing ZHAO[1]*, China University of Geosciences (Beijing) (hzhao@cugb.edu.cn)
Shihong Zhang[2], China University of Geosciences (Beijing)
Jikai Ding[3], China University of Geosciences (Beijing)
Tianshui Yang[4], China University of Geosciences (Beijing)
Haiyan Li[5], China University of Geosciences (Beijing)
Huaichun Wu[6], China University of Geosciences (Beijing)

Abstract

Paleosecular variation (PSV) studies in the Precambrian offer unique insights into the average morphology of the geomagnetic field and the operation of the geodynamo in Earth's early history. A relative predominance of paleomagnetic data around 1100 million years ago presents an opportunity to investigate PSV behavior during that period. We collected high-quality paleomagnetic data during 1130–1070 Ma and estimated PSV for the interval with magnetic field reversals (1130–1100 Ma) and the subsequent one of stable polarity (1100–1070 Ma), respectively. The Model G fit for the PSV data in the newly constructed data compilation reveals that the period with geomagnetic field reversals (1130–1100 Ma) was characterized by a mild increase in the angular dispersion of virtual geomagnetic poles with latitude. In contrast, the interval with a stable geomagnetic polarity (1100–1070 Ma) displayed a strong latitudinal dependence. This PSV transition resembles patterns observed in the Paleozoic and Mesozoic eras, suggesting that the relative contribution of the dipole dynamo family to the geomagnetic field is higher during low reversal rates compared to high rates. The analysis predicts similarities in geodynamo evolution 1.1 billion years ago and in the Phanerozoic. The geocentric axial dipole-dominated geomagnetic field around 1100 Ma establishes a robust foundation for paleogeography reconstructions.

Keyword

paleosecular variation, Proterozoic, geodynamo, geocentric axial dipole, magnetic field reversals

New paleomagnetic and geochronology data from Early Cretaceous volcanic rocks of the central Tethyan Himalaya: insights into the size of Greater India

Xianwei JIAO[1]*, China University of Geosciences, Beijing (jiaoxw@email.cugb.edu.cn)
Jikai Ding[2], China University of Geosciences, Beijing
Suo Wang[3], Ocean University of China, Qingdao
Wenxiao Peng[4], China University of Geosciences, Beijing
Jiahui Ma[5], China University of Geosciences, Beijing
Jiacheng Liang[6], China University of Geosciences, Beijing
Tianshui Yang[7], China University of Geosciences, Beijing
Shihong Zhang[8], China University of Geosciences, Beijing
Huaichun Wu[9], China University of Geosciences, Beijing
Haiyan Li[10], China University of Geosciences, Beijing

Abstract

The size of Greater India continues to be debated. Paleomagnetism is one of the principal approaches used to assess the expanse of Greater India, which is to compare the observed paleolatitude from the TH with the excepted paleolatitude for the same reference point calculated based on the Indian Apparent Polar Wander Path. However, the paleomagnetic data from the Zhongba area of the central Tethyan Himalaya suggest that Greater India with an extent of less than 1000 km (Yuan et al., 2023) or about 2000-3000 km (Meng et al., 2023). This controversy was caused by the disputed fossil age and the polarity of the Sangdanlin Formation. Therefore, the paleomagnetic data with precise geochronology limits from the central Tethyan Himalaya are vital for assessing the size of Greater India.

Here we report a combined paleomagnetic and geochronologic study on the Weimei Formation volcanic rocks, dated in the Early Cretaceous, from Zhongba county of the central Tethyan Himalaya. Stepwise thermal , alternating field, and hybrid demagnetizations successfully isolated reliable characteristic remanent magnetization (ChRM) directions that include antipodal dual polarities and pass positive fold tests at the 99% confidence level and reversal tests at 95% confidence level, indicating prefolding primary magnetizations. The distribution patterns of ChRM directions from the Weimei Formation volcanic rocks are consistent with young lava flows at similar latitudes, suggesting that secular variation has likely been averaged out. The tilt-corrected site-mean directions provide a paleopole and a corresponding high paleolatitude for the Zhongba sampling area. Our new results, together with the Indian APWP, demonstrate a smaller Greater India hypothesis. They are compatible (within errors) with the shortening amount measured by the balanced cross-section construction in the Himalayan fold-thrust belt.

References:

Meng, J., Gilder, S.A., Tan, X., Li, X., Li, Y., Luo, H., Suzuki, N., Wang, Z., Chi, Y., Zhang, C., Wang, C., 2023. Strengthening the argument for a large Greater India. Proceedings of the National Academy of Sciences 120. https://doi.org/10.1073/pnas.2305928120.

Yuan, J., Deng, C., Yang, Z., Krijgsman, W., Thubtantsering, Qin, H., Yi, L., Zhao, P., Wan, B., Zhao, L., He, H., Guo, Z., Zhu, R., 2023. New paleomagnetic data from the central Tethyan Himalaya refine the size of Greater India during the Campanian. Earth and Planetary Science Letters 622. https://doi.org/10.1016/j.epsl.2023.118422.

Keyword

Paleomagnetism, Early Cretaceous, central Tethyan Himalaya, Greater India

New paleomagnetic results from the late Mesoproterozoic Luanshigou Formation of the Shennongjia Group in south China, and their paleogeographic implications

Yixuan Liu[1]*, State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China. (tsunami4197@163.com)
Shihong Zhang[2], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.
Haiyan Li[3], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.
Kunkun Yang[4], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.
Nana Zhang[5], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.
Huaikun Li[6], Tianjin Institute of Geology and Mineral Resources, Tianjin 300170, China.
Zhixian Wang[7], Shennongjia National Park, Hubei 442421, China.
Tianshui Yang[8], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.
Huaichun Wu[9], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing 100083, China.

Abstract

The south China block (SCB) was traditionally subdivided into the Yangtze block to the northwest and the Cathaysia block to the southeast, separated by an early Neoproterozoic ocean. The identification of the Grenvillian-age ophiolite suites within the Yangtze block in recent years suggested that the northern Yangtze subblock (NYB) and the southern Yangtze subblock (SYB) were once separated by an ocean in the late Mesoproterozoic. Although some paleogeographic models advocated the Pre-Grenvillian connections between the south China blocks and Laurentia, none has been paleomagnetically tested. Here we report the new paleomagnetic results obtained from the ~1270 Ma purplish-red muddy dolomite beds of the Luanshigou Formation, Shennongjia Group, NYB, providing a new clue for reconstructing the south China blocks in Precambrian supercontinents. A total of 447 samples were subjected to stepwise thermal demagnetization. Two components were identified. The low-temperature component is interpreted as the recent viscous remnant magnetization. The high-temperature component was obtained below 580°C or 690°C from 241 samples, directed northeast-up or southwest-down, antipodally, which position the paleomagnetic pole at 18.5°S, 74.4°E (dm/dp = 2.5/1.6°). Rock magnetic results demonstrate that the magnetic carriers in purplish-red dolomite and pale-pink dolomite are predominated by hematite and magnetite, respectively. The data reliability is supported by an inverse baked contact test and a B-class reversals test. The resulting paleomagnetic pole is distinct from any younger poles of the region, which supports its primary origin interpretation. Based on the new results and the coeval poles available, aided by geological data, we propose a reconstruction in which the NYB was juxtaposed to southwestern Laurentia in the late Mesoproterozoic and suggest that the ~1100 Ma Miaowan-Shimian ophiolite zone in the Yangtze block was likely an extension of the

Grenville belt of Laurentia.

Keyword

Paleomagnetism, south China, Mesoproterozoic, Laurentia, Supercontinent

Paleomagnetic and geochronologic results from the Zenong Group and Yeba Formation volcanic rocks in the Lhasa terrane: New insights into the closure time of the Meso-Tethyan Ocean

Tianshui YANG[1]*, China University of Geosciences (Beijing) (yangtsh@cugb.edu.cn)
Suo Wang[2], China University of Geosciences (Beijing)
Jiahui Ma[3], China University of Geosciences (Beijing)
Weiwei Bian[4], China University of Geosciences (Beijing)
Xianwei Jiao[5], China University of Geosciences (Beijing)
Fei Han[6], China University of Geosciences (Beijing)
Jiacheng Liang[7], China University of Geosciences (Beijing)
Shihong Zhang[8], China University of Geosciences (Beijing)
Huaichun Wu[9], China University of Geosciences (Beijing)
Haiyan Li[10], China University of Geosciences (Beijing)

Abstract

The evolutionary history of the Meso-Tethyan Ocean is crucial to understand the formation and evolution of the Tibetan Plateau, but the closure time of the Meso-Tethyan Ocean still remains hotly debated, with estimates ranging from the Middle Jurassic up to the Late Cretaceous. To contribute to the mentioned issues above, a combined paleomagnetic and geochronologic study was performed on the Zenong Group volcanic rocks, dated at ~147 Ma, in the Shiquanhe area of the western Lhasa terrane and the Yeba Formation volcanic rocks, dated at ~170 Ma, in the Dazi area of the eastern Lhasa terrane. Stepwise thermal and alternating field demagnetizations successfully isolated reliable characteristic remanent magnetization (ChRM) directions that pass positive field tests, indicating prefolding primary magnetizations. The distribution patterns of ChRM directions from the Zenong Group and Yeba Formation volcanic rocks suggest that the geomagnetic paleosecular variation has been averaged out. The tilt-corrected site-mean directions for the Zenong Group and Yeba Formation volcanic rocks are D/I=342.0°/23.9° with α95=10.2°and D/I=64.0°/27.2° with α95=6.2°, which provides two paleopoles at 63.9°N, 304.4°E with A95=10.3° and at 29.8°N, 180.7°E with A95 = 5.7°, respectively. Comparing reliable Jurassic and Cretaceous paleomagnetic results from the Lhasa and Qiangtang terrane indicates that the closure of the Meso-Tethyan Ocean should be a scissor-like diachronous process, with its eastern part (29.7°N, 91.3°E) closed at ~168 Ma and its western part (32.4°N, 83.4°E) closed at ~143–139 Ma.

This work was supported by the National Natural Science Foundation of China (42072257), the Frontiers Science Center for Deep-time Digital Earth (2652023001), Fundamental Research Funds for the Central Universities (2652021105, 2652021106, 2652021107), and the 111 project (B20011).

Keyword

Paleomagnetism, Meso-Tethyan Ocean, Lhasa terrane, Yeba Formation, Zenong Group

Exploring rock-magnetic parameters for efficient sample preselection on the Tsunakawa–Shaw paleointensity method: a study from data of Cenozoic basalts

Hyeon-Seon AHN[1]*, Korea Institute of Geoscience and Mineral Resources (hs.ahn.86@kigam.re.kr)
Youn Soo Lee[2], Retired, Division of Environmental Science and Engineering, Pohang University of Science and Technology (POSTECH)
Yuhji Yamamoto[3], Marine Core Research Institute (MaCRI), Kochi University

Abstract

Despite being essential in determining absolute paleomagnetic field intensity (API) with high fidelity over research topics of Earth, planetary, and space sciences, API determination still suffers little quantitative success. This is due to common non-ideal magnetic behaviors in experiments using natural rocks caused by physiochemical changes in the magnetic minerals contained. While linking rock-magnetic parameters to API results may be fundamental, negligible effort has been made using the Tsunakawa–Shaw (TS) API method despite its potentially high experimental success rate in overcoming non-ideal magnetic effects. Here, we explore the relationships between rock-magnetic parameters retrieved using relatively rapid and widely pre-conducted measurements and TS API results from late Cenozoic basaltic rocks. We selected rock-magnetic parameters quantified from strong-field high-temperature thermomagnetic curves, magnetic hysteresis loops, and back-field isothermal remanent magnetization demagnetizations. We collected data of similar quality, and then compiled 133 pairs of rock-magnetic and TS API data at the sample level (38 sites). Using this data compilation, the following topics of interest were identified: Magnetic coercivity (Bc) and remanence coercivity (Bcr) among the hysteresis parameters, and the thermomagnetic parameter ITC|m| (an index of thermal change quantifying an average of the differences in saturation magnetization at a full temperature range of during a single heating-cooling run) allows meaningful and efficient discrimination between data subsets divided by ‘success’ or ‘failure’ in the API results. We propose sample preselection criteria for the TS experiment: a minimal set of Bc≥13 mT (or Bcr≥26 mT) and ITC|m|≤0.15. Moreover, we argue that extended consideration based on the preselection criteria may allow the screening of potentially biased specimen/sample-level API estimates in the site-averaged determination of such a site with a large within-site API dispersion.

Keyword

paleomagnetism, absolute paleointensity, Tsunakawa-Shaw method, rock-magnetic parameters, late Cenozoic basalts

New Early Permian Paleomagnetic Data from the Northern Margin of the North China Block and its Implications for Regional Climate and Biological Evolution

Qiang Ren[1]*, Chengdu University of Technology (renqiang@cdut.edu.cn)
Shihong Zhang[2], China University of Geosciences (Beijing)
Mingcai Hou[3], Chengdu University of Technology
Anqing Chen[4], Chengdu University of Technology

Abstract

In the early Permian period, North China experienced a change from humid-climate coal-bearing sedimentary facies to arid-climate redbeds and a sudden decrease in regional biodiversity, the main cause of which has been a mystery. In order to explore this scientific question from the perspective of land-sea pattern evolution, we conducted combined paleomagnetic and geochronological studies in the volcano-sedimentary strata of the Lower Permian Dahongshan and Qingfengshan formations in the northern margin of the North China Block (NCB). Zircon U–Pb dating of andesites and tuffs from the Dahongshan and Qingfenshan formations yielded ages of ~290 Ma and ~281 Ma, respectively. A total of 318 paleomagnetic specimens underwent stepwise thermal demagnetization. After removing the viscous remanent magnetizations of the recent geomagnetic field, stable high-temperature components (HTCs), carried by magnetite, were successfully acquired from 267 specimens. The HTCs of the Dahongshan Formation passed a fold test, a conglomerate test, and a paleosecular variation test, and those of the Qingfengshan Formation passed a reversal test and a fold test, suggesting that they represent primary remanence magnetizations. We used the elongation/inclination method to test and correct for all the HTC directions of the clastic rocks of the Qingfenshan Formation. Their corresponding paleomagnetic poles
are 41.5°N/5.4°E (A95 = 5.8°) at ~290 Ma for the Dahongshan Formation and 68.1°N/323.6°E (A95 = 2.5°) at ~281 Ma for the Qingfengshan Formation. The new Early Permian paleomagnetic data show that the NCB was located at 12.8 ± 5.8°N at ~290 Ma and 22.1 ± 2.5°N at ~281 Ma for a reference point at 42.5°N, 119.5°E. We used a Monte Carlo simulation to determine the rate of Permian plate motion and associated uncertainty; these analyses reveal rapid northward latitudinal motion of the NCB at 11.4 cm/yr with a 95% confidence range of 7.1–17.6 cm/yr from 290 to 281 Ma. The rapid northward movement of the NCB from 290 Ma to 281 Ma has shifted most of its land area (e.g., Chifeng, Daqingshan, and Ordos areas) from the Equatorial Rainy Belt (0°-14°N) to the Subtropical Arid Belt (14°-28°N), leading to a sharp decline in biodiversity as organisms fail to adapt to a rapidly changing climate.

Keyword

Early Permian, North China, Paleomagnetism, Plate motion, Climate change

The rock-magnetism and natural remanent magnetization of the Ordovician sedimentary rocks in the southwest Ordos Basin (Central China)

Shuang DAI[1]*, School of Earth Sciences, Lanzhou University & Key Laboratory of Strategic Mineral Resources of The Upper Yellow River, Ministry of Natural Resources (daisher@lzu.edu.cn)
Ronghua Wang[2], School of Earth Sciences, Lanzhou University
Weiguo Wang[3], Third Institute of Oceanography, Ministry of Natural Resources
Pengju Cao[4], School of Earth Sciences, Lanzhou University
Junhua Luo[5], School of Earth Sciences, Lanzhou University
Mark Dekkers[6], Faculty of Geosciences, Utrecht University

Abstract

The southwest Ordos Basin is an ideal place to understand the tectonic evolution and the source rocks formation in the North China Block During the Early Paleozoic. The Ordovician is a very important period for this. Great progress has been made in the tectonic evolution and the prospects of oil and gas of Ordos basin. However, the paleomagnetic and magnetostratigraphic study for the Ordovician of the Ordos is still lack. Here we present paleomagnetic and rock-magnetism studies of two sections (Qishan section and the Pingliang) in the southwestern Ordos, which have continuous stratum and over 2 km thickness of the Ordovician marine carbonate rocks and clastic rocks. The remanence magnetism characteristics and magnetic carrying minerals of Ordovician rocks in the studied sections will be analyzed, systematic thermal demagntization and alternating field demangnetization are applied to seperate different magnetization components. By comparing paleomagnetic poles calculated from different magnetization components in diffferent sedimentary formations, possibility and pathyway of remagnetization will be also discussed.

Rock magnetic studies show magnetic bearing minerals include maghemite, magnetite, goethite and hematite, with sizes of single-domain, multi-domain, and a small amount of superparamagnetic particles. Demagnetizations separated at least three components: low temperature component (NRM-150 °C), medium temperature component (150-350 °C) and high temperature component (350-580/650 °C). Through calculation of the corresponding paleomagnetic pole position and comparison with the paleomagnetic pole position of the North China block obtained by the predecessors, we conclude that the low temperature component is the viscous remanence of the modern geomagnetic field, and the medium temperature component is remagnetization one related to the exhumation of Ordos Basin in the Middle Permian and the collision between the North China plate and the Yangtze plate in Triassic. The high temperature component in a large proportion of samples is the characteristic remanence.

Keyword

rock-magnetism, natural remanent magnetization, sedimentary rocks, SW Ordos Basin,

Ordovician

How did the Jurassic True Polar Wander meet plate motion in Asia?

Yangjun GAO[1]*, Shengli Oilfield Branch Company, SINOPEC, Dongying 257001, China (g123y456j@foxmail.com)
Shihong ZHANG[2], School of Earth Sciences and Resources, China University of Geosciences, Beijing 100083, China

Abstract

True Polar Wander (TPW) is a migration of the entire mantle-crust system related to the rotation axis of Earth. The Jurassic TPW event was revealed by a large body of paleomagnetic data from continental and oceanic plates. Synchronously, Asia witnessed multiple oceanic subduction and continental mergence, which were closure of the Mongol–Okhotsk ocean (MOO) between Siberia and the eastern Asian blocks, and closure of the Tethyan oceans between Asia and Gondwana. In the context of TPW and oceanic subductions, paleogeographic changes of Asian blocks is still in discussion.

Recently, two studies reported that the north China block (NCB) was located in remarkable paleolatitude of 76°N and 62°N in Late Triassic and Early Jurassic, respectively (Yi et a., 2019; 2023). Comparing with the APWP of Eurasia, the authors argued that the eastern Asian blocks had welded with Eurasia continent already and experienced nothing but the motion of TPW after then. However, the data and interpretations are highly inconsistent with the paleomagnetic database. We suggest that at least the Triassic data that the authors cited from a previous study were wrongly recalculated for tilt-correction, because the geological evidence may demonstrate that the strata had likely been folded when the mafic dykes intruded them. Currently most reliable paleomagnetic data may suggest that the NCB and its then connected blocks did not undergo any significant paleogeographic shift during late Jurassic (Gao et al., 2021). In addition, the high-quality and well-dated paleomagnetic poles newly obtained from Tibet can also indicate that the Lhasa terrane remained latitudinal stand-still in late Jurassic due to the interaction between its northward plate tectonic motion and the simultaneous southward TPW (Li et al., 2022; Ma et al., 2022).

References

Gao, Y., Zhang, S., Zhao, H., Ren, Q., Yang, T., Wu, H., & Li, H. (2021). North China block underwent simultaneous true polar wander and tectonic convergence in late Jurassic: New paleomagnetic constraints. Earth and Planetary Science Letters, 567, 117012.

Li, Z., Ding, L., van Hinsbergen, D. J., Lippert, P. C., Yue, Y., He, J., ... & He, S. (2022). Jurassic true polar wander recorded by the Lhasa terrane on its northward journey from Gondwana to Eurasia. Earth and Planetary Science Letters, 592, 117609.

Ma, Y., Wang, Q., Wang, H., Wan, B., Zhang, S., Deng, C., ... & Dekkers, M. J. (2022). Jurassic paleomagnetism of the Lhasa terrane Implications for Tethys evolution and true polar wander. Journal of Geophysical Research: Solid Earth, 127(12), e2022JB025577.

Yi, Z., Liu, Y., & Meert, J. G. (2019). A true polar wander trigger for the Great Jurassic East Asian Aridification. Geology, 47(12), 1112-1116.
Yi, Z., Liu, Y., Meert, J. G., Wang, T., & Huang, B. (2023). A new view of the Pangea supercontinent with an emphasis on the East Asian blocks. Earth and Planetary Science Letters, 611, 118143.

Keyword

True Polar Wander, paleomagnetism, Mongol–Okhotsk ocean, Tethyan, Jurassic

New paleomagnetic results from the late Ediacaran Dengying Formation in South China

Haiyan LI[1]*, China University of Geosciences (Beijing) (hai2216@cugb.edu.cn)
Shihao Li[2], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing
Shihong Zhang[3], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing
Tao Zhong[4], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing
Tianshui Yang[5], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing
Huaichun Wu[6], State Key Laboratory of Biogeology and Environmental Geology, China University of Geosciences, Beijing

Abstract

The Ediacaran paleogeographic reconstruction is crucial for deciphering the biological evolution. However, the reconstruction is still not clear due to the lack of high quality paleomagnetic data. Palaeomagnetic studies were thus carried out on the Shibantan Member of the late Ediacaran Dengying Formation (551-538 Ma) in the Yangtze Gorges area, South China.

Oriented samples were drilled from four sections, including the Toudingshi, Qinglinkou, Jiuqunao and Zhengjiatang sections around the Huangling Anticline. The anisotropy of magnetic susceptibility (AMS) and thermal demagnetization were performed on 223 specimens of the four sections. The AMS results of the four sections showed no obvious deformation. All specimens of the four sections exhibited the same demagnetized characteristic. They all unblocked at 470 – 490 °C, indicating that the dominant remanence carrier was magnetite. Most specimens had three components. The low temperature component (LTC) was isolated below 150 °C. The sample-level mean direction before tilt correction of each section was close to the present geomagnetic field (PGF) in the sampling area. Therefore, the LTC was a viscous remanent magnetization (VRM) of the PGF. The intermediate temperature component (ITC) was isolated between 200 – 300 °C. The virtual geomagnetic poles (VGPs) of the site-level ITCs from the four sections clustered in the geographic coordinates, and the average VGP was close to the late Jurassic paleomagnetic pole of the South China, resulting in a late Jurassic remagnetization. The high temperature component (HTC) of the four sections was mainly isolated between 330 – 490 °C. Compiling the published paleomagnetic data of the Shibantan Member from the Sanxiarenjia section (Jing et al., 2018), the site-level HTCs passed a fold test (McElhinny, 1964; McFadden, 1990) at 99% confidence level and yielded a maximum grouping (“k” value) at 97.4% unfolding (Watson and Enkin, 1993). The site-level average of the VGPs of the HTCs from the Toudingshi, Qinglinkou, Jiuqunao, Zhengjiatang and Sanxiarenjia sections yielded a paleomagnetic pole DY of the Shibantan Member. This pole is near the middle-late Silurian palaeomagnetic pole, resulting in a possibility of remagnetization. However, the pole DY is preferred to be reliable based on the following two

factors. One is that the pole DY is also close to the reliable early Cambrian palaeomagnetic pole (Lin et al., 1985). The other is that the paleolatitude of the South China calculated from the pole DY is consistent with its Neoproterozoic - early Paleozoic paleolatitude shifting model, that is from high latitude to equator after ~720 Ma (Zhang et al., 2015). To sum up, the new paleomagnetic pole DY (~545 Ma) of the South China will be helpful for the paleogeographic reconstruction in Ediacaran time.

References

Jing, X., et al., 2018. Geophys J Int 212, 54-75.
Lin, J., et al., 1985. J Geodyn 2, 91-114.
McElhinny, M.W., 1964. Geophys J Roy Astron Soc 8, 338-340.
McFadden, P.L., 1990. Geophys J Int 103, 163-169.
Watson, G.S., Enkin, R.J., 1993. Geophys Res Lett 20, 2135-3137.
Zhang, S., et al., 2015. Precambrian Res 259, 130-142.

Keyword

South China, Paleomagnetism, late Ediacaran, Dengying Formation, Shibantan Member

Exploring sedimentary records of sea level and carbon cycling as independent tests of true polar wander: Case studies from the Paleoproterozoic to Cretaceous

Yu-Shu Liu[1]*, Institute of Geology and Geophysics, Chinese Academy of Sciences (liuyushu23@mails.ucas.ac.cn)
Ross Mitchell[2], Institute of Geology and Geophysics, Chinese Academy of Sciences

Abstract

True polar wander (TPW) is the rotation of solid Earth (mantle and crust) about the liquid outer core in order to realign the principal moment of inertia with the geographic location of the spin axis. TPW can significantly and potentially rapidly change the paleographic locations of continents. Therefore, it carries profound implications for the evolution of relative sea level of a continent, and can cause relocation of carbon depocenters which can reorganize the global carbon cycle. In this study, we consider two case studies where sedimentary records can provide tests of TPW independent of paleomagentism: (i) sea level changes of the North China craton in the Paleoproterozoic are compared with shifts in paleolatitude, and (ii) shifts in the carbon isotopes (δ13C) of the Indian Himalaya terrane in the late Cretaceous are compared with paleolatitude changes predicted by TPW. Our preliminary results suggest that shifts in paleolatitude are coincident and consistent with expected changes in relative sea level of North China craton in the Paleoproterozoic, and the paleolatitude predicted by TPW and the shifts in δ13C of Indian Himalaya in the late Cretaceous also exhibit consistency—as well as noted contrasts with the coeval δ13C record in England that was positioned in a different paleogeographic TPW quandrant. These results initially indicate that the response of sedimentary records of sea level and carbon cycling can also be used as stratigraphic tests of putative ancient TPW events independent of paleomagnetism.

Keyword

Paleomagnetism, True polar wander, North China craton, Indian Himalaya

Paleomagnetic studies of the Neoproterozoic Jinchuan Ultramafic rock Unit and Paleozoic dykes inside it, revealing its affinity to North China Block since Cambrian

Ronghua Wang[1]*, Lanzhou University (wangronghua@lzu.edu.cn)
Mingjie Zhang[2], Lanzhou University
Wenbo Xu[3], Lanzhou University

Abstract

Paleogeographic location of the Neoproterozoic Jinchuan Ultramafic Rock Unit is key to understand the geodynamic background of Rodinia breaking-up and its contribution to the extraordinary enrichment of Platinum Group Elements and cobalt metals in Jinchuan. Previous studies have discussed the changes of source material in Alxa block and corresponding tectonic movements by analyzing the zircon U-Pb age distributions and geochemical features in both sedimentary and metamorphic rocks, suggesting different timing of amalgamation between Alxa block and Ordos block. Here we will present a direct approach to obtain the paleogeographic location of Jinchuan Ultramafic Rock Unit by paleomagnetic studies. Oriented core samples from 23 sites were collected from both the outcrops and underground mines of Jinchuan Ultramafic Rock Unit, bedrocks and dykes in it. Rock magnetic studies suggest Pseudo single domain magnetite is the main magnetic mineral with few contribution of pyrrhotite and titanomagnetite. Stepwise thermal demagnetization show at least two components, with one component within 300℃ and 580℃ as the characteristic remanent magnetization (ChRM). Part of the samples reveal a different component above 540℃ (JC-H2). Except one site (JC5), all the other sites from Jinchuan Ultramafic Rock Unit present ChRM similar present geomagnetic field. Paleomagnetic poles calculated from JC5-ChRM is 61.2N14.2Edp/dm=3.6/-5.2, similar to the pole position of North China Block in Triassic Periods. Paleomagnetic poles calculated from JC-H2 of six sites in the Jinchuan Ultramafic Rock Unit is located at 20.8S, 125.6E,dp/dm=8.9/-14.08, which is consistent to reported poles (930 Ma) of North China Block, and also close to the reported pole position of North China Block in Cambrian/Ordovician periods. Since this component was carried by magnetic minerals with blocking temperature above 540℃ rather than the primary magnetite, we speculate this component as secondary component, and thus Cambrian/Ordovician remagnetization.

Four sites of the Paleozoic dykes423 Ma) exhibit different demagnetization behavior. Besides the low temperature component similar to present field, the ChRM is quite scattered while the demagnetization trajectory is within a confined great circle. Applying the poles of North China block (420 Ma and 220 Ma), the primary Ordovician magnetization and secondary Triassic remagnetization may all be recorded and fall on this great circle. We thus infer the dykes might also be remagnetized in Triassic Period.

To sum up, the remanent magnetization of Jinchuan ultramafic Rock Unit suffered two-three times of remagnetization. Although the primary magnetization component is not retrieved, the oldest

remagnetization in Cambrian/Ordovician periods suggests the affinity of the Alxa block to the North China block since Cambrian.

Keyword

Jinchuan ultramafic rock, Alxa Block, North China Block, Paleomagnetism, remagnetization

A Review of True Polar Wander in the Tonian (~850-750 Ma)

Joseph MEERT[1]*, University of Florida (jmeert@ufl.edu)
Manoj K Pandit[2], University of Rajasthan
N.V. Chalapathi-Rao[3], National Center for Earth Science Studies

Abstract

Paleomagnetic data from the Yangtze craton and Laurentia form the casus belli for an episode of true polar wander in the Tonian (~(850-750 Ma). The total angular shift implied by some of these data exceeds 90 degrees and the rates of TPW (depending on the choice of poles) is over 100 cm/yr. Recent paleomagnetic data either confirm or refute TPW with the most conservative estimates for rates of apparent polar wander less than 10 cm/yr. A new U-Pb titanite age of 820 ± 15 Ma is recorded from a lamprophyric dyke in the Harohalli alkaline province (India). Rb-Sr and K-Ar ages are similar to the U-Pb age, but Pradhan et al. (2012) obtained a much older U-Pb (1192 Ma) age from one of the dykes. Because the dated dyke in that study did not yield paleomagnetic data, caution was urged in using the Harohalli dykes paleomagnetic pole. We have reviewed the paleomagnetic data from previous studies and calculated an updated pole for the alkaline dykes (HD) at 36.1° N, 84.0° E (A95=11.3°, K=30). The Malani Igneous Suite (MIS; India) is used as the younger tie point at ~770 Ma. Coeval data from South China at 824 Ma (Yanbian Dykes-A=YA pole) and 770 Ma (Yangtze dykes=YD) can be used to reconstruct India and Yangtze. Poles from Yangtze craton are rotated into Indian coordinates using an Euler pole at 46° N, 106.1° E, -174.5°. The fit between the two pairs of similar age poles from both cratons is excellent (HD-YA Bayes error=.482 and MIS-YD Bayes error=.384) and supports conjectures about the contiguity of these two regions in the Tonian. If we assume that the Yangtze craton and India were fellow travelers during the 825-770 Ma interval, then we can use other poles from the Yangtze craton to evaluate plate/non-plate motions. Depending on the choice of poles used from the Yangtze craton, extreme rates of TPW are possible. While true polar wander is anticipated to produce a roughly synchronous global signal in paleomagnetic data, this poses a challenge to the extant database, particularly regarding data from Svalbard. Our presentation will focus on this time interval and the implications for both TPW and the breakup of the Rodinia supercontinent.

Keyword

True Polar Wander, Tonian, Yangtze, India, Rodinia

Progress and challenge in geoscience standards of the IUGS Deep-time Digital Earth program

Minghua ZHANG[1]*, CGI/China Geological Survey (zminghua@mail.cgs.gov.cn)
Harvey Thorleifson[2], CGI/University of Minnesota
Simon Hodson[3], CODATA
Francois Robida[4], CGI
Mark Rattenbury[5], CGI/GNS Science
Jianhui LI[6], CODATA/China Academy of Science

Abstract

Standards for global multiple disciplinary geoscience data Open and FAIR (findable, accessible, interoperable and reusable) are essential and critical for the IUGS Deep-time Digital Earth program (DDE) to achieve its goal of harmonizing global deep-time digital earth data for enhanced data and knowledge-driven discoveries. The DDE Standards Task Group (DDE-STG) was jointly established by CGI-IUGS and CODATA to work with DDE Working and Task Groups (DDE-WTGs) scientists. Aiming at facilitating DDE with implementable international geoscience standards, expertise and relevant supports on demand, big progress has been made in the past 4 years by the DDE-STG with timely and targeted products deliveries and conduction of R&D project Geosciences Data Standards for DDE. Six main achievements including work strands have been made and completed or are underway. (1) A formal DDE Knowledge System review procedure was issued and released in August 2020 and updated in May 2021 with recommendations and guides provided to the DDE-WTGs to enable the rapid development of DDE knowledge system. (2) DDE Geoscience Information Metadata Standard (DDE S01-2023) enabling DDE data and resources to be machine Findable online was formally released in November 2023 at CGI-DDE Global Geoscience Standards Workshop and Forum at Suzhou. The metadata schema has been utilized by DDE-WTGs since its first interim version in 2021 and has now been implemented by DDE and other organizations. (3) In-depth training and consultation to DDE-WTGs on existing geoscience standards and implementation methodologies have included formal training workshops (26-28 October 2021, 7-8 November 2023), informal daily consultations and technical documentation. These have assisted the DDE-WTGs with existing CGI/OGC standards like GeoSciML, EarthResourceML, GroundWaterML, geoscience terminology, and expertise from CGI, OneGeology, OGC, USGIN and CODATA. (4) A practical DDE Accessible Data Evaluation Guide was also drafted in 2022 with considerations of data authority, data quality, data volume, data openness, data service capability and data user scale. (5) A general guide for DDE geoscience standard framework is also being drafted based on the coordination of standards necessary to implement DDE. (6) Activities on international cooperation conducted by the DDE-STG has also significantly contributed to DDE including solid links with CGI, CODATA, national nodes and several regional and national geological survey organizations and the Global Open Science Cloud.

However, for DDE to fully achieve FAIR principles compliance and meet expectations around

Open data and knowledge transfer, further work is needed. In-depth training and consultation on existing CGI/OGC/ISO, CODATA and other related standards, FAIR principles application for DDE Knowledge System, DDE geoscience resource FAIR implementation profiles identified and achieved through partnership with the WorldFAIR+ initiative and global communities starting in 2024 are main works to be carried out by DDE-STG together with support from the R&D project FAIR Principles implementation for DDE. Upcoming challenges include (1)developing practical FAIR compliant standards for DDE multi-disciplinary databases and knowledge graph system, (2)finding skilled people, particularly early career scientists, with geoscience background, IT knowledge and understanding of information standards, and (3)building international cooperation, especially the network development among data/knowledge-rich geological surveys, institutes and international standards organizations.

Keyword

Geoscience standards, FAIR, Deep-time Digital Earth

DataExpo: A One-Stop Dataset Service for Open Science Research in Geosciences

Bin Lu[1]*, Shanghai Jiao Tong University (robinlu1209@sjtu.edu.cn)
Lyuwen Wu[2], Shanghai Jiao Tong University
Chenxing Sun[3], Shanghai Jiao Tong University
Wei Liu[4], Shanghai Jiao Tong University
Tingyan Ma[5], Shanghai Jiao Tong University
Ze Zhao[6], Shanghai Jiao Tong University
Gu Tang[7], Shanghai Jiao Tong University
Xiaoying Gan[8], Shanghai Jiao Tong University
Yunqiang Zhu[9], Institute of Geographic sciences and Natural Resources Research, Chinese Academy of Sciences
Weirong Li[10], College of Environment and Resources, Guangxi Normal University
Luoyi Fu[11], Shanghai Jiao Tong University
Xinbing Wang[12], Shanghai Jiao Tong University
Chenghu Zhou[13], Institute of Geographic sciences and Natural Resources Research, Chinese Academy of Sciences

Abstract

In the era of big data, rich geoscientific datasets on the internet lay a solid foundation for scientific research. However, the lack of unified semantic markups makes accurate data webpage retrieval a significant challenge. To address this problem, we developed a one-stop dataset service called DataExpo (https://dataexpo.deep-time.org/) in the context of the Deep-time Digital Earth Program (DDE). It introduces deep-learning-based methods for multi-source geoscientific metadata aggregation, data webpage classification, and structured information extraction.

DataExpo provides geoscientists with data discovery, search, and recommendation services for open scientific research. Considering the characteristics of Earth science data, DataExpo has also developed a spatiotemporal map retrieval service, which allows users to further refine search results based on geographic location and time scale. Taking the "Global Ocean Dissolved Oxygen Spatiotemporal Database" as an example, we have accumulated websites that not only include multidisciplinary databases such as GBIF and Zenodo, but also specialized geoscientific databases such as PANGAEA and NOAA, and even long-tail data that is difficult to find on the internet. We collect dissolved oxygen data from 1900 to 2023, and establish uniform quality standards for multi-source data to construct a global spatiotemporal ocean dissolved oxygen database.

In the future, we will continuously improve the services of DataExpo and facilitate data-driven scientific discovery for open science research.

Keyword

Data Discovery, Dataset Search, Webpage Mining, AI for Science

The Methodology, Progress and Challenges of Geoscience Knowledge Graph in International Big Science Program of Deep-Time Digital Earth

Yunqiang Zhu[1]*, Institute of Geographical Sciences and Natural Resources, Chinese Academy of Sciences (zhuyq@igsnrr.ac.cn)
Shu Wang[2], State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
Qiang Wang [3], State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
Jie Yang [4], State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
Kai Sun[5], State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
Xinbing Wang [6], Shanghai Jiao Tong University
Lv Hairong[7], Tsinghua University
Xiumian Hu [8], Nanjing University
Chenghu Zhou[9], State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

Abstract

Deep-time Earth research is of great significance for understanding the rate, law and mechanism of Earth evolution in geological history that can support mankind better predict climate change, explore natural resources and protect our planet in the future. In order to promote Deep-time Earth research in the era of big data and artificial intelligence, the International Union of Geological Sciences (IUGS) launched the "Deep-time Digital Earth International Big Science Program" (DDE) in 2019. One of the core objectives of DDE is to build multidisciplinary geoscience knowledge graph which support the integration and sharing, mining and analysis of heterogeneous geoscience big data, and promote geoscience knowledge discovery, and finally make the transformation of geoscience research paradigm driven by "data-model-knowledge". In order to push the construction of geoscience knowledge graph, DDE has adopted two ways which are top-down domain experts manual collaborative construction and bottom-up machine intelligent mining, updating and completing. And so far, DDE has developed a series of related software and tools, and formed three levels of basic, discipline and application geoscience knowledge graphs which cover about 20 geoscience disciplines.

This paper first introduces the organizational model and technical methods of the construction of DDE knowledge graph, and then systematically summarizes the progress of DDE geoscience knowledge graph construction, software system development and specifications in the past three years. Finally, it analyzes the shortcomings and challenges of DDE knowledge graph, and discusses the direction and key issues of DDE knowledge graph in the future. We hope that geoscientists around the world will understand the philosophy, methods and achievements of DDE knowledge graph, so as to promote the "" of DDE knowledge graph worldwide and finally drive the research and application of geoscience knowledge graph.

Keyword

Deep-time Earth, Geoscience knowledge, knowledge graph, open and sharing, Deep-time Digital Earth International Big Science Program (DDE)

Geoscience information metadata standard supports DDE resources Open and FAIR

Minghua ZHANG[1]*, CGI/China Geological Survey (zminghua@mail.cgs.gov.cn)
Steve Richard[2], USGIN
Hailong Yu[3], China Geological Survey
Rongmei Liu[4], China Geological Survey
Edd Lewis[5], British Geological Survey
Tim Duffy[6], CGI
Zuoqin Jiang[7], China Geological Survey
Juanle Wang[8], IGSNRR, CAS
Federica Foglini[9], ISMAR-CNR
Caterina Bergami[10], ISMAR-CNR
Junxuan Fan[11], Nanjing University
Xiumian Hu[12], Nanjing University
Yunqiang Zhu[13], IGSNRR, CAS
Marshall Ma[14], University of Idaho
Chao Ma[15], Chengdu University of Technology
Chengbin Wang[16], China University of Geosciences Wuhan
Kai Li[17], IGSNRR, CAS
Linshu Hu[18], Zhejiang University
Wei Ren[19], China Geological Survey
Sheng Zhang[20], China Geological Survey

Abstract

Metadata is critical for making resources Findable. FAIR (findable, accessible, interoperable and reusable) multi-disciplinary geoscience data, knowledge, and relevant services are required to achieve the IUGS Deep-time Digital Earth program (DDE) goal of data- and knowledge-driven scientific research. This requirement demands granular specific metadata standards based on generic standards like ISO19115, OGC CSW and Dublin Core. Thus the geoscience information metadata standard was built by CGI/CODATA/DDE scientists worldwide and the Edition1.0-2023 was formally released in Nov 2023 (https://cgi-iugs.org/publication/dde-metadata-standardv1). The DDE program is now developing a metadata aggregation and search application for its open data platform using the GeoNetwork-opensource software and this metadata schema to make DDE metadata interoperable with the global geoscience data ecosystem.

This metadata standard meets the demands from DDE for simplicity, efficiency, domain coverage, machine readability, consistency with existing standards and with geological history. It consists of 13 entities (MD_Metadata, MD_Identification, SV_ServiceIdentification, MD_Imagery, MD_SpatialRepresentation, MD_Distribution, CI_Date, EX_GeographicExtent, MD_Identifier, CI_OnlineResource, CI_Responsibility, EX_TemporalExtent, MD_Constraint) and 86 elements (22 Mandatory), 14 code lists (AcquisitionCode, CharacterSetCode, CountryCode, DateTypeCode, FunctionCode, LanguageCode, ProcessingLevelCode, ReferenceSystemCode, ResourceTypeCode, RestrictionCode, RoleTypeCode, SpatialRepresentationTypeCode,

ServiceTypeCode, TopicCategoryCode). The scheme is implemented in XML with transforms to and from ISO19115-3. It extends the one topicCategory code for geoscientificInformation in ISO 19115 to 41 secondary topicCategories existing currently and one more first category dataScience. Temporal extents can be specified using calendar Date and Time, geological time intervals from the International Commission of Stratigraphy, or numeric positions. Data, knowledge and various services are all defined as resources (both spatial and non-spatial) within MD_Identification. MD_Imagery covers key information from remote sensing and laboratory imaging of specimens, samples and analytical results. Typical and specific methods for geological data acquisition and observation are specified using a new codelist AcquisitionCode based on CGI's Observation Method Vocabulary. A code list for service types is defined in ServiceTypeCode to populate the serviceType property for common services and DDE provided specific services.

Keyword

metadata, standard, FAIR, Deep-time Digital Earth

A Geoscience Temporal Ontology Incorporating ISO Standards and Allen Temporal Relations

Shu WANG[1]*, Institute of Geographic Sciences and Natural Resources Research, CAS (wangshu@igsnrr.ac.cn)
Yunqiang Zhu[2], Institute of geographic sciences and natural resources research, CAS

Abstract

Time serves as a crucial reference system for documenting entities, events, and processes in the field of Geosciences. A unified and semantically clear expression of geoscience time serves as the semantic foundation for addressing ultimate geoscience questions such as climate change, the origins of life, societal behavior, and Earth's evolution. The field of Geosciences encompasses diverse expressions of time dependent on various reference frameworks, including the Julian calendar, Coordinated Universal Time, geological time, Hebrew time, and the Chinese lunar calendar, among others. These expressions share common elements such as time descriptions, reference systems, and units, but also possess diverse unique elements such as time zones, time uncertainties, epoch origins, and leap month records. Achieving a unified and accurate recording of geoscience time is of significant importance for the coordination of geoscience data, understanding geoscience phenomena, and resolving geoscience issues.

International organizations and scholars have made continuous efforts to standardize the expression of geoscience time, yet compatibility in terms of time expression elements and temporal relationship expression remains elusive. Efforts include ISO 8601:2004 standardizing the representation of calendars and Coordinated Universal Time, the International Chronostratigraphic Chart (ICS) unifying geological time representations after 2004, the Open Geospatial Consortium (OGC) Time Ontology detailing the construction of a standardized sequential expression of calendars and timing systems based on Allen's temporal relations, and Unified Temporal Framework (UTF) laying the groundwork for the unified expression of geological and modern time.

Building upon the foundation of the geoscience Unified Time Framework, this study expands upon temporal expression elements such as point time, interval time, and time references to conform to the standardized representations of time descriptions outlined in ISO 8601:2004 and ICS. Furthermore, the study inherits and incorporates various temporal relationships expressed in the OGC Time Ontology. It proposes a novel unified ontology for geoscience time and presents it through an open ontology website. The study discusses in detail the design motivations and background of the time ontology, the symbols, and namespaces used, the basic principles of time ontology expression, an overview of the overall vocabulary, detailed specifications of classes, properties, and relationships, and a series of time expression examples including calendars, Coordinated Universal Time, geological time, and historical periods. This research aims to establish the semantic foundation for the coordination of various types of geological time, thereby advancing the integration of Geoscience big data and large models.

Keyword

Temporal ontology, Geoscience time expression, time relation, Unified Temporal Framework(UTF)

Construction and Sharing of CGS National Geological Database

Shoutao JIAO[1]*, Natural Resources Survey of China Geological Survey
(jshoutao@mail.cgs.gov.cn)
Rongmei LIU[2], Natural Resources Survey of China Geological Survey
Xiaohong WU[3], Natural Resources Survey of China Geological Survey
Yan YANG[4], Natural Resources Survey of China Geological Survey
Hailong YU[5], Natural Resources Survey of China Geological Survey
Hanrui SUN[6], Natural Resources Survey of China Geological Survey
Mingming ZHAO[7], Natural Resources Survey of China Geological Survey
Min WEN[8], Natural Resources Survey of China Geological Survey
Yi YUE[9], Natural Resources Survey of China Geological Survey

Abstract

The China Geological Survey(CGS) is committed to the construction, update and maintenance, sharing and application of public welfare and basic geological databases and the development of related database standards, led by scientific and technological innovation and information technology, through more than 20 years of efforts, together with relevant units, to take the lead in the construction of 98 influential geological databases, with a data volume of about 6.6PB, which has laid a solid and valuable first-hand data resource foundation for the development of China's geological survey. GeoCloud adopts distributed technology architecture, based on distributed database, and adopts spatial data hybrid processing technology to realize the integrated management and sharing services of multiple heterogeneous spatial data, and based on service interface management, it constructs a rapid invocation mechanism of cloud service resources and realizes unified management and monitoring based on services, and constructs a unified cloud resource monitoring system to realize a map of cloud resource application services. GeoCloud 3.0 has realized the sharing services of 98 national core geological databases, initially built a geoscience big data system, released more than 3,700 data services, realized the data sharing and interconnection of 56 nodes, and released more than 20,000 new products, built an open cloud ecology and geological cloud platform. In 2023, CGS has released 12 national geological databases, including the spatial database of China's geological map. CGS has completed the update and maintenance of more than 30 databases, including the national work degree database, the global scale geochemical survey database, the national land quality geochemical data, and the global petrogeochemical database. CGS has organized and updated a number of dynamic observation and monitoring data, accessed the data monitoring data of 20 natural resource monitoring stations for the first time to share on the geocloud, and completed the update of domestic resource satellite image data, 10171 groundwater monitoring stations of the National Groundwater Monitoring Project, and 272,000 potential geological disaster sites across the country. As the main participating member, the China Geological Survey, together with DDE and IUGS-CGI, jointly released the international standard "DDE-DS01 2023: Geoscience Information Metadata". The general data model of 16 specialties such as regional geology have been

continuously studied. The China Geological Survey has built the DDE-CHINA national node and compiled the overall plan for the construction of the DDE national node. For international users, DDE-CHINA adopts GEOSCIML standard and conforms to the FAIR principle. CGS has realized the sharing of some data from 30 national geological databases, including 1/500,000 China Geological Map, 1/1,000,000 China Geological Map, 1/2.5M series of tectonic maps, 1/10M series of tectonic maps, 1/4M series of geochemical maps, etc., and has completed 5 DDE-CHINA promotion training sessions in the "One Belt and One Road" Advanced Workshop on Earth Observation Data Policy and Data Application, Slovenian GIC Conference, Armenia, CCOP-IGDP Training Course, and Moroccan Geoscience Information Training Course.

Keyword

National Geological Database, Geoscience Standards, GEOSCIML, DDE-CHINA, FAIR

Construction and application of an ontology-based domain-specific knowledge graph for petroliferous basin evaluation

Xianming TANG[1]*, SINOPEC (xianmingtang@qq.com)
Zhiqiang Feng[2], SINOPEC
Xinghua Wang[3], SINOPEC

Abstract

How to realize intelligent analysis and inference, and support exploration and development decision-making through the connectivity and correlation of the required data, models, methods, and knowledge in petroleum geological evaluations. The lack of unified semantic standard and is built in a fragmented manner in the petroleum geological knowledge impose great challenge on data integration and smart application for petroliferous basin. Knowledge graph, as an emerging technology, can potentially provide a way to tackle the challenges associated with petroliferous basin evaluation. This paper describes the knowledge system of petroleum basin evaluation in detail from the aspects of knowledge classification, attributes and relationships. On this basis, an engineering based method is proposed, which improves the traditional natural language processing method, and constructs the domain knowledge map based on the evaluation ontology of petroliferous basin. Through the integration of Sinopec multi-source heterogeneous database and millions of nodes, a unified knowledge map in the field of oil and gas basin evaluation is constructed, which supports the machine reading of massive literature and intelligent analysis of massive data, and promotes the transformation of Petroleum Geoscience Research Paradigm. The applications based on the constructed knowledge graph are developed and validated for effectiveness and advantages in providing better knowledge services for petroliferous basin evaluation.

Keyword

Knowledge Graph, Petroliferous basin evaluation, Natural language processing, Knowledge system, Ontology

[Keynote] Standards: a challenge for the future of geosciences

Francois Robida[1]*, CGI (f.robida@outlook.fr)

Abstract

Sharing data and knowledge has always been at the heart of the scientific process and the production of new knowledge.

Earth sciences are first and foremost observational sciences, based on data collected on the planet over generations. It is from data that interpretations, concepts and models are produced. The description of data by those who produced it, and its preservation, has always been a duty of scientists, to enable its reuse and reproducibility.

This sharing has long taken place between researchers, often from the same discipline. These exchanges have always been based on the development of a common language based on shared vocabularies and common standards, such as for indicating the geographical coordinates of an observation or the units of the measurements taken.

Today's scientific challenges, first and foremost the climate challenge, call for the mobilization of different scientific disciplines, often with different languages and practices.

At the same time, the development of data infrastructures on an international scale is giving researchers access, via computer protocols, to considerable sources of data from their own and other disciplines. Digital tools such as AI make it possible to make machines "reason" about data to produce new knowledge.

This ambition lies at the heart of DDE.

All these elements make it critical for both humans and machines to be able to "understand" the data they use. This understanding necessarily requires the adoption of common frames of reference on an international scale and across all disciplines. These frames of reference are based on a common "vision" produced by the scientific community (and updated as knowledge evolves), which translates into multilingual vocabularies and ontologies shared by this community.

In the past, this formulation has sometimes been seen as a low priority, outside the remit of the most advanced researchers, and to be delegated to specialists in knowledge management or information systems.

On the contrary, explicating a domain of knowledge in the formalism of ontologies reflects the state of knowledge and concepts at a given point in time, and therefore implies mobilizing the best experts in the scientific field.

It is therefore of the utmost importance that scientists are fully committed to this international approach, and that their contribution in these fields is recognized by their peers.

Keyword

Standard, Interoperability, Ontology, DDE

A comprehensive knowledge base for representing version information in geologic time scale knowledge graph

Hongwei Wang[1]*, School of Earth Sciences and Resources, China University of Geosciences, Beijing (wanghw2021@126.com)
Chao Ma[2], Institute of Sedimentary Geology, Chengdu University of Technology, Chengdu
Xiaogang Ma[3], Department of Computer Science, University of Idaho
Shu Wang[4], State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
Yunqiang Zhu[5], State Key Laboratory of Resources and Environmental Information System, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences
Chengshan Wang[6], State Key Laboratory of Biogeology and Environmental Geology and School of Earth Sciences and Resources, China University of Geosciences, Beijing

Abstract

Geologic time scale (GTS) stands as the unified standard for referencing Earth's temporal history. It is composed of time intervals which anchored with standard stratigraphic divisions based on rock sequences. The understanding of geological intervals mentioned in literature has been in alignment with the prevailing versions of the GTS at their respective times. However, GTS versions undergo dynamic updates in relative and absolute ages with the advent of new technology and data, leading to shifts in our comprehension and interpretation of historical data. In the current landscape of continuous data accumulation in various earth science domains, it is imperative to consider the temporal context of data during critical stages like data collection, cleansing, and storage. To quantitatively depict the evolution of the GTS, this study compiled GTS data spanning from 1893 to 2023 and harnessed a knowledge graph to represent this geological temporal knowledge. The outputting Geologic Time Scale Knowledge Graph (GTSKG) is an innovative knowledge base that encompasses all published versions of geological time scales, transformed into a machine-readable format. This compilation features data from 98 versions of global and regional geologic time scales of the Phanerozoic Eon. It involves encoding the geological time intervals across different versions and deriving semantic relationships between intervals of the same version through computational operations. The GTSKG aims to enhance data utilization by supporting improved data reusability, shareability, and scalability, thereby facilitating a more dynamic and integrated approach to analyze the Earth's complex systems.

Keyword

Knowledge Graph, Ontology, Knowledge Evolution, Platform, Deep Time

Paleobiogeographic Knowledge Graph: An Ongoing Work with Fundamental Support for Future Research

Linna ZHANG[1]*, Nanjing Institute of Geology and Palaeontology, CAS (lnzhang@nigpas.ac.cn)
Zhangshuai HOU[2], Nanjing University
Boheng SHEN[3], Nanjing University
Qing CHEN[4], Nanjing Institute of Geology and Palaeontology, CAS
Shaochun DONG[5], Nanjing University
Junxuan FAN[6], Nanjing University

Abstract

Paleobiogeography investigates the geographical distributions of fossil organisms and controlling factors that affect their distributions in geological history, to reveal the macro-evolution and coordinated development of life and the environment. It is a crucial window for understanding the biosphere and the geographical environment. After two centuries of development, paleobiogeographic studies have led to the accumulation of significant amounts of knowledge and data; however, the voluminous outputs present the characteristics of an “isolated island” with a scattered, limited number of authoritative definitions of terminologies and semantic heterogeneity among them. This makes data queries cumbersome, the rate of data reuse low, and data sharing more difficult. A knowledge graph (KG) has the advantage of expressing concepts and their semantic relations, which is an important tool for achieving data organization and fusion, and data mining; further, it is also a key technology for realizing the unrestricted sharing of paleobiogeographic information. Through our efforts over the past two years, a paleobiogeographic KG was developed based on the established construction procedure of the KG, which contains 273 concepts, 172 properties, and 47 rules. Meanwhile, the completion of this KG and the construction of a paleobiogeographic platform for display and analysis are now being carried out.

Keyword

biogeographic unit, knowledge base, artificial intelligence, knowledge inference, knowledge graph

Creating Open Standardized Global Networks of All Types of Geochemical Data from Multiple Countries, Repositories, and Researchers: The OneGeochemistry and WorldFAIR Initiatives

Kerstin Lehnert[1]*, Columbia University (lehnert@ldeo.columbia.edu)
Alexander Prent[2], AuScope Ltd., Australia
Lesley Wyborn[3], Australian National University, Australia
Marthe Klöcking[4], University of Münster, Germany
Stephen Richard[5], US Geoscience Information Network, USA
Angus Nixon[6], The University of Adelaide, Australia
Kirsten Elger[7], GFZ German Research Centre for Geosciences, Germany
Rebecca Farrington[8], AuScope Ltd., Australia
Dominik Hezel[9], University of Frankfurt, Germany
Lucia Profeta[10], Columbia University, USA
Manja Luzi-Helbing[11], GFZ German Research Centre for Geosciences, Germany

Abstract

Around the globe, geochemical datasets have been collected for nearly 180 years by thousands of researchers and research groups on an incredible diversity of samples (rocks, minerals, meteorites, fluids, gases, etc) using hundreds of analytical techniques across many disciplines. These geochemical datasets are notoriously heterogeneous and integration and comparison of datasets from multiple repositories is difficult because there has rarely been consensus on the definition of the minimum variables required for interchanging data from different analytical methods, combined with inconsistencies used in the vocabularies that describe each variable.

Next-generation analytical machines are producing data in exponentially increasing volumes, and there is a growing tendency for analytical results to be presented as 2D/3D imagery. Simultaneously, new data-driven research questions are emerging that require global aggregation of geochemical datasets for data analytics to enhance our understanding of earth and planetary system processes. Combined, these factors are accelerating the need to make geochemical data around the world Findable, Accessible, Interoperable and Reusable (FAIR), which in turn is driving an increasing demand for standardization of geochemical variables and vocabularies.

To accelerate the development of the much needed standards, the OneGeochemistry initiative (http://onegeochemistry.org/), formed in 2018, has been working towards enabling an Open Global Network of all types of geochemical data from multiple countries, repositories and researchers. To achieve a balance between meeting increasing demands for FAIR vocabularies versus time required to reach international agreement, OneGeochemistry has developed a four-tiered approach (local, regional, international, global):

1) Data providers with locally defined vocabularies are encouraged to make these available online and that ensure each term has a persistent identifier;

2) Groups with similar topics begin working together to harmonize multiple locally-derived concepts/definitions and publish these as regional resources;

3) Raising awareness of communities acting at a regional level and motivate them to come

together and decide on building crosswalks and mappings or coalescing regional resources into international resources;
4) Taking the best and most appropriate vocabularies from either local, regional, international resources and have them endorsed, maintained and extended as global vocabularies and resources by international authoritative groups (e.g. Scientific Unions/Societies).
As convergence takes place towards internationally-agreed terms, the size of the community that is able to share both metadata and data in machine to machine environments grows. As better defined vocabularies become available online they should be easy to translate into multiple languages.
The OneGeochemistry initiative is part of the CODATA/RDA-led WorldFAIR Project on Global Cooperation on FAIR Data Policy and Practice (https://worldfair-project.eu/). Geochemistry is one of 11 disciplinary and cross-disciplinary case studies, which together seek to advance implementation of the FAIR principles and to create a Common Data Interoperability Framework (CDIF) that improves the reusability of digital research data across multiple domains. The WorldFAIR project is providing valuable insights into the available vocabularies and other currently much used FAIR Enabling Resources, and is showing where standards are urgently required to advance a global network of geochemical data repositories within a multidisciplinary framework.

Keyword

geochemistry, community standards, FAIR, vocabularies, interoperability

DDE OnePetrology Database and Standard (Igneous Rocks)

Ying TONG[1]*, MNR Laboratory of Deep Earth Sciences and Technology(SinoProbe Laboratory) (yingtong@bjshrimp.cn)
Tao Wang[2], MNR Laboratory of Deep Earth Sciences and Technology(SinoProbe Laboratory)
Yi Ding[3], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

The OnePetrology database, built on the knowledge system of petrology with the idea of 'data+mapping+research', represents a significant advancement in the field of petrology and geoscience research by harnessing the power of big data and digital technologies. This initiative, supported by the Deep-time Digital Earth (DDE), an international Big Science Program of IUGS, aligns with the 21st-century scientific research paradigm that leverages data and models to drive new discoveries and insights. The database's mission is multifaceted, aiming to: (1)Integrate and Network Global Databases: By identifying, augmenting, and networking globally distributed petrological and geochemical databases for igneous rocks, OnePetrology seeks to create a comprehensive, service-oriented platform accessible via DDE. This platform is designed to facilitate in-depth data mining and comprehensive analysis, with the ultimate goal of addressing major geological challenges through big data analysis. (2) Elucidate Deep-Earth Material Evolution: Through the analysis of magmatic rock evolution, the database aims to understand the 3D architecture and 4D evolution of deep-earth materials across regional, orogenic, and global scales. (3) Provide Evidence for Deep-Time Processes: The database serves as a resource for understanding deep-time plate reconstruction, continental assembly processes, and paleogeographic reconstruction. It also aids in revealing the growth and evolution of the Earth's crust and mantle. (4) Reveal Deep-Earth Dynamics: By studying the movement of fluids and magma, material exchange from the core to the crust, and the mechanisms of tectonic plate movement and supercontinent cycles, OnePetrology contributes to the understanding of the Earth's Deep-engine workings. The database encompasses a wide range of data types, including rock types, occurrences, spatial information, geological background, geochronology, geochemistry, isotopes (including Sr-Nd-Hf-Pb-O), and non-traditional isotopes. These data come from published literature, our team's data, laboratory analyses, and interconnected international databases. OnePetrology also supports various software and tools that enhance its utility., including PDF data extractor, mapping services, and diagram plotting tools, all of which can be downloaded from the website. Adhering to principles of FAIR (Findable, Accessible, Interoperable, Reusable), TRUST (Transparent, Robust, Usable, Shareable, Transparent), and CARE (Consistency, Accuracy, Richness, Efficiency), etc., the database follows the concepts, semantics, and ontologies of the CGI (Commission for the Management and Application of Geoscience Information), API (Application Programming Interface), IUGS (International Union of Geological Sciences), textbooks, and online databases. The OnePetrology standard (Version 2.0) complies with relevant technical specifications for information technology and discipline

research, and efforts are underway to further refine this standard with the vision of becoming the benchmark for the IGC (International Geological Congress) and CODATA (Committee on Data for Science and Technology). In summary, OnePetrology is a groundbreaking resource that not only supports petrology education and research but also serves as a model for how big data can be utilized to advance our understanding of the Earth's complex geological history and processes.

Keyword

OnePetrology, Database, Digital mapping, Standard, DDE

Research on the standard of building database of Geophysical-Geochemical-Remote Sensing data based on data model

wei REN[1]*, Command Center for Integrated Natural Resources Survey (renwei@mail.cgs.gov.cn)
Xiaohong Wu[2], Command Center for Integrated Natural Resources Survey
Rongmei Liu[3], Command Center for Integrated Natural Resources Survey
Sheng Zhang[4], Command Center for Integrated Natural Resources Survey

Abstract

Geophysical, geochemical, remote sensing data is an important basis for resource exploration and development, resource evaluation and utilization and related decision-making, with the increasing development of materialized remote exploration technology, the amount of data shows explosive growth, geophysical, geochemical, remote sensing data exploration data into the big data era. This paper will refer to the concept of data model, constructed the physical remote data storage model and library building standards, to realize the construction of Geophysical-Geochemical-Remote Sensing data management system of cloud architecture.

Over 60 years of China's mineral geological survey , detailed survey and exploration work in key areas have accumulated a large number of Geophysical-Geochemical-Remote Sensing data resources. However, in terms of the way of data storage, the data are mainly scattered and stored in each exploration unit, maintained and operated in the form of projects, the data convergence mechanism has not yet been established, and the problem of "information silo" is still relatively prominent. In terms of database construction standards, due to the complexity of the professional direction of Geophysical-Geochemical-Remote Sensing, most of the geological exploration units have not established a unified physical and chemical remote survey database construction standards, which is not conducive to data sharing and comprehensive utilization. There is an urgent need to build a unified database construction standard and data management system for Geophysical-Geochemical-Remote Sensing data, so as to standardize the database, classify and manage the data, share the service and make comprehensive use of the data.

The standard for building Geophysical-Geochemical-Remote Sensing data libraries stipulates that the database is logically divided into three libraries, including the basic library, the core library and the auxiliary library. The basic library mainly stores the unstructured document data of each specialty of physical and chemical remote data, and with reference to the relevant technical standards and specifications and combined with the actual exploration and construction situation, it has formed the basic library model of 22 different specialty data types according to the combing of original data and result data categories. The core library mainly stores structured data of various specialties, and 35 core library models are formed by standardized extraction and quality checking of structured data files in the base library. The auxiliary library consists of data supporting system operation and management and front-end data sharing services. The data storage of the Geophysical-Geochemical-Remote Sensing data Management System is based on the hybrid architecture of PostgreSQL+MongoDB+distributed file system, and the independently researched

and developed cloud native raster map service RMapServer geographic information service engine is constructed to guarantee the consistency and completeness of the standardized and integrated library building requirements and data services for the Geophysical-Geochemical-Remote Sensing original data and the result data.

Keyword

geophysics, geochemical, remote sensing, database standards, management system

Study on the Crowdsourcing and Sharing System Model for Lithogeochemical and Geochronological Data

Rui YU[1]*, Development Research Center, China Geological Survey (yurui@mail.cgs.gov.cn)
Yanggang Wang[2], Development Research Center, China Geological Survey
Lirong Hao[3], Development Research Center, China Geological Survey
Yi Ding[4], Institute of Geology, Chinese Academy of Geological Sciences

Abstract

Lithogeochemical data and geochronological data are essential for understanding Earth's evolution, unraveling geological process, and mineral resources exploration. Scientists have established relevant geochemical databases such as EarthChem, GEoReM, GEOROC, and DataView separately for these purposes. But huge lithogeochemical data and geochronological data currently are still been stored many disparate flat files. It’s critical to accumulate those data scattered among research institutions and individuals and create a system for data uploading and sharing through a crowed-sourced database along with a data acquisition App.

A multi-terminal open system model for lithogeochemical data management has been developed, which integrates the collection of online/offline field data, laboratory analyzing data, description and literature data. While, users could also manage their data and share them independently with high efficiency. The database operates through an automated process for data compilation, quality control, uploading, and releasing, which helps consistent, standardized, and long-term data storage and management. The App designed to guarantee the traceability and accessibility of samples with their lithogeochemical and geochronological attribute data has also been created. It can be installed on a mobile terminal for use in laboratory and geological field. The sample origin and sample location information will be recorded by the mobile App in the field. The lithogeochemical and geochronological data will be recorded by lab App in the laboratory consistently.

The system model adheres to the FAIR principles (Findable, Accessible, Interoperable, and Reusable) and Open Science principles and practices which contribute to promoting earth science research from traditional theory-driven to data-driven. The system model has been adopted in the igneous database of the IUGS Deep-time Digital Earth Program. And its data are utilized in the Map of Mesozoic Granitoids and Related Rocks of Asia already.

Keyword

Lithogeochemical and geochronological data, open database development, multi-terminal system model, FAIR principle

Knowledge Graph Schema of Mineral Deposit: The Design, Application, and Significance

Chengbin WANG[1]*, China University of Geosciences(Wuhan) (wangchb@cug.edu.cn)
Mingguo Wang[2], China University of Geosciences
Jianguo Chen[3], China University of Geosciences

Abstract

The knowledge graph has become a hot topic for mining geoscience big data. The program of Deep-Time Digital Earth accelerates the development and application of a geoscience knowledge graph. However, the extraction of information from unstructured literature still remains a challenge, in which a fundamental issue is the categories and the type of discipline-specific information. This paper presents an effective workflow for designing a schema including geological entities and their semantic relations for mineral deposits. This paper includes the following aspects: (1) a use case-driven method for building an ontology of mineral deposits. The geological entity and semantic relation classes are derived from the ontology of mineral deposits based on background knowledge. (2) According to the schema of mineral deposits, relational data mapping, deep learning, and natural language processing are employed to build the knowledge graph of mineral deposits. (3) we will show several application cases of question-answering systems based on a mineral deposit knowledge graph and knowledge discoveries for mineral deposits. In the last parts, we will conclude the further challenges and opportunities of the knowledge graph in the domain of mineral deposits. Our studies will provide some experiences for construction of a knowledge graph and application for improving geoscience research.

Keyword

Knowledge graph, Mineral Deposit, Geological entity, Geological relations

Joint inversion of gravity and magnetic 2-3D for the structure of hidden phosphorus deposit

xingting WANG[1]*, 18309669725 (2429400825@qq.com)

Abstract

Northeast Yunnan is one of the important mineral resource gathering areas in China, with superior metallogenic geological conditions and good prospecting prospects.The regional stratigraphy has a well-defined double-layer structure, with a metamorphic basement in the lower part and an unspoiled caprock in the upper part.

At present, only Yangchang phosphate ore has been found in the Zhenxiong area of the region, and there are more than 20 boreholes with phosphorus in the early stage, and the phosphate rock body in the area is not encircled in the direction, and the degree of exploration in the middle and deep of the area is low , and the prospecting potential is huge.In this study, the gravity-magnetic joint inversion method was used to explore the study area and found out the occurrence of underground ore bodies.

According to the abnormal response of physical properties in the study area, combined with the profile information of the previous electrical exploration method, the joint inversion method between different physical property parameters is applied to achieve the following three main links:

(1)parameterization of the model; (2) the construction of the objective function; (3) Selection of inversion algorithms.Among them, the first two links are the basis for the realization of joint inversion.According to the current research status, in most of the existing joint inversion algorithms, it is necessary to clarify the correlation between the physical parameters used in advance, which makes the method more dependent on prior information.In this study, the stratigraphic mineral information obtained from geological drilling in the early stage will be used as the prior information of the joint inversion of gravity and magnetism, and then the underground structural morphology of the target geological body will be obtained based on the reliable information in the joint inversion of gravity and magnetism.

Keyword

Joint inversion of gravity and magnetism, Objective function, Physical property parameters

Master

YU FAN MENG[1]*, 1403999876@qq.com (1403999876@qq.com)

Abstract

Research on cloud geophysical data visualization technolog

In 2006, the concept of "cloud computing" was introduced. The development of cloud computing technology has promoted the transformation of the working model of the geophysical industry. The data visualization work after data discovery based on the network is to realize the geophysical data visualization operation of the original workstation (stand-alone) on the cloud platform, and further expand the online application of geophysical data processing and interpretation business. The overall work content of the project is huge, using web front-end technology to store and manage multi-source and large amounts of geophysical data on the cloud efficiently and reasonably, realize the storage, processing, display, interaction, analysis and output of geophysical data on the web, and solve the actual problems of users.In this study, we analyzed the various needs of geophysical data visualization and determined the necessary visualization functions. Based on the use and refactoring of existing code, a number of comparisons choose methods with strong adaptability to integrate, extensibility, and write code. Build a front-end framework, select an appropriate visualization library, form a complete geophysical data visualization interface, and determine each functional module. Practical application of successful geophysical visualization methods to ensure the feasibility of the study. Finally, the rapid analysis of geophysical data in the cloud is completed to form high-quality visualization images.

Keyword

geophysical data, cloud computing, visualization technology

An One-Stop Application for DDE Metadata

Yuhao Dong[1], Institute of Integrated Information Mineral Resources Prediction, Jilin University, China
Wei YAN[2]*, School of Geophysics and Information Technology, China University of Geosciences (Beijing) (yanwei_2021@126.com)
Yongzhi Wang[3], Institute of Integrated Information Mineral Resources Prediction, Jilin University, China
Xizhu Wang[4], College of Geo-Exploration Science and Technology, Jilin University, China
Minghua Zhang[5], Development Research Center China Geological Survey

Abstract

Metadata focus on describing basic information about various types of data. It also plays an important role in geosciences data in DDE big science program for resource Findable. DDE aims to provide a loosely one-stop data center that meets FAIR principles and serve global geoscientists by manipulating, integrating, sharing, applying all kinds of data such as geology, marine, tectonic, geophysics, geochemistry, remote sensing, borehole, planetary, etc. The variety of complicated geosciences data is a big challenge for search, accessing, management, integration, share, discovery, application, mining. In order to pave the way to utilize big data in DDE platform, DDE standard group has issued DDE geoscience information metadata standard, it offers core metadata requirements for all data participated in DDE. To managing DDE metadata efficiently , an application (APP) fits the standard was developed based on service-oriented architecture in DDE cloud computing environment. The APP performs registration, search, update, import, export, harvesting, cataloguing, publishing, visualization, statistics for DDE metadata. It is useful at both handling input metadata manually and dealing with local XML metadata and online metadata URIs. Same or similar values retrieved from local files or online URIs can be set to match corresponding elements/columns automatically. as a result the metadata center can be act as ALL in ONE for metadatabases in and outside DDE program. The metadata saved in DDE metadata center will be published as Web services when they were registered. Five format metadata so far can be reused for the core information from different specifications of metadata including OneGeology, CSW, DDE, ISO 19115 respectively. And this metadata App can interact with other geosciences application for metadata harvest with further imporvement . The APP has been integrated with DDE big data website for metadata collection in the past few years. It will contribute more for further interdisciplinary matadata applications in open science in the future.

Keyword

DDE metadata, one-stop, Application, FAIR

Construction and application of geophysical knowledge graph in Antarctica

Yuanyuan ZHANG[1]*, China University of Geosciences (Beijing) (yyzhang@email.cugb.edu.cn)
Changchun ZOU[2], China University of Geosciences (Beijing)
Cheng PENG[3], China University of Geosciences (Beijing)
Alexey Markov[4], China University of Geosciences (Beijing)
Sergei Popov[5], Saint Petersburg State University
Pavel Yu Pushkarev[6], Moscow State University

Abstract

Knowledge graph (KG) a tool for graphically presenting knowledge, consists of nodes and edges that represent the relationship between entities and nodes, respectively. KGs can effectively organize and manage massive amounts of data and mine for deeper knowledge and rules through associations between entities. In particular, the Deep-Time Digital Earth program (DDE), aims to build comprehensive KG to facilitate the creation of standard terminology and knowledge integration in geoscience.

Antarctica is important for global warming, resource sustainability, and the preservation of biodiversity as the last clean land on Earth that has not been exploited on a large scale. Advances in geophysical technologies have led to an exponential growth in scientific data from Antarctica, thereby presenting an unprecedented opportunity to delve deeper into the mysteries surrounding this enigmatic continent. To better exploit this data and derive valuable information from it, the construction of KG becomes essential. The KG in geophysics facilitates the integration of data scattered across diverse literature and reports, enabling the application of correlation analysis to elucidate the interrelations among a broad spectrum of geophysical data within the Antarctic region.

In this study, literature and textual information on geophysical research in Antarctica between 1982 and 2022 was systematically collected using the Web of Science database. An in-depth analysis of these materials was used to construct KG in Geophysics of the Antarctic. Six popular research topics were identified: Antarctic ice sheet instability and sea level change, Southern Ocean and sea ice, tectonic activity in the West Antarctic Rift System, paleo-continental rift and reorganization, magmatism and volcanism, and subglacial lakes and subglacial hydrology. These topics not only cover several important areas of geophysical research in Antarctica but also reflect research hot spots and research trends. In a drive to reveal further research directions, development trends, and challenges this study also analyzes in-depth the evolution of research themes of these popular topics within three consecutive subperiods (1990-1995,1996-2005, and 2006-2022) in geophysical research in Antarctica. By comparing the intensity, citation frequency per article(>10), main research content, and method of each topic during the different periods, it is possible to predict its likely future direction.

The construction of the Geophysical KG as a tool has provided researchers with new research perspectives, as well as strong support for scientific research in Antarctica. The results of this study will serve as a powerful reference and guide for future scientific research in the Antarctic.

Keyword

Antarctica, geophysics, knowledge graph

Geospatial-aware representation learning model for point of interest(POI) matching

Xiaoliang DAI[1]*, Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences (daixiaoliang079x@igsnrr.ac.cn)
Yunqiang Zhu[2], Institute of Geographic Sciences and Natural Resources Research, Chinese Academy of Sciences

Abstract

Point of interest (POI) data serves as a digital representation of real-world locations that may pique the interest of specific demographic groups. POI datasets from different sources often vary in spatial coverage, attribute emphasis, and data quality. To accurately portray locations within a research area, the integration of multiple POI datasets becomes crucial. POI matching stands out as a pivotal step in this amalgamation, discerning POIs from disparate datasets representing identical real-world locations.

Despite the multitude of POI matching methods developed, they typically cater to specific research domains, limiting their efficiency and generalizability. This paper introduces a geospatial-aware POI matching method. The approach initially transforms diverse POI attributes into vectors through POI name embeddings, POI type embeddings, and spatial location embeddings. Subsequently, vector similarity is computed, and the final POI matching is executed employing a deep neural network.

Experimental evaluations conducted on datasets from various regions in China conclusively demonstrate the superior performance of the proposed POI matching method over existing alternatives. It excels in terms of accuracy, recall, F1 score, and precision. Additionally, it showcases enhanced spatial generalization capabilities, making it a robust solution applicable across diverse geographical contexts. This method contributes to advancing POI matching techniques, providing a comprehensive and adaptable approach for spatial data integration.

Keyword

POI Matching, Location Embedding, Representation Learning, Points of Interest

How do Earth Sciences Contribute to Advancing the Sustainable Development Goals? A Bibliometric Analysis

Yu ZHAO[1]*, China University of Geosciences, Beijing (zhaoyu.cugb@gmail.com)
Li CHENG[2], China University of Geosciences, Beijing
Jiaxin DING[3], Shanghai Jiao Tong University
Meng WANG[4], Xiniang institute of Ecology and Geography, Chinese Academy of Sciences
Lyuwen WU[5], Shanghai Jiao Tong University
Xinbing WANG[6], Shanghai Jiao Tong University

Abstract

Earth science knowledge empowers us to adopt a global perspective and take local actions, contributing to the achievement of the Sustainable Development Goals (SDGs). This study aims to qualify the contribution of Earth Sciences towards realizing of the SDGs through a comprehensive bibliometric analysis.

We employed category filters induced by Dimensions AI to collect and analyze more than 282,000 articles and 36,000 datasets related to Earth Sciences and the SDGs spanning from 2015 to 2022. This extensive dataset pertains to the nexus between Earth Sciences and the SDGs. Our analysis encompassed an evaluation of indicators such as publication quantity, citation patterns, international collaboration networks and topic trends, elucidating the contribution and impact of Earth Sciences in achieving the SDGs.

Preliminary findings indicate that Earth Sciences play a significant role in multiple SDGs. For instance, Earth Sciences can offer scientific knowledge and technological support in some specific SDGs such as 13 Climate Actions(114,314 articles), 15 Life on Land(56,365 articles), 14 Life Below Water(47,836 articles), and 7 Affordable and Clean Energy(26,033 articles). Additionally, Earth Sciences facilitate cross-disciplinary collaboration(e.g.'Earth Sciences' and 'Environmental Sciences' 48,213 articles) and cross-field collaboration(e.g.'Geology' and 'Physical Geography and Environmental Geoscience' 21,837 articles), enabling cross-cutting solutions for sustainable development goals.

The insights derived from this study offer a nuanced understanding of the instrumental role played by Earth Sciences in sustainable development practices. They provide guidance and recommendations for policymakers, scholars, and practitioners regarding the role of Earth Sciences in achieving the SDGs. Further research can broaden the scope of data and employ more analytical methods to further delineate the impact of Earth Sciences on the SDGs.

Keyword

Earth Sciences, Sustainable Development Goals, bibliometrics, scientific contribution

Research on the method of signal-to-noise separation for aerial gamma ray spectrometry data based on curvelet transform

HUAIYUAN LI[1]*, Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei, 050002 (hylhy703@163.com)
XIANG ZHANG[2], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei, 050002
LIANCHENG SHI[3], 1)Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei,050002;2)China University of Geosciences (Beijing), Beijing 100083, China
WEICHONG NI[4], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei, 050002
NANPING WANG[5], China University of Geosciences (Beijing), Beijing 100083, China
BINGHAI LI[6], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei,050002
YAYUN LU[7], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei,050002
GUANGYA ZHANG[8], Airborne Survey and Remote Sensing Center of Nuclear Industry, Shijiazhuang, Hebei,050002

Abstract

Airborne gamma spectrometry is an important method of uranium exploration. It contains rich prospecting information in the data, but complex noise caused by various reasons will seriously reduce the signal-to-noise ratio of the data, especially affect the screening of anomalies, the extraction of weak information, and the analysis of uranium migration laws. It directly affects the effect of measurement and geological interpretation. Therefore, how to quickly achieve the signal-to-noise separation of a large amount of airborne gamma spectrometry data is one of the important issues to improve data quality and exploration results.

First, the basic principle of curvelet transform is studied. Compared with wavelet transform or other eigenvalue methods, this method not only inherits multi-scale, but also has multi-directionality, which can better represent two-dimensional or high-dimensional data. At the same time, in the process of signal-to-noise separation, curvelet transform generally only makes local changes to some detail scales and angles of the data, which is not easy to cause data distortion and try to retain real information. These features are suitable for denoising airborne gamma ray data, especially for full-spectrum data processing, which will achieve better results. Secondly, about 30,000 km of measured data in a certain basin in 2023 are processed using this method. Before processing, there are obvious white noise and northwest-southward strip noise in the original data. These two kinds of noise overlap in the anomaly area, which has a great impact on the identification of the true shape of the anomaly. After processing, the strip noise basically disappears, the white noise is significantly suppressed, the anomaly characteristics and other detailed geological information are preserved, and no data boundary distortion occurs. Good practical processing results are achieved.

Therefore, a curvelet transform-based technique for signal-noise separation in airborne

radiometric data is proposed, which is characterized by fast processing, high fidelity, and applicability to large amounts of data. It is also an effective technique for solving the problem of denoising data before weak signal extraction in basins.

This research was supported by the National Natural Science Foundation of China (U2067204).

Keyword

Airborne gamma spectrometry, curvelet transform, signal-to-noise separation, data processing

Underground spatial distribution of uranium and radium elements in Barun uranium deposit, Erlian Basin, Inner Mongolia

Nan Gan[1]*, Beijing research institute of chemical engineering and metallurgy
(152067094@qq.com)
Tingting Xie[2], Beijing research institute of chemical engineering and metallurgy
Nanping Wang[3], China university of geosciences beijing

Abstract

The characteristics of sandstone type uranium deposit in China is known as low ore grade and small ore body size, and the cost and technical difficulty of uranium exploration are getting higher and higher. The relationship between radon anomalies observed in soil gas and deep uranium deposits has always been an attractive subject. Therefore, a study on the distribution of uranium, radium and radon above the uranium deposits in the Barun Uranium Mine in Erlian Basin, Inner Mongolia.

Based on the borehole geological and geophysical logging data of the proposed mining area, a three-dimensional mixed geological model of heterogeneous layer and lithology of Barun uranium deposit was constructed by using smooth indicating kriging method in EVS software. By using the depth-quantitative gamma-ray logging and borehole uranium-radium equilibrium data, the spatial distribution of uranium and lithology interactively modeled are to show the spatial distributions of uranium elements in oxidizing and reducing sand layers. It is found that the specific activity of uranium and radium in sandstone in the group of Yierdinmanhe Formation above the ore bodys is higher than it in Saihan Formation, the ore-bearing layer, as well as in the surface soil. In addition, small local concentrations of uranium and radium were observed. The distributions of uranium element in ore-bearing layer, sand body and mudstone layer provide an important basis for the division of ore-bearing layer and the layout of boreholes in the leaching mining. The spatial distributions of uranium and radium elements from the uranium body roof to the near surface of the mine for the first time also provides important valuable data for understanding radon migration above the uranium deposits.

This research was supported by the National Natural Science Foundation of China (U2067204).

Keyword

Sandstone type uranium ore, uranium, radium, heterogeneous model

Paleontology knowledge graph for data-driven discovery

Yiying Deng[1]*, Hefei University of Technology (yydeng12138@foxmail.com)
Sicun Song[2], Nanjing University
Junxuan Fan[3], Nanjing University
Mao Luo[4], Nanjing Institute of Geology and Palaeontology
Le Yao[5], Nanjing Institute of Geology and Palaeontology
Shaochun Dong[6], Nanjing University
Yukun Shi[7], Nanjing University
Linna Zhang[8], Nanjing Institute of Geology and Palaeontology

Abstract

A knowledge graph (KG) is a knowledge base that integrates and represents data based on a graph-structured data model or topology. Geoscientists have made efforts to construct geoscience-related KGs to overcome semantic heterogeneity and facilitate knowledge representation, data integration, and text analysis. Paleontology is the study of the history of life on Earth based on fossils. An enormous number of fossil taxa have been recorded and published with their described information, such as diagnostic features, age, distribution, etc. Assembling and analyzing the information is the first essential step in reconstructing geological history. However, there is currently no comprehensive paleontology KG or data-driven discovery based on it. In this study, we constructed a two-layer model (the ontology layer and fact layer) to represent the ordinal hierarchical structure of the paleontology KG following a top-down construction process. An ontology containing over 19000 concepts has been defined up to 2023. It consists of six TopConcepts: Fossil, Taxonomy, Paleoecology, Evolutionary paleontology, Biostratigraphy, and Paleobiogeography. The construction of the paleontology KG ontology layer also marks the completion of the main framework of the paleontology knowledge system. Considering the increasing digitizing tendency in paleontology research, the paleontology KG would become a fundamental part of any paleontological database. On this basis, we derived the synonymy list based on the paleontology KG and designed corresponding online functions in the OneStratigraphy database to showcase the use of the KG in paleontological research.

Keyword

Paleontology knowledge graph, Ontology, Synonymy list, OneStratigraphy

Modelling Phanerozoic Climates and Biogeochemistry

Paul VALDES[1]*, University of Bristol (p.j.valdes@bristol.ac.uk)
Alex Farnsworth[2], Bristol Univesity
Daniel Lunt[3], Bristol University
Chris Scotese[4], Northwestern University

Abstract

The Phanerozoic period offers a unique insight into variability of the Earth System. Geological data provides a huge wealth of information about climate and biogeochemistry change during this period but it is difficult to attribute the mechanisms of change from data alone. Computer models of the Earth System provide an additional valuable tool to help us understand the causes of past changes and to quantify different processes. The talk will present results from a unique series of 109 simulations covering the whole of the Phanerozoic. We use the model (HadCM3) to quantify the contrasting roles of paleogeographic change, carbon dioxide variability, and solar constant changes on both the temperature and hydrological cycle. We show that a modified version of our model is able to reproduce the warmth of high latitudes during the Mesozoic and early Cenozoic, thus offering a solution to one of the long standing paleoclimate model-data challenges. Recently, the model has been extended to include a simple ocean carbon cycle model. We will use this model to show the changes in marine and terrestrial carbon cycle for a number of selected periods. The results show that the terrestrial (vegetation) carbon pools can vary significantly through the Phanerozoic due to the changes in climates.

Keyword

models, phanerozoic, carbon cycle

Phanerozoic Paleotemperatures and CO2 Levels

Christopher Robert SCOTESE[1]*, Northwestern University (cscotese@gmail.com)

Abstract

This presentation provides the first comprehensive and quantitative estimate of how global temperatures have changed during the last 540 million years. It combines paleotemperatures measurements determined from oxygen isotopes with broader insights obtained from the changing distribution of lithologic indicators of climate, such as of coals, evaporites, calcretes, reefs, and bauxite deposits. The waxing and waning of the Earth's great polar icecaps have been mapped using the past distribution of tillites, dropstones, and glendonites. The global temperature model presented here includes estimates of average global temperate (GAT), changing tropical temperatures (ΔT˚ tropical), deep ocean temperatures, and polar temperatures. The history of global changes in temperature during the Phanerozoic has been summarized in a "paleotemperature timescale" that subdivides the many past climatic events into 8 major climate modes; each climate mode is made up of 3-4 pairs of warming and cooling episodes (chronotemps). The paleotemperature model presented here allows for a deeper understanding of the interconnected geologic, tectonic, paleoclimatic, paleoceanographic, and evolutionary events that have shaped our planet. The quantitative paleotemperature model presented here makes explicit predictions about the Earth's past temperature that can be tested and evaluated.

By quantitatively describing the pattern of paleotemperature change through time, we may be able to gain important insights into the history of the Earth System and the fundamental causes of climate change on geological timescales. These insights can help us better understand the problems and challenges that we face as a result of Future Global Warming.

CO2 is a greenhouse gas that has played an important, if not the predominant role, in regulating the Earth's temperature through time. Global Climate Models, such as CESMX and the HadleyCM3 require estimates of atmospheric CO2 to modulate the temperatures produced by these simulations. Therefore, an accurate estimate of the ancient concentration of atmospheric CO2 is essential if we are to successfully model past climates. In order to improve the estimates of CO2, we have used our growing understanding of the temperature history of the Phanerozoic (Scotese et al., 2021) to refine and update the Foster CO2 curve. By considering an independent estimate of temperature, we can now "fill in the gaps" and reject contradictory CO2 data. At first this may seem like circular reasoning. However, no CO2 proxy data was used to determine the cool and warm intervals (Scotese et al., 2021). We are simply redrawing the CO2 curve so that it conforms with what we independently know about global temperature change. The goodness of fit between the revised CO2 curve and the CO2 proxy data actually improves as a result of the rejection of questionable CO2 values.

This is not a final answer. There are still large gaps in the CO2 proxy record, and the estimation of some of the CO2 peaks, where there is no data (i.e., Cambrian, early Triassic,Cenomanian-Turonian), is speculative. This curve, however, represents a testable hypothesis that awaits conformation or rejection with additional data.

Keyword

paleoclimate, paleotemperature, CO2, Phanerozoic

[Invited] The development of a Mediterranean climate resulted from the rise of SE Tibet

Lin DING[1]*, State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China (dinglin@itpcas.ac.cn)
Chenyuan ZHAO[2], State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China
Zhongyu XIONG[3], State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China
Songlin HE[4], State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China
Fan PING[5], State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China
Chao WANG[6], State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources, Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing 100101, China
Alex Farnsworth[7], School of Geographical Sciences, University of Bristol, Bristol BS8 1SS, UK
Robert Spicer[8], School of Environment, Earth and Ecosystem Sciences, the Open University, Milton Keynes MK7 6AA, UK

Abstract

The rise of the Tibet Plateau played a significant role in Asian climate evolution, especially the Southeastern (SE) Tibet which forms the transitional area where the South Asian Monsoon and East Asian Monsoon systems interact. The rise of SE Tibet potentially makes it one of the global biodiversity hotspots. However, the impact of the topographic evolution of SE Tibet on the development from the orbital climate to the Asian monsoon system is still unclear.

We reconstruct the uplift history of the SE Tibet in three Cenozoic basins, including Gonjo, Relu and Markam Basin. These basins are NW- SE trend and narrow, with an elevation of ~4000 m at present. Today the climate in these basins is semi-humid monsoonal with a mean annual air temperature (MAAT) of 5 ℃ and annual precipitation of 600 mm/yr. We found eolian deposits are popularly developed at the bottom of the SE Tibet Cenozoic basins before early Eocene (>50 Ma), especially in the Gonjo and Relu basins. Fluvial and lacustrine strata were deposited in the middle part of Gonjo Basin and the lower part of Relu Basin (50-45 Ma). A large number of lacustrine sediments (45-34 Ma) exists in the middle of the Relu Basin and the top of the Markam Basin. Oxygen and clumped isotopes from the Gonjo Basin suggested an earlier uplift from 0.7 km to 3.8 km during the middle Eocene (Xiong et al., 2020). The CLAMP and clumped isotope results for the Relu Basin in the Yidun Arc indicated a rise in elevation from 0.6 km to 3.7 km between 45 to 34 Ma (He et al., 2022). The Markam Basin remained at a moderate elevation of 2.6 km between 42 to 39 Ma, then rose rapidly to 3.8 km by 36 Ma as indicated by oxygen isotope paleoaltimetry (Zhao et al., 2023). Combined with published paleoelevation results from the Nangqian, Songpan and northwestern Yunnan Basins, the SE Tibet remained lowland until the

early Eocene, and then underwent quickly rise in the middle Eocene, so that all basins had reached or approached their present-day elevations by the latest Eocene of ~35 Ma, forming the high-landform of SE Tibet.
Numerical climate modelling with realistic paleo-landscapes shows that with the raising SE Tibet, a Mediterranean climate developed in SE Tibet and the adjacent southeastern China region characterized by bi-modal precipitation with two peaks during the spring (MAM) and autumn (SON) seasons, and a lower precipitation in the summer (JJA) seasons (He et al., 2022; Chen et al., 2023). Another line of evidence that supports the Mediterranean-like climate comes from the plant fossils. A typical semi-arid or arid flora that includes Palm, Eucalyptus, Palibinia and Quercus shows some similarity to Mediterranean vegetation. This flora co-evolved with the rise of SE Tibet in the Relu and Markam basins, and even dispersed to the southeastern China. The high topographic relief of SE Tibet, coupled with this distinctive Mediterranean climate system, significantly contributes to the development of the high biodiversity of the Hengduan Mountains.

Keyword

Raising SE Tibet, Mediterranean climate, Asian Monsoon, Early Cenozoic, Biodiversity hotspots

Steep oceanic DIC δ13C depth gradient during the Hirnantian Glaciation

Shengchao Yang[1]*, Nanjing University (scyang@smail.nju.edu.cn)
Junxuan Fan[2], Nanjing University
Thomas Algeo[3], University of Cincinnati
Chao Li[4], Chengdu University of Technology

Abstract

The Hirnantian carbon isotopic excursion (HICE) was characterized by a global positive δ13C excursion (up to ~+7‰ in excursion magnitude) during the Ordovician-Silurian (O/S) transition, while its mechanism remains controversial, impeding our understanding of this global event and its environmental significance. Since local and regional δ13Ccarb signatures can be decoupled from global seawater δ13CDIC and cause a bias in carbon cycle reconstructions, basin-scale investigations to fully assess local variations in carbon isotopic signatures are essential to elucidate the mechanism of the HICE, but few such studies have been conducted for the O/S transition.

In this study, we performed a comprehensive analysis of global carbon isotope records, based on 65 paleogeographically widely distributed sections (4,612 carbon isotope data in total), documenting a steep oceanic δ13C water-depth gradient (e.g., a 4.6‰ offset in the HICE excursion in Laurentia and 3.3‰ in South China) during the Hirnantian Stage. We propose a hybrid hypothesis that the HICE records a shift toward more positive values owing to a large glacio-eustatic fall (>100 m) under the herein-identified steep oceanic δ13C water-depth gradient, with potential contributions from global-ocean δ13CDIC changes and authigenic carbonates. This study provides the first large-data evidence for a steep oceanic DIC δ13C water-depth gradient and widely density-stratified ocean during the Hirnantian Glaciation, which has implications for reconstructions of the carbon cycle and ocean circulation during the Early Paleozoic.

Keyword

Ordovician, HICE, carbon cycle, ice age, dissolved inorganic carbon

Modelling the dramatic atmospheric and oceanographic changes during the end-Permian crisis

Yadong Sun[1]*, China University of Geosciences (Wuhan) (yadong.sun@cug.edu.cn)
Alexander Farnsworth[2], University of Bristol
Michael Joachimski[3], GeoZentrum Nordbayern, Friedrich-Alexander University Erlangen-Nürnberg
Paul B Wignall[4], University of Leeds
Leopold Krystyn[5], University of Vienna
David P.G. Bond[6], Univerisity of Hull
Domenico C.G. Ravidà[7], Georg-August-Universität Göttingen
Paul J. Valdes[8], University of Bristol

Abstract

The largest mass extinction in Earth history occurred at the end of the Permian (~252 Ma), and coincided with rapid global warming1, extraordinarily high sea surface temperatures and a perplexing homogenization of low-latitude climates. Voluminous CO2 emissions from Siberian Traps volcanism are widely regarded as the driver of the warming. Over 20 such volcanism-driven hyperthermals punctuate Phanerozoic history, yet only a few coincide with extinctions, and none of which approach the ~90% global species loss of the end-Permian. This raises the question of why the end-Permian world was so sensitive to CO2-degassing and challenges our understanding of climate modulation and Earth system tipping points. In order to understand the enigma of the Phanerozoic's hottest climate, we couple a new temperature proxy dataset with state-of-the-art Earth system model simulations. This reveals major changes in the ocean-climate system: El Niño-Southern Oscillation intensity became much higher than today in both amplitude and duration, and reorganization of atmosphere-ocean circulation caused ocean stagnation and contraction of Hadley cells. We postulate that the elevated climate variability caused extreme warmth and drought severe enough to cause the collapse of terrestrial ecosystems tens of thousands of years before that of marine ecosystems. Initially, plankton changes and the demise of reefs heralded the marine crisis before major extinction losses began. In conclusion, we show that short-term climate fluctuations, which are inter-annual today, can be amplified by extreme greenhouse gas forcing, leading to a cascade of catastrophic terrestrial and marine losses.

Keyword

Permian, Triassic, mass extinction, Siberian Traps, ENSO

How important is palaeogeography in simulating the evolution of the East Asian monsoon?

Alex James Farnsworth[1]*, University of Bristol (alex.farnsworth@bristol.ac.uk)
Paul Valdes[2], University of Bristol
Lin Ding[3], State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources (TPESER), Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China
Robert Spicer[4], The Open University
Zhongyu Xiong[5], State Key Laboratory of Tibetan Plateau Earth System, Environment and Resources (TPESER), Institute of Tibetan Plateau Research, Chinese Academy of Sciences, Beijing, China
Christopher Scotese[6], Northwestern University

Abstract

How and why has the East Asian summer monsoon evolved through time has been a topic of controversy for many decades. Once believed to be a Miocene phenomenon, recent work has been pushing this boundary further back in time. With the increase in computational resources, the use of paleoclimate models is now highly widespread. However, the computational cost of running these models has meant a tradeoff between running long integrations of simulations to ensure an equilibrium climate state versus running many time periods/boundary condition sensitivity studies (e.g. variable carbon dioxide) to assess temporal evolution through geologic time versus running different paleogeographic reconstructions. Here, we investigate the evolution of the East Asian monsoon system using three different paleogeographic reconstructions (Getech Plc, Roberstons Plc and Scotese) through the Cretaceous to the Modern (145 Ma – 0 Ma) where the mean climate state has reached equilibrium and compare with a compilation of proxy data. Further, a problem with many legacy as well as contemporary paleoclimate models is the inability to capture higher latitude warmth as reconstructed by various paleo-proxies. Using an improved version of HadCM3/L we analyse the impact of improved model physics that better captures higher latitude warmth and its impact on the East Asian Monsoon evolution.

Keyword

Monsoon, Paleogeography, Paleoclimate model, Moutains, carbon dioxide

The first Cretaceous dinosaur fossil assemblage in Southwest China

Hui DAI[1]*, Chongqing Key Laboratory of Paleontology and Paleoenvironment Co-evolution (Sichuan-Chongqing Joint Construction), China (dhui6251@qq.com)
Qingyu Ma[2], Chongqing Key Laboratory of Paleontology and Paleoenvironment Co-evolution (Sichuan-Chongqing Joint Construction), China
Yu Lin[3], Chongqing Key Laboratory of Paleontology and Paleoenvironment Co-evolution (Sichuan-Chongqing Joint Construction), China
Ming Xiao[4], Chongqing Key Laboratory of Paleontology and Paleoenvironment Co-evolution (Sichuan-Chongqing Joint Construction), China
Jian Yi[5], Chongqing Key Laboratory of Paleontology and Paleoenvironment Co-evolution (Sichuan-Chongqing Joint Construction), China

Abstract

The main dinosaur fauna of the Cretaceous period in China include the Early Cretaceous Psittacosaurus Fauna and the Late Cretaceous Hadrosaurus Fauna, primarily distributed in the northern and eastern regions. Cretaceous dinosaur fossils distribution in the southwest is extremely limited, which sharply contrasts with the abundant discoveries of Jurassic dinosaur fossils in the southwestern region of China. In recent years, a dinosaur fossil assemblage has been discovered in Zhengyang, Qianjiang, Chongqing. Through surveys conducted from 2022 to 2023, it has been confirmed that the distribution range of this fossil assemblage is 6.2 square kilometers, and the fossils are mainly found in the upper section of the Upper Cretaceous Zhengyang Formation. This is the only newly discovered Cretaceous dinosaur fossil assemblage in southwest China.The fossil group has a wide distribution range, abundant fossil quantities, and diverse species. The dinosaur groups mainly include sauropods, hadrosaurs, tyrannosaurs, and ceratopsians, with sauropods and hadrosaurs comprising the vast majority. Preliminary studies of skeletal morphology indicate that both sauropods and hadrosaurs in the Zhengyang area belong to new taxa. The rich dinosaur fossil resources in Qianjiang can fill the research gap in Cretaceous dinosaur fossils in southwest China and are of great significance for exploring the evolution of Cretaceous dinosaurs and the changes in the Earth's environment.

Keyword

Dinosaur Fauna, Cretaceous, Zhengyang, Southwest China, Dinosaur Fossil Assemblage

Dinosaur distribution under long-term climate changes

Qi Cui[1]*, Peking University (cyu@amnh.org)
Qi Cui[2], Peking University
Yihui Chen[3], Peking University

Abstract

Climate plays a pivotal role in shaping organism geographic distribution. Dinosaurs were the major terrestrial animals in the Mesozoic terrestrial ecosystems, which had achieved global distribution, both gigantic and miniaturized body sizes, and acquired a suite of ecological niches. Previous studies posited temperature as a principal factor controlling the distribution of dinosaurs, especially sauropods, but this hypothesis incompletely explains the variance at finer taxonomic resolutions. The role of other factors, such as the monsoon system, has been insufficiently considered. Here, based on a state-of-the-art earth system simulation model and global dinosaur fossil occurrences, we analyse long-term climatic influences on dinosaur distribution through the Mesozoic. Our results corroborate previous hypothesis that different lineages had distinct temperature preferences and tolerances. However, strong overlapping has been observed in the climate-space, which features temperature and precipitation. The monsoon systems emerged as critical in delineating dinosaur geographic distributions. Sauropodomorpha and Ornithischia had a strong preference for monsoon zones in the tropics, while this tendency is less pronounced outside the tropics. Our results show the complicated role of climate in shaping dinosaur distribution and the previously hidden climatic adaptabilities across different subgroups. The integration of large-scale sampled data with earth system models provides a robust tool for data-driven paleontological studies.

Keyword

Dinosaur, Climate, Simulation, Paleobiogeography

[Invited] Mass extinctions make way for metabolic makeovers: the rise of dinosaurs and the avian metabolism

Jasmina WIEMANN[1]*, Earth & Planetary Science, Johns Hopkins University
(jwiemann@fieldmuseum.org)

Abstract

Birds have the highest metabolic rates in the animal kingdom and are thus capable of physiological thermoregulation (endothermy). They generate heat as a by-product of mitochondrial respiration. The closest living relatives of modern birds are represented by the crocodile lineage which is characterized by reduced metabolic capacities, resulting in ectothermy. Due to the lack of a metabolic proxy integrable across extant and extinct taxa, it has been speculated that birds are the only clade of dinosaurs surviving into the present because of their uniquely high metabolic performance. Metabolic endothermy is thought to represent a major selective advantage in surviving the environmental and ecological perturbations associated with the Cretaceous-Paleogene (K/Pg) mass extinction event.

Here, I present a novel molecular metabolic marker detectable in modern and fossil skeletal tissues via non-destructive vibrational spectroscopy: systematic analysis (500-3000 cm-1, 10 replicates) of >80 modern and fossil amniote long bones, demonstrated that the quantity of metabolic lipoxidation markers, byproducts of aerobic respiration, correlates (r=0.87) directly to the metabolic rate. The effect of fossilization is empirically captured, modelled in vitro and in silico, and corrected, allowing for the integration of metabolic signals in extant and extinct taxa: tracing the evolution of the avian metabolism across a time-scaled consensus phylogeny allowed for the comparison of trends in the emergence of endothermy and its downstream manifestation in bone-microstructure and morphology. We constrained the evolutionary onset of avian-style metabolic endothermy to their ornithodiran (possibly archosauromorph) ancestor, refuting exceptional metabolic rates as a selective advantage of the avian clade during the K/Pg mass extinction event. Rather than representing a trait of resistance, metabolic endothermy appears to embody a trait of resilience, as it independently evolved along avian, mammalian, and marine reptile stem groups immediately after the Permo-Triassic (P/T) mass extinction event.

We find a significant positive correlation between the observed independent evolutionary origins of metabolic endothermy and niche space availability after the P/T mass extinction, and discuss the impact of ecological versus environmental variables on the selection toward increased metabolic fitness.

Keyword

Dinosaurs, Metabolism, Macroevolution, Mass extinction, Endothermy

The Digital Transformation of Geological Data in Cambodia

KEAT LENARITH[1]*, Ministry of Mines and Energy (keatlenarith@gmail.com)
MEAS PANHA[2], Ministry of Mines and Energy

Abstract

The digitization of geological and mineral data, coupled with research papers, brings about a major change in Cambodia's scientific scene, shifting from paper records to electronic databases. This transformation also demonstrates the commitment of Cambodia to developing digital infrastructure by lending important digital data to international scientific platforms, including AMDIS, GSi Portal, GSi WebGIS, and the GeoSample Data Repository project supported by KIGAM. Cambodia is bringing about a digital ecology and scientific robustness through programs such as streamlining the mining registrar system platform and the Khmer lexicon of geosciences in support of AMTG. Led by the Department of Geology and Minerals, Cambodia is promoting open science for geoscience that brings positive changes on a global scale.

In this digital revolution, Cambodia has proven to be a farsighted country by joining international platforms and establishing its own independent sharing platform. The conceptual center of geology functions as a merging scientific database to share comprehensive Cambodian geology and mineral data that provide an economic and propagating global knowledge bank. Utilizing advanced digital data management tools can significantly enhance Cambodia's earth sciences field, leading to tangible benefits and professional advancements. Embracing technology plays a pivotal role in progressing in this area and enjoying its advantages.

Investing in technology goes beyond just making changes; it's a strategic move towards sustainability for Cambodia. The country values cooperation and sees working with the international community as crucial. Overcoming challenges like data sharing and integrating new technology will follow the standards set by the DDE initiative. By collaborating with experts from around the world, Cambodia aims for success, speeding up scientific progress and working towards sustainable development.

Keyword

Cambodia, Transformation, Papper-based, Digitization, Lexicon of Geosciences

[Keynote] Data and model-driven paleogeographic research: some recent progress

Haipeng LI[1]*, Deep-time Digital Earth Research Center of Excellence (haipeng.geo@gmail.com)
Shuyan Xu[2], Zhejiang University
Han Cheng[3], Deep-time Digital Earth Research Center of Excellence (Suzhou)
Luoqi Wang[4], Zhejiang University
Yishuai Wang[5], Elemental Particles
James Ogg[6], Deep-time Digital Earth Research Center of Excellence (Suzhou)
Christopher Scotese[7], Northwestern University
Shanan Peters[8], University of Wisconsin - Madison
Sabin Zahirovic[9], The University of Sydney
Linshu Hu[10], Zhejiang University
Mingcai Hou[11], Chengdu University of Technology

Abstract

Paleogeography, pivotal for research from paleoclimate modeling to resource exploration, faces challenges in data availability and accessibility due to the fragmented nature and long-tail distribution of deep-time data. Additionally, complex workflows and the decoupling between reconstructions and their underlying data impede the efficient quality assessment and the updating of paleogeographic maps.

This study aims to address these issues through global collaboration within the framework of the IUGS Deep-time Digital Earth program. By implementing a mediated schema, we have successfully interlinked key stratigraphic and paleobiology databases, such as Macrostrat, PBDB, GeoLexicon, and Boucot's climate-sensitive lithology database. This linkage has greatly improved the accessibility of paleogeographic data, facilitating seamless cross-database queries.

Furthermore, we have integrated GPlates into the Unity engine to facilitate web-based visualization of deep-time geological data. This advancement allows for the dynamic rotation and rendering of extensive data points directly in a web browser. Moreover, by leveraging large language models with retrieval augmented generation and prompt engineering, we have achieved preliminary automated interpretations of sedimentary environments that are verifiable and less prone to interpretive bias.

Our research then extends into data-driven paleogeographic reconstruction, where we have successfully refined global paleo-coastlines using fossil evidence, and delineated climatic zones with climate-sensitive sediment data. These efforts significantly enhance the efficiency of paleogeographic reconstructions and establish a solid foundation for quality assessments and automated updates of paleogeographic maps, paving the way for future advancements in deep-time geological research.

Keyword

database interlink, GPlates, large language models, paleogeography

One-step Database Construction Based on Knowledge System: A Practice with the Example of DDE OnePetrology Database

DING YI[1]*, Institute of geology, chinese academy of geosciences (dingyi@cags.ac.cn)
Tao Wang[2], 1. Institute of Geology, CAGS, Beijing 100037, China 2. SinoProbe Laboratory, CAGS, Beijing, 100094, China
He Huang[3], SinoProbe Laboratory, CAGS, Beijing, 100094, China
Chaoyang Wang[4], SinoProbe Laboratory, CAGS, Beijing, 100094, China
Jianjun Zhang[5], jianjunzhang@live.cn
Lei Guo[6], SinoProbe Laboratory, CAGS, Beijing, 100094, China
Ying Tong[7], SinoProbe Laboratory, CAGS, Beijing, 100094, China

Abstract

Data-intensive scientific discovery is a new paradigm in the era of big data, and databases are an essential tool for accumulating data and conducting quantitative research in scientific work. However, researchers often lack the professional skills to build databases, failing to leverage the advantages of rapidly advancing IT technologies. The core issues are concentrated in: 1) Data structures need to change frequently as research progresses, which poses a significant challenge to traditional relational databases; 2) Researchers' deep understanding of domain knowledge cannot be effectively communicated to IT personnel, and IT personnel are unclear about how to apply new IT technologies in domain research, leading to communication gaps and difficulties in collaboration; 3) Earth science databases require spatial concepts and spatial analysis capabilities, which are further enhanced features of traditional relational databases. The DDE OnePetrology team, based on the concept of "data-graph-text" integration, has developed a one-stop database construction software system with the knowledge system at its core. Through this software system, researchers can easily edit their own knowledge trees, flexibly express domain knowledge, and the system converts the knowledge tree into Excel templates. By collecting and organizing data through the Excel templates and importing them into the system, the database construction is completed. As scientific research progresses, the knowledge tree can be adjusted flexibly, fully meeting the needs of scientific work to keep pace with the times. At the same time, researchers can fully utilize the big data filtering (spatial/attribute filtering), map analysis, and other functions provided by the software system, which perfectly solving the aforementioned problems encountered in library construction by researchers.

Keyword

DDE, OnePetrology, One-step database onstruction, Data-intensive, Knowledge System

Digital geological maps on the Global Layer platform

YANG SONG[1]*, Chinese Academy of Geological Sciences (sheep7878@163.com)
Yan Yang[2], Chinese Academy of Geological Sciences
Zhenhan Wu[3], Chinese Academy of Geological Sciences
Manuel Pubellier[4], Ecole Normale Supérieure

Abstract

On the DDE-Global Layer platform, we showcase a globally significant geological map that has been imbued with a renewed purpose. The world geological map at scale 1:5 MThe World 5M, available on this platform, presents an abundance of geological attributes, ranging from chronostratigraphic polygons and fault lines to seafloor ages and structures. Members of the public can easily engage in functions such as retrieval, browsing, viewing, and image generation at different scales, thereby effectively encompassing the entire workflow within the platform. During the project's implementation phase, to ensure the smooth presentation of this work compilation by international Earth Science experts, we conducted a comprehensive data exploration on the DDE platform. This entailed tracing the origins of global geographic data and acquiring additional geological maps and databases to supplement and enhance the geological and geophysical datasets, particularly for islands, located in the oceanic domains. This not only reduced a significant amount of vectorization work but also ensured data integrity and accuracy.

Notably, the Global Layer platform offers diverse options for visual presentation, including providing visual solutions for both raster and vector tiles. Real-time online rendering of geological maps was achieved through accurate symbology definition. As a result, DDE users can swiftly export unique geological maps using template-based operations and conduct online attribute information queries. This not only helps Earth science researchers with more precise data support to comprehensively comprehend Earth's dynamic processes but also catalyzes advancements in scientific research and outreach to the younger generations and various stakeholders. Concurrently, as the DDE platform propagates the dissemination of digital geological maps, it is poised to augment the geographic and geological knowledge of the general public and raise environmental awareness. This contribution holds significant implications for driving societal progress. Through the visual dissemination of the World 5M, it empowers the entire DDE community and its users to readily embrace the future of geographic spatial analysis, unlocking the concealed treasures embedded within the world's geological heritage.

Keyword

Global Layer platform, The World 5M, Databases, Visual presentation

The need for Open Multidisciplinary Geodatabases in Earth Sciences: from the World 5M to Basement Geology and Water Circulation

Benjamin SAUTTER[1]*, UBS (benjamin.sautter@univ-ubs.fr)
Yang Song[2], Chinese Academy of Geological Sciences, 26 Baiwanzhuang Road, Beijing, 100037, China
Manuel Pubellier[3], CNRS-UMR8538, ENS – PSL University, Paris – France
David Menier[4], Geo-Ocean UMR CNRS 6538, Université Bretagne Sud, 56017 Vannes Cedex, France

Abstract

The International Union of Geological Sciences (IUGS) initiated the Digital Data Exchange (DDE) program with the objective of disseminating geoscience knowledge and data openly to the global community. One of the initial projects within this initiative was the development of the World 5M, the Geological Map of the World at scale 1:5M. While such maps have been created at various scales in the past, achieving global harmonization has historically presented challenges. Utilizing advancements in computing capabilities and communication technologies, the collaboration between the DDE, the Commission for the Geological Map of the World (CGMW), and the Chinese Academy of Geological Sciences (CAGS) culminated in a significant breakthrough with the production of the World 5M. Notable features of this map include seamless layers, standardized attributes, rectified continental boundaries, and a comprehensive digitization of mid-oceanic ridges.

The World 5M geological map now serves as the fundamental framework for global geological studies, marking a critical milestone in the field. As the need for comprehensive geological data intensifies, there arises a demand for the incorporation of additional datasets into this compilation. Geological maps traditionally focus on surface rock formations, posing challenges in extrapolating subsurface information without access to depth profiles and well data, which are often not available.

In prevailing economic and environmental concerns, there exists an urgent need for a synthesis of basement structures and associated resources. The scarcity and degradation of potable water highlight the importance of exploring basement aquifers, requiring innovative techniques to characterize the complex geometries and properties of these heterogeneous reservoirs, along with their associated environmental and anthropogenic stresses.

In Brittany, where redundant studies have been conducted over time at local scale, without proper follow-up by changing elected governments and water management professionals, such kind of synthesis is crucial. In this French coastal region, where groundwater is essentially stored in fractured basement aquifers, a collaboration on the perturbations of the water cycle is bringing together the local government, professionals of water management and the university, sharing knowledge and data. The creation of a multidisciplinary database encompassing diverse datasets such as geoscience maps, field data, water properties monitoring data, natural vs man-made conduits for water flow, among others, allow for a better understanding of the stresses acting on

water quality and resources in the region. Similarly to geological maps being created from local scale field observations, and being synthetized at regional, national and international scale, the datasets of the collaboration mentioned above are being compiled at local scale, and the synthesis shall be integrated in multi-scale synthesis to promote and correlate similar initiatives in a DPSIR framework.

By providing such kind of synthesis to all, DDE contributes to centralizing access to data, thereby mitigating the heavy carbon footprint associated with duplicated data. Facilitating joint access to these datasets through widely used internet browsers will progressively enhance this effect. It is imperative to enhance collaboration and expand datasets and models collectively to avoid redundant work and datasets. Let’s unite efforts and embrace the DDE initiative.

Keyword

Multidisciplinary Database, Geological Map, Collaboration, Water, Basement

Global Layer and Geological Map of the World at a scale 1/5M

Xingchen YANG[1]*, Institute of Geomechanics, Chinese Academy of Geological Sciences
(530884521@qq.com)

Abstract

In the current stage of scientific research, it is necessary to break the barriers between traditional disciplines and promote the cross integration of various related disciplines. As one of the important carriers of research achievements of various disciplines, maps can be superimposed and integrated to more intuitively display the results of multidisciplinary integration, promote the integration of disciplines and discover new scientific problems. Traditional geological mapping is often based on different scales for single scale mapping, aiming at the mapping mode of paper printing results. It is difficult to read maps between different scales at the same time. To solve this probleman integrated platform named Global Layer is being built under the support of Deep-time Digital Earth (DDE). Global Layer is embedded with several core databases such as Geological Map of the World at a scale 1/5M, Global Geothermal Database etc. These databases presented in form of electronic map which enables the results of different scales to be displayed and browsed through one-stop hierarchical promotion. In addition, Users can also upload data in four ways: local file, database connection, cloud file and arcgis data service, and data or maping results can be shared to Facebook, Twitter and other platforms in the form of links, widgets, etc. Construction of Global Layer could provide experience and foundation for integrating global databases related to geological map and constructing data platforms.

Keyword

Global Layer, Geological Map, platform

Georjuridicality: law, forensics and the Anthropocene

Alexander DAMIANOS[1]*, University of Kent, Kent Law School (a.damianos@kent.ac.uk)

Abstract

The Anthropocene presents a paradox: it suggests that human activity is so intense as to have fundamentally changed the material constitution of the planet; a geological event on par with the extinction of dinosaurs, or the end of the last ice age. Yet it also confirms human finitude. It implies that humanity is simply a passing event, and that one day the planet will go on without us, albeit substantially altered by our lapsed presence. In this paper, I provide an outline of how a political assertion of this kind is uttered in the register of a hypothesized geo-scientific fact. I argue that the effort to formalise the Anthropocene as a geological unit unfolds as a techno-juridical exercise. Geologists generate new categories of artefacts, such as the technofossil, which furnish new species of 'geo-witnesses', in order to illicit accounts of human finitude and planetary dynamics from mundane artefacts of every-day life (the plastic bottle, the bones of genetically engineered chickens, the concrete foundations of buildings and transportation networks). They draw on the formalisation strategy of previous geological units as precedent, according to which they structure their account of the Anthropocene, so as to encourage consensus within the geoscientific community (the jury). They engage a formal decision making procedure, submitting their proposal for an Anthropocene unit to the judgement of their peers. What can law learn from an account of geo-science as a techno-juridical exercise? How can attempts to reassure ourselves that law has something to contribute in response to ongoing ecological devastation be expanded by an account of geo-science as juridical technique? Although I may not fully answer these questions, my ethnographic account of the Anthropocene Working Group's ongoing formalisation effort seeks to open a dialogue between disciplines in the face of earthly finitude. Ultimately, I ask whether the Anthropocene unfolds as a geo-judicial review of the administration of geological time and space itself.

Keyword

forensics, juridicality, witness testimony, precedent, Anthropocene

Soils and Sciences in the Anthropocene: Historiographic Considerations

Robert M. BRAIN[1]*, University of British Columbia (rbrain@mail.ubc.ca)

Abstract

Soils and Sciences in the Anthropocene: Historiographic Considerations

Soil exists at the centre of what geologists have called “the critical zone”: the porous living layer that bridges rock and sky, and underpins all terrestrial life. Because of its unique position in the biosphere, soil is a key variable of the Anthropocene crisis of threatened planetary boundaries. The recognized existential cornerstones for the sustainable development of human societies (Food Security, Water Security, Energy Security, Climate Change Abatement, Biodiversity Protection, Ecosystems Service Delivery) have threatened status. Soil is related to each of them and, despite two centuries of scientific research, remains probably the least understood of nature’s eco-systems and increasingly the most degraded. This paper explores how the history of soils and soil science might address this crisis. From the late 18th century, when soil was first conceived as a natural body worthy of its own scientific investigation, pedology explored soil as a system developed from a complex of natural processes. Classics by Dokuchev (1883), Darwin (1881), and Hilgard (1906) identified the five so-called “soil forming factors” (parent material, time, climate, topography, and organisms) as long-term processes that made soils. Yet in recent decades soil scientists have come to recognize that in the contemporary world each of these factors are significantly altered by anthropogenic impacts. Soils do not preexist the mundane practices in which humans interact with them, but are formed within these very practices. This entails an ontological approach to soils as human-made rather than found as an object of scientific practice. An Anthropocene historiography of soil science thus moves beyond disciplinary history to consider soils as a relational materiality formed in tandem with the histories of human-built infrastructures, waste production systems, agricultural practices, land use, and population patterns.

Keyword

soil, soil science, planetary boundaries, Anthropocene, Dokuchev

Anthropocene scepticism?

Michael WAGREICH[1]*, University of Vienna (michael.wagreich@univie.ac.at)
Diana Hatzenbühler[2], University of Vienna
Eva Horn[3], University of Vienna
Robert Braun[4], Institute for Advanced Studies, Vienna
Colin N. Waters[5], University of Leicester

Abstract

The Anthropocene Working Group (AWG) of the Subcommission on Quaternary Stratigraphy (SQS) of the International Commission on Stratigraphy (ICS) was founded in 2009 to investigate the potential of the Anthropocene as a chronostratigraphic unit of the Geological Time Scale. After more than 14 years of work, many key publications and fierce discussions both within and outside the AWG, and several rounds of voting, the AWG concluded by great majority that the Anthropocene concept of Crutzen (2002) has stratigraphic reality and that a formal GSSP definition is pragmatic and suitable at the mid-twentieth century, coincident with the Great Acceleration of Earth System Sciences. The resulting GSSP proposal is located in Crawford Lake (Canada) sediment core with the base of the Anthropocene marked by an upturn in plutonium coincident with autumn 1952. However, during the years of AWG investigations, criticisms from outside and a minority group within the AWG opposed to the majority consensus and published results of the AWG (see Zalasiewicz et al., in press) have undermined the significance, importance and usefulness of the Anthropocene as a (chrono)stratigraphic unit. Nevertheless, beyond its debated geological implications and in its wider interdisciplinary and popular context, the term has evolved into a symbol emblematic of global change, and the current climate and ecological crises. An argument of prominent critics is that the AWG is politically and not scientifically motivated when dealing with the Anthropocene. Despite the AWG following established ICS protocols and procedures for stratigraphic working groups and founding their conclusions transparently on a wealth of published geological data (e.g. Waters et al., 2016, 2023; Zalasiewicz et al., 2017), a political dimension is implicitly imposed on both, the Anthropocene supporters but also at the Anthropocene sceptics. Anthropocene scepticism maybe conceptualised as a form of agnotology (Proctor 2008) akin to the use and misuse of science to support climate scepticism (Oreskes 2019). To what extent would rejection of the Anthropocene proposal by the geological community be interpreted outside of the geosciences as a rejection of the scale of the current global crises and a step towards "business as usual"? AWG research into the Anthropocene has resulted in transparency, awareness and engagement of involved scientists in a crisis for which geology has some liability, resulting in a wider interest of the humanities, media and arts on the stratigraphic work of the AWG. Hence, one may interpret geological research in the Anthropocene as a great and timely societal and interdisciplinary mission for the geosciences, leading to a sustainable geological discipline emerging out of its historical linkage with the fossil energy sector.

Keyword

Anthropocene, agnotology, scepticism, geopolitics

Why the concept of the Great Acceleration is crucial to defining the Anthropocene

Francine M.G. McCarthy[1]*, Brock University (fmccarthy@brocku.ca)
Julia Adeney Thomas[2], University of Notre Dame
Jan A. Zalasiewicz[3], University of Leicester
Colin N. Waters[4], University of Leicester
Martin J. Head[5], Brock University
Mark Williams[6], University of Leicester
Simon D. Turner[7], University College London

Abstract

The conception of Earth as an evolving system in which humans have become a critical component is central to Paul Crutzen's assertion that we are no longer living in a Holocene world. The new world of the Anthropocene is marked by the precipitous rise of human domination and alteration of the Earth System, pushing it beyond Holocene norms. The Anthropocene Working Group, charged with the mission of discovering whether there was 'stratigraphic reality' to this concept, identified a clear, globally synchronous signature of humans "overwhelming the great forces of nature" in the mid-20th century. The proposed GSSP, at the base of the organic lamina that accumulated on the lakebed during fall turnover in Crawford Lake in 1952 CE, clearly illustrates this point. Indigenous agriculture from the late 13th through 15th centuries altered the lake chemistry sufficiently to allow varved sediments to accumulate in the deep basin of this meromictic lake, and the lumber mill that operated on its shore for several decades in the late 19th century further altered the lake's biogeochemical cycles – but these are inherently local signals. It is the sudden appearance of markers of the Great Acceleration that records the planetary-scale impact of the rapid increase in human population now reliant on fossil fuels for everything from chemical fertilizers to plastic, not only in the varved sediments of Crawford Lake but also at proposed auxiliary sections and in numerous other geologic archives around the world. It is important to engage the humanities and social science in understanding what it means in social, economic, political, and cultural terms that the well-intentioned goal of reducing hunger and disease through 20th century innovations was at a cost to future inhabitants of this planet: human and non-human. Erecting an epoch of the Cenozoic Era with ἄνθρωπος (Anthropos) as a prefix may help formulate the policies needed to minimize the hardships projected to result from the irreversible changes to the atmosphere that are quickly impacting on the hydrosphere, cryosphere, and biosphere, and are being recorded in the geosphere.

Keyword

Earth System, GSSP, Crawford Lake, Anthropos, policy

Climate change revealed by the sedimentary record of the Pearl River Estuary and its implications for the Anthropocene

Jianfang HU[1]*, Guangzhou Institute of Geochemistry (hujf@gig.ac.cn)
Lihui Wang[2], Guangzhou Institute of Geochemistry
Bingyan Zhao[3], Guangzhou Institute of Geochemistry

Abstract

The annual and winter sea surface temperatures (SST) in sediment Core S26 taken from the Pearl River Estuary were reconstructed using long-chain alkyl diols and GDGT-TEX86 proxy. The reconstructed results reveal that in the study area, the winter SST experienced a more pronounced increase compared to the annual average SST after 1900. This phenomenon is attributed to the joint impact of anthropogenic aerosol pollution and El Niño phases, which have contributed to the amplification of winter SST since 1900. The Pearl River Estuary has experienced a substantial rise in annual average SST since around 1950, primarily as a consequence of the significant increase in greenhouse gas emissions resulting from human activities, thereby exacerbating global warming. Hence, the disparities in the precise timing of the rise in annual average SST and winter SST might potentially indicate the gradual influence of human activities on climate change in the Pearl River Estuary.

After 1950s, the TOC (Total Organic Carbon) content in Core S26 also exhibited an increasing trend, accompanied by a corresponding negative deviation in δ13Corg. This indicates that the increase in sedimentary TOC during this period was primarily due to an enhanced input of terrestrial organic matter. Meanwhile, the Pearl River Estuary area experienced an increase in fossil fuel consumption and/or intensified soil erosion due to human activities after the1950s. Therefore, the intensified soil erosion caused by anthropogenic activities after the 1950s, has led to the increased input of terrestrial organic matter into the Pearl River Estuary.

Therefore, since 1950, human activities have become the primary factor influencing the climate/environment in the Pearl River Estuary. As a result, sediment records in the Pearl River Estuary indicate that the year 1950 is more suitable as a boundary for the Anthropocene - the epoch defined by significant human impact on the Earth’s ecosystems.

Keyword

Sea surface temperature, molecular biomarker, climate change

The Historiography of the Earth and 'Anthropocene': Regional Geo-history and Possible Worlds in the Steno-Leibniz Process

Toshihiro YAMADA[1]*, Taisho University (tosmak-yamada@muf.biglobe.ne.jp)

Abstract

While the 'Anthropocene' issue is going to be solved in a way of stratigraphy proper, we now seem to be facing with a 'historiographical' problem on the other hand. When we consult Steno's illustration of the six-stage procedure of regional geography developed from the sedimentological or crystallographic analysis and synthesis in his Prodromus (1669), we certainly recognize a description of regional geo-history in the Earth history, which then represented the universal history including Bible history. Leibniz adopted Steno's principles of 'solids within solids' to construct his whole Earth history in Prototogaea (c.1691/ 1749), in which three epochs were segmented: 'incunabula', the world of 'solids within solids', and human history. In the age of incunabular Earth, melting glass made an enormous round planet and gradually cooled down to the primitive Cartesian 'terra'. Secondary, Leibniz followed Steno's method of fossil analysis to reconstruct regional geo-history, which summary may be called geological times. And lastly, natural geo-history is complimented with human history. Namely, as a historian, Leibniz distinguished three dimensions of history in the Earth history. In this process from Steno to Leibniz, histories of sacred, secular, and nature were shaken and being reorganized. For example, Steno's friend and Leibniz's acquaintance Spinoza apparently introduced a concept of 'history of nature' by his Bible text critique while Steno introduced it by his principle of 'solids within solids'. Steno, at the same time, consider the sacred history compensated with natural history. Moreover, Leibniz philosophically and theologically mediated plurality of the world in a Cartesian sense in his Essais de Théodicée of 1710. If we redefine the third epoch of Leibniz's as 'Anthropocene', what kind of historiographical problem should we solve?

Keyword

Nicolaus Steno, Gottfried Leibniz, history of nature, Anthropocene, historiography

EARLY-MODERN VISIONS OF THE « EARTH SYSTEM » LEIBNIZ, TELLIAMED, HUTTON

Claudine COHEN[1]*, EHESS (cohen@ehess.fr)
Claudine Cohen[2], EHESS

Abstract

The vision of the Earth as a wandering planet, subject to the sole determination of its physical causes, emerged in whole Europe during the XVIIth Century among post-Galilean naturalists and physicists. Starting with Descartes's Principia books III and IV (1644) , and well into the 18th Century, a number of "Earth Theories" cultivated a new way of looking at the formation of the Earth, its transformations and its present aspect. Beyond their claimed attachment to the literacy of the Biblical narrative, these attempts aimed at finding keys to a self sufficient system. Descartes' physics of whorls, Leibniz's alternance of water and fire, Telliamed's "system" of the diminishing sea, or Huttons' vision of the Earth as a heat engine animating cyclic transformations through the action of an inner fire, were attempts at pointing out the definite causes of the Earth's history. These elaborations have often been neglected as constituting an inconsistent "prehistory" to more recent scientific elaborations.

Indeed in contrast with XIXth century scientific geology definitely focused on exploring and theorizing singular process such as volcanoes, glaciers, sedimentation, erosion, etc, the forgotten "genre" of Early-Modern Earth Theories can still be of interest for us today. Taking examples from some of these treatises, I will show how their various attempts at viewing the Earth as a totality, opened new question on life and its origin, on environnemental changes and on the relationships of Man with Nature. I will argue that these texts can be reread today with interest, in the light of the notion of the "Earth System" which conceptualizes the interactions of geosphere, biosphere, cryosphere, hydrosphere, and atmosphere, and constitutes a basis for thinking about the Anthropocene.

References :

R. Descartes, Principia philosophiae [1644], Principles of Philosophy, transl. by V. R. Miller & R.P. Miller, Kluwer, 1982

J. Hutton, Theory of the Earth, 1788

G. W. Leibniz's Protogaea, ed. and transl. by Claudine Cohen & André Wakefield eds. Chicago, 2008

B. de Maillet, Telliamed, Entretien d'un philosophe indien avec un missionnaire français sur la diminution de la mer, Claudine Cohen, ed. Grenoble, J. Millon, 2023

Keyword

Early Modern Earth Theories, Earth System, G.W. Leibniz's Protogaea, B. de Maillet Telliamed, J. Hutton

The Anthropocene, Crawford Lake and Human-Geological Interactions

Ernst HAMM[1]*, York University (ehamm@yorku.ca)

Abstract

The history of geology can be conceived of as geohistory, the idea that knowledge of the earth's crust is a fundamentally historical science concerned with temporal processes on a scale that bursts the limits of human history, or as geodynamics, the consideration of the causes that forged earth's crust to form mountains and continents, operating on a scale that dwarfs human action (Taylor 2016). Whatever shortcomings befall such grand narratives, it is remarkable how much of the history of geoscience they do encompass. It is also striking how awkwardly the Anthropocene epoch fits such schemes. The varves or sediments of Crawford Lake, the proposed "golden spike" marking the onset of the Anthropocene, are unquestionably historical depositions, just as nuclear weapons testing is the cause of plutonium-239 traces in the varves. However, that cause is not based on a reconstruction of the geological record, it is a confirmation of what is already known from the historical record; likewise, the record in the varves is not needed to know when humans began nuclear testing. That said, pollen analysis of the varves has yielded profoundly important evidence for reconstructing fifteenth-century Iroquaian agriculture and longhouse villages at Crawford Lake, though this considerably predates the proposed Anthropocene epoch (McCarthy 2022). Even small changes in the varves can be a trace of human activity of great consequence. They are an indicator that human activity is changing the Earth system, but they do not show that we are controlling that change. In that sense, at least, the Anthropocene epoch and its record preserved in Crawford Lake is enormously important, a geological symbol of largely unchecked human ambition. It is also noteworthy that there is a very distinguished pedigree for interactions between the human and geological record. Of these, the most well-known must be the columns of the so-called Serapis Temple, marked by a band of boreholes of marine lithophaga mussels, that adorn the frontispiece of Charles Lyell's Principles of Geology (1830-1833). These columns were a beautiful and powerful illustration of the principles Lyell claimed to be founding. Lyell was also keenly aware of the symbolic appeal that a reference to classical antiquity would have for his campaign to make geology a prestigious science. The Anthropocene epoch is not about establishing the prestige of the geosciences, but it is very much about demonstrating their relevance in a time of precarious, global environmental change. The simple and jewel-like beauty of Crawford Lake is a powerful symbol of the need for change in the way humans interact with the environment, and the record of the varves is a sobering reminder of the need for humility after so much hubris.

Taylor, K (2016) An Empire of Water, Islands of Fire: Perspectives on 18th-Century Geology, INHIGEO keynote address, IGC Cape Town

McCarthy F (2022) Stratigraphy: Finding Global Markers in a Small Canadian Lake. In Thomas JA, Altered Earth, Cambridge, pp 196-108

Keyword

Anthropocene, Crawford Lake, Geohistory

[Keynote] The decision in favor of the Anthropocene

Juergen RENN[1]*, Max Planck Institute of Geoanthropology (renn@gea.mpg.de)

Abstract

Although the Subcommission on Quaternary Stratigraphy of the International Union of Geological Sciences recently voted against the Anthropocene becoming an official geological epoch, it is clear that we live at a point in history when the Earth system cannot be understood without reference to human social, economic, and political systems and behaviors. But what exactly depends on the decision for the Anthropocene, and what does it concern us outside of geology? In my talk, I will argue that a decision for the Anthropocene concerns all of humanity and that it matters on how this decision is understood and what conclusions are drawn from it. The talk emphasizes the co-evolutionary dimension of the underlying Earth System processes that have led to an intensification of our species' involvement in planetary dynamics. The Anthropocene as humanity’s self-reflection on its position in nature is nothing new in itself. Such positionings have accompanied human history since its beginnings and are part of a self-analytical process that we refer to here as species reflection. A further aim of the talk is therefore to use the history of species reflection as a resource for the current discussion and to motivate the decision for the Anthropocene from this history.

Keyword

Anthropocene, AWG, Earth system

Impacts of plastic-rich sediments on the geological processes: A numerical investigation

Eun Young Lee[1]*, Department of Geology, University of Vienna, Vienna, Austria (eun.lee@univie.ac.at)
Veronika Koukal[2], Department of Geology, University of Vienna, Vienna, Austria
Érika Cristina Nesta Silva[3], Universidade Estadual de Campinas (UNICAMP), Geoscience Institute, Campinas, SP, Brazil
Zhongxian Zhao[4], CAS Key Laboratory of Ocean and Marginal Sea Geology, South China Sea Institute of Oceanology, Chinese Academy of Sciences, Guangzhou, China
Michael Wagreich[5], Department of Geology, University of Vienna, Vienna, Austria
Tae Soo Chang[6], Faculty of Earth and Environmental Sciences, Chonnam National University, Gwangju, Republic of Korea

Abstract

Plastic litter and particles have become pervasive in terrestrial and marine environments worldwide, as a consequence of a surge in global production and mismanagement practices since the mid-20th century. The widespread presence of microplastics across the Earth's surface not only signifies a critical environmental pollutant, but also serves as a distinct marker of the Anthropocene epoch. As plastics become a ubiquitous component of natural environments, it is imperative to recognize them as integral components of sedimentary systems. This study describes the characterization of plastic particles as sediment constituents and examines numerically their influence on geological processes. The trajectory of plastics, from disposal, disintegration to deposition, mirrors the source-to-sink dynamics observed in natural sedimentary systems. Microplastic particles, ranging from 1 μm to 5 mm in size, align with sediments spanning clay to gravel sizes. The diverse size, shapes, and polymer types affect sediment grain architecture, pore geometry, and physical properties of deposition. Notably, microplastics possess a distinct grain density averaging 1.3 g/cm3 when derived from polymer types in the ocean subsurface, which is approximately half that of typical sediments (~2.65 g/cm3). The lower grain density results in a deceleration of sediment settling velocity. As the volume of microplastic particles in sediments increases, a consequential decrease in the bulk density of sediments is observed during deposition and burial with depth. Our study suggests that microplastics alter fundamental sediment properties, including density, porosity, frictional properties, bonding dynamics, water content, wettability, as well as microbial communities. The alteration of physical properties and other characteristics in plastic-enriched sediments necessitates further research to comprehensively understand the intricate effects of microplastics on geological processes and ecosystems.

Keyword

Microplastics, Anthropocene, Low-density sediments, Plastic-rich sediments, Plastics

Introduction to UNESCO IGCP 732 LANGUAGE of the Anthropocene and the International Geoscience Program

Veronika Koukal[1]*, Natural History Museum Vienna (Veronika.Koukal@nhm-wien.ac.at)
Michael Wagreich[2], University of Vienna

Abstract

IGCP 732: LANGUAGE of the Anthropocene (Lessons in anthropogenic impact: a knowledge network of geological signals to unite and assess global evidence of the Anthropocene). Present and future Geology – the global scale evidence of the Anthropocene was granted as an UNESCO IUGS IGCP project in spring 2021 and will run for 5 years. The former International Geological Correlation Project, now International Geoscience Program started in 1972 as a knowledge hub of UNESCO to facilitate international scientific cooperation in the geosciences. IGCP Projects bring together scientists for workshops and field trips and support especially participation from developing countries.

Because the Anthropocene establishes a powerful concept associated with unprecedented global change, the aims of IGCP 732 are to involve a global community in geoscientific research into this topic and the anthropogenic predominance on the Earth System. Both recognizing and managing this novel situation in a sustainable way requires a planetary network and accompanying knowledge framework. IGCP 732 aims to engage new ideas and networks in the development of the Anthropocene concept by cooperating globally with scientists, especially those in developing and less developed countries. The core aims are to unite and assess global evidence of the Anthropocene and to establish the Anthropocene as a fertile framework for future geosciences. This will be achieved by developing a network of expertise and project partners globally; and designing and running workshops in developing countries. Close collaboration also takes place with the IUGS ICS-SQS Anthropocene Working Goup (AWG), especially related to the definition and the correlation of a GSSP (Global Stratotype Section and Point) and the base of the stratigraphic Anthropocene. So far, 138 scientists from 30 countries joined our network and participated in the annual meetings, that were held in Vienna (Austria, 2021: online kick-off meeting), Nairobi (Kenya, 2022: Nairobi's Anthropocene 2022 – past, present and future archives) and Xi'an (China, 2023: The Anthropocene 2023 – Impacts and Sustainability of Earth System Development). The annual meeting 2024 will be organized during the IGC at Busan (Republic of Korea: Session Session T38.2 - UNESCO IGCP 732 and the Stratigraphy of the Anthropocene). Ongoing projects within the IGCP 732 framework include the Austrian Academy of Science funded project on recent lake sediments from Pakistan, Austria and Kenya (PI Mehwish Bibi), a Brazilian project on correlating urban anthropogenic sediments of Vienna and Brazilian cities (PI Érika Cristina Nesta Silva), and a cooperation project of the Republic of Korea and Austria on the Holocene-Anthropocene transformation on the west coast of Korea and the Japan Trench (Eun Young Lee & Tae Soo Chang). Cooperation was also established with geoparks in Austria, China and the Republic of Korea, and potential geopark areas in Kenya.

Keyword

Anthropocene, IGCP 732, International Geoscience Program, urban anthropogenic sediment, Anthropocene network

Radioactive fallout defining the base of the proposed Anthropocene Series in the varved sediments of Crawford Lake

Francine M.G. McCarthy[1]*, Brock University (fmccarthy@brocku.ca)
Andrew B. Cundy[2], University of Southampton
Karin Hain[3], University of Vienna
Pawel Gaca[4], University of Southampton
Brian F. Cumming[5], Queen's University
Krysten M. Lafond[6], Queen's University
R. Timothy Patterson[7], Carleton University
Michael F.J. Pisaric[8], Brock University
Martin J. Head[9], Brock University
Paul B. Hamilton[10], Canadian Museum of Nature

Abstract

Individual varves from the meromictic basin of Crawford Lake (Milton, Ontario, Canada) provide an annually resolved record of radionuclides (239Pu, 240Pu, and 137Cs) deposited following nuclear weapons testing, here demonstrated from 1946 – 1971 CE. A well-defined increase in 239+240Pu activities (calculated from atom concentrations of 239Pu and 240Pu measured using Accelerated Mass Spectrometry) from 0.0007 Bq/g in 1951 to 0.0048 Bq/g in 1952 is consistent with the onset of thermonuclear weapons testing. The detonation of the first H-bomb, 'Ivy Mike' at Enewetak Atoll at 7:15 AM, Nov. 1, 1952 (7:15PM Oct. 31, GMT/ 2:15 PM at Crawford Lake), coincides with fall 1952 turnover, when most of the organic matter accumulates on the lakebed, with the base of the dark lamina marking the base of the proposed Anthropocene series/epoch in the varved succession. Activities of both Pu-239+240 and Cs-137 peaked in 1963 (0.0299 and 0.2652 Bq/g, respectively) before declining sharply after ratification of the Partial Nuclear Test Ban Treaty to nuclear era background by 1970 CE. Pu-240/ Pu-239 ratios provide an additional chronostratigraphic marker of the base of the proposed Anthropocene, showing a defined increase from the early 1950s to values typical of average global stratospheric fallout in the 1960s. The well-oxygenated monimolimnion where brackish bottom water conditions prevent macroscopic benthos from disturbing the lakebed may also play a role in preventing mobilization of plutonium in the varved succession, allowing the nuclear moratorium that lasted from November 1958 to September 1961 to be represented by a distinct shoulder, with lower activities of Pu-239+240 and Cs-137 in 1960 (0.0104 and 0.0025 Bq/g, respectively). This radionuclide signature, coinciding with the Great Acceleration, should be a globally synchronous marker of the associated permanent shift in the Earth system postulated by atmospheric chemist and Nobel laureate Paul Crutzen in 2000 CE.

Keyword

radionuclides, Anthropocene, plutonium, cesium

Does anthropogenic interference disturb sedimentation in closed lakes? Evidence from the Kalar Kahar Lake, Potwar Plateau, Pakistan

MEHWISH BIBI[1]*, University of Vienna, Austria (bibimehwish15@gmail.com)
SHAHID IQBAL[2], Department of Earth Sciences, Quaid-i-Azam University, Islamabad, Pakistan
MICHAEL WAGREICH[3], Department of Geology, University of Vienna, Austria

Abstract

Lacustrine sediments are considered key archives for tracing anthropogenic signals in the Earth's system and thus have remained the major focus for research into the Anthropocene. The present work focuses on the sediment geochemistry of the Kalar Kahar Lake located in the Potwar Plateau of Pakistan, to unravel the impact of decreasing siliciclastic flux over historical time due to anthropogenic controls. The Kalar Kahar Lake is an old (2 ka documented history) saline lake and the area gained fame during the 16th century CE when the Mughal king Zaheer ud Din Babar established an army camp on a hill near the lake. Since then the population around the lake has gradually increased and the lake area has shrunk. A core section of 180 cm was collected from the lake and continuous high-resolution samples were collected from this core for bulk sediment geochemical analysis. Preliminary results indicate a progressive upward decrease in SiO2 (54.6% to 16.4%) coupled with a decrease in Al2O3 (9.8% to 3.5%). Similarly, Fe2O3, K2O, and Na2O reflect considerable drops of 4.5% to 1.7%, 1.6% to 0.6%, and 1.5% to 0.3% respectively. Sc also reveals a significant drop from 10 ppm to 4 ppm. On the contrary, CaO displays a progressive upward increase from 11% to around 30% coupled with an increase in the Loss On Ignition (LOI) from 14% to 44%. Further, the Total Organic Carbon (TOC) and the Total Organic Sulphur (TOS) show the lowest values of around 3% and 0.3% respectively in the lower part (zone of high siliciclastic input) that reach higher values of around 15% and 0.9% in the upper part (zone of high carbonates precipitation). Thus the upward increase in TOC and TOS content supports "cultural eutrophication" like that observed in many European lakes due to anthropogenic polluting inputs including fertilizer runoff, sewage, and wastewater flows into the lake. The overall major elements geochemistry results indicate that the siliciclastic flux has reduced to around one-third during the time of the sampled interval. The decrease in siliciclastic input allowed carbonate precipitation to dominate and an overall three-fold increase in carbonate sedimentation has been observed in sampled interval. Thus the present results reveal that the establishment of human settlements around the Kalar Kahar Lake gradually blocked the natural drainage system around the lake. Urbanization during the last two centuries closed both natural water inflow into and outflow from the lake, therefore, inhibiting the siliciclastic flux into the lake. The lake has slowly transformed into a closed water body where carbonate precipitation is the major sedimentation process. Numerical age dating of the sampled interval will allow a more precise linkage between the siliciclastic flux fluctuation and various historical events in the area including both anthropogenic contribution and climate fluctuations.

Keyword

Lake Sediments, Geochemistry, Eutrophication, Anthropocene

[Keynote]Evolution of stratigraphy in the Anthropocene Across Africa

Lydia A. OLAKA[1]*, Technical University of Kenya (lydiaolaka@tukenya.ac.ke)
Christine A. Omuombo[2], Technical University of Kenya
George OKOKO[3], Lamont-Doherty Earth Observatory, Columbia University
Daniel O. OLAGO[4], University of Nairobi

Abstract

The widespread alteration of earth conditions and processes has brought humans to the fore as a formidable force of nature. Whilst the Anthropocene working group is working to determine the stratigraphic marker of the proposed new geological Epoch from Lake Crawford. Questions on the resolution and magnitude of change recorded in the environmental archives and markers in Africa where no candidate site was selected can be answered by comparing multiple records. This will help to understand the impact of global, regional and local drivers of change. The aim of this study is to present an Africa wide synthesis of the chronology and stratigraphy of different geological material derived from different archives from coasts, lakes and peat. Africa is the cradle of mankind and human occupation extends back thousands of years, but until about 300 years ago, their impact on the environment was localized and transitory. The impacts intensified during the 19th century due to rapid population growth and extension and intensification of agriculture, that was largely driven by colonists; during this period, the overprinting of natural environmental changes by humans is clear, marked by increased erosion, sedimentation, and changes in lake water quality and sediment geochemistry as a consequence of land and water degradation, expansion of urban environment and overexploitation of terrestrial, aquatic and marine ecosystems. As a result the geochemistry of soils and water resources have changed, major losses in biodiversity have occurred. Exhibiting spatial and temporal lags of the changes, depending on locality, but there is a widespread agreement of these effects from the mid-1900s, supporting the Anthropocene Working Group's proposed date of 1950 as the start of the Anthropocene.

Keyword

Stratigraphy, Land degradation, aquatic Degradation, Anthropocene

Progress on the Anthropocene study in China

Luyuan ZHANG[1]*, Institute of Earth Environment Chinese Academy of Sciences
(zhangly@ieecas.cn)

Abstract

Human activities had caused very profound impact on the Earth's environment, such as rapid increases in CO2, Methane, temperature since the mid-20th century. In 2000, Paul Crutzen proposed the Earth had entered a new geological epoch - the Anthropocene, following the Holocene. And other scientist suggests that the trajectory of the Earth System shifts away from the glacial–interglacial limit cycle toward new, hotter climatic conditions and a profoundly different biosphere.

Once being proposed, the concept of the Anthropocene have fast become a hot topic and been paid wide attention. It is the same case in China. Early in 2004, Prof. Dongsheng Liu has suggested that China has have a good foundation to study the Anthropocene on the basis of Holocene research. China has a long history, large population and intense human activities, rich records of human activity, historical documents and archaeological remains. In this presentation, we present some examples on the Anthropocene records including heavy metals, polycyclic aromatic hydrocarbons (PAHs), black carbon (BC), char, and soot, SCPs, radioactive proxies (14C, 137Cs, 129I and Pu), as well as paleo-environmental DNA, mainly in the archives of lacstrine sediments, tree rings and stalagmites. In Chine, we have proposed a Chinese Candidate GSSP of the Anthropocene, the Sihailongwan maar lake. There are twelve sites from the global, and the Sihailongwan is the only maar lake with no fluvial inlets or outlets, only receives the atmospheric input.

For in-depth study of the Anthropocene, the National Natural Science Foundation of China has approved a Major research project, entitle "Geological New Era—the Anthropocene: Timing, Characteristics and Impact", which include four subprojects: historical background of the Anthropocene, Markers and proxies, GSSP of the Anthropocene, as well as impacts and adaptation of human activities in the Anthropocene.

In terms of academic exchange, The Anthropocene Research Branch of the Geological Society of China was established in December 2021, which is affiliated to the Institute of Earth Environment of the Chinese Academy of Sciences. The aim of the branch is to promote the development of international and domestic Anthropocene research. The first Conference of the Anthropocene Science was successfully held in Xi ‘an on 17-18th June, 2023. This conference had 7 sessions and over 140 oral presentations. About 400 people on site, and nearly 7,000 people online have participant this conference. Other conference/sessions on the Anthropocene Science have been held, such as sessions on the 2023 Annual Meeting of Geological Society of China, The 8th Youth Geoscience Forum. On the aspects of international cooperation and exchange, Chinese scholars act as the members of the Anthropocene Working Group, proposed the Anthropocene research theme to the IGCP Council, and are involved into the IGCP project.

In summary, the Anthropocene study has been studied more and more by Chinese scholars, and

has also gradually been accepted and used by the general public. International cooperation is encouraged by the Chinese funding agencies to achieve a global view of the Anthropocene.

Keyword

Anthropocene study, research progress, Chinese records, academic exchange in China

Anthropocene 129I record in the Yellow Sea sediments and its indication for river-delivered radioactive pollution to marginal seas

Yanyun WANG[1]*, Institute of Earth Environment, Chinese Academy of Sciences
(wangyy@ieecas.cn)
Xiaolin HOU[2], Institute of Earth Environment, Chinese Academy of Sciences

Abstract

As the number of coastal nuclear facilities rapidly increases and the wastewater from the Fukushima Nuclear Plant has been discharged into the Pacific Ocean, the nuclear safety of China's marginal seas is gaining increased attention along with the heightened potential risk of nuclear accidents. However, insufficient work limits our understanding of the impact of human nuclear activities on the Yellow Sea (YS) and the assessment of their environmental process. This study first reported the 129I and 127I records of post-human nuclear activities in the two YS sediments. Source identification of anthropogenic 129I reveals that, in addition to the gaseous 129I release and re-emission of oceanic 129I from the European Nuclear Fuel Reprocessing Plants (NFRPs), the Chinese nuclear weapon testing fallout is an additional 129I input for the continental shelf of YS. The 129I/127I atomic ratios in the North YS (NYS) sediment are significantly higher than those in the other adjacent coastal areas, attributed to the significant riverine input of particulate 129I by the Yellow River. Furthermore, we found a higher 129I latitudinal disparity in the sediments than those in the seawaters in the various China seas, revealing that sediments in China's marginal seas already received a huge anthropogenic 129I from terrigenous sources via rivers and thus became a significant sink of anthropogenic 129I. This study will broaden the insight into the potential impacts of terrigenous anthropogenic pollution on the Chinese coastal marine radioactive ecosystem.

Keyword

Iodine-129, sediments, Yellow Sea, Riverine input, terrigenous 129I

A Marine Geological Park Concept for volcano-tectonic and Hydrothermally Induced Submarine Groundwater Discharge Features and Their Implications to Coral Reefs in Mabini, Batangas

Caroline Marie Brinas Jaraula[1]*, Marine Science Institute (cjaraula@msi.upd.edu.ph)
Iris Mabanta[2], Marine Science Institute

Abstract

A coordinated network of Marine Geological Parks are not yet established in the Philippines although there are diverse coastal scapes that can be incorporated into tourism activities while highlighting information on their formation, implications on coastal processes, (paleo)climate and (paleo)environment. So far, only one UNESCO Geopark has been established and this includes three marine geosites that are concretely linked to geological processes of formation. Only one paper about Marine Geological Park has been published in the literature and this is by Hartoko et al (2018) that emphasize Indonesia's endemic coastal ecosystems, maritime anthropology, ancient tribes, flora and fauna, as well as sunken ships and their Chinese and European ceramics. There are many more ways to diversify and enhance the current list of marine geosites. Similar to Indonesia, the Philippines is ripe in developing Marine Geological Parks with stronger emphasis on the links to influences of volcanic and tectonic processes or indicators, and oceanographic features. As part of the Verde Island Passage Marine Corridor, the "center of the center " for marine biodiversity, marine geological park can be used as an educational tool for tourists, researchers, and scientists alike, for a more informed tourism venture into the geological events in the area. A concept note for Mabini Marine Geological Park is being developed and focuses on an area where Hydrothermally Induced Submarine Groundwater Discharge in various coastal areas are emanating warm to hot mixture of recirculated seawater and fresh groundwater with or without bubbles, composed mainly of >95% Carbon Dioxide. Hot submarine springs even in intertidal areas or accessed through SCUBA diving are already part of tourism activities. With temperatures of the emitting waters as warm as 84 deg C, this hosts extremophiles, such as thermophiles, hyperthermophiles, and capnophiles providing a wide latitude of educational topics including natural analogues to warming seas and ocean acidification where the projected global warming scenarios are naturally in effect in these areas already.

Keyword

Geopark, Geosite, sustainable tourism, shallow hydrothermal vents, submarone groundwater discharge

Carbon Stock and Organic Matter Changes Three Decades After Mangrove Tree Planting Efforts in Kalibo (Aklan), Philippines

Caroline Marie Brinas Jaraula[1]*, Marine Science Institute (cjaraula@msi.upd.edu.ph)
William Dimalanta[2], Marine Science Institute, University of the Philippines
Rene Rollon[3], Institute of Environmental Science& Meteorology, University of the Philippines
Keith Paolo Landicho[4], Department of Geodetic Engineering, University of the Philippines
Maria Lourdes McGlone[5], Marine Science Institute, University of the Philippines
Keith Limuel Bejasa[6], Marine Science Institute, University of the Philippines
Toshihiro Miyajima[7], Atmospheric and Ocean Research Institute, University of Tokyo
Fernando Siringan[8], Marine Science Institute, University of the Philippines
Giannina Marie Albano[9], Institute of Environmental Science& Meteorology, University of the Philippines
Green Ann Cruz[10], Institute of Environmental Science& Meteorology, University of the Philippines
Jeffrey Munar[11], Marine Science Institute, University of the Philippines
Ariel Blanco[12], 4Department of Geodetic Engineering, University of the Philippines

Abstract

Some Anthropocene activities include biogeochemical alteration in the sediment deposits from landscape conversion. Mangrove tree planting since 1990 was encouraged at the mouth of Aklan River, which helped to trap the sediments and extended the forest area by at least a kilometer flourishing to around 121 hectares today. The mangrove area increased by an average of 52.42% every five years. The spatial evolution of enlarging sand bars combined with the biological transformation by maturing mangrove forests is also reflected in the evolution of soil deposits to which average total organic Carbon content at present increased to 4% and as much as 6.46% comprising mostly of labile carbon (3.92%). Belowground carbon was estimated at 31,011.69 Mg. The C:N ratio of planted mixed-species zones and sandbar were consistent with a mixture of riverine- and mangrove-derived organic matter. δ13C and δ15N values of sediment samples ranged from -28.75‰ to -26.11‰, and -1.09‰ to 1.37‰ respectively. For biomass samples, δ13C and δ15N values ranged from -30.82% to -27.85%, and -10.70% to 1.83%, respectively. Integration of landscape and forest cover and maturation of organic-rich soil have implications on the Carbon stock. A comprehensive evaluation on a larger perspective is necessary to check on impedance of sediment transport to coastal areas in the longshore current direction and stability of the accreted landforms against massive release of Carbon Dioxide from destabilization after extreme storm events.

Keyword

Carbon storage, Blue Carbon, accretion

Anthropogenic stratigraphic signals downstream a metropolis: Extracting Vienna's signature from Danube river plain archives (Austria)

Diana HATZENBÜHLER[1]*, Department of Geology, Faculty of Earth Sciences, Geography and Astronomy, University of Vienna (diana.hatzenbuehler@univie.ac.at)
Michael Weißl[2], University of Vienna, Department of Geology, Vienna, Austria
Christian Baumgartner[3], Donau-Auen National Park, schlossORTH National Park Centre, Austria
Karin Hain[4], University of Vienna, Faculty of Physics, Isotope Physics, Vienna, Austria
Alexander Hubmer[5], Paris Lodron University of Salzburg, Faculty of Geography & Geology, Salzburg, Austria
Andreas Lang[6], Paris Lodron University of Salzburg, Faculty of Geography & Geology, Salzburg, Austria
Michael Wagreich[7], University of Vienna, Department of Geology, Vienna, Austria

Abstract

The Anthropocene describes a potential new unit of the Geological Time Scale of rising anthropogenic influence on environmental and geological processes and how their traces are stored in geological archives. Even though this human impact can be seen on a global scale across multiple depositional environments, regional studies characterizing the onset and scope of anthropogenic influence, are still scarce, especially for urban or peri-urban fluvial environments. In this study, we investigate the anthropogenic impact of the European metropolis Vienna on its peri-urban environment and the potential base of the Anthropocene epoch in the 1950s CE by applying sedimentological, geochronological and geochemical methods.

The study area is set downstream of Vienna, in the Austrian National Park Donau-Auen, where direct human intervention into the archived Danube river sediments is currently nil. These river sediments represent an 'Urban Anthropocene Field Lab' to trace and quantify the human stratigraphic fingerprint and to search for potential markers and correlations to the proposed GSSP Golden Spikes of the Anthropocene. Within the proximal flood plain sediments of the Danube, i.e. erosional profiles and sediment cores, sedimentological, geochronological and chemostratigraphic markers are applied to characterize and date the anthropogenic strata in this area. First observations indicate three periods of distinct sedimentation patterns, potentially corresponding to the natural state prior to significant human intervention, the river system's reaction to the first extensive river channelization in the 1870s CE, and it's following response to the construction of hydropower stations (1956-1998 CE) and second river regulation (1990s). The lowermost section is characterised by clay and organic rich thin layers (few cm to mm) being suddenly replaced by alternating silt and sand packages of 5 to 20 cm beds. The uppermost silt to fine-sand dominated section is massive and shows almost not sediment structures, unlike the other sections, and exhibits a uniform light grey colour distinct from the light beige and dark brown colour of the underlying deposits.

The archive of natural Danube deposits is further analysed for natural and artificial radiogenic isotopes (210Pb, 239Pu, 137Cs), trace metals, and (micro-)plastics with the aim (i) to disentangle

the anthropogenic fingerprint of Vienna from the natural sedimentation and characterise the interplay between upstream human interventions and local river dynamics, (ii) to identify and evaluate the proposed Holocene-Anthropocene geological boundary around 1950 CE, and (iii) to evaluate markers for the Anthropocene and a potential correlative stratigraphic reference section downstream of Vienna.

Keyword

chemostratigraphic markers, anthropogenic fallout, (micro-)plastic, Anthropocene, floodplain archives

The geological usefulness of a defined chronostratigraphic Anthropocene for urban deposits of Karlsplatz, Vienna (Austria)

Michael WAGREICH[1]*, University of Vienna (michael.wagreich@univie.ac.at)
Maria Meszar[2], University of Vienna

Abstract

Anthropogenic strata form the primary geological legacy in the underground of large cities, the urban Anthropocene. We looked for geological markers for the Anthropocene using mainly artificial isotopes in the city of Vienna, the capital of Austria. The tested archaeological site Karlsplatz - Wien Museum is situated in a park area at the city center. Archaeology and historical data set age constraints in the 19th century, at 1922 (sales hall), 1936 (demolition of the sales hall), 1945 (WW2 rubble), and at 1959, with the opening of the Wien Museum at this place. A layer on top of the fundaments and rubble of the sales hall post-dates 1922/1936, and pre-dates the levelling of the artificial park ground in front of the Wien Museum of an inferred 1959 age. Archaeological stratigraphy and lateral correlation of layers specifies the dating of this uppermost soil layer with a mixture of historical artefacts including brick fragements, glass, slag and plastics to the interval of 1945 to 1959.

Using the primary marker suggested for the base of the geological Anthropocene, the artificial radionuclides of atmospheric atomic bomb testing fallout material (the "bomb-spike"), this soil layer could be more precisely dated than based on the archaeological record so far. The presence of Pu-239 and Pu-240, among others, and their typical isotope ratio clearly indicate an age of 1952 (first H-bomb testing with global fallout) to 1959 for this layer. Thus, the "bomb-spike" can be identified and used as a primary stratigraphic marker even in coarse urban anthropogenic sediments exemplifying the correlation potential of these radionuclides and demarking a reference section for the base of the proposed chronostratigraphic Anthropocene epoch. The stratigraphic markers and technofossils in the coarse urban sediments contain signals that have potential correlations with findings from other Anthropocene sites, namely the fallout radionuclides like plutonium, which can be correlated to the lake warves like the one from Crawford Lake, Canada.

Keyword

Antropocene, stratigraphy, urban deposits

Anthropogenic sediments in the urban setting of Karlsplatz, Vienna (Austria)

Maria MESZAR[1]*, University of Vienna, Austria (maria.meszar@univie.ac.at)
Michael Wagreich[2], Department of Geology, University of Vienna, Vienna, Austria
Janis Wolf[3], Helmholtz-Zentrum Dresden-Rossendorf, Dresden, Germany; University of Vienna, Vienna, Austria
Martin Mosser[4], Wien Museum, Vienna, Austria
Neil Rose[5], University College London, London, United Kingdom
Peter Nagl[6], Department of Lithospheric Research, University of Vienna, Vienna, Austria
Katrin Hornek[7], University of Applied Arts Vienna, Vienna, Austria
Veronika Koukal[8], Department of Geology, University of Vienna, Vienna, Austria
Kira Lappé[9], Department of Geology, University of Vienna, Vienna, Austria
Constance Litschauer[10], Wien Museum, Vienna, Austria
Nikolaos Piperakis[11], Wien Museum, Vienna, Austria
Karin Hain[12], Isotope Physics, University of Vienna, Vienna, Austria

Abstract

Deposits in an urban environment like the city of Vienna (Austria) pose many challenges compared to natural archives. They often have only limited lateral continuity, highly variable deposition rates, they are prone to (anthropogenic) erosion, resedimentation and show many omission surfaces. As part of a transdisciplinary project involving geosciences, isotope physics and urban archaeology, we investigated sediments from an archaeological excavation site near the city centre of Vienna at Karlsplatz. The study area records the changing land use of the expanding city, from the anthropogenic fill of the Wien River before 1900 to the latest levelling period of the park area in the 1950s. Archaeological stratigraphy and historic data sets provide age constraints for the multiple deposition phases, with the oldest road structures dating from the 18th century and the youngest deposits dating around 1922, post-1945 and the park opening in 1959. Anthropogenic materials found in the samples include bricks, ceramics, concrete, glass, plastics, metal slags and tiles. Sediment reworking is evidenced by a mix of artefacts from different time periods. The fine-grained matrix (< 2 mm grain size) of the deposits was used for X-Ray fluorescence (XRF) analysis of trace elements such as lead, copper and zinc, as well as for analysis of actinides by Accelerator Mass Spectrometry (AMS). Several artificial radionuclides, including 239Pu, 240Pu and 236U which are associated with atmospheric atomic bomb fallout material of the 1950s and beginning of the 1960s, were found in the post-1945 layer. These radionuclides and their ratios were successfully used to identify the signal from nuclear weapons testing and provide a primary stratigraphic marker for the Anthropocene, even in these urban anthropogenic sediments. Concerning trace metals, XRF analysis revealed the highest levels (Cu 330 ppm, Pb 633 ppm, Zn 852 ppm) in sediments of a 19th century deposit rich in charcoal and metal slags associated with nearby metal-working industry. The second highest peak occurs in a layer of WW2 rubble rich in technofossils of that era (Cu 71 ppm, Pb 208 ppm, 296 ppm). Higher depositional levels of the 1950s show again much lower values (Cu 24 ppm, Pb 28 ppm, Zn 61 ppm) similar to the range of low contamination background and infill materials, although the

uppermost topsoil layer shows a slight recent enrichment (Cu 35 ppm, Pb 56 ppm, Zn 99 ppm) compared to the 1950s. These XRF results indicate a local control on trace metal contamination and a correlation with technofossil findings. In addition, spheroidal carbonaceous fly-ash particles (SCPs), the product of industrial coal and oil combustion, were found in elevated concentrations in the post-1945 levels. In conclusion, stratigraphic markers for the Anthropocene were identified and quantified in the urban anthropogenic sediments of the Karlsplatz site. Therefore, the site could be used as a correlative reference section for the Anthropocene series.

Keyword

Anthropocene, Austria, trace metals, anthropogenic markers, urban

Geochemical evaluation of anthropogenic depositions in Brazil: case study in Rondonópolis-Mato Grosso

ÉRIKA CRISTINA NESTA SILVA[1]*, Federal University of Rondonópolis, Brazil (erikanesta@yahoo.com.br)
Francisco Sergio Bernardes Ladeira[2], Universidade Estadual de Campinas (UNICAMP)/Geoscience Institute, Campinas, SP, Brazil
Caio Augusto Marques dos Santos[3], Federal University of Rondonópolis/ Institute of Human and Social Sciences, Rondonópolis, MT, Brazil
Mehwish Bibi[4], University of Vienna/Department of Geology, Vienna, Austria
Michael Wagreich[5], University of Vienna/Department of Geology, Vienna, Austria

Abstract

Anthropogenic signals in sediments can be assessed through various methodologies and techniques, e.g. geochemical proxies. The present study presents geochemical data of four points located within the Córrego da Piscina basin, in the city of Rondonópolis, Mato Grosso, Brazil, being one natural soil and three anthropogenic deposits. The first profile, situated near the former location of the watercourse spring, was classified as an Arenosol, with presence of pedological structures such as subangular blocky (weak to moderate), and one anthropogenic deposit at the top layer. The second one was related to layers originating from a paving street, with layers exhibiting laterite, brick fragments and charcoal. The third profile presented layers composed of predominantly sandy sediments and anthropogenic materials, for example debris, fragments of bricks and plastics. The fourth profile was composed of natural sediments alongside anthropogenic materials, exhibiting interesting features related to pedogenesis. Geochemical analysis of sediments and various sizes of anthropogenic materials ground altogether – from some layers at these locations - was focused on the concentration of As, Ba, Cd, Cr, Cu, Ni, Pb, Sb, and Zn, obtained through ICP-OES analysis, and Al obtained through XRF analysis (used for the calculations). We compared the results with the values specified in RESOLUÇÃO CONAMA Nº 420, DE 28 DE DEZEMBRO DE 2009 (a resolution providing criteria and reference values for soil quality in Brazil in terms of chemical substance presence). Subsequently, calculations were performed for the Enrichment Factor (EF), Degree of Contamination (Cdeg), and Pollution Load Index (PLI), using the Upper Continental Crust values as background. The results for the first profile revealed EF <1.5 for all the elements and layers analysed, as well as PLI and Cdeg <1; for the second profile, the highest EF values were Zn (2.7) and As (2.6) for the layer 5, PLI <1 for all this profile layers and the highest Cdeg value was 6.7. Relative to Brazilian resolution, the first profile present low concentrations values, and the second one, in the layer 8, Ba considered as “Investigation Value” (478ppm), and in the layer 5, Ni (42ppm) considered as “Prevention Value”. The third profile garnered the most attention. For instance, in layer 5, the EF for As was 9.4, the PLI for this layer was 1.6, and Cdeg was 16.1. Furthermore, according to the Brazilian resolution, As (37ppm) and Cr (353ppm) presented values considered as "Investigation Values". And in the last profile, just the Cr present value considered as “Prevention Value” in the layer 3C1

(94ppm), and the EF for the same layer and element was the highest in this profile (3.1), PLI <0.4 and Cdeg <2.4 for all this profile. This way, the highest values were related the third profile, the one in which the layers present a significant amount of anthropogenic materials.

Grant 2019/21885-7 and 2023/03963-6 - São Paulo Research Foundation (FAPESP).
The opinions, hypotheses, and conclusions or recommendations expressed in this material are those of the author(s) and do not necessarily reflect the views of FAPESP.

Keyword

Anthropogenic signals, Geochemical proxies, Córrego da Piscina basin

Introduction and first results from FT-IR microplastics identification in natural sediments

Veronika Koukal[1]*, Natural History Museum Vienna (Veronika.Koukal@nhm-wien.ac.at)
Eun Young Lee[2], University of Vienna
Mehwish Bibi[3], University of Vienna
Michael Wagreich[4], University of Vienna

Abstract

Plastics became a very abundant novel material since the late 19th century, with an increase in production and variations starting from the 1950s onwards. Nowadays, polymers are found almost everywhere around us, in remote places like the deep sea or isolated lakes and even within the human body. Microplastics (MP), either manufactured as small polymer particles (primary MP) or fragmented by degradation of larger plastic litter pieces (secondary MP), are noticed as an environmental pollutant, studied by a broad range of disciplines worldwide. MP has been also proposed as a secondary marker for the stratigraphic Anthropocene by the ISC Anthropocene Working Group. Nevertheless, a standardised definition of the size classification of microplastic particles is still missing, despite the existence of several established size classification schemes, commonly determining size class boundaries in geosciences between 1 µm to 5 mm.

In contrast to the first attempts of MP identification in natural sediments, where particles were identified and counted by visual criteria using a stereo-microscope, the identification of polymer types has become indispensable. This is often accomplished by destructive thermoanalytical methods, such as pyrolysis gas chromatography-mass spectrometry or thermal desorption gas chromatography-mass spectrometry. To avoid loss of the sample material, non-destructive vibrational spectroscopic identification techniques, like Fourier transform infrared spectroscopy (FT-IR) or Raman spectroscopy can be used.

For this study, core samples of the coastal sediments of Jeungdo and Ganghwado islands (Republic of Korea) and riverbed sediments of the Kabul River in Nowshera (Pakistan) were prepared for MP identification using FT-IR (Bruker Lumos II, nitrogen-cooled MCT detector). No established workflow existed for this technique at the labs of the Department of Geology, University of Vienna so far. Furthermore, existing methods described in the literature lack standardization regarding sampling, removal of natural organic material, sample density separation, and measurement mode (transmission, ATR, kind of detector). Therefore, the main focus shifted towards implementing a best practice method suitable not only for artificially with new polymers spiked sediment samples, but for natural sediment samples yielding altered MP particles and fibers. These particles might have undergone various environmental and depositional processes, including sediment sorting, (re)deposition, burial, compaction, cementation, leaching, degradation, UV and/or biofilms exposure. Another challenge is given by the fact that most

polymers contain producer-specific additives or auxiliary materials, depending on the intended use, which can be substituted in the recipe quickly and without declaration. This might cause problems for the interpretation of the FT-IR spectra, particularly for older samples, because limited information exists regarding the alteration and degradation effects of the additives in combination with changes of the primary polymer component.

Keyword

Anthropocene, FT-IR, microplastic, polymers, microplastics identification

Anthropogenic activities tamper with Laguna Lake's (Philippines) 20th century record of the Pacific Decadal Oscillation

Chris Carl Agustin Vargas TOYADO[1], Marine Science Institute, University of the Philippines
Caroline Marie Briñas Jaraula[2]*, Marine Science Institute, University of the Philippines
(cjaraula@msi.upd.edu.ph)

Abstract

Increased land use changes in the suburbs of Manila during the 1960s to the 1980s [1], presently the constituent cities of Philippines' Capital Region, could have contributed to the contemporaneous increase in and sustained high input of terrigenous Al, Ti, and Fe to the east-bordering Laguna Lake [2]. These changes could also have elicited changes in the grain sizes of sediments coming into the lake, and so a sediment core from the lake's western lobe was analyzed for its grain size and bulk elemental profiles. Seven major chemo- and litho-stratigraphic zones for the 20th century were delineated by Constrained Incremental Sum of Squares hierarchical clustering: Clusters pre-1912, 1912-1932, 1932-1953, and 1953-1957, with a 7-year lag, coincide with the phases of the Pacific Decadal Oscillation (PDO) whereas clusters 1957-late 1960s, late 1960s-1981, and post-1981 are identified as the first three phases of the Anthropocene [2]. Wavelet analysis also reveals common cyclicities in %sand, %silt, mean grain size, standard deviation, and 95th percentile grain size from 1916 to 1956 with periods of 17 to 18 and 20 to 23 years ($p<5\%$) which could correspond, respectively, to the 16.7-year [3], 20- and 23-year [4] modes of PDO. Since the 1950s, however, these cyclicities lost statistical significance ($p>5\%$), suggesting anthropogenic structures/processes which (1) generated more silt- and clay-sized sediments, (2) retained the sand-sized sediments on land, or (3) reduced the sand-sized sediments into finer particles. Studies pinpointing these anthropogenic structures or processes and their effects on the grain size profiles of nearby sedimentary archives are recommended for future study.

References: [1] Philippine National Statistical Coordination Board cited in Murakami A, Palijon AM. Journal of Asian Architecture and Building Engineering May 2005, 177-183. [2] Toyado and Jaraula, in prep. [3] Lee HS et al. (2012) Progress in Oceanography 105, 67–80. [4] Gedalof Z et al. (2002) Geophys Res Lett 29(24), 2204.

Keyword

Grain size profile changes, Pacific Decadal Oscillation record, Anthropocene

Anthropogenic large-scale dune remobilization in medieval–early modern Central Europe, evidenced by multi-proxy data and radiocarbon dating

Krzysztof Ninard[1]*, Faculty of Geography and Geology, Jagiellonian University, Kraków, Poland (krzysztof.ninard@uj.edu.pl)
Alfred Uchman[2], Faculty of Geography and Geology, Jagiellonian University, Kraków, Poland
Piotr Łapcik[3], Faculty of Geography and Geology, Jagiellonian University, Kraków, Poland

Abstract

The chronology and determinants of Late Pleistocene–Early Holocene dune development in Central Europe were studied for several decades, but research on analogous Late Holocene processes remains less advanced. While Late Glacial–Early Holocene dune formation was climatically controlled, remobilization of inland dunes during the Middle and Late Holocene is attributed exclusively to anthropogenic factors: deforestation and land cultivation. In the case of coastal dunes, numerous coasts worldwide admittedly experienced extensive dune activity during early modern period, but only rarely human impact is strongly evidenced to be a trigger of large-scale coastal dune buildup.

The present contribution reveals the scale of anthropogenic dune remobilization based on 27 new AMS 14C dates from 17 Polish inland and coastal dune sites, complemented with ichnological and palynological records. All calibrated 14C dates from paleosols buried in dune deposits fall within the range of 5th to 19th centuries. The widespread occurrence of such young paleosols under cover of aeolian sand reflects the scale of dune remobilization during the medieval and early modern periods. Even though the volume of anthropogenically-remobilized sand was limited compared to the Late Glacial–Early Holocene period, the impact of human activities on dune mobility seems to be far more widespread than it was known before.

The highest dune ridge of the Vistula Spit, a sandy coastal barrier on the Polish Baltic coast, extends to a height of over 25 m and reaches 500 m landwards. This transgressive dune ridge was hitherto reported to have been formed between 4k and 2k years BP. In contrast, recent excavation of Vistula Spit ship canal allowed to reveal that the highest dune ridge overlies small dune hillocks that were stabilized for several thousand years. They are covered by paleosol and peat lenses that were developing up to the 15th century and were buried afterwards. The nearby Curonian spit (Lithuanian Baltic coast), which was subjected to more intense settlement, experienced large-scale dune advances during the early modern period, which led to the burial of several villages reported in the historical sources.

Either in the case of Polish inland and coastal dunes, pasture and farming is directly recorded in the paleosols and their sandy overburden as trample grounds containing human and livestock footprints, as well as grazing-indicator pollens and spores. In addition to deforestation,

overgrazing could promote desertification and soil erosion, leading to dune remobilization and land-use abandonment.

Examining the spatio-temporal frames and mechanisms of human-related dune environment change during the last two millennia, the study contributes to the present discussion on the proposed Anthropocene epoch.

This research was financed by the National Science Centre, Poland, from the programme Daina 1, grant agreement No 2017/27/L/ST10/03370 and by Jagiellonian University from Initiative of Excellence programme, Research Support Module.

Keyword

dunes, radiocarbon dating, human footprints, anthropopressure, Poland

Anthropogenic landscape changes with planting pines on coastal dune fields

Kwang Hee CHOI[1]*, Catholic Kwandong University (geoist@cku.ac.kr)
Jun Ho Lee[2], Catholic Kwandong University
Jae Hyun Hwang[3], Catholic Kwandong University

Abstract

Planted sand dunes covered with pine trees are common along the coasts of East Asia including Korea and Japan. Black pine (*Pinus thunberggii*) was planted since the early 20th century to protect the hinterland of coastal area from salt spray, blown sand, and strong winds. Although the tree-covered dunes may seem to stabilize the natural landscape, they actually weaken the coastal barrier as the wind field shifts and the landforms become more fixed. This study aims to discuss the effects of coastal afforestation on the landscape changes, focusing on wind environment and topography of coastal dunes on an island in the Yellow Sea. The coastal dunes in this area were formed about 5.6 ka and were active dunes until a few decades ago due to abundant sand supply. The average sand size in these dunes is approximately 220-230 μm, which makes them susceptible to wind blowing. However, since the large-scale planting of black pine in the early 1980s and late 1990s, trees between the fore and hinter dunes have acted as a barrier to sand exchange between the two dunes. To investigate the wind changes caused by the trees, four Automated Weather Stations (AWS) were set up at the front and back of the forest, and topographic changes were measured using drone-based photographs, LiDAR, and Network RTK-GPS surveys. As a result, severe changes in wind field and topography were found. According to the data collected from three AWSs in the front area, it appears that strong winds are blowing towards the landward side. However, the AWS located at the base of the dune behind the forest indicates a noteworthy shift in wind direction. Furthermore, the dune volume has decreased significantly compared to the topographic survey data from about 15 years ago, and the elevation of dune crest has become lower and flatter. The reason for this phenomenon is that the sands from the beach have not moved towards the hinterland dunes, while the sands of the hinterland dunes have been washed away by rainfall and carried towards the sea. This has caused the neighboring port to fill with sand, and a new sand bar is gradually forming in front of the coastline. In order to restore the natural resilience of the coastal dunes in the study area, the planted trees need to be removed to allow the sand to move dynamically.

Keyword

coastal sand dunes, afforestation, resilience, dynamic restoration

Geomorphic Succession of an Abandoned Paddy Field in Mountain Area

Junho LEE[1]*, Catholic Kwandong University (juno9705@cku.ac.kr)
Kwang Hee CHOI[2], Catholic Kwandong University

Abstract

As paddy fields are left unused for extended periods, they tend to transform into wetlands through ecological succession. Many of the mountain wetlands in South Korea are a result of abandoned paddy fields that were previously used to cultivate grains such as rice. These fields usually have the necessary environmental conditions to develop into wetlands even before cultivation. However, previous studies have overlooked meteorological and hydrological conditions and the processes of landscape change, instead emphasizing morphological factors such as reliefs and slopes. In this study, we aimed to examine the physical environment of a mountainous abandoned paddy wetland in Gyeonbuk-do, South Korea, and explore its successional process over the last millennium. The wetland was formerly a rice field until 1996 but has now transformed into a wetland. We conducted topographic analysis, local meteorological observations, and sediment analysis. We analyzed its morphological characteristics like slope, curvature, and topographic position index using a digital elevation model of its drainage basin and soil characteristics such as grain size, moisture, and electrical conductivity. We also analyzed local climatic and hydrological conditions using an automated weather system and water level gauges in the wetland. The geomorphological succession history was identified using radiocarbon dating on the organic matter from a 1.5-meter-long core. The results showed that the topography of the study area is gently sloping and concave, making it conducive for moisture collection. The inflow between late spring and summer predominantly contributes to the total water content of the wetland. The soil core was divided into three units based on their grain size characteristics. The lower unit, mainly composed of organic matter and silt, was dated to approximately 1.6 ka, indicating that the wetland was a peat wetland before cultivation. All three samples from different depths in the middle unit, composed of very poorly sorted soils, were dated to about 0.35 ka, indicating the period of human cultivation. In conclusion, the wetland in this study formed over a thousand years ago in a place with favorable topographical conditions, and cultivation has been carried out for at least 350 years. Since the land has been left unused for several decades, it is gradually returning to a mountain wetland.

Keyword

Mountainous wetland, Land cover change, TPI, Radiocarbon dating

Interplay of climate forcing and human impact during the Holocene: a case study from an inner marine basin in the Mediterranean region

Gabriele NICCOLINI[1]*, Dipartimento di Scienze della Terra, Università degli Studi di Firenze (gabriele.niccolini@unifi.it)
Adele Bertini[2], Dipartimento di Scienze della Terra, Università degli Studi di Firenze
Niccolò Degl'Innocenti[3], Dipartimento di Scienze della Terra, Università degli Studi di Firenze
Massimo Moretti[4], Dipartimento di Scienze della Terra e Geoambientali, Università degli Studi di Bari Aldo Moro
Giuseppe Mastronuzzi[5], Dipartimento di Scienze della Terra e Geoambientali, Università degli Studi di Bari Aldo Moro

Abstract

During the Holocene the Mediterranean Region underwent significant environmental transformations, due to rapid climatic changes and increasing human activity. High-resolution palynological analyses focusing on pollen, dinocysts, and Non-Pollen Palynomorphs (NPPs) were carried out on a well-preserved sedimentary core retrieved from the Mar Piccolo, a small inner marine basin of the Taranto Sea system (Southern Italy). The selected core interval, 30-meter thick, provides invaluable insights into climate dynamics and environmental responses, spanning from the latest Pleistocene to recent times. At the onset of Holocene, increased freshwater input into the basins favoured the expansion of freshwater marshes (e.g., Cyperaceae) over saltmarshes (e.g., Amaranthaceae) and steppe (e.g., *Artemisia*) which characterized the end of the Pleistocene under a dominant arid climate (H0). Evidence of some precursor marine spillovers is also indicated by organic foraminiferal linings and halophythes. The clearest evidence of marine ingression is found from 10.30 ka BP with the consistent presence of dinocysts (e.g., *Impagidinium patulum*) providing insights into sea level fluctuations in the Mediterranean. Concurrently, an increase in mixed semi-deciduous oak forests suggests a climatic improvement, likely resulting from global circulation reorganization following the retreat of the ice sheet in the Northern Hemisphere (e.g., Laurentide Ice Sheet). The palynological record reveals 22 rapid climate changes including the 8.2 ka BP, 4.2 ka BP and 2.8 ka BP events, all characterized by an increase in aridity as evidenced by the expansion of steppe vegetation and the contraction of thermophilic forests. Between 11.8–7.2 ka BP, such aridity events in the Mediterranean region (and cooling in the North Atlantic) are significant and concomitant with the melting of ice sheet leading to a slowdown in the Atlantic Meridional Overturning Circulation (AMOC). After the complete melting of the ice sheets, around 6.8 ka BP, rapid climate changes driven by variations in solar insolation led to the expansion of steppes, albeit more limited than the previous ones, with the exception of the 4.2 ka BP event. For the last 2700 ka Mar Piccolo emerges as a pivotal site to illuminate the intricate interplay between natural climate factors and the most recent human influence, given its historical significance as a cultural crossroads dating back at least the Bronze Age. Starting from the Greek Period (Taras foundation at 706 BC) human impact on Mar Piccolo became evident by several shifts in flora and vegetation. Pollen records indicate a notable increase

in Olea cultivation (olive trees) accompanied by biodiversity loss, likely related to deforestation. Major historical events, including agrarian reforms, famines, and wars, are discernible by fluctuations in *Olea* and Cerealia-group. During the Roman Period and the Middle Ages, intriguingly, pandemics manifest as an abundance of resting eggs of human parasites such as *Trichuris* and *Ascaris lumbricoides*. Today, the Taranto Sea system stands out as one of the most polluted marine areas in Europe; understanding paleoclimatic changes and human adaptations could provide invaluable insight for anticipating future scenarios amidst contemporary Global Warming and escalating environmental degradation.

Keyword

Palynology, Coastal areas, Climate change, Sea level fluctuations

Stratigraphic signals of human-environment interactions on the Meghalaya Plateau: Implications for defining the Anthropocene boundary

Pawel PROKOP[1]*, Institute of Geography and Spatial Organization Polish Academy of Sciences (pawel@zg.pan.krakow.pl)

Abstract

The Meghalaya Plateau in northeastern India serves as a unique site for the study of human-environment interactions and their stratigraphic signatures. This study examines the stratigraphic record of human-induced change on the plateau, focusing on the Meghalayan and Anthropocene within the context of the broader Holocene. Through a comprehensive review of lithostratigraphic, biostratigraphic and chemostratigraphic markers, this study elucidates the complex interplay between natural processes and anthropogenic activities.

The Meghalayan age, ratified by the International Union of Geological Sciences (IUGS), provides a crucial temporal framework for understanding environmental changes in the region. Speleothems, particularly stalagmites, are proving to be valuable archives for reconstructing past climatic conditions and human impact. These stalagmites, found in caves such as Mawmluh Cave, provide insights into variations in monsoon intensity and vegetation cover over millennia. In addition, dendrochronological data from *Pinus kesiya* trees indicate localised climate responses, albeit limited in extent.

Sedimentary records further underline the dynamic nature of the Meghalaya Plateau landscape. Radiocarbon dating reveals the dominance of Holocene sediments, possibly accelerated by high rainfall and human interventions such as deforestation and agriculture. Pollen and grain size analyses corroborate these findings, indicating a shift from subtropical forests to open grasslands and subsequent deforestation episodes associated with agricultural expansion and iron ore mining. The onset of Neolithic activity, marked by the production of pottery and iron smelting, further accentuates the human impact on the geomorphology of the region.

Stratigraphic signals also extend into the post-industrial era, characterised by radionuclide fallout from nuclear weapons testing. Studies of caesium (137Cs) and lead (210Pb) concentrations in soil profiles near Shillong and Cherrapunji provide insights into the dynamics of soil erosion and the pervasive nature of anthropogenic impacts. In addition, the emergence of a distinct anthropogenic layer characterised by concrete, brick and plastic debris underscores the contemporary human alteration of the landscape.

In summary, the Meghalaya Plateau offers a rich tapestry of stratigraphic signals reflecting millennia of human-environment interactions. From prehistoric deforestation to modern industrialisation, these records provide invaluable insights into the environmental history of the region. Moreover, the implications of these findings extend beyond regional boundaries, shedding light on broader debates about the boundaries of the Anthropocene. By integrating multidisciplinary approaches, this study contributes to a nuanced understanding of humanity's imprint on the Earth's geological record.

Keyword

Anthropocene, Meghalayan, Holocene, Stratigraphy, Human impact

Lithostratigraphic Study on Human-made strata in Kirishima City, Kagoshima Prefecture, Japan

Hiroshi TAKASHIMA[1]*, Daiichi institute of technology (h-takashima@daiichi-koudai.ac.jp)

Abstract

Human-made strata are defined as geological formations formed through human activitiesNirei H. et al., 2012These formations are created through human activities and constitute the primary geological structure in urban areas. They are typically categorized into two associations: dumped associations formed through embankment construction on terrestrial land, and landfill associations formed through water area reclamation (Kazaoka O. et al., 1994). Despite their widespread use, detailed analysis of the lithology and stratigraphy of human-made strata is often lacking. This deficiency can be attributed to the diverse nature of human-made strata compositions across different land parcels, time, and the lack of continuity in strata deposition (Ford, T., et al. 2014). However, the sourcing of embankment materials from nearby construction sites often leads to the development of human-made strata with compositions resembling natural strata in general, particularly in regions where the same geological strata extend over large areas. In these areas, lithologic differences are likely to be dominated solely by sedimentary structures and heterogeneous material contamination, making it easier to characterize the human-made strata.

This research explores the lithostratigraphy formation and characteristics of human-made strata in Kirishima City, located within the Kagoshima Graben, Japan. The city's central district, Kokubu, sits on the Kokubu Plain, characterized by river lowlands and terraced surfaces. Surrounding the plain are extensive deposits of the Ito and Iwato Pyroclastic Flow deposits originating from the Aira Caldera, forming elevated plateaus (Aramaki S., 1969). These pyroclastic flow deposits serve as essential materials for embankments and are extensively utilized in the region.

Excavation investigations in three locations within the Kokubu district revealed the stratigraphy of human-made strata, identifying rice paddy paleo-soils beneath and several formation s of human-made strata above. The mineralogical analysis showed that the human-made strata were composed of the same types of mineral particles found in natural strata—plagioclase, quartz, orthopyroxene, amphibole, and magnetite, with the addition of four varieties of volcanic glass. However, specific differences were noted, such as the presence of ilmenite and biotite in human-made strata, which is rare in neighborhood natural strata, and the surface of minerals is coated with artifacts, such as Ca-carbonate, making it impossible to identify the original mineral. Additionally, human-made strata subjected to surface ground improvement exhibited particles with radial coverage by volcanic glass, indicating specific construction practices. Related to this, the results of grain size analysis showed that the coarse-grained fraction of the human-made strata were enriched compared to that of the natural strata.

As a result of the investigation, special constituent materials of the human-made strata were identified, and the characteristics of the human-made strata in the Kirishima area were clarified. This could be used to distinguish between natural and human-made strata and to identify the Jin-ji

unconformity Nirei H. et al., 2012 boundary between natural and human-made strata.

Keyword

Human-made strata, Dumped associations, Jin-ji unconformity, Lithostratigraphy, Kirishima City Kagoshima Japan

Vegetation and land-use changes during last two millennia in the Baspa valley, Kinnaur, Western Himalaya

NIDHI TOMAR[1]*, Birbal Sahni Institute of Palaeosciences, Lucknow, India AND Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, India (tomar.nidhi@bsip.res.in)
Ipsita Roy[2], Indian Institute of Tropical Meteorology, Dr. Homi Bhabha Road, Pashan, Pune, India
Parminder Singh Ranhotra[3], Birbal Sahni Institute of Palaeosciences, Lucknow, India. Academy of Scientific and Innovative Research (AcSIR), Ghaziabad, India
Mayank Shekhar[4], Birbal Sahni Institute of Palaeosciences, Lucknow, India
Pankaj Kumar[5], Inter-University Accelerator Centre, New Delhi, India

Abstract

Climate change coupled with the increasing anthropogenic activities is modifying the vegetation distribution and land-cover of the Himalayan region. Here we compared the modern pollen dispersal along the valley gradient of 2700-3500m amsl with the sub-surface pollen assemblage from a 60 cm deep peat deposit collected at ~3400m amsl altitude in the, Baspa valley, Kinnaur, Western Himalayas. Baspa valley is presently characterized by the temperate to sub-alpine vegetation type, occupied by conifers, broadleaf trees and non-arboreal taxa. The pollen assemblages from surface and sub-surface sediments represented the extant flora growing in the valley, and also captured the land-use signatures during last two millennia. In the modern pollen assemblage along the valley gradient, high pollen percentages of conifers (*Pinus*, *Cedrus*, *Picea*, *Abies*) and broadleaf taxa (*Alnus*, Rosaceae and *Quercus*) are consistent with the present dominant growth of arboreal vegetation in the valley. Moreover, abundance of *Picea* and *Cedrus* pollen is reported within the vicinity of their respective forest patch. Significant frequency of micro-charcoal content and cultivated (Cerealia) Poaceae pollen (>35µm) reported at 3000-3500m amsl altitudes represent the ongoing burning and land-use activities at higher elevations.

Sub-surface pollen assemblage showed marked changes in the vegetation and land-use in the valley during last two millennia. We recorded decline in the pollen percentage of subalpine tree-line taxa (*Juniperus*, *Rhododendron*, *Betula* and *Abies*) and temperate tree taxa (*Cedrus*, *Picea* and Rosaceae), and gradual rise in wild and Cerealia Poaceae pollen since 6th century till recent. This indicated the timber extraction from temperate forest and land clearance activities at the higher elevations for cultivation. Significant increase in micro-charcoal percentage during last millennium reflects the intensifying wood burning activities, thus supporting the exploitation of forest for fire-wood in the valley. Declining trend of aquatic pollen taxa (*Potamogeton* and *Typha*) and increase in the pollen percentage of Cyperaceae, steppe and other non-arboreal ground vegetation represents the soil moisture decline till recent. However, increase of Asteraceae elements since last millennia possibly indicates the grazing activities at the site. During last millennia, anthropogenic pressure has become a significant factor in controlling the vegetation and land-use pattern of the area. Results illustrated a close intertwinement of climate and local human

activities during past two millennia. Generation of such datasets from the Himalayan region is highly crucial for demystifying the role of climate and human factors responsible for alteration of the natural vegetation at a finer spatial and temporal scale.

Keyword

Palaeo-vegetation, Microcharcoal, cultivation, wood-burning, anthropogenic impact

(Ivy Mike) at Enewetak Atoll.
If ratified by the International Union of Geological Sciences Executive Committee, this would be the first such unit that directly reflects a pervasive and largely irreversible shift in the Earth System due to human activities. This study provides a unique opportunity to investigate deep-time stratigraphic techniques applied on contemporary successions with ultra-high resolution data on the timing of drivers and resultant geological responses.

Keyword

Anthropocene, chronostratigraphy, Great Acceleration, plutonium isotopes

Deciphering Social-Ecological Transitions in the Anthropocene: An Evolutionary Framework Reveals Dynamics and Decoupling in China's Yangtze River Delta

KE ZHANG[1]*, Chinese Academy of Science (kzhang@niglas.ac.cn)

Abstract

Understanding the transient dynamics of interlinked social-ecological systems (SES) is imperative for assessing sustainability in the Anthropocene. However, how to identify critical transitions in real-world SES remains a formidable challenge. In this study, we present an evolutionary framework to characterize these dynamics over an extended historical timeline. Our approach leverages multidecadal Rates of Change (RoCs) in socioeconomic data, paleoenvironmental, and cutting-edge sedimentary ancient DNA records from China's Yangtze River Delta, one of the most densely populated and intensively modified landscapes on Earth.

Our analysis reveals two significant social-ecological transitions characterized by contrasting interactions and feedbacks spanning several centuries. Initially, the regional SES exhibited a loosely connected and ecologically sustainable regime. Nevertheless, starting in the 1950s, an increasingly interconnected regime emerged, ultimately resulting in the crossing of tipping points and an unprecedented acceleration in soil erosion, water eutrophication, and ecosystem degradation. Remarkably, the second transition occurring around the 2000s, featured a notable decoupling of socioeconomic development from eco-environmental degradation. This decoupling phenomenon signifies a more desirable reconfiguration of the regional SES, furnishing essential insights not only for the Yangtze River Basin but also for regions worldwide grappling with similar sustainability challenges. Our extensive multidecadal empirical investigation underscores the value of co-evolutionary approaches in understanding and addressing social-ecological system dynamics.

Keyword

Anthropocene, paleoecology, resilience, tipping point, lakes

Anthropogenic beachrock analogues and their significance for the Anthropocene stratigraphy

Agnieszka GAŁUSZKA[1]*, Jan Kochanowski University (Agnieszka.Galuszka@ujk.edu.pl)
Zdzisław M. Migaszewski[2], Jan Kochanowski University

Abstract

Current coastal sedimentary formations including human artifacts were reported as rock analogues by many researchers. Most of these rock analogues consist of plastic waste as a major constituent mixed with a variety of mineral grains and rock pieces. In many cases, the plastic component is thermally-altered. The examples of such rock-like materials are termed plastiglomerates, anthropogenic beachrocks, anthropoquinas, plasticrusts, pyroplastics or plastistones (Wang and Hou, 2023). Here, we report a material composed of a fragment of brass gun bullet which is attached to a ferruginous micritic light brown limestone pebble and a dark brown ferruginous conglomeratic quartz-limestone sandstone resembling a natural conglomerate. It was found in northwestern Poland, on the Kołobrzeg beach of the Baltic Sea. This military artifact dates back to the World War II. It can be linked to a battle between Polish-Soviet armed forces and German troops that defended the strategic fortified town of Kołobrzeg on March 4 through 18 of 1945.

Rapid cementation of coastal sediments favors the formation of beachrocks containing recent human artifacts. It has been estimated that lithification of such sediments may occur within a few years (Vousdoukas et al., 2007). These artifacts may be a proxy for the Anthropocene strata. In our presentation, we show different types of beachrock analogues and discuss their relationship to a rock definition commonly used by geologists. We also point to their preservation potential in the present and future geologic record as evidence for the Anthropocene epoch.

References

Vousdoukas, M.I., Velegrakis, A.F., Plomaritis, T.A., 2007. Beachrock occurrence, characteristics, formation mechanisms and impacts. Earth-Science Reviews, 85(1-2), 23-46. doi:10.1016/j.earscirev.2007.07.002

Wang, L., Hou, D., 2023. Plastistone: An emerging type of sedimentary rock. Earth-Science Reviews, 104620.https://doi.org/10.1016/j.earscirev.2023.104620.

Keyword

rock-like materials, beachrocks, Anthropocene stratigraphy, lithification, human artifacts

Anthropocenic significance of waste strata

Wook-Hyun NAHM[1]*, Korea Institute of Geoscience and Mineral Resources
(nahmwh@empal.com)
Min HAN[2], Korea Institute of Geoscience and Mineral Resources
So-Jeong KIM[3], Korea Institute of Geoscience and Mineral Resources

Abstract

The most stark measure of our daily lives is 'waste.' Various types of waste have already been produced in enormous quantities, threatening the right to survival and health of humans and the ecosystem for a long time. The waste problem is being addressed from a variety of perspectives, not only in the engineering field but also in the humanities, economics, and arts fields. Recently, the field of geology has also begun to think of waste as sediment and landfills as artificial strata. A landfill is considered a sedimentary basin where artificially generated sediments (waste) are moved and deposited artificially.

Debate is currently underway as to whether the Anthropocene is a 'period' that can be recognized by sedimentological strata division or an 'idea' that reflects various perspectives on the relationship between humans and nature. Whatever it is, the waste produced by humans tells the story of many of the issues we are struggling with, namely, how we can understand the Anthropocene, including the Capitalocene, Carbocene, Chthulucene, Manthropocene, Phagocene, and Plantationocene.

In particular, plastic waste has become a symbol of the Anthropocene, creating several new types of plastic rocks such as plastiglomerate, plasticrust, anthropoquinas, and plastitar. Additionally, e-wastes such as computers, monitors, cell phones, batteries, and televisions contain harmful substances such as lead, mercury, and cadmium, but can also be a source of urban mining containing gold, nickel, lithium, and manganese. In the field of geology, there is a need to look at the waste problem from a geological perspective, actively discover research topics, and seek appropriate response measures.

This work is supported by the National Research Foundation of Korea (NRF) grant funded by the Korea government (MSIT) (NRF-2018R1A5A7025409, NP2018-026), and the Basic Research Project (GP2022-006) of the KIGAM funded by the Ministry of Science and ICT, South Korea.

Keyword

Anthropocene, landfill, e-waste

[Keynote] Time to explore more of the Anthropocene

Buhm Soon PARK[1]*, KAIST (parkb@kaist.edu)

Abstract

In March 2024, the International Union of Geological Sciences (IUGS), in conjunction with the International Commission on Stratigraphy (ICS), approved the vote to reject the proposal for an Anthropocene Epoch as a formal unit of Geological Time Scale. They then added a forward-looking statement that “the Anthropocene will nevertheless continue to be used not only by Earth and environmental scientists, but also by social scientists, politicians and economists, as well as by the public at large” (IUGS official website). This decision prompts an important question on how the future multi-disciplinary exploration of the Anthropocene will or should differ from previous efforts that have focused on establishing stratigraphic evidence for its status as a geochronological epoch. Interpreting the Anthropocene as a general descriptor of anthropogenic impact on the Earth system is one thing; viewing it as a specific signifier for the existential crises of humans and nonhumans is another. This paper aims to revisit the implications of two sets of graphs depicting the Great Acceleration, i.e., Earth System trends and socioeconomic trends, by updating and revising some of them. Additionally, the paper argues for a more robust study of the Anthropocene by geological scientists, not only within their disciplinary boundary but also in cross-disciplinary spaces for broad scholarly and public engagement.

Keyword

Anthropocene, Great Acceleration, multi-disciplinary approach

Anthropogenic changes in river landforms and application of nature-based solutions in South Korea

Dahae GO[1]*, Catholic Kwandong University (ekgo3232@cku.ac.kr)
Kwang Hee Choi[2], Catholic Kwandong University

Abstract

Rivers have historically been a reliable source of water for humans and have acted as natural infrastructure. People have traditionally settled around rivers and managed them. Gray infrastructure, which is a traditional method of river management, mainly involves using materials from civil engineering, such as dams, embankments, and weirs and straightening the river to make it easier to manage. However, these artificial rivers are now more vulnerable to flood risks, as heavy rains and tropical cyclones have increased due to climate change. Recently, Nature-based Solutions (NbS) are emerging as a new river management method. NbS is a river management plan that sustainably manages and utilizes nature to solve social and environmental problems using ecosystem functions. It is implemented in various ways, such as floodplain acquisition, levee relocation, and small dam removal. Similar concepts such as close-to-nature river techniques (CRT), green infrastructure (GI), and low-impact development (LID) have been proposed. The study attempts to categorize the NbS types of river management in South Korea and examines three case sites. In the case of Gapcheon River in Daejeon, a barrage was removed in 2023 to improve the water ecosystem connectivity. The study compared the DTMs before and after the removal of the barrage to check the landform changes. In Yeongwol-gun, a reservoir for the Seogang River was created in 2012 using the abandoned channel. The study aims to check the flood reduction effect after the reservoir was built. In the Jangdong region of Geumgang River, a project to remove part of the existing embankments will be implemented soon. Through drone-based photogrammetry, cross-sectional surveys, and sediment surveys, the study aims to gather the basic data on the future landscape changes.

Keyword

River management, Nature-based Solutions (NbS), Green infra

How palaeontological signatures of the Anthropocene are stratigraphically unique.

Mark Williams[1], University of Leicester, UK
Colin Neil WATERS[2]*, University of Leicester (cw398@leicester.ac.uk)
Jan Zalasiewicz[3], University of Leicester, UK
Anthony D. Barnosky[4], University of California, Berkeley, USA
Reinhold Leinfelder[5], Freie Universität Berlin, Germany
Martin J. Head[6], Brock University, Canada
Francine M.G. McCarthy[7], Brock University, Canada
Alejandro Cearreta[8], Universidad del País Vasco, Spain Bilbao
Colin P. Summerhayes[9], Scott Polar Research Institute, Cambridge University, UK
Jaia Syvitski[10], INSTAAR and CSDMS, University of Colorado, USA
Andrew B. Cundy[11], University of Southampton, National Oceanography Centre, UK
Barbara Fiałkiewicz-Kozieł[12], Adam Mickiewicz University, Poznań, Poland
Michinobu Kuwae[13], Ehime University, Matsuyama, Japan
Neil L. Rose[14], University College London, UK
Simon D. Turner[15], University College London, UK
Michael Wagreich[16], University of Vienna, Austria
M. Allison Stegner[17], Stanford University, California, USA
Moriaki Yasuhara[18], University of Hong Kong, China
Amy Wrisdale[19], University of Leicester, UK
Mary McGann[20], U.S. Geological Survey, USA

Abstract

Increasing human interactions with the biosphere over tens of millennia have left a fossil record that shows the growing geographical spread and technological sophistication of humans evident in patterns of extinction and domestication of the landscape and its plants and animals. Here, we focus on the “Great Acceleration” of the mid-20th century (e.g. Steffen et al. 2015) which provides the causal mechanism of the proposed Anthropocene epoch (Waters et al., 2023) in which rapid increases in human and domesticated animal populations, energy consumption and technological innovation coincide with globalization of industry and commerce. Key parameters and their diagnostic palaeontological signals of the Anthropocene include: 1) the rapid breakdown of discrete biogeographical ranges for marine and terrestrial species with successions in North America, South America, Africa, Oceania, Europe and Asia correlatable using palaeontological signatures of highly invasive species and changes to ecologies that demonstrate the growing interconnectivity of human systems through expansion of global shipping, road networks, physical connection of water masses and recent development of aquaculture; 2) rapid changes to ecologies resulting from climate change, e.g. loss of coral reefs and poleward shifts of species through thermal stress, and ecological degradation, e.g. nutrient enrichment in lakes and coastal zones causing eutrophication and hypoxia, and extensive damming of rivers inhibiting movement of species and causing local extirpation; 3) an ‘acme biozone’ of human and domesticated animal

skeletons co-occurring with a domesticated plant pollen record and coincident with greatly reduced populations, ecological ranges and extinctions of ‘wild’ species; 4) the rising volume and unique depositional settings of landfills containing large quantities of organic wastes recording the spread of exotic foodstuffs far beyond their geographical range of environmental tolerance, notably of seeds of internationally traded fruits, e.g. avocados, coconuts, mangos and peaches; and 5) the accumulation of reconfigured forest materials including paper, paperboard and engineered wood products such as medium density fibreboard (MDF). The presentation addresses how a range of depositional settings may preserve a long-lived, unique palaeontological record for post-mid-20th century deposits that is distinct from all past records of deep-time biotic change, including those of the Holocene, and is consistent with the proposal of the Anthropocene as an epoch of geological time.

References

Steffen, W., Broadgate, W., Deutsch, L. et al., 2015. The trajectory of the Anthropocene: The Great Acceleration. Anthropocene Review 2 (1): 81–98.

Waters, C.N., Turner, S.D., Zalasiewicz, J., Head, M.J. (Eds.), 2023. Candidate sites and other reference sections for the Global boundary Stratotype Section and Point of the Anthropocene series. Anthropocene Review 10(1): 3–24.

Keyword

Anthropocene, Biostratigraphy, Neobiota, Ecological change, Landfills

Mapping of submerged landforms by dam construction using historical aerial photos

Jae Hyun HWANG[1]*, Department of Sustainable Environment, Catholic Kwandong University (hjh3962@cku.ac.kr)
Kwang Hee CHOI[2], Department of Geography Education, Catholic Kwandong University

Abstract

A dam is an artificial reservoir created to control the water in a river. Dams supply water for living or industry to surrounding areas, control floods, and produce electricity. However, large-scale dams significantly impact the climate and landscape of their neighboring areas. The construction of such dams can lead to the submergence of important geomorphic features, causing the loss of historical information and local communities that once lived there. Current digital maps based on aerial surveys only display the topography above water level, omitting submerged areas. However, it is possible to use past data, such as historical aerial photographs and topographic maps, to identify the old landforms beneath the lake's surface. Using the data, we can create a Digital Elevation Model (DEM) of the lake bed to reveal its topography.

This study focuses on the Daecheong dam, which was constructed in the central area of South Korea between 1975 and 1980. During the dam's construction, 50.3 of rice fields, villages, and other areas were submerged, displacing 4,075 households. The lake created by the dam makes it difficult for researchers to access the past landforms, including river terraces that are not well-known in this region. To overcome this challenge, this study created a past DEM of the submerged area by merging the interior and exterior of the lake, using historical aerial photos. The past DEM shows the submerged landforms such as old channels, bars, floodplains, river terraces, and small tributaries. The river terrace identified for the first time in this study appears to have at least three thread surfaces along the old channels. This study concludes that the hidden landforms can be recognized in submerged areas through the DEM generated using the combination of historical aerial photographs and current maps. This approach can help researchers identify past landforms, including those not well-known in the region.

Keyword

Anthropocene, Fluvial landforms, Past DEM, River terrace

The lagoon of Venice (Italy) in antiquity: insights into settlement dynamics, adaptive behaviours, and palaeoenvironmental reconstructions

Carlo Beltrame[1], Dipartimento di Studi Umanistici - Università Ca' Foscari Venezia
Adele BERTINI[2]*, Dipartimento di Scienze della Terra - Università degli Studi di Firenze (adele.bertini@unifi.it)
Paolo Mozzi[3], Dipartimento di Geoscienze - Università degli studi di Padova
Gabriele Niccolini[4], Dipartimento di Scienze della Terra - Università degli Studi di Firenze
Alessandra Forti[5], Dipartimento di Studi Umanistici - Università Ca' Foscari Venezia
Samuele Rampin[6], Dipartimento di Geoscienze - Università degli studi di Padova
Sandra Donnici[7], CNR-IGG

Abstract

This interdisciplinary research project (PRIN 2022), funded by the Italian Ministry for University and Research encompasses historical, archaeological, geomorphological, palaeoecological, and palaeoclimatic investigations, with the focus on the intricate relationship between environmental changes and cultural responses during the latest Holocene in the Lagoon of Venice (Italy). Central to the research is the interaction between human activity, water, and coastal wetlands in Roman times. The lagoon of Venice and similar environments likely served as pivotal economic resources and strategic seaport locations. This is evidenced by the analysis of Roman construction techniques, such as the utilization of wood and reused amphoras, which offer valuable insights into their adaptive strategies tailored to the unique environmental conditions. Geophysical surveys, coring, and targeted excavations are currently underway at key sites within the northern Venice Lagoon and in the harbour area of Altinum. Palynological (pollen, dinoflagellate cysts, and other Non-Pollen Palynomorphs-NPPs) and carpological analyses from archaeological deposits and nearby natural sedimentary archives provide valuable insights into both cultural practices and environmental changes. The tracing of floristic, vegetational, and climatic changes including those with decadal resolution offers snapshots of vegetation responses during key periods (e.g. Roman Periods, Medieval Climate Anomaly and Bond events). Previous proxies together with foraminifers provide insights into aquatic environments, furnishing evidence on lagoon palaeohydrology and connections with the sea. This contributes to the detection of sea-level fluctuations and changes in coastal ecosystems, including modifications in the extent of fresh to salt marshes. Collectively, these diverse observations enrich our comprehension on the palaeogeography of the lagoon and coastline in antiquity, offering perspectives into how lagoon systems responded to relative sea-level rise. They also help to better understand settlement dynamics in the Venice lagoon and similar environments in antiquity, shedding light on human adaptation and resource exploitation. As part of public outreach, this historical, geoarchaeological and anthropological approach may augment local awareness of origins and environment, potentially fostering community cohesion and mitigating depopulation. The collection of data from imperilled archaeological sites, aimed at preserving their significance, is crucial when considering the growing risks associated with erosive phenomena caused by environmental

factors, exacerbated by the construction of the MOSE flood barriers, in use since October 2020, which pose a threat to some sites, such as the Roman villa of Lio Piccolo. An integrative aspect of this research involves active collaborations with several institutions such as the Museo di Storia Naturale di Venezia and the Museo Archeologico Nazionale di Altino, facilitating educational initiatives addressing past and future sea-level and environmental changes. Valorisation of archaeological sites in the Venice lagoon could bolster cultural tourism offerings, and support museums like the future Museo Nazionale della Laguna di Venezia. The findings will be shared with a wider audience also through the creation of a digital storytelling platform.

Keyword

Archaeology, Geomorphology, Palynology, Lagoon, Latest Holocene

Radiogenic Isotopes, Geochemistry, Petrography of Raw Materials: A Case of Archaeological Ceramic Circulation in the Atacama Desert (Iluga Túmulos, Tarapacá, Northern Chile)

Camila RIERA-SOTO[1]*, University of Cape Town (cami.riera.soto@gmail.com)
Petrus le Roux[2], University of Cape Town
Osvaldo González-Maurel[3], Universidad de Concepción
Mauricio Uribe[4], Universidad de Chile

Abstract

Sands and clays can make an ideal mixture with precise colour and granulometry, which can be used to define the primary petrography determined by ancestral pottery knowledge with agency and social meanings. From the archaeometric point of view, the petrographic or textural differences that can be determined with the help of hand lenses or microscopes give a closer approximation of the detail of the components of the raw materials.

These groupings are created through a visual petrography classification closely related to the geochemical data. These data can reveal the geological environments from which the raw materials originated, such as volcanic, fluvial or coastal. These environments can be familiar and repeated within human circulation circuits, especially in the Andes, where the central part of the landscape is volcanic. So, what is its relationship with social-geological landscapes and local or foreign pottery traditions?

This research focuses on the ceramic fragments recovered from the site of Iluga Túmulos (900 BC - 1600 AD), an archaeological area located in the Tarapacá Region (northern Chile), with abandoned agricultural and public structures partially buried by desertification processes in the Pampa del Tamarugal, the hyperarid core of the Atacama Desert. Within the material recovered at the site, ceramic fragments abound in quantity, types or styles and periods; identified specimens correspond to the Formative, Late Intermediate of the Western Valleys and Altiplano periods, along with Imperial, Provincial and Local specimens from the Inca period, as well as Hispanic colonial pieces.

In this work, we present detailed microscopic petrography (optical and automated SEM mineralogy), together with new trace elements and REE, and strontium and lead isotope data, for ceramic fragments from Iluga Túmulos. We have identified three distinctly different groups of ceramic fragments: Arica, Tarapacá, and Altiplano-Inca. These groups, differentiated in terms of macroscopic attributes (such as surface finish and fresh paste) and microscopic petrography, have been classified among the most representative pottery traditions in northern Chile. In addition, the radiogenic isotope and geochemical data have shown that some petrographically different pastes share a similar isotopic/geochemistry signature, which is interpreted as different sources of raw

materials within a given geological context.

With this archaeometric review of the ceramic materials from Iluga Túmulos, we hope to rethink the supply of raw materials, ceramic production and the circulation of vessels that keep the different experiences and pottery traditions of these pre-Hispanic populations that inhabited the South Central Andes.

Keyword

Isotopes, Geochemistry, Archaeology, Circulation, Ceramics

Tracing Anthropocene signatures: Sediment core analysis along the west coast of Korea, Yellow Sea

Eun Young LEE[1], University of Vienna
Tae Soo CHANG[2]*, Chonnam National University (taesoo20@jnu.ac.kr)
Michael WAGREICH[3], University of Vienna
Veronika KOUKAL[4], University of Vienna
Serin LIM[5], Chonnam National University
Maria MESZAR[6], University of Vienna
Chaon KIM[7], Chonnam National University

Abstract

In recent years, the concept of the Anthropocene has emerged as a prominent topic of discussion, symbolizing humanity's profound impact on geological processes. Human activities have reshaped the Earth's systems to such an extent that contemporary geological deposits now bear unmistakable anthropogenic signatures. Since the 1950s, fundamental shifts have occurred in the structure and functioning of the Earth's system, manifesting in increased concentrations of long-lived greenhouse gases, rising surface temperatures, and ocean acidification. These transformations are closely linked to socio-economic trends like population growth, industrialization, and intensified use of minerals and energy. Notably, the widespread proliferation of manufactured materials like aluminium, concrete, and plastics has become a marker of Anthropocene sediments.

The Yellow Sea region stands out for boasting one of the world's most developed coastlines, situated between mainland China and the Korean peninsula. Since the mid-20th century, rapid population growth along the coastline has led to widespread loss and degradation of natural intertidal zones and basin areas. Annually, more than 1.6 billion tons of sediments and anthropogenic materials are transported from metropolitan areas into the Yellow Sea by river systems including the Yellow River, Changjiang River in China, and Han River in South Korea. Consequently, the coastal area has received significant international attention as a focal point for studying the impacts of human activities on natural systems. To investigate anthropogenic signatures in coastal sediments of South Korea, core sections were collected from two islands, Ganghwado and Jeungdo, on the west coast of South Korea. Comprehensive core descriptions, including analyses of macroscopic components and sedimentary features, were conducted. Select core samples underwent thorough processing to determine characteristics of geochemical and mineralogical composition, microplastic contents, and variations in Anthropocene deposits. This study presents our findings regarding anthropogenic signatures in coastal sediments on the west coast of Korea. The distinctive markers can be correlated with diverse environments and socio-economic trends in Korea and globally. Through this international research collaboration, our aim is to deepen our understanding of local and regional anthropogenic signatures, thereby contributing to broader insights into the Anthropocene.

Keyword

Anthropocene, Anthropogenic markers, West coast of Korea, Yellow Sea, Microplastics

The duration of the Anthropocene epoch

Colin P. Summerhayes[1], Scott Polar Research Institute, Cambridge, UK
Jan A. Zalasiewicz[2], Leicester University, UK
Martin J. James Head[3]*, Brock University (mjhead@brocku.ca)
Anthony D. Barnosky[4], Berkeley University, USA
Alejandro Cearreta[5], Universidad del País Vasco, Spain
Barbara Fiałkiewicz-Koziel[6], Adam Mickiewicz University, Poland
Jacques Grinevald[7], Geneva Graduate Institute, Switzerland
Reinhold Leinfelder[8], Freie Universität Berlin, Germany
Francine M.G. McCarthy[9], Brock University, Canada
John R. McNeill[10], Georgetown University, USA
Yoshiki Saito[11], Shimane University, Japan
Jaia Syvitski[12], University of Colorado, USA
Michael Wagreich[13], University of Vienna, Austria
Colin N. Waters[14], Leicester University, UK
Mark Williams[15], Leicester University, UK
Jens Zinke[16], Leicester University, UK

Abstract

Applying the basic principles of carbon chemistry and physics, along with a comprehensive understanding of past climate change, Steffen and colleagues confirmed in the Proceedings of the National Academy of Sciences 115, in 2018, that fossil fuel usage and resulting carbon emissions will cause substantial global warming into future millennia. The climate shift caused by increasing greenhouse gases is provoking a major perturbation to the Earth System likely to last for hundreds of thousands of years according to Talento & Ganopolski in Earth System Dynamics 12, in 2021, because of (i) the long residence time of CO2 in the atmosphere; (ii) the reduced ability of the global ocean to serve as a carbon sink as warming continues; (iii) the release to the atmosphere of CO2 currently stored in the ocean to maintain chemical equilibrium between the ocean and atmosphere as emissions of CO2 begin to decline; (iv) the decrease in albedo through continuing ice melt; and (v) a transgression forced by sea level rises of 10-15m or more supplying organic rich sediments to coastal seas and thus increasing the ocean's carbon content. These drastic changes and associated largely irreversible changes to the biosphere justify the creation of a new epoch – the Anthropocene.

Intensification of the greenhouse effect results from the growth in emissions of the CO2 equivalent (CO2-eq), calculated as the sum of the effects of CO2+CH4+N2O+CFCs and other trace gases. According to NOAA's Annual Greenhouse Gas Index, in spring 2022 the CO2-eq had reached 523 ppm. Such high concentrations of greenhouse gases in the atmosphere are above those identified in the early Late Pliocene, around 3.5 Ma ago, and are close to those identified for the mid-Miocene (16.9–14.7 Ma ago), which were known intervals of uncommon warmth during Neogene times. According to the IPCC's 6th assessment report (of 2023) projections based on

intermediate emissions scenarios place us on track by 2100 to experience CO2 concentrations of 600 ppm that would raise mean global temperature by 2.7°C, a level higher than experienced during Quaternary time. That same report considered that global mean sea-level rise approaching 2m by 2100 and over 15 m by 2300 cannot be ruled out due to deep uncertainty in ice sheet processes, with severe impacts on coastal populations. The ensuing prevention of the glacial maxima typical of the past 1 Ma is expected to last at least 500,000 years, assuaging concerns that the Anthropocene it too short in duration to qualify as a new epoch.

Keyword

Anthropocene, Holocene, Geological time scale, Climate change, Climate modeling

Towards Integrating Indigeneity and Geoethical Practice – Case Studies from Aotearoa New Zealand

Matthew W. HUGHES[1]*, University of Canterbury (matthew.hughes@canterbury.ac.nz)
Norm Kereikeepa[2], Te Rūnanga o Kaikōura
Clint McConchie[3], Te Rūnanga o Kaikōura
Alexander R.L. Nichols[4], University of Canterbury

Abstract

When they arrived in Aotearoa New Zealand (ANZ), the Polynesian peoples who would become Māori rapidly explored the landmass to identify Earth resources. Development of settlements entailed local terraforming – the sculpting of landforms for defensive purposes and food production – leading to empirical knowledge of rock and soil properties encoded in language and traditional practice. Land was intrinsic to identity, and narrative traditions developed in which landscape features were considered ancestors. In Māori philosophy, humans were a dependent component of wider dynamic geo-ecosystems. Māori therefore have a rich legacy of anthropogenic landforms, and deep spiritual ties to geomorphic and geological features across diverse landscapes. British colonisation in the 19th century brought different philosophical approaches to landscapes, and land alienated from Māori through military conquest and purchases was developed for agriculture and municipal infrastructure systems, resulting in significant alteration of traditional landscapes by forest clearance and earthworks. These tensions between Indigenous Māori and European settler approaches to landscape values and management persist today. Māori philosophical views have evolved from being solely dependent on the natural world to acknowledging their role as stewards and guardians of it – the concept of kaitiakitanga – and in recent years natural systems such as rivers have been awarded legal personhood to acknowledge their geo-ecological integrity and tribal importance. While greater emphasis is placed on sustainable infrastructure development and resource extraction, current and future landscape disturbance without regard to Indigenous values and concerns is still problematic. Here we present case studies of past and future potential conflict between Indigenous landscape values, national prioritisation of post-disaster infrastructure recovery, and potential mineral extraction to support climate mitigation technologies. The aim is to encourage geoethical thinking and practice among relevant professional geoscience and engineering communities.

The first case study concerns re-instatement of coastal transportation infrastructure following the 2016 Hurunui/Kaikōura Earthquake in Te Wai Pounamu (South Island) of ANZ. This coastline has a rich and dense Indigenous history evidenced by archaeological sites and terraformed landscapes. Due to the government wanting to expedite recovery of infrastructure deemed of national economic importance, legislation requiring environmental safeguards and community engagement was suspended, with subsequent negative impacts on sacred sites and heritage landscapes by construction works. Although eventual community input led to preservation of culturally significant coastal landforms, there remains a need for increased awareness within the

engineering profession of Indigenous landscape values, and to proactively address concerns. The second case study concerns the potential extraction of olivine-rich lithologies such as serpentinites (hydrated exhumed mantle peridotites) for geo-engineered carbon dioxide sequestration. In ANZ potentially exploitable serpentinite deposits are concentrated in Te Wai Pounamu along an ophiolite belt, comprising distinct landscapes with recognised conservation and heritage values and lying within traditional Māori domains. In the event that technological constraints are overcome for serpentinite-mediated carbon dioxide sequestration, cultural and environmental factors may preclude resource extraction. A geoethical framework informed by Māori conceptual approaches is presented to facilitate discourse among communities, geoscientists and engineers, and to inform decision making in the context of competing landscape values.

Keyword

Geoethics, Māori, Aotearoa, New Zealand, Landscape

Operational ethics for researching geohazards

ILAN KELMAN[1]*, University College London / University of Agder (ilan_kelman@hotmail.com)

Abstract

Researching geohazards can, in itself, be hazardous to researchers and to others. Hazards to researchers are often known, identified, and accepted, with an example being institutional risk assessment processes. Geohazards research might also require formal ethics approval. Hazards to others, even when documented in any risk assessment or ethics approval processes, can be harder to fully account for.

This investigation examines three main questions regarding the ethics of the hazardousness of geohazards research:
1. How might conducting geohazards research produce problems for risk reduction and risk management?
2. How might publishing geohazards research produce problems for risk reduction and risk management?
3. How much responsibility should geohazards researchers take for any detrimental operational outcomes of their research?

Science diplomacy is used as an example, drawing on disaster diplomacy research, in order to demonstrate how these questions and the answers might be addressed to improve operational ethics for researching geohazards. Key areas for exploration and discussion include:
1. How useful are codes of conduct for improving ethical behaviour?
2. How much is risk reduction a preference compared to risk management?
3. How effective are monitoring, enforcement, and accountability mechanisms?
Some geohazards researchers might suggest that no further governance of operational ethics would be needed, indicating the importance of open and respectful discussion.

Keyword

diplomacy, disaster, risk

Geoscience Across Borders: Leveraging Geoscience Diplomacy for International Cooperation.

Munira Raji[1]*, University of Plymouth, United Kingdom (munira.raji@plymouth.ac.uk)

Abstract

Geoscience diplomacy involves international collaboration among geoscientists from different countries to address pressing global challenges. Global challenges such as climate change, energy poverty, environmental degradation, geological hazards, and resource scarcity have complex, interconnected causes that span national and geographic boundaries. Cooperation between geoscience experts from different countries and backgrounds is necessary to develop comprehensive solutions. Geoscience diplomacy facilitates this by encouraging the exchange of geoscientific knowledge and best practices. It brings together geoscientists, policymakers, interdisciplinary researchers, and other stakeholders to leverage their expertise in finding real-world solutions to global problems. Even if they don't label it as such, geoscientists can practice geoscience diplomacy through international research projects. The core goals of geoscience diplomacy are to strengthen cooperation between geoscientists worldwide and enhance relationships between nations. It is an important approach that allows geoscientists to work together globally to address global challenges.

For example, the Group on Earth Observations (GEO) is an intergovernmental organisation that aims to make environmental data more accessible for informed policymaking. Through initiatives like the Global Earth Observation System of Systems (GEOSS), GEO connects thousands of scientists across disciplines and nations to collaborate on gathering environmental data and information from the large array of observing systems contributed by members from 115 countries and organisations within GEO. This information informs disaster management and climate change adaptation strategies. The Integrated Research on Disaster Risk (IRDR) program, co-designed by the International Council for Science and the United Nations Office for Disaster Risk Reduction (UNDRR), also exemplifies geoscience diplomacy. IRDR brings together researchers worldwide across fields like volcanology, environmental science, seismology, climate science, ecology, health, engineering, social science, economics, etc. Their interdisciplinary collaboration aims to develop solutions for managing all types of natural disasters, including flooding and erosion, landslides, earthquakes, tsunamis, and those associated with active volcanoes, increasing resilience, mitigating their impacts, and improving policy-making mechanisms. International collaborative initiatives, such as UNESCO's International Geoscience Programme (IGCP), facilitate joint research collaborations between geoscientists from different countries. The IGCP projects promote North-South and South-South cooperation and prioritise societal benefits, skill development, knowledge advancement, and sharing. By fostering collaboration and exchange among geoscientists worldwide, such initiatives address global challenges and contribute to sustainable development through geoscience research and innovation. On a smaller scale,

partnerships between specific universities and institutions across borders on joint geoscience research projects represent geoscience diplomacy.

Keyword

Geoscience Diplomacy, Geoethics, International collaboration, Sustainable Development Goals, Geoscience without borders

An infrastructure designed for the research and global promotion of geoethics

Giuseppe Di Capua[1]*, Istituto Nazionale di Geofisica e Vulcanologia (giuseppe.dicapua@ingv.it)
Silvia Peppoloni[2], Istituto Nazionale di Geofisica e Vulcanologia (Rome, Italy), International Association for Promoting Geoethics (IAPG), IUGS Commission on Geoethics, CIPSH Chair on Geoethics

Abstract

In recent years, there has been a notable surge in the refinement of the theoretical foundations of geoethics and its practical applications. A growing number of scholars from diverse disciplines are actively engaging in this progressive development. This has increasingly underscored the need for establishing platforms where reflections, discussions, findings, and study materials can be readily exchanged and disseminated. The network of scholarly relationships has evolved to create both physical and conceptual spaces for meaningful discussions. The aim has been to maintain conceptual coherence in geoethical thinking by grounding reflections in the discipline's historical evolution and encouraging further advancements through open analysis, inviting contributions from a diverse array of disciplinary backgrounds. Today, the research infrastructure dedicated to geoethics and the promotion of its content is characterized by a complex structure, acting as a focal point for diverse cultural and scientific experiences. At the heart of this infrastructure is the International Association for Promoting Geoethics - IAPG (https://www.geoethics.org), founded in 2012. It comprises an Executive Committee, national sections, and Task Groups dedicated to specific topics within geoethics. More recently, two additional entities have complemented this structure: i) the Commission on Geoethics of the International Union of Geological Sciences (IUGS), established in February 2023, serving as the supporting branch of the IAPG to the IUGS and officially handling geoethics and social geosciences for the Union; ii) the Chair on Geoethics of the International Council for Philosophy and Human Sciences (CIPSH, an organization operating under the umbrella of UNESCO), established in January 2024, with the aim of expanding and strengthening an international research network involving institutions, non-governmental organizations, and individual scholars to promote interdisciplinary initiatives bridging geosciences, humanities, and social sciences through geoethics. The research infrastructure on geoethics has evolved and expanded with the addition of two editorial initiatives: a) The SpringerBriefs in Geoethics series by Springer Nature (https://www.springer.com/series/16482), established in 2020 and endorsed by the IAPG. This series aims to provide concise publications discussing the ethical, social, and cultural implications of geosciences knowledge, education, research, practice, and communication; b) The Journal of Geoethics and Social Geosciences (https://www.journalofgeoethics.eu/), a diamond open-access publication of the National Institute of Geophysics and Volcanology (Rome, Italy), supported by the IAPG, and founded in 2021. Lastly, the research infrastructure on geoethics is complemented by the School on Geoethics and Natural Issues (the "Schola"), established in 2019 (https://www.geoethics.org/geoethics-school). The “Schola” serves as a dedicated space for the

teaching and learning of the principles and values of geoethics within the context of the philosophy and history of Earth sciences. Its purpose is to furnish foundational knowledge and critical evaluation skills needed to comprehend the intricate relationship between human actions on ecosystems and the decisions made by geoscientists in the discipline that have societal and environmental implications. This includes enhancing the awareness of professionals, students, decision-makers, media operators, and the public regarding accountable and ecologically sustainable development.

Keyword

geoethics, social geosciences, ethics in geosciences, professional ethics, infrastructure

Responsible Earth/Geosciences and Planetary-Scale Anthropogenic Change

Martin Bohle[1], International Association for Promoting Geoethics (IAPG), Ronin Institute Research Scholar
Giuseppe Di Capua[2]*, Istituto Nazionale di Geofisica e Vulcanologia (giuseppe.dicapua@ingv.it)

Abstract

In an age marked by planetary-scale anthropogenic change (PSAC), the Earth sciences, including Geology, face a pivotal transformation. They gain the status of providing vital knowledge for the stewardship of planetary commons. Considering this context, this talk presents a book project that explores intersections between science and society from a geoscience perspective.

The proposed book project critically examines the dynamic interface between Earth/Geosciences and the profound concept of PSAC, particularly accentuated by the proposed Anthropocene. Recognizing the Anthropocene's unsettled formal status, this work delves into the ethical, philosophical, and cultural implications surrounding PSAC, reflecting its inevitable impact on communities, individuals, and societies globally. Against this background, the book project delves into the interdisciplinary debates and geo-philosophical considerations that emerge from PSAC. These discussions encompass geological perspectives and extend to the humanities and political sciences, highlighting the multifaceted impact of PSAC.

The geoethical perspective, a leitmotif of the book, emphasizes responsible conduct in Earth/Geosciences, especially considering experiences and challenges posed by unfolding PSAC. The epochal transformation of Earth's systems through PSAC calls for an appraisal of Earth/Geosciences' societal responsibilities. This book project, backed by the International Association for Promoting Geoethics, dissects PSAC's societal, cultural, and ethical ramifications. Central to the book's narrative is a geoethical perspective, underpinning a responsible approach to Earth/Geosciences. This perspective critically engages with human practices and behaviours in the face of PSAC. The geological community's forthcoming decisions regarding a possible geological notion of Anthropocene add urgency and significance.

Structured in three parts, the book initially situates Earth/Geosciences at the intersection of STEM disciplines and PSAC, emphasizing its multifaceted impact on research, engineering, and commercial sectors. The second part interweaves concepts of 'responsible science', 'citizen science', and 'stewardship' within Earth/Geosciences, showcasing their integral role in societal and environmental stewardship. The final part champions geoscience literacy as a cultural and educational imperative in navigating PSAC. The conclusion reflects on the emerging research questions and the necessity of developing geoethical perspectives for responsible Earth/Geosciences. The book aims to deepen societal understanding of PSAC, advocating for informed decision-making and collective action. It is a clarion call for embedding geoethical perspectives, responsible practices, and geoscience literacy in the discourse of Earth/Geosciences amidst the challenges of PSAC.

In summary, the book aims to foster a deeper understanding of the PSAC implications for

Earth/Geosciences and emphasize the critical role of geoethics in guiding responsible scientific inquiry and public discourse in an age of planetary-scale human impact.

Keyword

Planetary-scale Anthropogenic Change (PSAC), Geoethics, Science-Society Earth-Stewardship, Responsible Earth/Geosciences, Civic Earth/Geoscience Literacy

Bridging Continents: Building Environmental Awareness and Sustainability with geoscience communication through EuroGeoSurveys' PanAfGeo and GSEU projects

Julie Alison HOLLIS[1], EuroGeoSurveys
Krishnan Subramani Ramakrishnan[2], EuroGeoSurveys
Céline Andrien[3], EuroGeoSurveys
Francesco Pizzocolo[4], TNO - Geological Survey of the Netherlands
Nicolas Charles[5], BRGM - French Geological Survey
Josephine Uushona[6], GSN - Geological Survey of Namibia
Tracey Dancy[7], EuroGeoSurveys
Jean-Claude Guillaneau[8], BRGM - French Geological Survey
Rokhaya Samba Diene[9], CGS - Council for Geoscience
Mosa Mabuza[10], CGS - Council for Geoscience
Patrick Wall[11]*, EuroGeoSurveys (Patrick.wall@eurogeosurveys.org)

Abstract

Environmental awareness and sustainable use and management of the Earth are at the heart of the mission of EuroGeoSurveys – the collaborative association of the Geological Surveys of Europe. EuroGeoSurveys is involved in two major projects which are PanAfGeo and the Geological Service for Europe (GSEU). PanAfGeo aims to increase African-owned geological knowledge and skills for sustainable natural resources management through geoscientific on-the-job training, including geoscience communication and dialogue training, for geoscientists of the African geological surveys. GSEU aims to deliver a permanent collaborative network of European geological surveys to provide up-to-date, high-quality harmonised information on the European subsurface. While these projects are distinct in many ways, both address training or data and knowledge services across a wide range of geoscientific thematic areas, and both are united by a shared vision of subsurface management and sustainability practices supported by a wide-reaching commitment to geoscience communication and dialogue with diverse stakeholders.

To ensure maximum outreach and engagement, the communication activities of PanAfGeo and GSEU use methods and language tailored to specific target audiences, including industry, academia, government, civil society, and the broader public. Communication channels cater to diverse audiences through the use of social media platforms for online interactions, face-to-face workshops, conferences, and training sessions, stakeholder interviews, surveys, reports, and explanatory videos.

In PanAfGeo, science communication plays a pivotal role in empowering African geoscientists to effectively explain the significance of Earth sciences to non-specialists, to support environmental management, and to promote sustainable practices. Through a combination of social media engagement, reports, public speaking, and training, PanAfGeo fosters collaboration and knowledge exchange among participants, transcending geographical boundaries, and fostering a

deep understanding of Earth's interconnectedness.

Through GSEU, EuroGeoSurveys promotes awareness of the many crucial roles of the European subsurface in achieving net zero and promotes its sustainable use. GSEU engages diverse stakeholders, including governmental agencies, industry partners, and civil society organisations, to ensure that the harmonised geoscientific data, information and knowledge that fits their needs can reach them through the European Geological Data Infrastructure (EGDI) and associated expert services. GSEU focuses on result-driven stakeholder analysis and implementing diverse engagement methods to drive dialogue, build partnerships, and promote evidence-based decision-making for sustainable subsurface use and resource management practices across the continent.

Through both projects, EuroGeoSurveys delivers comprehensive information and communication campaigns. By tailoring messages to specific stakeholder groups and using diverse communication channels, EuroGeoSurveys aims to cultivate a geoscience-informed society committed to preserving the planet for future generations. These concerted efforts not only focus on geoscience education as a foundation for promoting environmental awareness, but also contribute to the development of a new generation of geoscientists deeply invested in sustainability practices.

EuroGeoSurveys' collaborative efforts through PanAfGeo and GSEU represent a holistic approach to advancing environmental awareness and sustainable practices globally. By empowering geoscientists with effective communication skills and engaging diverse stakeholders in meaningful dialogue, these initiatives contribute to building a more sustainable and resilient future for all.

Keyword

PanAfGeo, GSEU, EuroGeoSurveys, Environmental Awareness, Science Communication

Ethical Solutions: Climate Intervention Research, Experimentation, and Potential Deployment

Lisa Graumlich[1], American Geophysical Union
Janice Lachance[2]*, American Geophysical Union (AGU) (jlachance@agu.org)
Mark SHIMAMOTO[3], American Geophysical Union (AGU)
Billy Williams[4], American Geophysical Union

Abstract

Climate change requires urgent action. Aggressive actions toward carbon emissions reduction must remain the primary strategy for reversing and addressing climate change. However, increasingly the world is considering technology-based climate intervention approaches—often called climate engineering. There are major practical and ethical questions about the significant risks and potential trade-offs some of these approaches would bring and how they would be measured against the risks of our warming world. Recognizing the need for guiding principles in this fast-moving, dynamic space and building on AGU's longstanding history of advancing and advocating for strong scientific ethics, AGU is facilitating the development of a draft Ethical Framework for Climate Intervention Research, Experimentation, and Deployment. The ethical framework will be released in 2024 and will serve as a resource to help governments, researchers, NGOs, and the private sector make responsible decisions when engaging in climate intervention research or policy. In 2023, the draft framework completed a rigorous three-month public comment period and consultation process to include more holistic input from other scientists and ethicists, as well as community voices, youth advocates, and many more. This presentation will highlight the ethical principles and how the science community can incorporate and advocate for ethics in climate intervention research.

Keyword

geoethics, climate solutions, policy

Ethical Frontiers and Legal Landscapes: The ethics of geoengineering the Moon, Mars and other celestial bodies

Dov GREENBAUM[1]*, Reichman University/Yale University (dov.greenbaum@yale.edu)

Abstract

As humanity eyes the colonization of celestial bodies like the Moon and Mars, the endeavor to geoengineer these environments for human habitation presents a unique constellation of ethical, legal, and social challenges. These challenges, while echoing the concerns associated with terrestrial geoengineering methods such as solar radiation management (SRM) and carbon dioxide removal (CDR), also diverge significantly in context and complexity. Terrestrial methods, which address the pressing issue of climate change, involve moral, governance, and societal dilemmas around the potential alteration of Earth's climate. In contrast, the concept of terraforming celestial bodies like Mars necessitates a thorough examination of our ethical responsibilities and the possible ramifications of such profound interventions. The ethical questions surrounding the geoengineering of planets like Mars are particularly poignant. There is a critical moral consideration regarding the potential disruption of undiscovered ecosystems or the destruction of nascent astrobiological life. This underscores the imperative to approach our cosmic ventures with utmost caution, to prevent irreversible harm to these alien environments. The legal considerations are equally complex, rooted in the Outer Space Treaty's directives against harmful contamination and the unilateral annexation of celestial territories. Proposals by visionaries like Elon Musk to geoengineer Mars for human habitation prompt a reevaluation of these legal frameworks, suggesting the need for updated or supplementary guidelines that reconcile the ambition to colonize Mars and other celestial bodies with the imperatives of international space law. Moreover, the social implications of geoengineering Mars introduce a further layer of complexity. There is a valid concern that in our rush to colonize other planets, we might replicate the environmental mistakes made on Earth, exacerbating planetary degradation on a galactic scale. In light of these considerations, it becomes clear that the journey towards making Mars habitable demands a holistic integration of ethical foresight, legal precision, and social justice, some of which we can extrapolate from efforts here on Earth. Such a multidimensional approach is essential not only for the responsible stewardship of extraterrestrial environments but also to ensure that our endeavors in space are aligned with the highest ethical standards and contribute to the collective good. This strategy promises not only to safeguard the integrity of celestial ecosystems but also to inspire a framework for interplanetary exploration that honors our shared values and responsibilities as stewards of the cosmos.

Keyword

geoengineering, outer space, legal, ethics, astrobiology

Geotourism and geoethics as support for rural development in the Sundarbans Wetlands - a Ramsar site of West Bengal, India

Amit Mandal[1], Geological Survey of India
Sayani KHAN[2]*, Geological Survey of India (sayanikhan@gmail.com)

Abstract

The study aimed to emphasise geotourism potential and geoethics in rural development of Sundarbans Wetlands, one of the richest areas in India, specifically in West Bengal in terms of Geoheritage and Geoconservation.

Sundarbans, world's largest delta system is formed by Ganges-Brahmaputra-Meghna River confluence with innumerable channels-tidal creeks in Bay of Bengal. Sundarbans are also badged as world's largest contiguous mangrove belt, covering ~1,44,000 hectares. The system acts as a barrier against cyclones-tidal surges-saltwater intrusion, where mangroves play the most important role. Sundarbans are a hotspot of rich flora-fauna, habitat of unique and endangered biodiversity including trees like Sundari (Heritiera spp.), Gewa (Excoecaria agallocha), and animals like Royal Bengal Tiger (Panthera tigris tigris), Gangetic (Platanista gangetica) and Irrawady (Orcaella brevirostris) Dolphins, Greater Adjutant Stork (Leptoptilos dubius), Masked Fin Foot (Heliopais personata), River Terrapin (Batagur baska), Shark (Glyphis gangeticus), Estuarine Crocodile (Crocodylus porosus), 315-avian species, etc. Four-protected areas have been enlisted as UNESCO World Heritage Sites in Sundarbans.

Apart from scenic beauty and rich biodiversity, making it a popular international tourist destination, Sundarbans is also a paradise for Geoscience researchers. Being a classic example of a tide-dominated delta, active geomorphic processes can be studied and compared here with similar other systems in world. Wave-dominated sedimentary regimes in Matla-Saptamukhi riverfronts, text-book-like asymmetrical ripples near Bakkhali-Henry islands, aeolian dunes, cross-beddings at Sitarampur beach, accretionary tidal landforms in Hatania-Doania channel, mid-channel-bars in Thakuran river, sand-bars at MuriGanga riverfront, mudflats in Saptamukhi river are well-preserved. River bank erosion is pronounced by high-energy current flow and wave activity, banks of Sagar-Gorumara-Ghoramara islands in Hugli-MuriGanga rivers being highly susceptible. Bank erosion vulnerability, cyclonic-supercyclonic storms, loss of riverine islands over last-hundred-years, mangrove forests destruction thereby removing topsoil, changing landuse-landcover, global climate change affecting sea-level, natural geomorphic processes, etc. are the alarming issues for Sundarbans research. Mangrove ecosystem morphodynamics and diverse geomorphic features of creeks-channels-rivers of Sundarbans enriched with magnificent biodiversity, thus has vast possibilities for developing geo-heritage as well as geo-tourism site, which in turn help in increasing awareness about nature and its conservation.

Despite being a biodiverse reserve and an important Ramsar Site, Sundarbans are under severe threats due to anthropogenic stress imparted by ~4-millions inhabitants, vulnerability to climate change, alteration of natural habitats because of shrimp-crab-molluscs-fish farming, dredging-

oil/gas drilling-logging-wood harvesting-hunting-fishing-aquatic resource exploitation etc. However, its potential for geotourism development has been ignored, and geoheritage has not been sufficiently explored.

This study makes an inventory of geosites in Sundarbans. Selected sites are evaluated by applying Geosite Assessment Model to discover the most suitable geosites for future geotourism development, to support rural development as well. Results uncover information about areas of improvement for each evaluated geosite. Moreover, areas demanding more attention and better management in upcoming period to become recognisable geotourism destinations are identified. In present scenario of fast disappearing Wetlands, it is high time to take preservation steps on a serious note on geoethical point of view. Sundarbans require better management and precautionary conservation measures. Geoethical implications in geosite management can contribute to sustainable geoconservation in Sundarbans Wetlands.

Keyword

Sundarbans, Delta, Conservation, Geosite

Synthetic Seas: Ethical, Legal, and Social Dimensions of Genetically Engineered Phytoplankton for Climate Mitigation Contrast with Ocean Iron Fertilization

Dov GREENBAUM[1]*, Reichman University/Yale University (dov.greenbaum@yale.edu)

Abstract

The burgeoning field of synthetic biology offers transformative approaches for mitigating climate change, notably through the genetic engineering of marine microorganisms to enhance their carbon sequestration capabilities. Specifically, we will examine the ethical, legal, and social implications of deploying genetically engineered phytoplankton as a novel strategy. This strategy will be juxtaposed and contrasted with established geoengineering methods such as ocean iron fertilization, a well-discussed CDR method that involves the addition of iron to ocean waters to stimulate phytoplankton blooms.

Genetically modified phytoplankton potentially represent a scalable and efficient solution for reducing atmospheric CO2 levels, offering additional enhancements such as increased growth rates and improved resilience to changing ocean conditions. We further introduce yet another novel dimension by examining the potential role of artificial intelligence (AI) in refining these genetic modifications. Leveraging AI researchers may be able to predict optimal genetic alterations that enhance phytoplankton's carbon sequestration capabilities, potentially revolutionizing our approach to mitigating climate change.

However, this approach raises significant ethical concerns regarding the manipulation of natural ecosystems, potential ecological risks, including biodiversity impacts and unforeseen ecological consequences, and the moral considerations of intervening in oceanic biospheres. Moreover, legally, the deployment of genetically modified microorganisms in international waters presents complex jurisdictional challenges, necessitating a global governance framework to ensure responsible research, development, and monitoring of such efforts. Social implications revolve around public acceptance, the equitable distribution of technology and its benefits, and the engagement of indigenous and local communities in decision-making processes. The potential integration of synthetic biology with AI further poses unique ethical and regulatory challenges, particularly in terms of algorithm transparency and data usage.

In contrast to our proposal, ocean iron fertilization, while seemingly less invasive than genetic modification, has also been criticized for its unpredictable ecological impacts, potential for toxic algal blooms, and uncertain long-term carbon storage outcomes.

Ultimately, we argue for a cautious, ethically grounded approach to the use of synthetic biology in CDR, emphasizing the need for comprehensive risk assessment, transparent stakeholder

engagement, and international cooperation to navigate the complex interplay of ecological benefits, risks, and ethical considerations inherent in these innovative yet contentious methods of climate intervention.

Keyword

CDR, Synthetic Biology and AI, Carbon Sequestering, Ethics, iron fertilization

Geological and Natural Inheritance of Uzbekistan: Research and Conservation of Wealth

Ziyoda Kamunalovna AKHMEDOVA[1]*, Ministry of Mining Industry and Geology (ziyoda06-28@mail.ru)

Abstract

Geoethics and Earth studies are of great social relevance as they aim to explore different aspects of our planet and its interaction with society. This field of study is important to all of us as it allows us to better understand our Earth, predict change and address the world's challenges related to climate change, biodiversity conservation, resource management and building a sustainable future.

Geoethics serves as an aide in the study and management of our planet's natural resources such as water, minerals, oil, gas, energy and others. It allows us to better understand how to utilize and conserve these resources, taking into account environmental, economic, and social factors.

At the same time, the earth sciences, including geoethics, study the state of ecosystems, climate, the Earth's surface, the atmosphere, and other components of the environment. This allows us to assess the impact of human activities on nature, identify the causes of global climate change and develop strategies for more environmentally sustainable development. Geoethics and Earth studies also play an important role in planning urban environments and regulating land use. They help to determine the optimal location of buildings, efficient use of resources and population, natural disaster risk management and the creation of sustainable cities.

It is also worth mentioning that geological and geographical studies play an important role in studying earthquakes, volcanic eruptions, floods and other natural disasters. Through these studies, warning and monitoring systems are created to protect life and reduce losses in the event of disasters.

Uzbekistan, which occupies a significant area in the centre of Central Asia, is becoming an indispensable part of our planet Earth.

The nature of Uzbekistan amazes with its diversity and beauty. The majestic Tien Shan Mountains, the breathtaking Kyzylkum Desert, the picturesque Aidarkul Lake and the Ugam-Chatkal Mountains - all these natural wonders are only a small part of the uniqueness of Uzbek nature.

Uzbekistan is located in the northern part of the Pamir-Alai and Gissar mountains, part of the majestic Tien Shan range. Uzbekistan's mountain systems present stunning landscapes with high mountain lakes, mountain passes and unique climatic conditions.

In the west of Uzbekistan stretches the vast Kyzylkum Desert, one of the most extensive deserts in the world. Here majestic sand dunes, oases and unique flora and fauna create unique landscapes and leave a deep impression.

Rivers such as the Amu Darya, Syrdarya and Zarafshan, which flow through the territory of Uzbekistan, play a significant role in farming and water supply for the country. In addition,

Uzbekistan has beautiful lakes such as Aidarkul and Charvak, which are becoming places of recreation and natural reserves of amazing beauty.
Uzbekistan is truly an amazing country with a wealth of nature and the living creatures that inhabit it. All this beauty inspires us to care for and preserve this unique natural world for future generations.

Keyword

geoethics, Uzbekistan, Kyzylkum Desert, earth studies, monitoring

Regulating Geoscience in a Diverse Federation of Independent Regulators – The Canadian Example

MARK PRIDDLE[1]*, Egis Group (priddlemw@gmail.com)
Andrea Waldie[2], Geoscientists Canada

Abstract

Professional Geoscience is regulated in eleven of the thirteen provinces and territories in Canada. These jurisdictions vary significantly in size, demand for geoscience services, mineral resources and population. The numbers of professional geoscientists varies widely (~100 to 5000) between these jurisdictions, and most are co-regulated with engineers.

Geoscientists Canada is the national organization for ten of the geoscience regulated jurisdictions and provides a forum for cooperation and information sharing. The licensure requirements are consistent across Canada; however, the practice of geoscience is regulated independently by each province and territory. Because of this independent regulation and the need for mobility of geoscientists, cooperation between associations, and consistent practice across Canada, a national body such as Geoscientists Canada plays an important role. One key item developed and maintained by Geoscientists Canada is the Geoscience Knowledge and Experience Requirements for Professional Registration in Canada utilized by Canadian geoscience regulators in the assessment of applicants for professional licensure.

Geoscientists Canada does not license or regulate geoscience in Canada, but provides a forum for the independent regulators to work together on common goals. Several recent examples of cooperation will be presented:

• Development of an admissions support tools
• Review of all professional practice guidelines related to geoscience in Canada
• Preparation of a “qualified persons” short course (for students and practitioners
• Spearheading competency-based assessment for licensing practitioners

These activities all promote and enhance the regulation of professional geoscience and geo-ethics in Canada.

Keyword

geoscience regulation, geo-ethics, licensure, self regulation, qualified person

Bias in accepting diversity of interpretation in Earth Sciences – historical perspectives and modern challenges

Rob BUTLER[1]*, University of Aberdeen (rob.butler@abdn.ac.uk)
Clare Bond[2], University of Aberdeen
Mark Cooper[3], University of Aberdeen

Abstract

As in all areas of human investigation, as Earth Scientists we need diverse explanations if we are to evaluate uncertainty in geological interpretations. But do we practice what we preach?

Famously, in November 1926, a group of leading American Earth Scientists met in a symposium in New York to debate Alfred Wegener's proposal of continental drift. They rejected not just of Wegener's hypothesis but also the general notion of significant horizontal tectonics, globally or in orogenic belts. The aggressive, mocking tone of his opponents closed down debate. Deep irony lies at the heart of this. Much of the hostility towards continental drift, and the assertion of a fixist Earth disregarding empirical evidence to the contrary, can be traced to Thomas Chrowder Chamberlin (1843-1928), and his son Rollin Thomas Chamberlin (1881-1948). As well as being a geologist with wide-ranging interests, Chamberlin senior is credited with promoting the approach for establishing knowledge in science through the method of multiple working hypotheses. Continental drift was evidently a hypothesis too far for the Chamberlins. Earth Science had to wait until the 1960s before fixism was broadly abandoned in favour of plate tectonics. Today scientific debates are generally more respectful, and we may believe that we are now less prone to such biases. But are we really?

Modern Earth Scientists may consider themselves as above the polemical debates of the 1920s. Scientific conferences of course regularly pit opposing views. This however does not mean that diverse geological interpretations are given appropriate consideration. Our concern is the role of Earth Science in characterising and forecasting behaviour of the subsurface for engineering projects, in sedimentary basins. Much existing understanding has come from the extraction of earth resources – especially hydrocarbons. Uncertainties in geological interpretation can be met iteratively, perhaps by drilling another well when the initial hypothesis fails. But for subsurface geo-storage there is far less tolerance of failure.
These engineering challenges demand different approaches – and the recognition of uncertainties. How well are alternative interpretations and approaches valued? It is very rare for scientific journals to publish multiple interpretations. And the problem is exacerbated by literature search engines – that return literature on the basis of citation. This is an inherent bias that is self-reinforcing, reducing visibility of less cited texts, and therefore consideration of alternative approaches and opinions by the community. These approaches to seeking literature can have a similar effect to the infamous echo-chambers of social media – where a narrow range of opinions

and information are selectively reinforced to the exclusion of others.

While we are becoming better at accepting, promoting and valuing diversity in our community of scientists, the IT tools we use may engender exclusive and biased appreciation of science. Studies have recognised this for paper citation metrics of scientists in different communities and with different characteristics but to date, not about the literature itself. We draw examples from studies of the geological interpretation of complex subsurface structures, examining biases and impacts on uncertainty assessments .

Keyword

cognitive bias, tectonics, subsurface, uncertainty, history of science

Geological Surveys, Mining Industry Cycle and Government management! Sustainable development or conflict in national interests!

shirin safavi[1]*, UNESCO Chair on Coastal Geo-Hazard Analysis, Research Institute for Earth Sciences, Geological survey of Iran, Tehran-Iran (Shirin.safavi50@gmail.com)

Abstract

In the path of sustainable development, the mining economy chain lies in the harmonious link of exploration, extraction and processing, which, due to the breadth of the cycle in the case of continuity and production of final added value, in addition to entrepreneurship, can also play a role in the regeneration of gross national product. The Geological Surveys, with the twin key missions of generating capital and safeguarding national wealth in the field of geosciences, are among the most notable government institutions in terms of utilization of internationally expert.

In countries such as Iran with an oil-based economy, the share of mines and mineral industries without considering its downstream industries and uses, although at an increasing rate, still seems to be small, in order to make the national cost in the financial compensation of natural damages, the role Constructive and key governing organizations and basic knowledge such as Geological Survey doubles the economic cycle of developing countries!

Due to the increase in population and the increasing need of humans to know and use as much as possible from the few minerals and available biological resources in the earth's crust, as the only currently known habitat, exploration and search for mineral resources as the foundation and the first link. In the chain of mining industries, in addition to the unquestionable need for risky investment, it is dependent on having modern knowledge, using modern tools and equipment along with risk capital coverage mechanisms. In the meantime, based on the global experience, governments enter in the form of devices such as Geological Surveys, only in the two initial and final parts of the production cycle, in providing basic information for national exploration or entering specific cases targeted for the future, which the possibility can be defined due to the lack of investors or the lack of knowledge and technology in a period of time beyond the ability, or the interest of the private sector.

Keyword

Sustainable Development, Geological Survey, Mining Industry, Government Management

Fossils, museums and ethics – from site based conservation to institutional acquisition

Kevin Neil Page[1]*, ProGEO (kevinnpage@gmail.com)

Abstract

Considerations of geological heritage conservation and related legal issues are fundamental to both the initial collection and the subsequent acquisition of geological specimens by an institution as a resource for future generations - not least as there can be legal consequences for all involved if they are ignored… Ideally, the conservation measures in place should be beneficial to science and heritage custodianship by ensuring that key localities remain available for study as well as ensuring that key specimens of scientific and heritage importance are deposited in appropriate institutions for safeguard for future generations. This is not always the case, however, as highly restrictive measures can virtually prevent continued scientific study, as well as making it almost impossible for all but a very small number of local or national institutions to legally hold material from such sites.. In many cases, such restrictions represent either a confusion with the very restrictive regimes needed for rare species or archaeological conservation or attempts by national and regional agencies to safeguard a national heritage which had historically been plundered or otherwise damaged though misuse.. More insidiously, however, they can also reflect attempts by individual, politically influential scientists or institutions, to ‘control’ a resource for their own ’exclusive’ use – and this can take place at all levels from regional to national. In a few cases, however, the motivations are altogether darker, and it is an unfortunate fact that the palaeontological resource can be economically controlled by oppressive regimes or criminal activity, leading to a concept of ‘Blood Fossils’. But whatever the on-site, regional or national legal framework is, there are four key themes to consider, both in the field and as a manager of palaeontological collections: 1. Who does the fossil belong to? (e.g. landowner, collector, commercial company, governmental body, etc?); 2. Do any local, regional and/or national legal regulations apply to the source locality, and can or have the specimens been collected in accordance with such regulations?; 3) Can or has the specimen be legally removed from a region or country, according to regional to international level legislation?; and crucially, 4) Are there any ethical considerations, such as supporting damage to protected sites and loss of palaeontological heritage (i.e. irrespective of any legal consideration), supporting oppressive regimes and organised criminal activity, ‘neo-colonisation’ of heritage and science of low to middle income countries by high-income countries, and the contravention of established regional, national and international guidelines, agreements and conventions. Against this background, a concept of ‘Palaeontoethics’ has been developed, but as in so many of the broader themes relevant to modern geosciences, the issues represent an interface between several different disciplines, in this case geological heritage, field geology, palaeontology, institutional collection and ethical professional practice. As such there is a very strong need that international guidance is developed and approved by organisations such as IUGS, IUCN and UNESCO to ensure that all geoscientists are fully aware of not just the

legal considerations behind any field sampling or specimen acquisition, but also the ethical context.

Keyword

Palaeontoethics, palaeontological heritage, conservation, museums, fossil collecting

Science of Geoethics: Challenges and Opportunities

Devesh WALIA[1]*, North-Eastern Hill University (deveshwalia.17@gmail.com)

Abstract

Geoethics combines a complex of ethical relation to the components of the Earth, and to the diverse socio-economic objects, by preserving the geo-diversity and geo-heritage with knowledge expansion and is the crucial pillars for maintaining scientific integrity and credibility. Ethical conduct involves responsibilities toward society and Earth System. Self-monitoring and self-regulating behaviors promote knowledge, truth, trust, respect, and objectivity while avoiding conflicts and make geoscientists accountable for the quality and outcome of the earth system study following the ethical norms to unravel the geo-resources.

Geoethical principles aimed at implementing geological projects provide realistic and efficient support to not only apply economic criteria, such as profitability, commercial viability and profit margins because of continuous technological evolution and requirements, for which more and more earth resources are needed, but also consider ethical and transparent practice of management, improving the effectiveness, regeneration of mineral reserve base, and making sure the mineral resources are being used taking into account their exhaustibility, scarcity and resource ownership by future generations. Hence, promoting deep moral essence with spiritual development of personality to avoid social conflicts with deep time.

The challenges are plenty, but we need this opportunity to inculcate the science of geoethics to protect the mother earth for sustainable future generations.

Keyword

Geoethics, Sustainable Future Generations, Geo-resources, geo-diversity, geo-heritage

Martha Cornelius-Furlani (1886-1974) and Adelheid Kofler (1889-1985) - the First Female Geoscientis at the University of Vienna

Margret HAMILTON[1]*, University of Vienna (margrethamilton@hotmail.com)

Abstract

Martha Cornelius-Furlani (1886-1974) and Adelheid Kofler (1889-1985) – The First Female Geoscientists at the University of Vienna

Margret Hamilton
Geological Archive, Department of Geology
University of Vienna
margret.hamilton@univie.ac.at

Abstract
In the late 19th and early 20th centuries, social and political life in the Habsburg monarchy was male-dominated, despite some women's activities in 1848 and 1866. In 1897 women were admitted to the faculty of Philosophy for the first time. All candidates needed to have high school diplomas. The final certificate from the secondary schools intended for girls was not recognized for university studies due to the shorter school duration. Therefore, the candidates had to take an additional exam in order to be recognized as regular university students.
The first female doctors (PhD) were Adelheid Kofler at the mineralogical-petrographic institute and Martha Cornelius-Furlani at the geological institute.
Adelheid Kofler (Schaschek) was born 1889 in Haugsdorf, Lower Austria. In 1907 she passed the school leaving examination and enrolled at the philosophical faculty of the University of Vienna as an extraordinary student. In 1911 she passed the Matura examination “Maturitätsprüfung” so that she could continue studying as a regular student and passed her rigorous exams in mineralogy with the well-known Professor Friedrich Becke (1855-1927). Four years later she received her doctorate in medicine. In 1922 she got married with the medical doctor Ludwig Kofler (1891-1951). In 1926 the family moved to Innsbruck. Here Adelheid Kofler supported her husband in setting up the pharmacological institute at the University of Innsbruck. She worked on the micro-thermoanalysis of two- and three-substance systems and thereby created a way to qualitatively record the themodynamic behavior of two substances without serial experiments on a single microscopic preparation. After her husband's death in 1951, she continued to work successfully at the institute in the microscopic field. For her scientific work she received the Fritz-Pregl-Prize from the Academy of Sciences and the Austrian Cross of Honor for Science and Art.
Martha Cornelius-Furlani was born 1886 in Triest. After graduating from the teacher training college) in Triest in 1905, she enrolled as an extraordinary lecturer in geology at the University of Vienna. In 1907 she passed the Matura examination, which made her a regular student and in 1910 she got her PhD for Geology under the professor Viktor Uhlig (1857-1911). And in 1911 she

passed the examination for becoming a teacher in the subjects Natural History. In 1921 she got married with the geologist Peter Cornelius (1888-1950). She joined him on numerous excursions in the Alps, which resulted in a number of joint publications. After her husband's sudden death in 1950, she published the textbook "Geschichte der Geologie” (Principles of Geology), which she wrote with her husband. After her retirement she worked at the Natural History Museum in the paleontology department.

The two female scientists were able to successfully improve their knowledge and skills in the scientific subjects of mineralogy and geology after finishing their studies.

Keyword

Mineralogy, Geology, History, Female, scientists

Etheldred Benett (1776-1845) and the Unacknowledged Contributions of an Early English Woman Geologist

Renee M CLARY[1]*, Mississippi State University (rclary@geosci.msstate.edu)

Abstract

Etheldred Benett (1776-1845) is largely unknown as an early woman participant in geology, although she preceded Mary Anning (1799-1847) in her fossil interests and paleontological contributions. As a woman of independent means, Benett could pursue her investigations in paleontology. She amassed large numbers of fossils, through both self-collection and purchase, and she generously donated or loaned many of her specimens to other paleontologists and museums. Some of the local collectors who provided fossils to Benett were also women. Benett's paleontological interests were not fleeting; she regularly investigated fossil taxa in her area and networked with important geologists, including George Bellas Greenough (1778-1855) and Gideon Mantell (1790-1852), the latter with whom she had a three-decade long correspondence. Although barred from participation in the Geological Society of London because of her gender, Benett named fossil taxa, constructed and revised a stratigraphic column, published a fossil monograph, and may have been the first person to sieve for microfossils. Benett's letters document her thorough understanding of fossils and taphonomy. She felt confident enough to challenge Mantell's interpretations as early as 1815; he included some of her interpretations in his book, The Fossils of the South Downs. While Mantell emerged as a celebrated English paleontologist, Benett remained in the shadows. Other gentlemen geologists used her fossils and knowledge, but they did not always acknowledge her contributions. James Sowerby (1757-1822) even published her stratigraphic column without citing her authorship, and without her consent. Benett, however, seemed to accept her secondary role as a woman in geology, and even apologized for naming new fossil sponges, noting that after three scientific gentlemen did not describe and name these new genera, "I have done the best I could." Two centuries later, we should recognize and acknowledge Benett's contributions to geology.

Keyword

Etheldred Benett, history of geology, first women geologists, paleontology

Marie Stopes (1880-1958) and Kono Yasui (1880-1971)- the beginning of paleobotany in Japan

Michiko dvan Yajima[1]*, Tokyo Metropolitan University (pxi02070@nifty.com)

Abstract

Abstract
Marie Stopes was born in UK and presented her dissertation in German and received a PhD in botany in 1904. She came to Japan in 1907 and explored coal mines on Hokkaido for fossilized plants. She came back to UK and published the paper (Stopes and Fujii, 1910). It gave a great shock to Japanese scientific world that there is a woman paleontologist who had doctorate, made research even in coal mine .

Kono Yasui, who was born in 1880, came to Tokyo to enter the Women's Higher Normal School. After graduation, she worked as a teacher for 3 years at a middle school for girls. In 1905, in order to study biology more, she joined the graduate course first established at the Women's Higher Normal School as its only one science student. She published the first paper, "Weber’s organ of carp fish" in 1905 and changed the research to botany, particularly in cytology. She completed the graduate course at Women’s Higher Normal School, became assistant professor in 1907.
Japanese universities could give the doctorate students who studied at the foreign universities after graduation of universities in Japan. Yasui also had to go abroad to study more in order to get doctorate. Yasui applied for going abroad many times and at last in 1913, she was ordered by Japanese Government to go to USA and Germany to study more on biology. In 1914 she studied abroad in the US, at first conducted cytological research at the University of Chicago and began research on coal under the professor Edward Charles Jeffrey (1866-1952) at Harvard University. Jeffery might know that a good paper on Japanese coalStopes and Fujii, 1910.
Upon returning to Japan, she found it difficult to secure research funds at the Women's Higher Normal School in order to continue her study of coal. However, through the efforts of Professor Kenjiro Fujii (1866-1952) at the Botany Course of Tokyo Imperial University, she was able to continue this research for 10 years at Tokyo Imperial University. Yasui collected coal samples from various places around Japan by entering the deep shafts of coal mines using a basket. This was regarded as outstanding research that could not be surpassed by others, and thus bore fruit as the doctorate thesis "Botanical Study on Coals Produced in Japan"(Yasui, 1928). In this way, in 1927 the first female doctor of science among universities in Japan was born.
References
Marie C. Stopes and Kenjiro Fujii, “Studies on the structure and affinities of Cretaceous plants,” Philosophical Transaction of the Royal Society of London, Series B, 201 (1910), p. 1-90.
Yasui K. (1928) Studies on the structure of lignite, brown coal, and bituminous coal in Japan. Jour. Faculty of Science, 1mperial Univ.ersity of Tokyo, Sect.1II, Botany 1 Part 4: 381-468

Keyword

Kono Yasui, Marie Stopes, Kenjiro Fujii, palaeobotany

Geological Scenes from Two Marriages – Mary Elizabeth Lyell and Emma Darwin Compared

Martina KÖLBL-EBERT[1]*, Ludwig-Maximilian Universität Munich (m.koelbl@lmu.de)

Abstract

When Charles Lyell married Mary Elizabeth Horner in 1832, he had found himself a well-educated wife who took interest in his geological endeavours. She acted as his geological and secretarial amanuensis. She accompanying him on his travels, went in the field together with her husband as well as alone. As Charles Lyell had trouble with his eyesight, Mary Elizabeth did a considerable part of his correspondence. She was fluent in German and French, which allowed her to act as interpreter. However, she was also greatly interested in palaeontology and over the years became an accomplished taxonomist of fossil shells in her own right.

Seven years after Lyell, Charles Darwin married his cousin Emma Wedgwood. When she expressed her plans to read up on geology after people of their acquaintance had commented on her ignorance, her husband told her not to bother. Charles apparently was favouring a wife that took care of his household, played the piano and pampered him during his long phases of illness. As to his friend Charles Lyell, Darwin commented rather negatively about his marriage, believing that Lyell ill-treated his wife, when she sat by when the two men talked science.

The paper explores the respective gender roles of the two women, the views of their husbands and how these were shaped by their upbringing.

Keyword

gender studies, history of geosciences, Lyell, Darwin

Women and diamonds

Leonid R. KOLBANTSEV[1]*, Russian Geological Research Institute (VSEGEI)
(Lkolb57@Gmail.com)

Abstract

Everyone knows that women love diamonds. However, in the history of geology, the topic of "women and diamonds" has a completely different meaning. In the discovery of Yakut diamonds in 1954-1955, 4 woman geologists played an important role: N.Sarsadskikh, L.Popugaeva, N.Kind and E.Elagina. In the extremely difficult climatic and living conditions of Yakutia, they became the discoverers of kimberlite bodies.

The search for diamond deposits in the USSR began in the late 1930s. Then the main search area was the Urals, where individual diamonds had been found since 1829. After World War II, intensive searches for diamonds began throughout the country: in the Urals and Kazakhstan, Karelia, Siberia, the Far East, etc. Intensive searches led to the discovery in 1954 of the first kimberlite pipe "Zarnitsa" (L.A.Popugaeva, based on materials from N.N.Sarsadskikh), and in 1955 - one of the richest diamond pipe "Mir" (discovered by E.N.Elagina and Yu.I.Khabardin, according to the forecast of N.V.Kind).

Natalia Sarsadskikh (1916-2013), mineralogist and petrographer, began searching for diamonds during WWII, when she was evacuated to the Urals from besieged Leningrad together with her husband, mineralogist A.A. Kukharenko. In the late 1940s, she ended up in Siberia, where she participated in prospecting for diamonds. The main merit of N.Sarsadskikh is the identification of minerals - genetic satellites of diamond, the proposal of the "pyrope" method for searching for kimberlites and the localization of the most promising area for the discovery of kimberlite bodies: the valley of the Daldyn River. In 1954, due to the birth of her daughter, she was unable to go to fieldwork, sending L. Popugaeva there.

Larisa Popugaeva (1923-1977) has been participating in the search for diamonds since 1950. In 1954, she went on an expedition alone and, using the "pyrope" method, discovered the first kimberlite pipe, "Zarnitsa". Later she searched for colored stones and discovered several deposits.

Natalya Kind (1917-1992). Geologist and geomorphologist, specialist in the geology of Quaternary deposits. She began searching for diamonds in 1939 in the Urals. Since 1950 she worked in Siberia, found the first diamond on the Malaya Botuobia River, compiled a forecast map of the location of primary sources of diamonds in this area, sent her employees there. Subsequently, she worked in Moscow, was engaged in human rights activities, together with dissidents: A.Solzhenitsyn, I. Brodsky, etc.).

Ekaterina Elagina (1926-2011). In 1941, she was evacuated from Moscow to the Urals, where she began searching for diamonds. In 1951, she went in Siberia, where she worked together with N.V.Kind, on whose instructions in 1955, having gone to field work with geologist Yu.I.Khabarnin, discovered the "Mir" pipe at the very beginning of the season. The famous radiogram was sent: "We lit a "Mir" pipe, good tobacco."

Despite the important discoveries made by woman geologists, the state was extremely stingy in gratitude and rewards. Their merits were hushed up and consigned to oblivion, and they themselves were often persecuted. However, justice gradually finds its way and memory returns.

Keyword

diamonds, woman geologists, kimberlite, Yakutia

Mrs A. H. Foord and G. M. Woodward: 19th century translators and illustrators of cephalopod studies

Catherine (Kathleen) HISTON[1]*, IUGS INHIGEO (hiscat@interfree.it)

Abstract

British palaeontologist Arthur Humphreys Foord (1844-1933) and the Austrian palaeontologist Johann August Georg Edmund Mojsisovics von Mojsvar (1839-1907) are well known for their contributions to cephalopod studies in the late 19th century. However, the contribution of two women to their most famous works has remained very much hidden in the background where one is mentioned in a title page as translator and the other in the authors' introduction as illustrator. Reference to both women was discovered during biographical research on A. H. Foord.

Foord worked as a volunteer in the collections at the Natural History Museum (London) and was highly regarded by Henry Woodward (1832-1921), Keeper of the Geological Department, for his diligent study of the collections. He was assigned the task of compiling detailed systematic descriptions of the cephalopod faunas for the 'Catalogue of the fossil Cephalopoda in the British Museum (Natural History)'. Two volumes were published in 1888 and 1891, however, on transferring to Ireland to take up a position as librarian and scientific editor at the Royal Dublin Society in 1891 he completed the third volume of the catalogue from there through correspondence with co-author G. C. Crick and this was published in 1897.

Foord had been renowned as a scientific illustrator, had held the position of artist in the Geological Survey of Canada up until 1883 and had been praised by Henry Woodward in the preface by the museum keeper in Vols I and II. No mention is made in Woodward's preface in part III regarding the illustrations. However, Foord in the introduction to Vol. III with co-author G. C. Crick acknowledges G. M. Woodward for her careful preparation of the illustrations. Gertrude Mary Woodward (1861-1939) was the daughter of the museum keeper.

Foord obtained a doctorate from the University of Munich in 1896 by submitting a thesis to the distinguished palaeontologist Karl Alfred von Zittel (1839-1904). This thesis was in German and presumably had been translated from English.

On the 2nd of April 1896 Foord married Ida Franziska Adelheid Kuhlmeyer (1842–1916) of German origin in Dublin. Both Dr A. H. Foord and Mrs A. H. Foord are cited as translators of the Monograph by E. Mojsisovics (1902) Upper Triassic Cephalopod Fauna of the Himalaya.

The aim of this presentation is to shed light on the identity and role of both these women in the shadows who contributed by their work as illustrator and translator to cephalopod studies in the 19th century.

Keyword

History of geology, women in geology, paleontology, biography, museum collections

Anna Hietanen (1909–1994) – from Finland to the world

Elina LEHTONEN[1]*, University of Helsinki (elina.lehtonen@helsinki.fi)

Abstract

Anna Hietanen (1909–1994) was a Finnish-born geologist who defended her doctoral thesis in 1938 (Hietanen 1938). Hietanen was the first woman to have a doctorate in the field of geology in Finland.

In the fall of 1938 Hietanen moved to the United States for two years on a researcher exchange. She spent her first year at Brywn Mawr College and the second year at the Johns Hopkins University. During her time in the United States Hietanen worked for example with Ernst Cloos (1898–1974). Their joint study published in 1941 (Cloos & Hietanen 1941) has been described as an outstanding publication (Waters & Stanley 1980).

Hietanen returned to Finland later in 1940 and made, for example, extensive fieldwork during the Continuation War. Hietanen applied for an assistant position in geology and mineralogy that was open in the 1940s at the University of Helsinki, but was not selected to the position. In 1946, Hietanen moved to the United States, where she continued her career as a geologist. For most of her career, Hietanen worked at the United States Geological Survey, and progressed all the way to the chief of the petrology unit (see e.g. Isakson n.d.). Many of Hietanen's research articles were concentrated on the metamorphic rocks, and in the USA her research areas were, for example, Idaho and California. Hietanen was also a pioneer in terms of research, as she was the first researcher to present a plate tectonic model to explain the development of the Finnish bedrock (Hietanen 1975). Hietanen's career has been recognized both in the United States and in Finland, but, to my knowledge, no extensive research or biography has been done on her before. She is shortly featured in the Woman of Learning project (Isakson n.d).

In my research on Anna Hietanen, I have focused especially on the first half of the 20th century, when she mainly lived in Finland. In addition to the external stages, I have been interested, for example, in thinking about how the wartime and social structures possibly affected Hietanen and her career as a geologist. The research is still partially in progress, and I am also working on a non-fiction book based on the research.

References:

Cloos E & Hietanen A (1941) Geology of the “Martic Overthrust” and the Glenarm Series in Pennsylvania and Maryland. Geological Society of America, vol. 35.

Hietanen A (1998) On the petrology of Finnish quartzites. Bulletin de la Commission Geologique

de Finlande 122, 118 p.

Hietanen A (1975) Generation of potassium-poor magmas in the Northern Sierra Nevada and the Svecofennian of Finland. Journal Research of the U. S. Geological Survey 3, 631–645.

Isakson E (n.d.) Anna Hietanen, geologist, 1909–1994. Women of Learning. https://www.mv.helsinki.fi/home/eisaksso/tiedenaiset/english/hietanen.html

Waters CW & Stanley SM (1980) Ernst Cloos 1898–1974. National Academy of Sciences, Washington D.C.

Keyword

Anna Hietanen, petrology, bedrock geology, Finland

[Keynote] Mexican Women in the Paleontology and Oil Industries

Lucero MORELOS-RODRIGUEZ[1]*, UNAM (lunalucerom@yahoo.com.mx)

Abstract

In history, the forgeting and invisibilization of women who stood out in fields such as science is commonplace. In an exercise of memory and in order to rescue them from oblivion and value the lives of intelligent women, who studied, held positions and great responsibilities, traveled, led communities, laboratories, museums, imposed themselves and built their scientific-technical practice. And they opened a gap, is that we propose to offer a glimpse of the history of Paleontology developed for more than 90 years at the Institute of Geology of Mexico. Among the pioneers in the study of Micropaleontology in Mexico we place María Luisa Robles Ramos and Clara Flores Covarrubias, who carried out their work since the 1930s. Both were part of the academic team of the Institute of Geology and simultaneously worked in the Paleontology Laboratory of the Exploration Management of Petróleos Mexicanos (PEMEX) a state company created to contribute to economic development through the exploration, exploitation and marketing of oil. It was not a research laboratory per se, but was aimed at solving problems related to oil exploration through the study of fossils and microfossils, such as foraminifera from the various basins of oil interest in the Mexican Republic. The laboratory team was made up of 35 people, among whom were 12 women who formed a group of geas that experienced serious labor challenges after the expropriation of the oil industry in 1938, since with the departure of foreign companies from the country, experts , archives, collections and machinery, forced Mexican specialists to start from scratch and launch Petróleos Mexicanos (PEMEX). The legacy of these geas is overwhelming since Micropaleontology is one of the most cultivated disciplines in the highest house of studies in Mexico: the National Autonomous University of Mexico (UNAM).

Keyword

Women, Mexican, 20th century, Paleontology, Oil Industries

[Keynote] Takla Makan, Pamirs, Karakorams, Indogangetic Plain, Singhala and Java: The Buddhist topography of Faxian (Fa-Hien), at the beginning of the 5th Century CE.

Sharad MASTER[1]*, School of Geosciences, University of the Witwatersrand
(sharadmaster@yahoo.co.uk)

Abstract

Faxian or Fa-Hien Kung (c. 337-422 CE) was a Buddhist monk from Shaanxi Province of central China. While in Chang'an (near modern Xi'an), Faxian bemoaned the degraded state of the copy of the Buddhist scriptures in their possession, and resolved to make a journey to India to obtain new copies of these and other texts. He departed Chang'an in 399 CE, accompanied by several fellow monks. His wanderings on foot would take him across deserts, mountains, great rivers, and many towns through 30 kingdoms (in the present day countries of China, Afghanistan, Pakistan, India, Nepal, Sri Lanka and Indonesia) over a period of sixteen years. He ultimately returned to China in about 415 CE, and brought back many Buddhist manuscripts to Nanjing, where he spent several years translating them from Sanskrit into Han Chinese. He died in Jingzhou in Hubei, aged 88 years.

Faxian recorded a detailed account of his journey, giving incidental information about the distances travelled, the length of his stays, and the landscapes and natural topographic features he encountered, such as deserts, rivers, mountains, caves, rocks, minerals, as well as the climate, vegetation, peoples and animals. His main interest was to record the people, their temples, their lives and their habits in the Buddhist countries he had visited, and to collect scriptures. His journey took him to Lanzhou, Zhangye, Dunhuang, then into the Takla Makan Desert along the northern foothills of the Kunlun Mountains, Shan-shan south of Lop Nor, then NW to Woo-e (Karashahr), then SW across the desert, to Khotan, where he spent three months. He then went into the mountain kingdom of Tsze-hoh (Karghalik), then crossing the Tsung-ling (Onion) mountains (Bolor Tagh range) to Taxkurgan in the Pamir Mountains, then to the city of Kashgar, in the crook of the Tien Shan and Pamir ranges. Thence they crossed the Snowy Mountains (Karakorams) and emerged at a steep gorge of the Indus, which they crossed on a rope bridge, to emerge into Udyana and Gandhara (northern India), and on to Takshasila (Taxila). They proceeded across the Indus, to Purushpur (Peshawar), and further west into the Hindu Kush. From here they crossed the Safed Khirs, re-crossed the Indus across a flat plain, and entered northern India in the Indogangetic Plain. Many years were spent travelling back and forth along the Ganga basin, visiting the Buddha's birthplace at Lumbini, Varanasi, Pataliputra (Patna) and the nearby gneissic Vulture Peak (Gridhra-kuta Hill), and layered rocks resembling the Vindhyan sandstones. From Tamalipti on a western distributary channel of the Ganga-Brahmaputra delta, Faxian boarded a boat for Singhala (Sri Lanka), where he visited caves and Anuradhapura (and mentioned Buddha's footprint on Adam's Peak), After two years he sailed east to a large island

abounding with pirates (Great Nicobar), and then travelled through phosphorescent waves across unfathomable depths (over the deep Sumatra-Java Trench) to Java. From here he headed back to China, arriving on the Shandong Peninsula, before making his way to Nanjing.

Keyword

China, Afghanistan, Pakistan, India, Sri Lanka

The first geophysical studies, and descriptions of mineral deposits, in Thailand: The French Jesuits under Guy Tachard, and Simon de la Lubère, at the Siamese Court in 1687 and 1689.

Sharad MASTER[1]*, School of Geosciences, University of the Witwatersrand
(sharadmaster@yahoo.co.uk)

Abstract

In 1685 and 1689 the Jesuit savant Père Guy Tachard (1651-1712) led two expeditions of astronomers and mathematicians to the court of the Kingdom of Siam (Thailand), on behalf of the French King Louis XIV. On the first voyage, which arrived in Siam on 23 September 1685, at the invitation of King Narai, Tachard was accompanied by five other astronomers. They came with a large consignment of scientific instruments (including telescopes, compasses, magnets, equinoctial quadrants, thermometers, barometers, microscopes, burning mirrors and repeating pendulums), as well as books. When Tachard was sent back to France to recruit another, larger group of savants (who came on his second expedition), his remaining men continued with their astronomical studies in Siam. Two of them (the Fathers Visdelon and Bouvet) were sent to visit magnetite mines near Bansoun in the Chainat district (about 100 km north of Ayutthaya on the Chao Phraya River) in January 1687. The purpose of their visit to the magnetite mines was to determine whether the variation of the compass needle is caused by the unequal attraction of magnetic parts of the terrestrial globe. In the first geophysical study in Siam, they took measurements of magnetic declination and found huge variations in the magnetic field as given by the needle as they approached the magnetite mines. They concluded that the local concentrations of magnetite were responsible for the magnetic anomalies, and cautioned against the use of magnetic compasses when constructing maps of the region. On Tachard's Second Expedition in 1689, he was accompanied by Special Envoy Simon de la Lubère (1642-1729), who gave the following description of Siam's mineral riches: "…the greatest riches of Siam lies in the Bowels of the Earth, there being no country in greater reputation for mines than this. The great quantity of Gold which appears in their temples,… show that they have had large mines, from whence it was extracted, though the King that now reigns [Mahaburut] hath not been able to find any, though he employed several Europeans to search them out. They, after much pains, found some mean Copper-Mines, mixed with small quantities of gold and silver". La Lubère further stated that they have plentiful profitable mines of lead, and tin, which they mix with Cadmia to render it harder and whiter (but more brittle), to produce a White Tin called Tontinaque. He noted the Lodestone mines near Louvo, the iron mines near Campeng-pet, as well as occurrences of curious Agates and Sapphires, and the recent discovery of diamonds. A French physician, M. Vincent Francois, was given 1000 ecus by the King of Siam, to inspect the work on his mines, and he shortly discovered many mines, including of iron, crystal, antimony, emeralds, white marble, and one of gold, which, so far as he could judge without assays, was "very rich" but which he would not show to the Natives (according to La Lubère).

Keyword

magnetic studies, magnetite mines, Siam, 17th Century

Crossing the Urals: A Glimpse into Asia in 1841

John DIEMER[1]*, UNC Charlotte (jadiemer@charlotte.edu)

Abstract

In 1840 and 1841, Roderick Murchison and his collaborators, Edouard de Verneuil and Alexander von Keyserling, engaged in two extensive field campaigns to explore the geology of Russia in Europe and the Ural Mountains. The results of their research were published in The Geology of Russia (1845), a two volume book accompanied by numerous plates containing geological sections and maps as well as fossil illustrations. Their campaigns were undertaken at a time of important developments of the geologic time scale and a growing awareness of the practical utility of applying 'system' terminology to lithostratigraphy. During the 1841 campaign, Murchison and his team crisscrossed the Urals as many as seven times. They had been charged by the Czar and his ministers to assess the state of mineral production in the Urals and their routes were governed in part by the locations of mining establishments. Plates 2 through 7 of The Geology of Russia (1845) provide a record of the routes they took, and the geology they observed along those routes is explained in the text of the book. Those records are supplemented by Murchison's field notebooks, his journal, and detailed letters written to his wife, Charlotte. The discoveries they made, the people they met, and the new cultures they experienced are reported on here. Murchison's experiences inspired him to make plans to travel farther east to the Altai Mountains in subsequent years. Murchison's glimpse to the east of the Ural Mountains, while tantilizing, did not in the end lead to him making additional expeditions to Asia.

Keyword

Ural Mountains, Roderick Murchison, Edouard de Verneuil, Alexander von Keyserling, The Geology of Russia (1845)

Drainage work at the Clausthal mine in the Harz region in the 17th century: Achievements of the Japanese Peter Hartzing1637-1680

Takeshi Ozawa[1]*, NAA Retailing Corporation (bzp17623@nifty.com)

Abstract

The Harz region in the eastern part of north-central Germany covers parts of the states of Lower Saxony, Saxony-Anhalt and Thuringia and is located approximately 100 km south-east of Hannover, the capital of Lower Saxony. The Harz region was originally developed as a mining area with many underground resources including lead, silver, copper, zinc and iron ore. Mining took place as early as the 13th century, stagnated in the 14th century and was revived in the first half of the 16th century. At the Clausthal Mine in the Duchy of Hanover, miners faced the problem of dealing with waste water - finding a way to pump the groundwater that was constantly seeping into the mine to the surface. However, as the mine became deeper, human and animal labour could no longer cope with the problem. Developing a countermeasure was a major challenge. The solution was to use a water wheel to pump out the seeping water. A mining engineer, Peter Hartzing (1637-1680), was sent to Clausthal to find a way of making the water wheel run stably. He was born in Japan and moved to Germany as a child. His idea was to create a recirculating system by returning the river water used to power the water wheel to a reservoir. This ensured a stable supply of water to power the water wheel. This idea of using recirculating water to ensure a stable source of water was also proposed by Gottfried Wilhelm Leibniz (1646-1716), who was later involved in the project. However, it was Hartzing who first proposed the idea. This study presents the drainage project at Clausthal Colliery, focusing on the water wheel plan document in the Clausthal Colliery archives that Hartzing submitted to the local mining authority.

Keyword

Clausthal mine, Peter Harzing,, G.W.Leibniz, German-Japanese

Charles Gould: Travels in Asia

Carol Anne Bacon[1]*, INHIGEO (gclota@trump.net.au)

Abstract

Charles Gould (1834–1893) BA FGS was the first government-appointed geological surveyor of Tasmania. He was a son of the famous ornithologist, John Gould and his wife, Elizabeth (Coxen) and was educated at Kings College London and the Royal School of Mines. He worked for a time for the British Geological Survey before taking up a contract with the Tasmanian Government in 1859. During the next ten years he produced numerous reports on and carefully drawn maps of the geology of Tasmania. His employment ceased in 1869 when the government was unable to continue financing his position.

In the years after he left Tasmania, Gould travelled extensively through Asia and South America, taking work if offered, but for the most part living on an allowance from his father while indulging his curiosity about the origins of mythological creatures. Gould spent the years from 1879 to 1889 largely in China, Hong Kong and Japan, interspersed with trips to Singapore, Myanmar, Korea and Thailand.

In China he visited Peking (Beijing), Canton (Guangzhou), Shanghai and numerous smaller towns; at one time travelling on the Hai (Peiho) River when it was choked by ice, with workmen cutting a passage for the steamer. In Japan he had lengthy stays at many places including Nagasaki and Tokyo, visited Hakodate and Yokohama, went shooting at Kobe, salmon fishing on Hokkaido and travelled the Nakasendo between Tokyo and Kyoto in a rickshaw. Gould immersed himself in cultural traditions, visiting hot springs and a ceremony at a Shinto shrine.

Gould wondered if mythological creatures described in legends were based on animals that had once existed, with the descriptions of them distorted through time. His thoughts on the subject were published in a book, Mythical Monsters, in 1886. To make his arguments, Gould drew upon observations made during his travels, his extensive knowledge of ancient texts and depictions of such creatures in woodcarvings and other art.

Dragons, which Gould noted featured in the legends of many societies, were of particular interest. He noted the similarity between ancient flying reptiles such as the Pterodactyl and dragons, and observed that modern flying lizards (Draco sp.) need only the element of size to render them also sufficiently to be dreaded. He surmised that the dragon in mythology comes from a now extinct terrestrial lizard, which had the ability to glide. Gould devotes chapters in his book to the Chinese dragon and the Japanese dragon, quoting exhaustive references in historic writings to both. He was also interested in the Chinese phoenix, surmising it might be a memory of an extinct bird similar to Semioptera wallacii (standardwing bird-of-paradise) and he thought that depictions in Japanese art of a giant octopus strangling a human could be derived from a type of giant cuttlefish with long tentacles.

Gould spent the last few years of his life in South America. He died in Montevideo, Uruguay, in 1893.

Keyword

Charles Gould, mythological creatures, travel

Geological travels and mapping in the Himalayan region between the 19th and the 20th century

Ezio VACCARI[1]*, INHIGEO - IUGS Commission on the History of Geological Sciences / University of Insubria, Italy (ezio.vaccari@uninsubria.it)

Abstract

The history of the geological travels and fieldwork in the Himalayan region, and in particular around Mt. Everest, still needs to be properly investigated. During the years 1848-49 some early geological fieldwork was carried out in India by Richard Strachey (Bengal Engineers) and his brother John Strachey (Bengal Civil Service), which led to the publication of the first printed geological map of a part of western Himalayas (1851). More extended fieldwork was undertaken during the early years of the 20th century by geologist Henry Hayden of the Geological Survey of India, with the help of military engineer Sidney Burrard, Surveyor General of India. Their studies led to another map, which shows a surveyed area in the north-western region of Himalaya, including Kashmir and a portion of southern Tibet, the latter investigated in 1904. Other attempts to explore and describe the mountains of the Himalaya include the first climbs in Karakorum by mountaineers Martin Conway and Charles Granville Bruce in 1892, as well as some photographical reports, like those by the Italian Vittorio Sella during a journey with Douglas Freshfield in 1899, or by Claude White in 1904. Later, the report given in 1919 by British explorer and photographer John Noel, about his journey in Tibet in 1913, where he traveled only about 30 miles east from Everest, contributed to reinforce the idea to climb and to explore this impressive mountain and its region. On January 10, 1921, during a meeting held in London, the Royal Geographical Society and the British Alpine Club established a joint Everest Committee, chaired by Francis Younghusband, in order to organize the first reconnaissance expedition to Mount Everest. The expedition, took place from April to October 1921 and included, among its nine members, also the Scottish geologist Alexander Macmillan Heron, who had the task to study the geology of the region, with particular attention to the age and the structure of the Himalayan range. Heron undertook a series of excursions and fieldwork on high grounds in Nepal, in some valleys around Mt. Everest and in Sikkim. This work, undertaken by Heron with the assistance of cartographers Henry Morshead and Oliver Wheeler, produced a preliminary geological map over about 8000 square miles, which was published in 1922 as the first geological map of the Everest region. The geological research on this area continued with some difficulties in the following years, as in the case of the geological map prepared by Noel Odell after the 1924 expedition to Mt. Everest. Heron's geological map was revised in 1933, within the second edition of the 1908 memoir by Hayden and Burrard, A sketch of the geography and geology of the Himalaya mountains and Tibet. The aim of this paper is to reconstruct the extent of some relevant geological travels, undertaken in the Himalayan region between the mid-19th century and the early decades of the 20th century.

Keyword

history of geology, geological maps, Himalaya, geological travels, 19th-20th centuries

The Early History of Graptolites Discovery in Asia

Muhammad Aqqid Saparin[1]*, Universiti Teknologi PETRONAS (otakuclubrkidz@hotmail.com)

Abstract

The discovery of graptolites in Asia took almost a century after the earliest recognition of graptolites as true fossils in Europe. The first record of these organisms in Asia is credited to F. von Richthofen during his exploratory journey in the Kiangsu Province of China between 1868 and 1871, however, the results were not published until more than 40 years later by Frech in 1911. As such, the earliest reference to graptolite in geological literature of Asia was made by Lydekker in 1883 who attributed the obscure marking found on the rock of Panjal System, Kashmir, to possible graptolite remains. In the latter years of the 19th century, reconnaissance surveys in Upper Myanmar (Burma) recognised widespread graptolite-bearing strata. For over the next 4 decades, more graptolite faunas were collected in the Shan States of Myanmar and the neighbouring Yunnan Province of China. The appointment of A.W. Grabau in 1920 to the post of Chief Palaeontologist in the National Geological Survey of China established the basis for systematic palaeontology research in the country. Numerous graptolite discoveries were made in the following decades and work had been proceeded vigorously even during and after the political changes in 1948-50. Many papers dealing with graptolites appeared in the Journal of the Geological Society of China before 1948 and have since contributed to Acta palaeontologica Sinica after 1952. The early graptolite research in China culminated in the publication of “Chinese Graptolites” by Mu and Hsü in 1962. Meanwhile in Southwest Asia, Blanckenhorn (1914) described graptolites from Arabia, while oil companies in the region managed to report the occurrence of graptolite-bearing strata, including in Turkey, Syria and Iran. In central and northern Asia, geological exploration after the end of the Second World War has also revealed extensive tracts of graptolite-bearing strata in the region. These findings were later published by the Geological Institute of the Soviet Academy of Sciences and other Russian organisations. In other parts of Southeast Asia, graptolite work had been done, such as in Vietnam by Mansuy (1915,1918) and much later by Nguyen Van Phuc from 1978 to 1995. In West Malaysia, graptolites were first discovered from the Langkawi islands in 1955 by C. R. Jones. Subsequently, systematic mapping by other geologists in Peninsular Malaysia in the late 1950s and early 1960s led to the discovery of further graptolite localities and the results were compiled in a two-volume PhD thesis, a summary of which was published in a publication of the Institute of Geological Sciences in 1973. In Thailand, the presence of graptolite was first reported by Kobayashi (1964), and subsequent graptolite finding was made later in southern Thailand. Overall, the discoveries of graptolite fossils in Asia have significantly contribute to our understanding of the rich geological history of the region.

Keyword

Graptolites, Asia, Palaeontology, History, Travel

Prussian geographer J. J. Rein travelled to Japan in 1873-76 and introduced Japan to the world

Michiko dvan Yajima[1]*, Tokyo Metropolitan University (pxi02070@nifty.com)
Naotoshi Yamada[2], ex-AIST

Abstract

Prussian geographer Johannes Justus Rein (1853 - 1918) made various scientific journeys in Europe, Asia, and America. Under Prussian government orders Rein came to Japan in 1873. He spent the first five months in Japan, residing in the German Legation in Tokio [Tokyo] and studying lacquer. After submitting a detailed report on the subject, he traveled throughout Japan for three years. He traveled mainland Japan, Shikoku and Kyushu. He extensively researched not only the industry and commerce of Japan, which was the main task with which he was entrusted by the government, but also the geography, geology, botany, zoology, and meteorology of Japan, as well as other scientific fields, based upon his own interests. He collected specimens of plants, molluscs and other organisms during his travels. He was also interested in volcanoes, mountains, mountain ranges, geology, geomorphology and so on. He walked, climbed mountains such as Mt Fuji, Ontake, Hakusan, Asama, Nikko Nantaisann and so on, measured the height of mountains using Aneroid altimeter, made maps and named mountain ranges. In a clockwise round trip through mountainous regions, where he observed the mountains, rivers, plants, animals, climates, and lives of inhabitants along the roads. He presents a topographic division of the region, proposing that “the Japanese Snow-ridge Range”-roughly corresponding to the present-day Hida Mountain Range- is the most important mountain range, and mentionsed its climatic significance. He found plant fossils near Mt. Hakusan which is the first discovery of Jurassic fossils in Japan.
After he came back to Prussia, he wrote “Japan nach Reisen und Studien im Auftrage der Königlich Preussischen Regierung. 2 Bände” based on travels and researches undertaken at the cost of the Prussian government, as was also his book “The Industries of Japan together with an Account of its Agriculture, Forestry, Arts, and Commerce”.

Keyword

Rein, “Japan", Hakusan

Professional Travelers -– Considering Expanding Process of Professionalism in the Nineteenth-Century United States --

Tomomi NAKAGAWA[1]*, Meiji University (peppermint-wind@ever.ocn.ne.jp)

Abstract

In our time, there exists little doubt that professionalism is the premise of our intellect. However, as a system of intellect, it has been only two hundred years from its launching. Since then, professionalism came to grow, and is still in the process of expanding, probably almost unconsciously. Throughout the process, the United States has long played a key role. It is no exaggeration to say that the global expansion a of professionalism could be regarded as a cultural strategy of the United States.

In this presentation, I would like to consider a few American geological advisors visiting Japan: mainly Horace Capron and William Clark. These advisors of the early Meiji Era (around 1880) had an important mission to convey the early phase of professionalism now on the process of its establishment.

After introducing their visions, this presentation will advance to the earliest phase of professionalism in the United States in the middle of the nineteenth century. At that time, professionalism emerged a new and alternative way to replace the traditional college education based on liberal arts. It was the educational backgrounds of the generation of “Founding Fathers.” On the other hand, those in industrial or commercial career, without academic backgrounds, were virtually excluded from the center of politics at that time.

However, according to the growth of industries and commerce, the voices and influences engaging in these fields came to be difficult to ignore. The inauguration of Andrew Jackson as President (1829) was the pivotal moment of transformation in politics in the United States. After that, educational backgrounds came to be more negligent, and “self-made men” were easier to access into the center of the federal government. Borrowing partially from the term of Richard Hofstadter, the time of Jacksonian Democracy could be understood as that of “Anti-Intellect;” those without college education could gain their footsteps firmly in the American society.

The emerging self-made industrialists yet wanted to have academic career. It is well-known that they have contributed to the establishment of academic institutions such as schools, societies, and research institutes, and supported them for a long time in the United States. They were absorbed in the advancement of practical sciences: in particular, agriculture and engineering. Therefore, the origin of professionalism in the United States could be traced back unexpectedly to democracy and anti-intellect. Since then, professional schools came to be settled one after another; its culminating moment would be the establishment of Johns Hopkins University in 1876, which had been envisioned as a graduate school in the first place. In the twentieth century, especially after the World War I, the United States came to expand its control with elites acquired professional education.

In a sense, the American advisors coming to Meiji-era Japan could be understood as the earliest

“travelers” to spread the emerging professionalism. In the end, I would like to propose that reconsidering the total process of professionalization become significant for those engaging in academic fields.

Keyword

professionalism, Horace Capron, William Clark, democracy, anti-intellect

Ennin’s Pilgrimage Travel in China: Japanese Buddhist Geo-consciousness in the Ninth Century

Toshihiro YAMADA[1]*, Taisho University (tosmak-yamada@muf.biglobe.ne.jp)

Abstract

In 840, the Japanese Buddhist priest from Tendai sect Ennin (794–864, also Jikaku Daishi) traveled on foot to the Mt. Wutai, which has five summits of around 3,000m high, in northern China. Fortunately, we have a detailed record of the itinerary in his diary. He started at Chishan in Shandong Peninsula on February 25th and arrived at the foot of mountain on April 23rd. He made pilgrimage to many temples of Manjusri Bodhisattva and stayed there to study Tendai doctrine by transcription of many sutras. He left the Mt. Wutai on July 1st to Chang-an, the capital of the dynasty. He stayed there for six years and then became forced to go back Japan in 847. The orientalist scholar and American Ambassador to Japan Edwin Reischauer (1910-1990) once studied the Ennin’s diary and published his work in 1955, in which he estimated the contribution of Ennin to Sinology contrasting with the work of the Venetian merchant Marco Polo (c.1254–1324). Additionally, in this presentation, we would like to recognize geo-consciousness of this Japanese intelligence’s diary, especially in not only geographical domain (triad cosmology of India, China, and Japan) but also in meteorological and geological ones. Because this is the very time of Japan which the historian of science George Sarton in his Introduction to the History of Science (1927) called one of five ninth-century renaissances in the world: Carolingian, Islam, Byzantine, southern India, and Japan.

Keyword

Ennin (Jikaku Daishi), pilgrimage travel, geo-consciousness, Mt. Wutai (China), ninth-century renaissance

BRONISŁAW GRĄBCZEWSKI AND LEON BARSZCZEWSKI, THEIR TRAVELS IN CENTRAL ASIA IN XIX CENTURY AND CONTRIBUTIONS IN GEOLOGY

Piotr KRZYWIEC[1]*, Institute of Geological Sciences, Polish Academy of Sciences
(piotr.krzywiec@twarda.pan.pl)

Abstract

At the end of 18th century Poland lost its independence and has been partitioned between Prussia, Austria and Russia until 1918 when it reappeared on the political map of Europe as independent country. During all those years Polish travelers, geographers and geologists contributed to the recognition of occupying countries and neighboring areas. Well known are geological and paleontological discoveries made in Siberia by Aleksander Czekanowski (1833-1876), Jan Czerski (1845-1892)or Benedykt Dybowski (1833-1930). Little less known are two other Polish discoverers active at the turn of 19th and 20th centuries in Central Asia: Leon Barszczewski (1849-1910) and Bronisław Grąbczewski (1855–1926). They both served in army of the Russian Empire, reached high ranks in imperial hierarchy, and spend considerably parts of their lives in distant part of the empire, dividing their time between official duties and scientific work.

Leon Barszczewski was born in Warsaw but spent most of his youth in what is now Ukraine. He was educated in military schools in in Kyiv and Odessa. Because of his support for January Uprising in Poland he was relegated from military academy in Odessa and transferred to regular army stationed in Cherson district. In 1876 he moved to Turkmenistan and for many years stationed in Samarkand. He was involved in numerous topographic and geological studies of territories between Russian Empire, China and Afghanistan. He was pioneering archeologists for that area, gathered significant collection of archeological artefacts that laid the foundation for the very first archeological museum in Samarkand. He was also vivid photographer. His interests in natural sciences included geology (including coal deposits – he even opened his own coal mine) and glaciology. Barszczewski's photographs of, between others, glaciers of Pamir were highly acclaimed and reworded at several international exhibitions. At the Paris exposition of 1895, he won a gold medal for his photographs of minerals. He was rewarded by several important models for his achievements in the field of natural sciences, in particular in glaciology. One of glaciers in the Hisar Range has been named after Barszczewski.

Bronisław Grąbczewski is well known for his participation in The Great Game between Russian and British empires. He was born near Kowno (now Lithuania), and moved to Warsaw after his father was sent to Siberia after January Uprising. He received training from St. Petersburg Mining Institute and St. Petersburg University, he spoke Polish, Russian, Uzbek, Tajik, and Persian languages. After joining the army he was stationed in Turkestan and then organized several field expeditions in Pamir, Tian Shan and Kunlun during which he made numerous observations on geology of surrounding mountains and discoveries of mineral deposits, onyx, coal etc. For these expeditions, he was awarded a silver and gold medal by the Russian Geographical Society. During

Bolshevik revolution he was imprisoned in Siberia and escaped via Japan to Poland, where he settled and worked in the State Institute of Meteorology. Grąbczewski published three volume book with detailed accounts and numerous photographs documenting his travels in Central Asia.

Keyword

central Asia, Leon Barszczewski, Bronisław Grąbczewski

Multifaceted Nature of Japanese Geological Explorations amid Japanese Imperial Expansion to China in the early 20th century

Shigeo KATO[1]*, Waseda University (kato@waseda.jp)

Abstract

This presentation will offer a multifaceted examination of the scientific and political aspects of Japanese geologists' travels to China and the geological surveys conducted in the early 20th century and delve into the discourse surrounding mineral exploration in China conducted by Japanese geologists within the broader context of Japan's imperial ambitions. While Western geologists like Ferdinand von Richthofen had previously ventured into China, several Japanese geologists also embarked on similar expeditions, producing various academic and practical reports. While existing studies have focused on Japanese geological surveys of coal mines in Manchuria, exploration efforts regarding other mineral resources such as iron, copper, tin, lead, zinc, antimony, manganese, and tungsten have yet to be noticed. This presentation seeks to rectify this gap by examining the intertwined strategic, economic, and academic objectives that underpin Japanese geologists' surveys in China.

Special attention is given to the insights of OGAWA Takuji (1870-1941), whose multidimensional background—rooted in Confucian scholarship and Western geological education at the Imperial University—informed his geological surveys in China. Ogawa's engagement with Chinese classics, exemplified by his critical readings of the _Book of Mountains and Seas_, culminated in the publication of _Studies on Chinese Historical Geography_ (1928). Additionally, Ogawa contributed to the advancement of geological theory with his work _New Interpretation of Geological Phenomena_ (1929), wherein he proposed novel ideas on crustal tectonics and the geological structure of the Japanese archipelago. Notably, Ogawa's academic pursuits were paralleled by his political commentary, as seen in his writings critiquing the Chinese government of his time. This presentation aims to unravel the intricate connections between Ogawa's diverse discourses within his era's historical and geopolitical context.

In addition to Ogawa Takuji's surveys, this presentation will also incorporate a historical examination of the geological surveys in China conducted by the Tokyo Geographical Society from 1911 to 1916. The Tokyo Geographical Society dispatched ISHII Yamajiro to the Yangtze River coast in 1911, followed by NODA Seijiro and IIZUKA Noboru to Zhejiang, Hunan, and Hubei provinces in 1912, and SUGIMOTO Isuzu to Hunan province in the same year. In 1913, KOBAYASHI Giichiro and HORIUCHI Yoneo were sent to Sichuan and Shaanxi provinces, while YAMANE Shinji and KAWAI Kokichi were dispatched to Zhejiang, Jiangxi, and Fujian provinces, and FUKUCHI Nobuyo to Hunan province. This presentation seeks to elucidate why the Tokyo Geographical Society undertook such large-scale surveys in China, how the surveys were conducted, and what the results entailed. Furthermore, it aims to examine how these survey

findings subsequently influenced the field of geology and impacted Japan's continental policies.

This presentation shed light on the multifaceted nature of Japanese geological exploration in China during a period marked by imperial expansion.

Keyword

History of Geology in Japan, History of Geology in China, Science and Empire, Science and Imperialism

Western scholars' geoscientific travels in China during the late 19th and early 20th centuries

Chengsheng SUN[1]*, Institute for the History of Natural Sciences, Chinese Academy of Sciences (scs@ihns.ac.cn)

Abstract

With the opening of China's gates in the late 19th century, Western scholars, missionaries, businessmen, and explorers, regarded China as a huge "open-air museum" and came to China for various scientific travels and explorations. For example, Raphael Pumpelly (1837-1923), Ferdinand von Richthofen (1833-1905), Béla Széchenyi (1837-1918) and Lajos Lóczy (1849-1920), Vladimir Obruchev (1863-1956), Bailey Willis (1857-1949), Roy Chapman Andrews (1884-1960) and Sven Hedin (1865-1952) respectively organized many large-scale geological surveys in China. They not only wrote important research works, but also left detailed records of their travels. These explorations enriched western scholars' understanding of China's geology, and inspired geological research of Chinese counterparts as well. After the 20th century, explorations of Westerners in China aroused Chinese scholars' nationalistic backlash, and even encounter their sovereignty demands. In particular, the Sino-Swedish Scientific Expedition to the North-Western Provinces of China organized by Sven Hedin became one of the landmark events. With the efforts of academic community, the government gradually imposed clear legal restrictions on foreigners' explorations in China, and Chinese scholars also spontaneously began to carry out independent geological investigations. In this paper, by reading the travel journals of these scholars and their scientific writings, I will analyze how they organized their geological surveys, their cooperation and competition with Chinese counterparts, as well their knowledge and understanding of Chinese culture at the time.

Keyword

geological survey, scientific travel, China, late 19th and early 20th centuries

Legacy etched in Stone: Field Inscriptions of BGS Geologist E. Vredenburg Enduring for 125 Years in the Chagai Desert, Pakistan

Mukhtiar GHANI[1]*, Geological Survey of Pakistan (mukhtiar.ghani@gmail.com)
Muhammad Qasim Jan[2], National Center of Excellence in Geology, University of Peshawar
Rahat Ullah[3], Geological Survey of Pakistan

Abstract

Many geoscientists made significant contributions to the Geology of Indo-Pakistan during the British era. Their scientific endeavors earned them recognition within the scientific community. Some of these journeys have left indelible marks on the landscape, etched into rocks and outcrops. Among these pioneers is E. W. Vredenburg, who served with the Geological Survey of India and conducted groundbreaking reconnaissance work in the remote and challenging Indian frontier region of Balochistan.

Balochistan, the largest province of Pakistan, is predominantly characterized by rugged mountainous terrain and desert landscapes, long notorious for its compromised security situation spanning for centuries. Vredenburg undertook extensive surveys and mapping activities in this region during the late 19th and early 20th centuries. While his work encompassed a broad spectrum of studies across Balochistan, we have discovered some of his hand-carved inscriptions on the outcrops in the far western region of the Chagai district in Western Pakistan.

Based on the timeline, this inscription, carved during his expeditions in the Balochistan desert and eastern Persian region, is approximately 125 years old. This inscription represents pioneering geological work in the Chagai region. Vredenburg meticulously described the area southeast of Saindak, and east of MushkiChah and Juzzak, delineating various lithological units of igneous and sedimentary rocks. He assigned ages to these units based on their index fossil groups, ranging from Cretaceous to Pleistocene.

The units described by Vredenburg were later formalized into different formations, including the Cretaceous Sanjrani and Humai formations, Paleocene Juzzak formation, and Eocene Saindak and Amalaf formations, among others. Notably, Vredenburg's work indicated the presence of sulphide valleys in the Chagai region, which later developed into significant porphyry Copper-Gold deposits such as Saindak and ReKoDik. Sulphur mining in the region commenced during World War I and II.

The hand-written inscription is preserved on the Humai limestone near the Amir Chah area (29°12'54.30"N / 62°27'53.40"E). Dating back to 1899, approximately 124 years ago, it serves as a testament to the enduring legacy of E.W. Vredenburg, who persevered through harsh rainy seasons and fast-blowing winds, amidst shifting sand dunes, to contribute to our understanding of

this region's geological history.

Keyword

Field Inscriptions, Geoscientific Trails, Chagai Desert, Balochistan Pakistan, Historical Geology

The "Treatises on How to Recognise Gems" of Al-Biruni (11th century) and the development of mineralogy in The Muslim world.

khallaf EL GHALBI[1]*, Moulay Ismail University of Meknes (k.elghalbi@umi.ac.ma)

Abstract

Abu al-Rayhan al-Biruni was a distinguished encyclopedic scholar, who excelled in mathematics, medicine and astronomy. He is also considered a historian, philosopher, linguist, and anthropologist.

Al-Biruni's writings amount to about 180 books, of which he devoted the book (Al-Jamahir fi Ma'rifat al-Jawahir) study of a group of minerals and precious stones that were known in his time, a careful scientific study, the aim of which is to combat fraud and counterfeiting, by identifying minerals accurately, allowing to distinguish valuable gems, from its less valuable similar ones.

The German orientalist Fritz Czenko may be the first to verify and publish this book. He collected his manuscripts and published it in Hyderabad, India, in 1936.

In These (Treatises on how to recognise gems), Al-Biruni has proven that he was a great mineralogist, centuries before this knowledge reached those to whom the paternity of this scientific branch is attributed. He contributed significantly to the establishment and development of this science on several levels:

- At the level of mineral definition;
- At the level of knowledge of existing minerals, their numbers, names, languages, locations, and prices;
- At the level of mineral classification;
- At the level of describing minerals and studying them based on the similarities of their properties, indeed he studied characteristics and physical properties of minerals, in accordance with the currently study of minerals;
- On a theoretical level, the discours of Al-Biruni about the formation of some minerals, can be considered an unprecedented theoretical contribution.

The Russian orientalist Karachovsky says: We have nothing but bowing in submission and respect in front of the brilliant scientific results that Al-Biruni reached and the rich scientific heritage that he produced in the circumstances of the time in which he lived.

It must be emphasized that the study and publication of manuscripts and scientific heritage left by Al-Biruni (in metallogeny, mineralogy and other sciences), still need further very in-deep follow-up, to complete knowledge regarding the scientific contribution of Abu Rayhan Al-Biruni

Keyword

Mineralogy, 11th century, Muslim Heritage

Image Builders between Mineralogical Knowledge, Possession and Perception in the 18th Century: Catalogues, Collections and Credibility

Marianne Dr. Dr. KLEMUN[1]*, Department for History, University of Vienna (marianne.klemun@univie.ac.at)

Abstract

Image Builders between Mineralogical Knowledge, Possession and Perception in the 18th Century: Catalogues, Collections and Credibility
Marianne Klemun
Abstract
In the 18th century, more than in any other period, socially heterogenous groups of actors operated their own mineral collections. This is reflected, among other things, in the steady increase in printed catalogues during this period. Previous historical research on collections has mainly focused on their representative, institutional, politico-state, economic and epistemological functions. In contrast, this paper takes a novel and innovative view of collections as sites of communication, interpreting catalogues as 'knowledge-making itself as a form of communicative action' (Secord). My point of departure is the large number of printed catalogues, which between 1600 and 1800 amounted to more than 350 compendia. The authors of these catalogues were usually not identical with the owners or custodians of the collections. I argue that their compilation not only contributed to an extraordinary gain in credibility and status for all concerned but also enhanced the reputation of the collection documented. Catalogues are to be located in the in-between, between the actors, that is between owners and describers and their various practices as well as the principles of display of collections and the management of the perception of collections by third parties. These interactions are themselves a site of knowledge construction as they were subject to processes of negotiation and reconfiguration. As image-builders, catalogues not only promoted careers, or at least maintained status, but also stabilized credibility, which is my main argument. Catalogues also served as powerful media in the encounter with collections in cross-cultural and supranational contexts. Indeed, even at a distance from the collections, catalogues had an impact as they circulated, maintaining their validity across time and space, even when the collections they described no longer existed as a separate corpus.

Keyword

mineralogical collections, catalogues, credibility, 18th century

[Keynote] Exposing Earth Sciences History: challenges and perspectives (invited Keynote)

Maddalena NAPOLITANI[1]*, Museo Galileo (maddalena.napolitani@gmail.com)

Abstract

(Invited Keynote)
Number of recent researches in the field of history of science is nowadays particularly interested to the visual and material culture of science, and the history of Earth sciences is no exception.
Within these research perspectives, temporary exhibitions appear as a mean of valorization of both scientific research and collections related to Earth sciences, often constituted by rich and varied materials (minerals and rocks, fossils, archive documents, iconographical sources including geological maps, illustrated treatises, etc.).
Through the analysis of two recent case-study, this communication studies the potential of temporary exhibitions for disseminating scientific research, and how they can emphasize the multidisciplinary characteristics of Earth sciences history, that have historically built a dialogue with other disciplines (the scientific reference disciplines as geology, paleontology, but also philosophy, literature, archeology, and more recently art history and architecture).
Temporary exhibitions are often in close dialogue with permanent collections, and another question addressed by our communication is how such initiatives tell the history – or some aspects of the history – of Erath sciences, and how this history relates to contemporary issues, such as the environmental and climate crisis, or the administration of Earth's resources.
Finally, the practical aspects related to exhibition-making in this field will also be considered.
Our communication, aiming to foster a collective reflection, especially concern two case-study: the exhibition Visions. The Earth Sciences in the popular Literature of the 19th Century (Varese, Italy, November-December 2023) and Collectible Minerals (Paris, September 2023-March 2024).

Keyword

exhibition, valorization and communication, material culture, visual culture, heritage

The Geological Commission of the Shevchenko Scientific Society: Institutions, Personalities, Publications

Ihor BUBNIAK (BUBNYAK)[1]*, Lviv Polytechnic National University (ihor.m.bubniak@lpnu.ua)

Abstract

The Shevchenko Scientific Society is one of the oldest and most prestigious scientific institutions in Ukraine. Founded in 1873 in Lviv, it was named after the renowned Ukrainian poet, artist, and thinker, Taras Shevchenko. This organization has a long history of contributing to the development of Ukrainian science, education, and culture. It unites scientists and researchers from various specialties, including history, literature, linguistics, ethnography, natural sciences, and many others. The Society works on publishing scientific works, organizing conferences, lectures, and seminars, and also plays a key role in preserving and promoting Ukrainian cultural heritage.

Members of the Shevchenko Scientific Society include well-known Ukrainian and foreign scientists. Throughout its existence, the Shevchenko Scientific Society has undergone various changes and transformations due to political and social circumstances in the region. Despite this, it continues to be an important center of scientific and cultural life in Ukraine.

Geological research is part of the activities of the Shevchenko Scientific Society. The Society has a multifaceted structure and covers various fields of science, including natural sciences and geology. The Geological Commission of the Society actively conducts research in the field of geology, focusing on the history of geological discoveries, the contribution of Ukrainian scientists to the development of this field, as well as organizing and conducting lectures and seminars on geological topics.

One of the features of the Geological Commission's activity is conducting geological excursions. These excursions provide an opportunity not only to delve deeper into geological science but also to directly observe geological objects and processes in natural conditions. Excursions are organized both for members of the society and for the general public, aiming to popularize geological knowledge and increase awareness of Ukraine's natural heritage.

Members of the Geological Commission also work on additions to natural history museums and publish a collection of "Works" where they publish the results of their research. This allows for the preservation and dissemination of important information about geological research and discoveries and promotes scientific exchange and collaboration among researchers.

Keyword

Shevchenko Scientific Society, Research, Geological Excursions, Education, Ukraine

James Dwight Dana and his geological excursions in New South Wales, 1839-40

Wolf Mayer[1]*, Eneritus Faculty Australian National University, Canberra
(wolf.mayer@outlook.com.au)
Wolf Mayer[2], Emeritus Faculty, Australian National University, Canberra, Australia

Abstract

The mineralogist and geologist James Dwight Dana (1813-1895) was a member of the United States Exploring Expedition, commanded by Captain Charles Wilkes, which carried out hydrographic and scientific research along parts of the coasts and islands of the Pacific Ocean and in Antarctica. Dana, who had studied geology and mineralogy under Professor Benjamin Silliman at Yale University, was given the opportunity to spend some three months in New South Wales to carry out geological research while the expedition's ships sailed to Antarctica. At the time little was known of the colony's geology. Accounts of the early work in the Sydney region and in the Blue Mountains by French geologists and naturalists on short visits at the beginning of the century was not widely read outside France. Resident naturalists, some with considerable knowledge of geology but no academic qualifications in the subject, had described the lithologies and succession of rock sequences mainly in outcrops along the New South Wales coast. Universities and geological surveys had not yet been founded in Australia.

Dana's stay in the colony coincided with the arrival, some months earlier, of the Rev. Willian Branwhite Clarke (1798-1878), a former student of Professor Adam Sedgewick at Cambridge University, with whom he formed a close association, both in the field during his sojourn and later by correspondence. Over the following decades Clarke would make major contributions to Australian geology. Dana spent time in the Sydney area, visited the Illawarra district to its south in the company of Clarke, and carried out independent investigations in the Hunter Valley to its north. During his stay in the colony, he examined widely separated outcrops, in an area extending over 250 km, and recognized massive sandstone layers at the base, conformably overlain by a sequence of coal measures, with further thick beds of sandstone above, all now accepted as forming part of the Permo-Triassic Sydney Basin. The age of the coal measures was the subject of often bitter debate that lasted for almost forty years, with opinions variously placing the strata in the Carboniferous, Triassic, or Jurassic periods. Dana, in assigning the coal measures to the upper Carboniferous to lower Permian, was the first to place them, at least in part, into the latter period, their now accepted age. He drew detailed stratigraphic sections of outcrops of the sedimentary sequence, some with interstratified volcanic rocks, and was the first to draw a geological map of the Illawarra region.

Keyword

Surveys, Coal, Age

Learning the Soviet Union and Earth Sciences of China: An investigation centered on Specialty Settings of Geography in Peking University In the 1950s

Chao LIU[1]*, Inner Mongolia Normal University (lc.2018@tsinghua.org.cn)

Abstract

In the 1950s, China sparked a wave of learning from the Soviet Union, and China's earth sciences actively learned from the experience of the Soviet Union. The Department of Geology and Geography at Peking University was established during the wave of studying the Soviet Union. This article will focus on the initial specialty settings of Peking University's Department of Geology and Geography to explore the connection between the development of earth sciences in China and Learning the Soviet Union.

At the beginning of New China, geography theory foundation is weak, the geography education is the weakest link in the national higher education. The Department of Geology and Geography created by Peking University in 1952, had promoted the development of geography and geography education. In the early years of the department, the specialty settings of geography was modeled on the Soviet Union, combing the department faculty and the Soviet union expert opinion. The only professional physical geography in 1952 developed to three major physical geography, economic geography and geomorphology in 1956, established the prototype of Peking University geography specialty settings. This article tries to analyze the influence of "learning the Soviet union" on the specialty settings of geography in Peking University and on the development of geography, according to oral interview records and historical data such as the documents of Peking University.

Keyword

Learning the Soviet Union, Peking University, Specialty Settings, Higher Education of Geography

The heydays of geological research in Finland – Storylines from the museum collections

Jaana HALLA[1]*, Finnish Museum of Natural History, University of Helsinki
(jaana.halla@helsinki.fi)

Abstract

The history of geological research and collections in Finland includes great achievements as well as tragic moments. The building up of the 'Mineral Cabinet' started in the 18th century at the Royal Academy of Turku – Finland belonged to Sweden in those days – where professors of chemistry curated geological samples. The most famous was Johan Gadolin (1760-1852), who discovered the first rare earth element, yttrium. Element gadolinium and mineral gadolinite are named after him. The great fire of Turku in 1827 was a terrible catastrophe: the whole collection was destroyed. Next year, the building up of the collections started again at the Imperial Alexander University in Helsinki (Finland was part of the Russian Empire 1809-1917). The 19th and 20th centuries brought several renowned Finnish geologists. Axel Gadolin (1828-1892) proved mathematically the existence of 32 crystal classes, Wilhelm Ramsay (1865-1928) found the alkaline massifs of the Kola Peninsula, Jacob Johannes Sederholm (1863-1934) first introduced the word 'migmatite', and Pentti Eskola (1883-1964) first proposed the concept of 'metamorphic facies'. We at the Finnish Museum of Natural History aim to use preserved stories and samples from the heydays of Finnish geology to attract interest among the public and Society. Our aim today is to create a platform for geological collections, education, and research dissemination by developing exciting exhibitions, events, and courses with fascinating historical and modern narrative storylines as well as organize and digitize collections for hands-on and online use for the public, geologists, historians, artists, hobbyists, tourists, politicians, children, students, teachers, and media.

Keyword

History of geology, Collections, Exhibitions

Geological and Hydrological Knowledge of the Aztecs

Sharon LOCKE[1]*, Southern Illinois University Edwardsville (slocke@siue.edu)
Kathleen Vongsathorn[2], Southern Illinois University Edwardsville
Robyn Roberts[3], Colorado State University
Hugo Gutierrez[4], University of Texas-El Paso

Abstract

Integrating humanities and science has been shown to increase student interest in STEM (science, technology, engineering, and math). We have developed three university level courses in geoscience related degree programs that integrate historical perspectives of science to increase student learning about the humanistic elements of science. Working with a historian of science, we developed a case study on the Aztecs that uses information from the Florentine Codex to teach students about the hydrological and geological knowledge of the Aztecs living at Tenochtitlan in the early 16th century in the area that is now Mexico City. The case study asks students to use the drawings and translations of the Codex to identify the knowledge that the Aztecs had about hydrological and biogeochemical cycles and how they used that knowledge to provide food for the densely population area. The information in the Codex demonstrates the Aztecs sophisticated understanding of the types of water bodies in the region. Their understanding is consistent with paleoenvironments constructed from sediment records in the region, while also incorporating beliefs and myths associated with their culture. Our instructional team found that adding a humanistic perspective of science helps students to consider scientific problems from multiple perspectives, which is a critical skill for geoscientists working in the 21st century.

Keyword

Aztecs, humanities, Hydrology, Mexico City

Geological maps throughout the hundred years of the Czech Geological Survey (1919–2024)

Vladimir ZACEK[1]*, Czech Geological Survey (vladimir.zacek@geology.cz)
Petr Mixa[2], Czech Geological Survey

Abstract

Geological maps throughout the hundred years of the Czech Geological Survey (1919–2024)

Vladimír Žáček1 and Petr Mixa1

1Czech Geological Survey (CGS), 118 21 Prague, Klárov 3, Czech Republic

vladimir.zacek@geology.cz

The Geological Survey of the Czechoslovak Republic was founded in 1919, one year after the establishment of the independent Czechoslovakia. It followed the work of geologists of the Geological Survey of the Austrian Monarchy founded in 1849. The first geological map of the state (Czechoslovak) territory at a scale of 1: 400,000 was printed in 1924. A synoptic geological map of Czechoslovakia at a scale of 1:200,000, a mosaic of 33 sheets, was the result of the long-term work of geologists from the Czech and Slovak geological surveys. This set of maps was completed in 1959 and was presented at the International Geological Congress in Delhi, India in 1964. Czechoslovakia became the first country in the world to have a geological map covering the whole of its territory at this scale. In 2000, 221 sheets of geological maps at a scale of 1:50,000 were completed covering whole state territory. A program of geological mapping at a scale of 1:25,000 has been underway since 1970, and unified rules for the compilation of geological and applied maps and explanatory booklets have been followed since 2007. The Czech Geological Survey has also co-operated in mapping programs in many other countries around the world, e.g. Costa Rica, Cuba, Ethiopia, Mongolia, Nicaragua, Iran, Iraq, Peru, El Salvador, Syria, Vietnam, and Zambia. Recently, the Czech Geological Survey is responsible for the Geoscience Mapping (WP1) work package of the PanAfGeo Project in Africa (2017–2024). The maps and other geoscience information are available on the website www.geology.cz.

Keyword

geological map, history, Czech Republic

From Mines to Strata: The Spatial Sciences of the Earth in Britain in the Long Eighteenth Century

Joshua HILLMAN[1]*, University of Leeds (prjbh@leeds.ac.uk)

Abstract

Master narratives in the historiography of geology have focused on the reconstruction of geo-history since 1800, and, accordingly, they have tended to interpret the first three quarters of the eighteenth century as a latency period in the development of the earth sciences. By reorienting towards geological space instead of geological time, I shall provide a new account of the earth sciences in the long eighteenth century, focused on the development of spatial knowledge about the strata in Britain. Utilising new archival sources, I reconstruct four neglected sciences of the earth – coallery, the natural history of mines, the natural history of the Earth, and the natural history of strata – that have been overlooked in the existing master narrative. I argue that British naturalists developed these sciences in an attempt to appropriate the spatial knowledge of the strata that mineworkers possessed.

In the seventeenth century, coal surveyors already possessed expertise on coal-bearing strata (coallery), but this was little tapped by naturalists more interested in metal mines (the natural history of mines). Strata became more seriously studied around 1700, when John Woodward developed a new approach that showed that they could be traced over vast horizontal distances (the natural history of the Earth). Many naturalists traced strata in the eighteenth century, and those that visited coal mines recognised that strata had a regular vertical order. This finding was applied more broadly over the century as naturalists recorded both the horizontal continuity and vertical order of the strata in different locations (the natural history of strata).

I make two further claims. First, pace Martin Rudwick, William Smith's nineteenth-century achievements in the field of stratigraphy must be situated in the wider context of British coallery, not German geognosy. Second, the eighteenth century was not a latency period for the earth sciences: it was the period when the regular order of the strata was recognised, and this spatial contribution was a necessary precondition for the temporal contribution that followed.

Keyword

mining, stratigraphy, eighteenth century, natural history, historiography

150 years of the Italian Geological Survey and the new database of national georesources

Mauro LUCARINI[1]*, ISPRA (mauro.lucarini@isprambiente.it)
Maurizio Guerra[2], ISPRA
Gabriele Leoni[3], ISPRA
Stefano De Corso[4], ISPRA
Luca Puzzilli[5], ISPRA
Giorgio Vizzini[6], ISPRA
Monica Serra[7], ISPRA
Fiorenzo Fumanti[8], ISPRA
Daniele Spizzichino[9], ISPRA
Pio Di Manna[10], ISPRA
Anna Maria Blumetti[11], ISPRA
Giovanni De Caterini[12], ISPRA
Roberto Pompili[13], ISPRA
Valerio Comerci[14], ISPRA
Deborah Maceroni[15], ISPRA
Maria Gabriella Andrisani[16], ISPRA

Abstract

In 2023, the Geological Survey of Italy celebrated 150 years: founded in 1873, just two years after Rome became the Capital of Italy, under the name of Royal Geological Office, as a section of the already existing Mining Corps. These Corps controlled mining activity through Mining Districts, tasked with managing licenses and collaborating with mining industry, maintaining statistics on production, economic and financial aspects.

The Royal Geological Office developed the Italian geological map but, over time, it ended up neglecting the mining aspect. The first mining map of Italy was published by the Royal Mining Corps about 50 years after its foundation, also thanks to the issuance of the Royal Decree of July 29, 1927, no. 1443 "Legislative provisions to regulate the exploration and cultivation of mines in the Kingdom". Then, the last mining map was published on the 100th anniversary of the Geological Survey of Italy (1975) releasing at a scale of 1:1,000,000.

Mining activity in Italy was very active between the 1930s and the 1970s, and a big push was given in 1982 by the Law no. 752 "Rules for the implementation of mining policy", modified and supplemented by Law no. 246/84, that relaunched basic mining research: started in 1986 the Rimin project constituted a support action to the mining sector for identifying new areas for subsequent operational research by mining companies.

However, at the end of the 20th cent., the State transferred competences regarding quarries and mines to the Regions, each of which began to manage them in different ways.

In Italy, despite a decrease in production, recorded since 2008, the extractive industry remained an important sector, especially for industrial and construction minerals.

In 2019, the European Council issued the Green Deal, aimed at fostering climate neutrality through policies that promote economic growth by means of technological development, creation

of new businesses, new markets and creation of increasingly qualified jobs. The green transition represents, in fact, the chance to transform the EU community into a fair and prosperous society, based on a modern economy, through a holistic and cross-sectoral approach in which all strategic sectors contribute to the definition of a new balance between man and nature.

Aware of this, the EU has expressed concern about the supply of raw materials trying to regulate the sustainable supply of critical minerals through the Critical Raw Materials Act (2024): it provides an updated list of 34 critical minerals and of 16 strategic minerals, and it states, for instance, that EU Members have to achieve at least 10% of critical materials from internal extractions, elaborating the National Mining Plan to define its own mining potential and characterizing extractive waste.

In light of these new needs, the Geological Survey of Italy is developing a database containing geological, mining and environmental information on mineral resources.

This could become a valid tool for developing national and regional policies oriented towards the sustainable mining/quarrying of primary mineral resources, in a circular economy perspective, considering also the exploitation potential of any secondary resources produced.

Keyword

critical minerals, extractive waste, mining sector

Solving the Urgent Situation: Analysis of Local Mineral Resource Survey Institutions during the period of the Republic of China

weiwei HU[1]*, 15811441919 (huweiwei@cugb.edu.cn)

Abstract

In the first half of the 20th century, the significant role of mineral resource exploration in economic construction has attracted high attention of the local governments. Surveys of geological and mineral resources have been organized all over the country except Xizang province.Through the review of provincial archives, government bulletins and periodicals of the Republic of China, this paper makes a macro review and case analysis of the investigation background, organizational forms and functions of geological and mineral resources organized by local governments during the period of the Republic of China. It is hoped that this study can provide some reference for the organizational construction of local resource survey by exploring the organizational form and general characteristics during the period of Republic of China.At present, Chinese scholars have made remarkable achievements in the collation of historical documents, such as climate change, disaster prevention and control, etc. .However, the comprehensive combing of the mineral investigation report in the period of the Republic of China remains to be deepened.The collation of geological and mineral investigation reports will not only bring academic research value, but also contribute to the collection and collation of historical documents in the National Mineral Resources Database.So,it is important to make more and more such survey.

Keyword

mineral resources, geological survey, organizations and institutions, the period of the Republic of China

The collection of geological wall maps and their importance in teaching

Maria MESZAR[1]*, University of Vienna, Austria (maria.meszar@univie.ac.at)
Peter NAGL[2], Department of Lithospheric Research, University of Vienna, Austria
Margret HAMILTON[3], Geological Archive, Institute of Geology, University of Vienna, Austria

Abstract

Geological maps are not only the basis for orientation in the field, but are still important in the education of students in earth sciences today. Although in today's digital age, GPS and mobile devices are omnipresent in the reproduction of terrain images.
In the Geological Archive of the University of Vienna, historical geological wall maps were reviewed by the authors, reorganised and recorded in the digital database. The results and those of the resulting research are presented in this poster.

The graphical representation of geological content is an important part of teaching and initial knowledge transfer and can be seen as a preliminary stage to field visits. Unfortunately, only a few remnants of the original collection of more than a hundred wall maps have survived, and their state of preservation varies greatly.
The oldest catalogued maps date back to the foundation of the Geological Institute of the University of Vienna in 1862 and the most recent maps to 1992. The maps are mainly in German and English, but there are also some in French. One example is a geological map of England and Wales from 1865, which, like most of the others, was mounted on linen and measures 191.5 cm in length with a width of 163.5 cm.
The maps depict individual areas, countries, continents or the whole world. Due to the historical location of the collection, areas in and around Austria were favoured. The collection includes geological and tectonic maps, as well as educational panels on resources. The presentation of the contents corresponds to the respective historical state of knowledge. The scales of the oldest maps are still given in historical units of measurement.
A large number of the maps were actively used for teaching purposes, and a few also contain handwritten and coloured additions. The state of preservation varies from very good to badly damaged. The older maps in particular are heavily yellowed and the linen has become brittle. Most of the wall maps have numbers that were recorded in inventory lists at various times. This made it possible to trace the downsizing of the collection.

Although the current map collection is quite small in comparison to the largest extent of the historical collection, it provides a good indication of the application and presentation of historical-geological knowledge in teaching.

Keyword

historical maps, teaching, geoscientific representation on maps

Predictive Mapping of Exploration Targets with Interpretable Machine Learning and Moderated Prediction Values

Nini Mou[1], China University of Geosciences, Beijing
Emmanuel John CARRANZA[2]*, University of the Free State (ejmcarranza@gmail.com)
Gongwen Wang[3], China University of Geosciences, Beijing
Xiang Sun[4], China University of Geosciences, Beijing

Abstract

Predictive mapping of exploration targets (PMET) using machine learning (ML) has been under development for several years now; however, the global mineral exploration industry has not yet widely adopted it. That is because the black-box character of various ML methodologies of PMET is not fully appreciated by many exploration geoscientists. In addition, most predictive maps of mineral potential are either biased towards known deposits or delineate disappointingly large exploration targets, rendering such maps unreasonable. It is motivating, however, that a few data-driven methods of PMET exists for interpreting black-box ML prediction models and addressing the issue of large exploration targets delineated by models. The latter likely stems from the inherest stochastic uncertainty of training data for PMET. Here, we show a methodology for making better the operation and trustworthiness of data-driven PMET by ML, using the Qulong–Jiama mineral district of Tibet as a case study. Initially, suitable targeting criteria and corresponding spatial proxies were defined and derived, respectively, based on the mineral systems concept. Then, to enable the interpretability of the ML models used for data-driven PMET, we used methods that are model-agnostic, namely, permutation feature importance, partial dependence plot, individual conditional expectation plot, and Shapely values. Lastly, we used an ensemble technique that couples the Random Forest algorithm and bootstrapping to derive moderated prediction values and the spatial distribution of their associated uncertainties. The delineated exploration targets (i.e., areas with high moderated prediction values and low uncertainties) cover only ~3% of the study area in the Qulong–Jiama mineral district.

Keyword

Exploration targeting, Mineral systems, Interpretable machine learning, Uncertainty

Dual branch convolutional neural network and its post-hoc interpretability for mapping mineral prospectivity

Fanfan YANG[1]*, China University of Geosciences (yangff@cug.edu.cn)
Renguang Zuo[2], State Key Laboratory of Geological Processes and Mineral Resources, China University of Geosciences, Wuhan, China

Abstract

The purpose of mineral prospectivity mapping (MPM) is to discover unknown mineral deposits by means of fusing multi-source ore-prospecting information. In recent years, with rapid advancements in artificial intelligence, deep learning algorithms (DLAs) as a groundbreaking technique have exhibited outstanding capabilities in geoscience. However, conventional DLAs for MPM face certain challenges in feature extraction and the fusion of multi-modal prospecting data. Moreover, opaque DLAs lead to not enough understanding of the predictive results by experts. In this study, a dual branch convolutional neural network (DBCNN) and its post-hoc interpretability were jointly constructed to map gold prospectivity in western Henan Province of China. In particular, channel and spatial attention modules were integrated into two branches to complement the respective advantages of multi-channel and high spatial prospecting data for MPM. The Shapley additive explanation (SHAP) framework was then adopted to explain the predictive results by exploring the feature contributions. The comparative experiments illustrated that the proposed DBCNN can enhance feature representation and fusion abilities, and therefore improve the performance of MPM compared to conventional DLAs. The high-probability areas delineated by the DBCNN model exhibited a close spatial relevance with known gold deposits, and the SHAP further proved the reliability of the predictive result obtained by the DBCNN model, thereby guiding future gold exploration in this study area.

Keyword

Mineral prospectivity mapping, Deep learning, Convolutional neural network, Attention module, Shapley additive explanation

A hybrid deep learning model of superpixel graph convolutional network and 1DCNN for geochemical anomalies identification

Ying Xu[1]*, China University of Geosciences (xvying1021@gmail.com)

Abstract

Machine learning algorithms have been extensively utilized for geochemical anomaly identification, which can be categorized into three types: spectrum-based, spatial-based, and spatial-spectrum-based models. The spectrum-based model cannot fully account for the spatial characteristics of geochemical element distribution. Simultaneously considering spatial and spectrum information in the geochemical data cube can help smooth out spectrum differences. The graph-based model, a classical spatial-based method, can comprehensively consider spatial information in the data and incorporate further distance information as input. This study proposes a dual-branch fusion network to extract spatial–spectrum features from a geochemical survey data cube. The spectrum branch consists of a one-dimensional convolutional neural network (1DCNN) that can be utilized to extract geochemical spectrum information within a single pixel, which involves major and trace geochemical elements and considered both positive and negative geochemical anomalies. The spatial branch is a superpixel graph convolutional network (SGCN), which is composed of both internal and external graph convolutions. SGCN can not only extract spatial relationships between neighboring pixels and even pixels at a long distance, but also take into account the anisotropy of mineralization. A case study was conducted to identify mineralization-related geochemical anomalies for validating the proposed hybrid deep learning model in northwestern Hubei Province of China. The resulting experiments have shown that: (1) superpixel segmentation is an effective tool in geochemical anomalies identification; (2) the incorporation of spectrum- and spatial-based methods contributed to the model's ability to discern anomalies and backgrounds within the geochemical data cube, enhancing its anomaly detection precision; and (3) the identified anomalous areas provide clues for the search for mineralization in the future.

Keyword

Geochemical exploration, Geochemical data cube, Spatial-spectrum models, Convolutional neural network, Superpixel-based Graph neural network

Decision-tree models used to detect mineral deposits in Uzbekistan by analyzing ring, lineament structures, and faults

Oksana Gennadevna TSAY[1]*, INSTITUTE OF GEOLOGY AND GEOPHYSICS named after Kh.M. Abdullaev (oksana_tsay@list.ru)
Bakhtier Sayfullaevich Nurtaev[2], INSTITUTE OF GEOLOGY AND GEOPHYSICS named after Kh.M. Abdullaev

Abstract

This paper presents decision-tree models that help in identifying the most significant factors for detecting deposits in the Republic of Uzbekistan. To achieve this, a spatial geodatabase that included ring structures (RS), faults, and lineaments was created in ArcGIS. The ArcGIS tools were used to find the center of the RS and the nearest distances between deposits and linear structures such as RS, faults, and lineaments. The density of these structures was also determined. Using this database, nine factors were identified which were associated with the deposits. These factors included the nearest distances to RS and RS center, fault, and lineament. The density of RSs, faults, and lineament nodes were also identified. The total densities of RSs and faults and RSs, faults, and lineament nodes were also considered.

The study examined the relationship between deposits and nine factors using four models (CHAID, Exhaustive CHAID, QUEST and CRT). For the analysis, 434 deposits were selected as dependent variable, with 273 representing ores and 161 representing hydrocarbons.

After testing the models using 10-fold cross-validation, the CHAID model was found to have the highest accuracy at 77.0%. The CRT model had an accuracy of 76.7%, while the Exhaustive CHAID and QUEST models had 76.0% accuracy. The most important factors for prediction were found to be the nearest distances to RS center, fault and RS (CHAID); the nearest distance to the RS center and fault (Exhaustive CHAID and CRT) and the nearest distance to the RS center (QUEST).

These results suggest that decision-tree models could be a useful tool in detecting mineral deposits.

Keyword

mineral deposits, ring structures, faults, lineaments, decision-tree models

The 3D/4D high precision modeling and AI-driven for 3D Au targeting in the gold districts of North China Craton

Gongwen WANG[1]*, China University of Geosciences(Beijing) (gwwang@cugb.edu.cn)

Abstract

In the eastern part of North China Craton (NCC), gold deposits associated with the Late Mesozoic craton destruction are widely distributed. However, there are significant differences in research depth, ore-forming characteristics, and proven reserves among different regions. The Liaodong area in eastern NCC shares similar regional geological characteristics with the Jiaodong area and has also experienced the Late Mesozoic craton destruction in the NCC. Yet, there is a substantial disparity in the theoretical research on gold mineralization and the proven gold resources. Based on the big datasets analysis of regional geology, Mesozoic magmatic-tectonic evolution, geological foundation of deposits, and geophysics and geochemistry in the study area, this paper proposes using data-driven dand knowldge-driven and AI-driven that the primary source of Late Mesozoic gold enrichment in NCC originated from mantle-derived melt fluids induced by craton destruction. The gold deposits in the study area are primarily controlled by NE-NNE trending faults, with the main types being fracture zone altered rock and sulfide-bearing quartz vein. The 3D/4D modeling study identifies the main fault zones and there related secondary faults, as well as the periphery and deeper parts of known mining areas, as important regions for future gold resource exploration. The gold resource potential of the NCC metallogenic belt using AI-driven is predicted to be enormous, with the potential to add thousands of tons of new gold resources.

Keyword

Integrated Geophysical Exploration, 3D/4D modeling, AI-driven, North China Craton, Gold district

Lithological mapping based on multi-source geoscience data and deep learning algorithms

Ziye WANG[1]*, China University of Geosciences (ziyewang@cug.edu.cn)
Renguang ZUO[2], China University of Geosciences

Abstract

Lithological mapping is essential to determine target lithologies within surrounding rocks, which is growing applied in various field such as geological survey, mineral exploration, and agriculture. However, lithological mapping under poor environments faces two challenges: insufficient data and restricted methods. Lithology describes the chemistry, mineralogy, physical properties, spectral reflectance, and spatial texture of rocks, rendering it identifiable using geochemical, geophysical, and remote sensing data. For the first issue, the incorporation of multi-source geodata is considered an effective and inexpensive approach for the comprehensive analysis of various geodata especially in areas with limited geological data. Recent methodological advances have focused on deep learning algorithms that emerges as state-of-the-art methods for many important breakthroughs. These deep learning methods exhibit considerable potential for correlation extraction from geodata to support geological tasks related to mineral exploration and lithological mapping. Considering the second issue, deep learning algorithms provide access to learn and extract information directly from raw geodata through multi-level networks and outputting end-to-end classification in contrast with traditional methods. Accordingly, this study aims to develop a promising framework for lithological mapping based on deep learning algorithms and multisource geoscience data. Multi-source data fusion technology is first adopted to achieve a comprehensive analysis of geodata by integrating geochemical, geophysical and remote sensing data. Deep learning models include convolutional neural network and recurrent neural network are then developed to learn the global, local, and contextual features of the fused geodata for lithological mapping. The proposed framework is illustrated in mapping regional and local leucogranite in the Himalayan orogen, China, which is confirmed to be potential resources of rare earth metals. The following conclusions were drawn: (1) multisource data fusion provides a solution by combining diverse types of information from the same target; (2) deep learning algorithms can efficiently explore multi-source geoscience data and significantly improve lithological mapping than traditional methods; (3) this study provides a critical insight into identifying geological features to aid in prospecting mineral exploration in poorly mapped areas.

Keyword

Lithological mapping, Deep learning, Multi-source data fusion

A semi-supervised learning method applied in designing optimal infill drillings, a case study at the Dalli porphyry Cu-Au deposit in Iran

Hooshang Asadi[1]*, Tethyan Gold Exploration Company (hooshang.asadi@outlook.com)
Moslem Fatehi[2], Iranian Giti Mine Company
Maryam Veiskarami[3], Geo Persia Company

Abstract

Using machine learning algorithms in designing the best possible boreholes to successfully intersect mineralized intervals is an important cost-effective approach in different stages of mineral exploration. In this research, a transductive support vector machine (TSVM), an innovative semi-supervised learning algorithm, was employed to enhance and integrate various spatial exploration proxies to identify potential targets for infill drilling at the South Dalli Cu-Au porphyry deposit, located in central Iran. Supervised learning methods incorporate training functions to classify certain data, whereas unsupervised learning methods extract the hidden data structures and assign them to various clusters. A semi-supervised learning method is a hybrid learning method that simultaneously extracts the hidden structure of non-training data and uses training data to improve the clustering analysis. To begin with, the Dalli porphyry mineral system and earlier exploration activities were used to locate the spatial Cu-Au exploration proxies including host intrusions, the buffered contact zone of the host intrusions and andesite porphyry, favorable hydrothermal alterations, copper-gold geochemical anomalies, and strong magnetic signatures associated with mineralized potassic alteration. Then, the proximity to the mineralized intervals in 6 earlier boreholes and 7 trenches was considered to divide the pixels in each spatial proxy into training (labeled) and non-training (unlabeled) data. By applying the TSVM algorithm to both training and non-training data, the study area was classified into two Cu-Au ore and waste domains. Furthermore, the results were compared and validated by the outline of the earlier available block model of the subsurface ore, projected at the surface. In addition to the TSVM algorithm, the supervised support vector machine (SVM) algorithm was implemented in the study area to identify high-potential areas for comparison. Thirty percent of the labeled exploration data was used to verify the performance of these two algorithms. The results revealed 87 percent correct recognition accuracy for the TSVM algorithm and 82 percent for the SVM algorithm. Compared to the SVM algorithm, the boundaries of Cu-Au mineralization identified by the TSVM algorithm showed a better correlation with the surface projection of the mineralized intervals along the deepest inclined borehole of the area. By using the TSVM algorithm, six new additional boreholes were suggested for infill drilling at the South Dalli deposit. This research revealed that the TSVM learning algorithm could be a useful tool for integrating exploration data with a limited amount of training data and enhancing zones of mineralization and consequently, ensuring a more accurate infill drill hole planning.

Keyword

Machine learnig, Semi-supervised, drilling, porphyry, Dalli

Mapping geology using textural feature extraction and unsupervised community detection models on airborne geophysics

Katie L Silversides[1]*, Datarock (katiesilversides@datarock.com.au)
Jack Maughan[2], Datarock
Mark J Pawley[3], Geological Survey of South Australia

Abstract

Airborne geophysics can provide useful information that can assist in large scale geological mapping. However, this data can be hard to interpret, especially when there is limited ground truth due to varying cover thickness. Here, we demonstrate how computer vision based feature extraction combined with unsupervised community detection models can be used to identify areas with similar geological textures to aid in interpretation and mapping.

The test area is in the Gawler Craton in South Australia. The area contains Archaean to Mesoproterozoic basement, mainly comprising metamorphic, felsic magmatic and bimodal magmatic units. There is extensive sedimentary cover, including the Neoproterozoic Stuart Shelf in the North Eastern region. The area contains significant economic mineralisation, including Iron Oxide Copper Gold (IOCG) and orogenic gold deposits.

Gravity and total magnetic intensity (TMI) vertically reduced to pole (VRTP) were used as inputs. Each data layer was divided into 2km overlapping tiles. Each tile was then passed through a pre-trained convolutional neural network (CNN) model to extract textural information. These models are trained to recognise everyday objects. In this case, instead of getting a discrete object classification, numerical representations (vectors) of the textures were obtained by taking the last layer of the CNN. This resulted in 256 features for each geophysical data layer. A uniform manifold approximation and projection (UMAP) was fitted to the data to reduce the dimensionality of the combined features to 80. The UMAP also produces a graph that shows how the points in the data are connected.

Community detection algorithms can use the graph produced by the UMAP to detect groups with similar properties. Unlike classical clustering algorithms, community detection methods use modularity to decide which points belong to a cluster. Modularity is a measure of how comparatively dense the edges within the groups are compared to the density of the connections between groups. We used the Louvain (using both Potts and Dugue modularities), Leiden and Walktrap algorithms. The results were compared to the mapped Archean to Early Mesoproterozoic geology to assess model performance.

All models identified some clusters that aligned to mapped geological units. For example, Moondrah Gneiss was frequently identified as a unique cluster relative to the surrounding area. Other clusters were identified by one method but not others. Walktrap identified the most clusters, over double that of the other methods. However, it also had the noisiest results.

Three mapped lithologies were compared to the clusters they intersected. When looking at the percentage of the lithology that was covered by the cluster with the highest overlap, Louvain with

Potts had the best results. Walktrap performed the worst. The results varied by lithology. All methods produced similar results for one lithology but some methods had poor results for the others.
Unsupervised community detection models can provide information to assist with geological mapping. However, when implementing them both the method chosen and the tile size need to match to the scale of the geological features being investigated.

Keyword

airborne geophysics, CNN feature extraction, community detection, geological mapping

Neural kriging-based specification and 3D modeling of concentrated zones of rare earth elements in deep-sea mud layers

Vitor Ribeiro de Sa[1]*, Kyoto University (ribeirodesa.vitor.7c@kyoto-u.ac.jp)
Katsuaki Koike[2], Kyoto University
Oak Yono[3], Ocean High Technology Institute, Inc.

Abstract

3D geological modeling plays a crucial role in mineral exploration, but its reliability is often challenged by data heterogeneity, sparsity, and biased collection. Lithotype variations, particularly in deep-sea environments, introduce significant uncertainty, hindering accurate resource estimation and prospectivity mapping. In response to these challenges, this study presents an alternative approach to conventional geostatistical methods utilizing neural kriging (NK: Koike et al., 2022), a method based on a deep neural network with a semivariogram learning criterion, to address the complexities of spatial modeling. Focused on a rare earth elements and yttrium (REY) deposit within the Japanese exclusive economic zone, characterized by its association with pelagic deep-sea regions exceeding 5000 meters below sea-level and high grades of up to 8000 ppm, primarily linked to biogenic calcium phosphate, namely apatite. These elements play a pivotal role in facilitating the energetic transition and mitigating climate change, making the accurate identification and delineation of REY-rich muds of paramount importance. In addition to REY, this study incorporates Scandium (Sc), Thorium (Th), and Uranium (U) as input variables due to their high affinity with the elements of interest. These elements share a high affinity with REY, further enhancing the model's ability to identify promising exploration targets. The study demonstrates the effectiveness of NK in handling data sparsity, particularly over large spatial scales reaching up to 12 km and modeling the continuity of REY-rich mud layers. The input dataset utilized in this study was sourced from Tanaka et al. (2020), which is downloadable from the online “Appendix A. Supplementary data”. By leveraging AI-driven approaches like NK, researchers and stakeholders can make more informed decisions regarding resource exploration and exploitation, thereby contributing to sustainable development and resource management initiatives.

Appendix A. Supplementary data:

Koike, K., Yono, O., de Sá, V.R., Tomita, S.A., Nozaki, T., Takaya, Y., Komori, S., 2022. Effectiveness of neural kriging for three-dimensional modeling of sparse and strongly biased distribution of geological data with application to seafloor hydrothermal mineralization. Math. Geosci. 54, 1183–1206. https://doi.org/10.1007/s11004-022-10011-3

Tanaka, E., Nakamura, K., Yasukawa, K., Mimura, K., Fujinaga, K., Iijima, K., Nozaki, T., Kato, Y., 2020. Chemostratigraphy of deep-sea sediments in the western North Pacific Ocean: Implications for genesis of mud highly enriched in rare-earth elements and yttrium. Ore Geol. Rev. 119, 103392. https://doi.org/10.1016/j.oregeorev.2020.103392

Keyword

Neural kriging, Deep learning, Semivariogram, Rare earth elements, Mineral prospectivity, Deep-sea mining

Detailed mineral, grade, and potential mapping by applying deep neural network-based methods to remote sensing, drilling, and seafloor data

Katsuaki KOIKE[1]*, Kyoto University (koike.katsuaki.5x@kyoto-u.ac.jp)
Nguyen Tien Hoang[2], The Research Institute for Humanity and Nature (RIHN)
Yusuke Hashimoto[3], Kyoto University
Vitor Ribeiro de Sá[4], Kyoto University

Abstract

Mineral exploration needs detailed and accurate mapping of minerals related to deposits on the surface and metal contents using drilling data. Remote sensing and 3D modeling techniques are applicable to the former and latter purposes. We try to demonstrate capability of deep neural network (DNN)-based methods for them through the following three approaches and case studies.

The first approach is spectral downscaling of multispectral imagery to transform into hyperspectral imagery with many reflectance data. Although hyperspectral imagery provides mineral identification accuracy much higher than multispectral imagery, the cover areas by hyperspectral imagery are much less than those by multispectral imagery represented by Landsat 8 OLI and ASTER images. Therefore, we developed Pseudo-Hyperspectral Image Transformation Algorithm (PHITA) that simulates pseudo-hyperspectral image from multispectral satellite image through a DNN-based correlation analysis between hyperspectral and multispectral band reflectance data. By applying PHITA to hydrothermal deposit areas, distributions of alunite, kaolinite, pyrophyllite, and muscovite were discriminated and delineated in even the areas outside the hyperspectral image scenes: these minerals were not identified from the original OLI and ASTER images.

The second approach is extrapolation of metal content data by drilling. Targeted deposit is volcanogenic massive sulfide, kuroko-type below the seafloor and in a land area. In seafloor mineral exploration, the number of drillings is few and the drilling depths are shallow due to difficulty and high cost of drilling investigation. For a case study of a hydrothermal vent area in the Okinawa Trough, a plausible 3D metal-content model was produced by a DNN-based method using variogram and geophysical data from a linearly distributed drilling data. High-content zones appeared in the areas beyond the data cover region. For a land kuroko-deposits area, a drilling dataset that did not include the metal data in the mines was used. Despite this condition, high anomaly content zones were specified at the actual mine locations by a DNN-based method using geological and geophysical data. In addition, through a sensitivity analysis of the constructed network and metal content distribution, influence factors on the metal contents, basically tectonic setting such as fault zone or lithotype related to the generation of deposits such as dacite and dolerite, were identified. The directions of sensitivity vectors towards the high anomaly content zones suggested a formation process of deposit, deposited in the upflow of hydrothermal fluid-

dominated zones or downflow of seawater-dominated zones.

The third approach is a regional potential mapping of seafloor hydrothermal deposits in the Okinawa Trough and Izu-Ogasawara Sea area. The locations of hydrothermal deposits were used for a training dataset, and the data of seafloor topography, heat flow, Bouguer gravity anomaly, and earthquake hypocenter and magnitude were considered as the input information for a DNN-based method. As a result, high potential zones were revealed to be along the major faults and around the zones with concentrated hypocenters in a certain depth range.

Consequently, through the above three approaches and obtained results, DNN-based methods were demonstrated to be highly effective for mineral exploration both in land and seafloor areas.

Keyword

remotely-sensed image, hydrothermal alteration mineral, metal content, 3D spatial model, seafloor deposit

3D Mineral Prospectivity Mapping from 3D Geological Models Using Return–Risk Analysis and Machine Learning on Imbalance Data

Qingming PENG[1]*, China University of Geosciences (Beijing) (1792542113@qq.com)
Gongwen Wang[2], China university of geosciences (Beijing)
Zhongzheng Wang[3], China university of geosciences (Beijing)

Abstract

Three-dimensional Mineral Prospectivity Mapping (3DMPM) stands out as a pioneering approach in mineral exploration, leveraging diverse geological data sources to construct a three-dimensional (3D) model of mineral deposits. This technique offers a precise subsurface representation, enabling the identification of areas with significant mineral potential. However, the imbalance between mineralized and non-mineralized classes poses challenges in classification results, favoring the more observed classes.

To address this issue, we employ Borderline-SMOTE (BLSMOTE), an oversampling technique that mitigates the imbalance problem by generating synthetic data points along the boundary line between minority and majority classes. Unlike other methods, BLSMOTE effectively balances datasets without introducing excessive noise.

In this study, we focus on the Guizhou Lannigou gold deposit, utilizing the shallow-forming low-temperature hydrothermal deposit as a case study. We extract ore-controlling elements and establish a 3D geological model, incorporating a total of 50 training samples generated through the BLSMOTE method. Additionally, 50 mineralization prospects are identified using Random Forests.

A return–risk analysis is applied to explore uncertainties associated with synthetic positive samples and randomly selected negative samples, determining final mineral potential values. Evaluation metrics, including G-mean and F-value, reveal that the BLSMOTE-enhanced model outperforms counterparts without the synthetic algorithm, as well as those using SMOTE and KMeansSMOTE. The optimal BLSMOTE18 model achieves an impressive AUC of 0.9288.

Our methodology demonstrates robust performance across various levels of class imbalance datasets. Excluding predictions overlapping with known deposits, we identify five target zones using a P-A plot, all exhibiting distinct metallogenic geological features. Notably, Target1 and Target2 emerge as promising areas for mineralization, offering valuable insights for future mineral exploration endeavors.

Keyword

3DMPM, Uncertainty, Random forest, Borderline-SMOTE, Gold deposit

Machine learning-based 3D mineral prospectivity mapping

Bingli Liu[1]*, Chengdu University of Technology (liubingli@cdut.edu.cn)

Abstract

The research on three-dimensional (3D) quantitative prediction methods of mineral resources at depth provides important technical support for deep mineral resources exploration. The three core scientific problems to be solved in three-dimensional quantitative mineral resources prediction are: 3D meticulous modeling of mineralization space, deep geological and geochemical information extraction and inference, and quantitative metallogenic prediction at large depth. In view of this, this paper mainly discusses from the following aspects: based on the combination of explicit and implicit modeling method, 3D visualization of geology and geochemistry are carried out; based on the multifractal content volume (C-V) model, the spatial distribution of primary halo geochemical elements is studied; based on data- and knowledge-driven compositional data analysis (CODA) framework, the characteristics of element associations are extracted and inferred; On the basis of machine learning and deep learning methods, quantitative mineral prediction at large depth is carried out. Based on the metallogenic model of deposit, the deep geological and geochemical indicators are quantitatively extracted, and the deep geological and geochemical exploration model is constructed. Three quantitative mineral prediction models of machine learning and deep learning, including maximum entropy model, Gaussian mixture model and convolutional neural network model, are designed. These three models are used for deep quantitative mineral prediction, which provide a new prospecting direction for deep quantitative prediction.

Keyword

Mineral prospectivity mapping, Deep learning, Multifractal

Three-dimensional mineral prospectivity mapping based on positive-unlabeled learning algorithm and return-risk analysis in the Lannigou Au district, Guizhou Province, China

Zhongzheng WANG[1]*, 3001230110@email.cugb.edu.cn (3001230110@email.cugb.edu.cn)
Gongwen Wang[2], gwwang@cugb.edu.cn
Qingming Peng[3], qmpeng@email.cugb.edu.cn

Abstract

The application of three-dimensional (3D) geological modeling and machine learning provides a novel method for mineral prospectivity mapping (MPM). However, mineralization is a rare event, which leads to the fact that in 3D geological model, ore body as positive samples of machine learning only occupy a small proportion, and the majority are unlabeled data of unknown ore-bearing data. Nevertheless, supervised machine learning algorithms widely used in MPM require balanced positive and negative samples. Therefore, the selection of negative samples and the class imbalance of samples pose the challenge of 3DMPM. In this study, positive-unlabeled learning class (PULC) machine learning algorithm was selected and applied to the Lannigou Au district, Guizhou province, China. While addressing the issue of class imbalance in samples, the impact of different negative sample selection methods (from unlabeled data) on the prediction model was compared. Two-step positive-unlabeled learning (TSPUL) is a prediction algorithm that identifies accurate negative samples. It constructs a balanced training set for prediction by labeling accurate negative samples from unlabeled data based on a probability threshold determined from positive samples. Bagging-based positive-unlabeled learning (BPUL) is another prediction algorithm that treats all unlabeled data as negative samples. It repetitively selects an equal number of negative samples (treating unlabeled data as negatives) to form a balanced training set with positive samples for prediction. This study employed random forest (RF) as the base learner for PULC, constructing TSPUL-RF and BPUL-RF models, respectively. The performance of the PULC algorithm was further compared with the RF model based on ROC curves and P-A plots. The results demonstrated that the BPUL-RF model outperforms both the TSPUL-RF and RF models. Utilizing return-risk analysis model for evaluation, high return and low risk 3D grid cells are selected, while integrating ore-forming geological conditions, to determine the I-level exploration targets. The I-level exploration targets are all located within the buffer zones of ore-forming faults F3, F70, and F80. The 3D exploration targets delineated in this study hold significant importance for both deep and peripheral mineral exploration in the Lannigou Au district of China.

Keyword

Two-step positive-unlabeled learning, Bagging-based positive-unlabeled learning, Mineral prospectivity mapping, Uncertainty quantification, Lannigou Au district

Automated boundary detection in drillhole data by leveraging AI and machine learning algorithms

Hamid ZEKRI[1]*, UNSW | MinEx CRC (h.zekri@unsw.edu.au)
David Cohen[2], School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2052, Australia
Neil Rutherford[3], School of Biological, Earth and Environmental Sciences, University of New South Wales, NSW 2052, Australia

Abstract

Boundary detection is crucial in identifying the facies interfaces or discontinuities within the cover. Separating and characterising transported from in-situ regolith horizons is critical to detecting geochemical signals and patterns in regolith material derived from underlying mineralisation versus the influence of other factors. Such boundaries may exhibit only subtle mineralogical variations but represent significant differences in geochemical characteristics and sources of trace elements. However, these features might be overlooked by even experienced geologists during visual loggings. Real-time multivariate analysis of geochemical and mineralogical data acquired from drilling programs, linked to suitable data-driven methods for boundary detection and horizon characterisation offer an objective, rapid and powerful method of achieving such classification.

An AI-assisted tool has been developed for multivariate boundary detection applicable to any drillhole data. The approach is based on supervised classification algorithms, automatically evaluating the accuracy of the lithological margins detected by the workflow. The outcome is a data-driven log of core or chips, that quantifies the significance of each variable in delivering more accurate boundary detection.

This tool has been implemented on an integrated geochemical and mineralogical dataset acquired from a historic drillhole near McKinnons Gold mine in New South Wales, Australia, using portable X-ray Fluorescence and spectroradiometer data. A combination of major, conserved, target and pathfinder elements, as well as various spectral features relating to the type and abundance of Fe-oxyhydroxides, kaolinites and chlorites was used for multivariate change point detection, employing a linearly penalised segmentation approach. Random Forests and Support Vector Machine techniques were implemented to identify optimum penalty values in the cost function, leading to more accurate boundary detection. By adjusting penalty value as a crucial parameter to balance sensitivity and specificity, the boundary detection process is fine-tuned to distinguish between significant geological transitions and minor variations, ensuring that only meaningful changes in rock types, mineralisation zones, or other geochemical features are recognised. The results provided a detailed data-driven log, identifying a horizon in the saprolite dominated by kaolinite and elevated Fe and Mn. Moreover, a new interval in the saprock zone above the fresh siltstone bedrock was detected where elevated concentrations of Pb, Zn, As and Sb had accumulated. This interval, dominated by iron oxides, has been selected for further geochemical studies. The pseudo log resulting from this approach is matched with known

interfaces and assisted in delineating the significant interfaces which were overlooked in the initial visual log interpretations.

Keyword

Change Point Detection, Artificial Intelligence, Machine Learning, Mineral Exploration, Regolith

Geological data mining in mineral resources national survey database

Zhao TING[1]*, Chinese Academy of Geosicence(CAGS) (771899460@qq.com)
Liu Chao[2], Chinese Academy of Geosicence(CAGS)

Abstract

Geological big data has significant characteristics such as multi-source, multi-category, multi-dimensional, multi-topic and multi-time and space. The national survey of mineral resources of China has formed a massive amount of data on national conditions of mineral resources accumulated since the founding of the People's Republic of China. It undoubtedly has the characteristics of geoscience big data and is a set of multiple Dimensional, multi-level, seemingly scattered but actually organically coupled data sets also reflect the real data records that we face every day in the actual work of mineral resource management. Big data mining is to capture everything from the ore body to the mining area and from the mine. to macro resource security, from micro to macro, peek into the multi-dimensional and comprehensive real world, and restore the full picture of China's resource security from seemingly fragmented information. These massive data elements with more than one million levels are the basis of national situation survey data. Data mining, scientific management, and information sharing have brought unprecedented challenges. This article established a set of innovative data standardization methods of "multi-dimensional fusion of all survey elements" to quickly discover, locate and obtain survey data and related factors. relationship, compiled the technical requirements for building a mineral survey database, developed five innovative applications of national survey data mining including machine learning for mineral deposit knowledge discovery, spatial data quality inspection, and geological multi-source data consistency evaluation, and built a geological big data storage and management system. and visual mining platform.

Keyword

Geological data mining, national survey database, mineral resources, machine learning

Research on Key technology of 3D ore-forming field simulation of Caixiashan Pb-Zn deposit, Eastern Tianshan area, Xinjiang autonomous Region

Li SUN[1]*, Institute of Mineral Resources,Chinese Academy of Geological Sciences (sunli0727@163.com)
Keyan Xiao[2], Institute of Mineral Resources,CAGS
Yang Gao[3], China Nonferrous Metal Mining(Group) Co.,Ltd
Xuchao Dong[4], Institute of Mineral Resources,CAGS
xinfei Yu[5], Institute of Mineral Resources,CAGS
Xin Yang[6], Institute of Mineral Resources,CAGS

Abstract

The study of fluid inclusions in the Caixiashan deposit indicates that the ore-forming fluids exhibit characteristics of magmatic fluids, potentially superimposed by basin fluids. The surrounding rock also contributed partially to the mineralization, with the Hualixi period rock providing material and thermal sources for the mineralization. Fault structures and silicate calcium surfaces represent the most direct mineralization spaces. A comprehensive analysis suggests that the Caixiashan deposit hosts a mid-to-low-temperature hydrothermal type deposit associated with the Kavaluruk Group and the Hualixi period magmatic rock.Observations of fluid inclusions in the II ore body of Caixiashan deposit indicate that the inclusions are predominantly rich in liquid phases, with a gas-liquid ratio of 5-40%. Homogenization temperatures are mainly distributed between 100-280°C, with salinity ranging between 2-10% NaCl. The ore-forming fluids at Caihuxia are characterized as medium to low temperature and salinity. The favorable temperature range for mineralization is 140-240°C, with a favorable salinity range of 3-10% NaCl.The analysis of the fluid inclusion samples indicates a strong correlation between the main ore-forming elements Pb, Zn, Cu, and Cd, while their correlations with other elements are weaker. There is no significant correlation between Pb, Zn, and the homogenization temperature, salinity, ice melting point, gas phase composition, and liquid phase ion composition of the fluid inclusions.Using five machine learning algorithms Support Vector Machine (SVM), Decision Tree (CART), Random Forest, Artificial Neural Network (NNET), and K-Nearest Neighbors (KNN),for modeling fluid inclusion data, and the Root Mean Square Error (RMSE) was used to compare and select SVM as the preferred modeling method.Based on the three-dimensional numerical modeling of homogenization temperature, salinity, and ice melting point, a basic three-dimensional fluid field of the Caihuxia II ore body was established. Analysis of this model suggests a gradual decrease in homogenization temperature, salinity, and ice melting point from east to west and bottom to top.

Keyword

3d data modelling, ore-forming fluid field, machine learning, Caixiashan Pb-Zn deposit, mineralisation potential mapping

Advances in Mineral Resource Assessment: A Comprehensive Overview

keyan XIAO[1]*, Chinese academy of geological (kyanxiao@sohu.com)

Abstract

Mineral resource assessment plays a pivotal role in guiding sustainable resource utilization and development. As a Professor at the Institute of Mineral Resources, Chinese Academy of Geological Sciences, I have dedicated my career to advancing quantitative prediction and evaluation techniques in this field. With over 40 national projects under my belt, ranging from key R&D programs to geological surveys, my research has focused on deepening our understanding of mineral deposits and refining predictive models.

In recent years, our team has made significant strides in deep resource prediction systems, particularly in addressing the complexities of three-dimensional geological modeling and the prediction of concealed ore bodies. Our innovative approaches have been successfully applied and demonstrated in various regions, including Shandong, Gannan, Tibet, and Xiangxi. Through projects like the Deep Resource Prediction System for National Key R&D, we have formulated theoretical frameworks and methodological systems that enhance our ability to assess mineral potentials accurately.

Furthermore, our efforts have extended to the evaluation of western superior mineral resources and the assessment of 25 important mineral resources nationwide. By integrating comprehensive geological information, we have developed methods for estimating potential resource quantities based on mineral systems. This has culminated in the development of advanced regional mineral assessment software, which has proven instrumental in guiding breakthroughs in key mining areas such as Jiama in Tibet and Caixiashan in the Eastern Tianshan region.

Our contributions have been recognized through numerous awards and honors, including the National Science and Technology Progress Award and the Ministry of Land and Resources Science and Technology Progress Award. With over 100 publications and five monographs to our credit, our work continues to shape the landscape of mineral resource assessment.

As we look forward to participating in the 37th International Geological Congress in Busan, Korea, we are eager to share our insights and experiences in resource evaluation, contributing to the global dialogue on sustainable resource management and geological innovation.

Keyword

Mineral resource assessment, Quantitative prediction techniques, Three-dimensional geological modeling

Convolutional Neural Network and numerical modeling-based 3D mineral prospectivity modeling for targeting concealed mineralization

Xiaohui LI[1]*, Hefei university of technology (lxhlixiaohui@163.com)
Feng Yuan[2], Hefei University of Technology
Mingming Zhang[3], Hefei University of Technology
Yuheng Chen[4], Hefei University of Technology
Xiangang Xie[5], Hefei University of Technology
Chaojie Zhen[6], Hefei University of Technology

Abstract

Recently, Three-dimensional mineral prospectivity modeling (3DMPM) has gained popularity in mapping the prospectivity of deep-seated and concealed mineralization. However, the majority of previous studies on 3DMPM have primarily relied on shallow supervised machine learning models and dimensionality-reduced 3D predictive maps, creating a constraint on the availability of predictive maps.

The Northeast of Liqiao area is located within the Yangtze metallogenic belt of Anhui Province, China. Many concealed skarn and porphyry-type deposits have been discovered within this area, indicating its significant potential for hosting hydrothermal deposits. In this study, we take this area as a case study. We generate various 3D predictive maps based on numerical modeling and other 3D methods, then integrate and delineate the highly prospective areas based on a convolutional neural network that has multi-scale characteristics and integrates spatial attention approaches.

The results of this study demonstrate that 3D predictive maps generated through numerical modeling enhance the information available for 3DMPM. Additionally, the CNN model used in this study exhibits superior prediction capabilities compared with other commonly used machine learning models. It can more effectively capture the correlation between 3D predictive maps and known mineralization. This combined approach can serve as an effective tool for delineating deep concealed targets for further exploration.

Keyword

3D mineral prospectivity modeling, CNN, Numerical modeling, Concealed mineralization

Feature optimization of machine learning and its application in mineral prospectivity mapping

Ke GUO[1]*, Chengdu University of Technology (guoke@cdut.edu.cn)

Abstract

Machine learning (ML) have seen widespread application in the quantitative prediction of mineral resources in recent years. Yet, during the application process, challenges such as data quality or algorithmic limitations frequently result in low classification accuracy for the predictive models. Feature optimization serves as a critical tool to enhance the classification accuracy and robustness of Machine learning. This approach effectively aids researchers in identifying the feature variables for machine learning prediction models, though it often goes overlooked. This study focuses on the Lhasa region in Tibet. Utilizing ensemble learning techniques like Random Forest (RF) and Gradient Boosting Decision Tree (GBDT), 43 feature variables including geological, geochemical, and geophysical were optimized. Then the Support Vector Machine (SVM) model with optimized features were constructed. Compared with the traditional SVM models, the SVM model based on feature optimization significantly improves the prediction performance and effectively solves the problems of subjectivity, complexity and uncertainty in the construction of artificial features. It is worth noting that when comparing RF _ SVM and GBDT _ SVM, the high-value areas observed by GBDT _ SVM are more closely related to the space between known deposits. The ROC curve further verifies that the GBDT _ SVM model has higher classification accuracy and provides strong support for future mineral exploration. Employing this approach, a metallogenic probability map of the study area was created, providing valuable guidance for further mineral exploration in the region.

Keyword

Machine learning, Feature optimization, Mineral prospectivity mapping

Machine Learning-based approach to exploration targeting of porphyry Cu-Mo deposits in the Duobaoshan district of Heilongjiang province,China

Xiumei LV[1]*, China University of Geosciences Beijing (lvxm163@163.com)
Gongwen Wang[2], China University of Geosciences Beijing

Abstract

The driving role of mineral resources in the economic development and technological progress of a country is self-evident. However, surface and shallow minerals are increasingly diminishing, making the exploration of concealed and deep-seated ores a primary target. With the rapid advancement of artificial intelligence technology, machine learning-based exploration and integration of geological ore information provide an efficient and reliable technical approach for mineralization prediction.In this study, three models based on Random Forest, Support Vector Machine, and Radial Basis Function Link Network were employed to conduct a case study on feature vector construction, feature extraction, integrated fusion, and two-dimensional mineralization prediction using multi-source data such as geological, geophysical, and remote sensing data in the Duobaoshan mining area of Heilongjiang Province, China. The results indicate that all three machine learning algorithm models can effectively identify favorable ore zones, with the Random Forest algorithm producing the optimal results. The comprehensive analysis of the results from the three models, coupled with the delineation of prospective exploration areas, provides a scientific basis for further exploration work in the region. Compared to traditional prediction methods, machine learning-based mineral prospecting demonstrates excellent performance in extracting the corresponding relationship between multi-source geoscientific information and mineral distribution, showcasing a significant trend in the quantitative prediction of future mineral resource development.

Keyword

Machine Learning, Geoscience multi-source data, data mining and integration, mineralization prediction

Numerical simulation and prediction of mineralization using a physical information neural network surrogate model: A case study of the Fankou lead-zinc mine.

tang AO[1]*, Sun Yat-sen university (tangao3@mail2.sysu.edu.cn)
Xiao Fan[2], Sun Yat-sen university

Abstract

Numerical simulation has become a pivotal tool in Earth sciences for comprehending and delineating geodynamic mechanisms, encompassing intricate ore-forming systems. However, the substantial sensitivity of numerical outcomes to parameters prohibits the reuse of existing computational results in tasks demanding iterative simulations like optimization design and sensitivity analysis, thereby resulting in elevated computational expenses and diminished efficiency. Therefore, this paper presents a method for developing a Physical Information Neural Network (PINN) aimed at solving the interconnected partial differential equations governing force, flow, and heat within numerical simulations of ore-forming dynamics. The objective is to optimize the numerical simulation parameters, consequently minimizing the uncertainty associated with ore-forming numerical simulation outcomes. Initially, we concentrated on the Fankou lead-zinc mine area and developed a numerical simulation model to elucidate the dynamics of ore formation. This model integrates the coupling of force, heat, and flow fields. Following this, we integrated the model with explicit ore-forming elements representing exploration anomalies, resulting in the creation of a metallogenic prediction model. Subsequently, parameterized scans were conducted to test the numerical simulation model, collecting numerical simulation results under 128 sets of rock physical property parameters. Next, by integrating deep learning with numerical simulation results, we established a data-driven surrogate model to predict ore-forming elements like stress and temperature. Finally, multiple Physical Information Neural Networks (PINNs) were constructed to solve partial differential equations, including Darcy's law and the energy conservation equation. These two neural network frameworks were utilized to numerically simulate the force-flow-heat field in the ore-forming process, and their effectiveness, accuracy, and stability were compared and validated on the test set. Additionally, genetic algorithms were employed to optimize rock physical parameters such as density and heat capacity under both methods, yielding optimized parameter values and mineral prediction model. The findings suggest that both neural network architectures effectively forecast the accumulation of stress and strain, the spatial temperature distribution, and the enrichment of ore-forming elements in finite element simulations. In comparison to data-driven surrogate models, the Physical Information Neural Network (PINN) method demonstrates a reduced regression error (R2).

Keyword

Numerical simulation, Physical Information Neural Network, metallogenic prediction model

Fractals and Multifractals in Geosciences: An Introduction to a New Reference Book

Behnam Sadeghi[1]*, 1. CSIRO Mineral Resources, Australian Resources Research Centre, Kensington, WA 6151, Australia || 2. Earth and Planets Laboratory, Carnegie Institution for Science, 5251 Broad Branch Road NW, Washington, DC 20015, U.S.A. (behnam.sadeghi@csiro.au)

Abstract

This presentation will introduce the latest reference book in the field of mathematical geosciences, an in-depth examination of 'Fractals and Multifractals in Geosciences', authored by Behnam Sadeghi and published by Elsevier in June 2024. This book details the application of a wide range of multifractal methods, including the traditional methods, and many novel ones developed by the author, along with an assessment of uncertainty in sample classification and stability of spatial patterns. It also provides criteria for the selection of the most effective combination of data pre-processing and multifractal modeling to extract desired features or signals in the data. The book specifically aims to introduce, apply, and test novel multifractal models that account directly for changes in relationships between variables, as well as the effects of distance between samples and the source of anomalous metal contents in geoscience samples. Linked to this will be the assessment of the effects of different pre-processing of data prior to the application of the models and quantification/model uncertainty in geochemical anomaly maps, associated with sample classification and spatial interpolation. Gaussian simulations such as Sequential Gaussian Simulation and Monte Carlo Simulation will be applied to the new multifractal models developed and a suite of existing models, including (simulated) concentration-area, spectrum-area, singularity, and others. Here, the author discusses how this book will be invaluable for mathematical geoscientists, geostatisticians, exploration and environmental geochemists, computational geoscientists, data scientists, GIS professionals, and decision-makers in the mining and mineral industry, who need to better understand fractal geometry, along with its theory and applications in geochemical anomaly classification to generate maps that are helpful for decision-making for follow-up sampling and explorations.

Keyword

Multifractals, Exploration & Environmental Geosciences, Critical Minerals, Anomaly Classification, Uncertainty Quantification

Fractal modeling of the analytical signal for interpreting gravity and magnetic data: A case study from the Eastern Tianshan orogenic belt

Fan XIAO[1]*, Sun Yat-sen University (xiaofan3@mail.sysu.edu.cn)

Abstract

Aerial gravity and magnetic data is crucial for understanding the tectonics and deep geological structures of an area of interest due to their high lateral resolution. Neverthless, geophysical survey data including gravity and magnetic reconnaissance often contains various sources of noise and interference, which can obscure meaningful anomalies. In this regard, we propose using fractal filtering and singularity analysis methods to characterize multifractally in three-dimensional analytic signals of gravity and magnetic data. It aims to decompose multi-scale anomalies and enhance weak anomalies caused by the field sources with relatively low density and magnetic contrasts. Through forward modeling, the applicability of these two fractal modeling methods in processing three-dimensional analytic signals is investigated. This also helps to reveals the geological and geophysical significances of the processing results. In the case study, we employ fractal filtering and singularity analysis methods to process the direct analytic signals of Bouguer gravity and aeromagnetic data in the Eastern Tianshan orogenic belt. On one hand, regional anomaly is used to interpret the structural settings of the Eastern Tianshan district, and the geodynamic contexts of these structures were discussed. On the other hand, concealed magnetic plutons in the Gobi-desert covered area are inferred based on local anomaly.

Keyword

Bouguer gravity, Aeromagnetic data, Fractal filtering, Singularity analysis, Eastern Tianshan

Multifractal modeling of current and past Earth's climate

Frits AGTERBERG[1]*, Geological Survey of Canada (frits@rogers.com)

Abstract

Anywhere on Earth, weather is a chaotic manifestation of local climate. According to chaos theory, the cause of unusual weather generally cannot be established with certainty but minute perturbations of initial conditions can result in unusual large-scale weather-generating processes that are deterministic and can be modeled statistically. The current (Anthropocene) relatively rapid global warming is primarily caused by an approximately linear increase of the atmospheric CO2 content This results in various types of weather with properties that can be modeled statistically. Multifractal modeling of pre-Quaternary paleoclimates that resulted in abnormal kinds of weather is difficult, because of erosion and limited precision of age determination methods. However, several climatological features of Anthropocene age and, to some extent, fossilized consequences of other late Quaternary climates can be modeled statistically, particularly by using a modified version of the double Pareto-lognormal frequency distribution. Examples to be discussed are (1) current worldwide annual increases in frequencies of forest fires, and (2) relatively rapid annual increases in numbers of hottest and coldest days in part of Europe. It is shown that parameters of the double Pareto-lognormal frequency distribution can be estimated for these examples. Special care has to taken to account for the approximately linear increase over time of the mean value of the frequency distributions taken for example.

Keyword

Multifractals, Pareto-lognormal, Climate, Weather

Singularity Analysis and Dynamic Mechanisms of Extreme Geological Events Originating from Plate Motion and Occurring at Their Boundaries

Qiuming Cheng Cheng[1]*, IUGS/China University of Geosciences (Beijing)/Sun Yat-sen University (qiuming.cheng@iugs.org)

Abstract

Research shows that various extreme geological events originating from plate motion and occurring at their boundaries are intermittent, avalanche and singular, and their spatiotemporal distribution is periodic, sporadic and aggregated. The mass accumulation or energy release caused by these extreme events is often non-differentiable or singular and needs to be measured and characterized by fractal calculus (FC). From the perspective of nonlinear mathematical physics, the occurrence of such events may be related to lithospheric phase transitions, self-organized criticality and multiplicative cascade mechanisms.

This study introduces the local singularity theory and fractal density analysis method proposed by the author in recent years and applied them to the modeling of various extreme geological events. These methods have proven effective in quantitatively characterizing the singularity and complexity of the energy released and accumulated mass of the events described above. Local singularity analysis (LSA) developed based on the fractal density concept can be used as a scale-invariant filtering technique for spatiotemporal sequences, highlighting weak anomalies corresponding to deep-time extreme geological events, and decomposing mixed anomalies caused by the superposition of multiple processes. It can also establish dynamic model based on fractal calculus for simulating extreme geological events. Starting from the analysis of nonlinear process mechanisms, fractal density concepts, fractal calculus, the article studies the spatiotemporal distribution characteristics of clustering of earthquakes, magmatic activities, and mineralization along plate boundaries such as the Pacific Rim, Tethys Domain, and mid ocean ridges. Focus on studying the impact of tectonic movements and plate characteristics on the occurrence of extreme events. The cases used herein have proven that singularity theory and methods can be used as effective theories and methods for quantitative analysis of abnormal geological events.

Keyword

Plate motion, earthquakes, magmatism, plate boundaries, fractal calculus

Modelling spatial uncertainty of geochemical anomalies integrating C-A fractal and geostatistical simulation methods

Haicheng WANG[1]*, China Geological Survey (wanghch0324@163.com)
Ruiwen Shen[2], China Geological Survey
Shengyuan Zhang[3], Hebei GEO university
Qiuming Cheng[4], China Geological Survey

Abstract

Mapping of geochemical anomalies is crucial to exploration and environmental geochemistry. The complex geochemical landscape, multiple geological sources and various secondary surficial processes impose a certain degree of spatial uncertainty in mapping of geochemical anomalies. Quantifying this uncertainty is significant for improving the efficiency of environmental monitoring or mineral prospecting. In this paper, concentration–area (C–A) fractal model and geostatistical simulation was integrated to assess local and spatial uncertainties of geochemical anomalies. A case study was carried out to illustrate the feasibility of this method. Ag concentration data of 1880 soil samples collected from NE of the Dong Ujimqin Banner district of Inner Mongolia, North China, was used in this study. Based on a set of simulation realizations of Ag concentrations, it was concluded that areas with low local (i.e. single-location) uncertainty of Ag concentrations entail low risk for mineral exploration. However, the spatial uncertainty for multi-locations showed that the joint probability statistics were stricter than local uncertainty. Therefore, combining local probability and spatial joint probability for delineating geochemical anomalies of Ag is more acceptable and reliable. The hybrid approach using the C–A fractal model and SISIM provides a new way to delineate anomalous areas by considering the uncertainty of spatial distributions of geochemical elements.

Keyword

mineral exploration, geochemical anomaly, spatial uncertainty, fractal model, geostatistics

Ocean singularity analysis and global heat flow prediction reveal anomalous bathymetry and heat flow

Yang ZHANG[1]*, Sun Yat-Sen University (zhangy2336@mail2.sysu.edu.cn)
Tao Hong[2], School of Earth Science and Engineering, Sun Yat-Sen University
Qiuming Cheng[3], School of Earth Science and Engineering, Sun Yat-Sen University
Junjie Ji[4], School of Earth Science and Engineering, Sun Yat-Sen University

Abstract

The investigation of physical attributes of oceans, including parameters such as heat flow, bathymetry, and gravity, has garnered substantial attention and is particularly valuable for examining Earth's thermal structures and dynamic processes. Nevertheless, classical plate cooling models exhibit disparities when predicting observed heat flow and seafloor depth for extremely young and old lithospheres. Furthermore, a comprehensive analysis of global heat flow prediction and regional ocean heat flow or bathymetry with physical models has been lacking. In this study, we employed power-law models derived from the singularity theory of fractal density to meticulously fit the latest ocean heat flow, bathymetry, and Bouguer gravity anomalies. Notably, power-law models offer distinct advantages over traditional plate cooling models, showcasing robust self-similarity, scale invariance, or scaling properties. The outcomes of our singularity analysis concerning heat flow and bathymetry across diverse oceanic regions exhibit a degree of consistency with the global ocean spreading rate model. In addition, we applied the similarity method to project a higher resolution (0.1° × 0.1°) global heat flow map based on the most recent heat flow data and geological/geophysical observables refined through linear correlation analysis. Regions displaying significant disparities between predicted and observed heat flow are closely linked to hydrothermal vent fields and active structures. Finally, combining the actual bathymetry and predicted heat flow with the power-law models reveals anomalous areas of subsidence and heat flow. Regions of anomalous subsidence in the ocean exhibit a strong correlation with large igneous provinces, seamounts, and hotspots. Additionally, hydrothermal circulation may have an impact on areas in close proximity to mid-ocean ridges.

Keyword

Heat flow, Fractal density, Power-law model, Singularity analysis, Similarity method

Unveiling geothermal anomalies in South America: machine learning predictions and spatial correlations with multiple geothermal activities

Junjie JI[1]*, School of Earth Science and Engineering, Sun Yat-Sen University.
(jijj3@mail2.sysu.edu.cn)
Tao Hong[2], School of Earth Science and Engineering, Sun Yat-Sen University.
Yang Zhang[3], School of Earth Science and Engineering, Sun Yat-Sen University.
Yuanzhi Zhou[4], School of the Earth Sciences and Resources, China University of Geosciences
Qiuming Cheng[5], School of Earth Science and Engineering, Sun Yat-Sen University.

Abstract

Geothermal heat flow (GHF) is crucial for characterizing the Earth's thermal state. Compared to other regions worldwide, GHF measurements in the South American continent are relatively sparse and insufficient for mapping GHF over the continent based on traditional model. Here we apply the machine learning techniques including Random Forest (RF), Support Vector Machine (SVM), and Extreme Gradient Boosting (Xgboost) algorithms to predict the GHF in South America. The prediction uses the global GHF data with local constraints of seventeen geological and geophysical features. The results obtained from these new models decipher that the machine learning model shows the optimal performance by several statistics such as in the mean absolute error, root mean squared error, and normalized root mean squared error. In combination machine learning model with the local singularity analysis of heat flows, active volcanoes, and igneous rock samples, we suggest that geothermal anomalies along the Andean Mountain Range are periodic and spatially correlated with magmatic activities. In addition, machie learning results show that geothermal anomalies in the Andes are not only influenced by magmatic activities from subuduction zones, but also by other additional elements. We delineate two geothermal areas of additional indictive significance, which are related to geothermal springs and the slab window in South America.

Keyword

Geothermal heat flow, Machine learning, Local singularity analysis

A study of thermal gradient effects in the North China Craton magmatic rock

Jinming LI[1]*, Sun Yat-sen University (lijm227@mail2.sysu.edu.cn)
Yang Zhang[2], School of Earth Science and Engineering,Sun Yat-sen University
Qiuming Cheng[3], China University of Geosciences/Sun Yat-sen University

Abstract

The North China Craton(NCC) is the oldest craton in the world, and the Craton lithosphere has been strongly reformed and destroyed since the Mesozoic.Heat flow is the comprehensive information of geothermal gradient, rock thermal conductivity, thermal productivity, and crustal/mantle heat flow, and it is an important parameter for many studies, such as regional geothermal resource evaluation and mass loss prediction of ice sheet. The eastern and western surfaces of NCC are covered by large areas of Quaternary sediments, so the search for Hot-Dry-Rock(HDR) in these areas covered by sedimentary layers is an extremely meaningful and challenging task.

In this study, we integrated heat flow data from several databases and previous published literature, as well as several geological and geophysical factors related to heat flow, and analysed that the crustal thickness of NCC shows a gradual thinning trend from west to east, and the surface heat-flow values also decrease almost with the increase of crustal thickness.However, there are some abnormal characteristics in the eastern and western Quaternary sedimentary cover areas: Relatively low heat flow values occur in parts of the eastern crust that are thin, and relatively high values in parts of the western crust that are thick.In view of these phenomena, we calculate the theoretical heat-flow values of the NCC by using the method of layer-by-layer stripping to calculate the geothermal gradient.Comparing the theoretical and measured heat-flow values, it is concluded that the difference in the singularities between the two may be related to thermal tectonic activities, such as hidden high-temperature magmatic rock mass and tectonic fracture zones. After removing the influence of tectonic fracture zones, the distribution of the singularities is greatly correlated with the distribution of hidden high-temperature magmatic rock mass. Therefore, this study is of great help and indicative significance in further promoting the exploration of HDR using heat flow.

Keyword

North China craton, Heat flow, Thermal gradient, Magmatic rock

Multifractal and singularity analysis in support of new discoveries of mineral deposits

Wenlei WANG[1]*, Institute of Geomechanics, Chinese Academy of Geological Sciences (wenleiw@163.com)
Jie TANG[2], Institute of Geomechanics, Chinese Academy of Geological Sciences

Abstract

This study introduces a sophisticated approach for geo-exploratory data analysis in underexplored regions. We employed nonlinear methods to scrutinize geological mapping and geochemical data at a 1:50,000 scale in the Zhule-Mangla district of Northern Tibet, China. Our focus was on Cu mineralization linked to porphyry systems. By applying local singularity analysis, we evaluated the spatial changes in Cu's geochemical patterns. This revealed a distinct mesh-like structure with anomalies aligned in northeast and northwest directions, providing a detailed structural understanding of the region and highlighting areas of potential interest. Additionally, we used multifractal analysis to gauge Cu distribution across various scales. We introduced a new multifractal metric, the relative enrichment index H, tailored to assess element distribution patterns. Global multifractal spectra formed the basis for local scale multifractal parameter analysis. By studying Cu concentrations in different geological units, we pinpointed ore material accumulation zones, indicating mineralization potential. In conclusion, our integrated approach, combining local singularity and multifractal insights, identified four promising exploration zones. These targets offer valuable guidance for future mineral exploration efforts, promoting a more meticulous and comprehensive exploration process. Furthermore, an enhanced exploratory data analytical strategy is proposed and prcatically applied in support of mineral exploration in unwell explored areas.

Keyword

Munltifractal spectrum, Complex mineralization, Spatial pattern, Anomaly, Geo-information

Collaborative Seismic Impedance Inversion based on Bayesian Estimation

Lilong REN[1], Chengdu University of Technology
Jianguo YAN[2]*, Chengdu University of Technology (yanjianguo@cdut.edu.cn)
Wenlu HUANG[3], Chengdu University of Technology

Abstract

Seismic impedance obtained by inversion of measured seismic data, combined with well-logging interpretation results, can directly reflect the reservoir properties of oil and gas reservoirs, such as lithology, physical properties, and oil-bearing properties. Due to the different algorithms used, seismic inversion methods are divided into two major categories: deterministic and geostatistical. Deterministic inversion directly modifies the model parameters through optimization algorithms to obtain a definite solution under given initial constraints. However, the accuracy and reliability of the inversion results mainly depend on the frequency bandwidth of seismic data and the accuracy of the initial model. Geostatistical inversion uses random simulation methods based on the probabilistic theory, such as Bayesian estimation, to obtain inversion results through the simulation of reservoir parameters and the selection of the simulation results starting from the given information, such as well-logging data and seismic data. However, the accuracy and reliability of the inversion results mainly depend on the rich and detailed known information, e.g., a number of drilled wells with high-quality seismic-well-tied data. So, there are still a lot of challenges to select the best method based on the known information in practice by tackling the capabilities of the different methods, such as analysis of application conditions and characteristics of two categories of methods, as well as the way of combining the methods, etc.

To address the above challenges, this article unifies deterministic and geostatistical inversion under the Bayesian parameter estimation framework and proposes a new collaborative inversion method and workflow of seismic wave impedance by using the two categories of the methods. The basic idea and workflow of the "collaborative inversion" method can be described as using geostatistical methods, e.g., the sequential Gaussian geostatistical inversion, to simulate seismic impedance from known wells for N times and randomly select M impedance simulation results from N simulations. Then, M results are selected as the initial model of deterministic inversion, e.g., conjugate gradient optimizing inversion. Finally, the posterior probability of multiple inversion results is calculated, and the best results are selected by the Bayesian method.

By the synthetic examples and application of field data in the Xinjiang Oil field in western China, this paper proves the proposed collaborative inversion can increase the accuracy of characterization of oil and gas reservoirs based on the same known information and fewer wells compared to using deterministic or geostatistical methods separately. So, the results of the analysis and the proposed methods and workflow in this paper can be taken as good guidance for the selection and application of the method of seismic impedance inversion in practice.

Keyword

Seismic impedance inversion, Reservoir Characterization, Bayesian parameter estimation, Deterministic inversion, Geostatistical inversion

Exploratory functional data analysis of multivariate distributions for the identification of agricultural soil contamination by risk elements

Karel Hron[1]*, Palacky University Olomouc (karel.hron@upol.cz)
Tomas Matys Grygar[2], Czech Academy of Sciences
Una Radojicic[3], TU Wien
Ivana Pavlu[4], Palacky University Olomouc
Sonja Greven[5], Humboldt-Universitat zu Berlin
Johanna G. Neslehova[6], McGill University
Stepanka Tumova[7], J. E. Purkyne University in Usti nad Labem

Abstract

Geochemical mapping of risk element concentrations in soils is performed in many countries around the world. It results in numerous large datasets of high analytical quality, which can be used to identify soils that violate individual legislative limits for safe food production. However, there is a lack of advanced data mining tools that would be suitable for sensitive exploratory data analysis of big data while respecting the natural variability of soil composition. To distinguish anthropogenic contamination from natural variations, the analysis of the entire data distribution for smaller subareas is key. In this contribution, we propose a new data mining methodology for geochemical mapping data based on functional data analysis of probability densities in the framework of Bayes spaces after post-stratification of a big dataset to smaller districts. The tools we propose allow us to analyse the entire distribution, going well beyond a superficial detection of extreme concentration anomalies. We illustrate the proposed methodology on a dataset gathered according to the Czech national legislation (1990 - 2009), whose information content has not yet been fully exploited. Taking into account specific properties of probability density functions and recent results for orthogonal decomposition of multivariate densities enabled us to reveal real contamination patterns that were so far only suspected in Czech agricultural soils. We process the above Czech soil composition dataset for Cu, Pb, and Zn by first compartmentalizing it into spatial units, the so-called districts, and by subsequently clustering these districts according to diagnostic features of their uni- and multivariate distributions at high concentration levels. These clusters were seen to correspond to compartments that show known features of contamination, such as historical metallurgy of non-ferrous metals and iron and steel production. Comparison between compartments, notably neighboring districts with similar natural factors controlling soil variability, is key to the reliable distinction of diffuse contamination. In this work, we used soil contamination by Cu-bearing pesticides as an example for empirical testing of the proposed data mining approach. In general, there are no natural and justifiable thresholds of risk element concentrations that would be valid for geographical areas with too much natural heterogeneity. Therefore, national (or larger) soil geochemistry datasets cannot be processed as a whole. As we demonstrate in this contribution, empirical knowledge and careful tailoring of statistical tools for the characteristic types of soil contamination are essential for unequivocal identification of the anthropogenic component in real datasets.

Keyword

FDA for geochemical maps, compartmentalisation, identification of Czech agricultural soil contamination, Cu-bearing pesticides, Bayes spaces

Geochemical diagrams and exploratory data analysis with CODA

Solveig POSPIECH[1]*, Helmholtz-Zentrum Dresden-Rossendorf e.V. (s.pospiech@hzdr.de)
Raimon Tolosana-Delgado[2], Helmholtz-Zentrum Dresden-Rossendorf
Gerald van den Boogaart[3], Helmholtz-Zentrum Dresden-Rossendorf

Abstract

In geochemical studies, graphs and plots serve as essential tools for displaying and interpreting measured data. Over time, the geochemical community has developed a range of specialized plots tailored to different types of geochemical data. These include classical ternary diagrams, Piper diagrams, e.g. for hydrochemistry and QAPF diagrams for rocks, along with spider diagrams showing element concentrations normalized to upper crust chondrite levels, such as rare earth element (REE) patterns, and scatter plots of elements, element groups or their log-ratios, e.g. TAS diagram.

Geochemical element data are inherently compositional, meaning the individual element concentrations express the abundance of this element in relation to all other elements. For all research questions where the element pattern and changes of element pattern are important, a fundamental insight from Compositional Data Analysis (CODA), pioneered by Aitchison in 1986, is that the individual concentrations can only be interpreted in their relation to other concentrations, but not for themself alone, because all processes will influence the absolute concentration of all elements. Plots using absolute concentrations may introduce artifacts and distortions, whereas those using ratios, logs, or log-ratios are a more useful measure of dissimilarity or effect size. Many geochemical plots already adhere partially or fully to CODA principles, which aids in understanding and avoiding artifacts in data visualization. CODA theory can assist in comprehending which plots effectively avoid these artifacts and which still possess susceptibility to specific types of artifacts. Moreover, it enables the creation of graphics that convey the same content while circumventing such artifacts.

This contribution examines which classical geochemical plots align with CODA principles and how they align. For plots that deviate from these principles, we illustrate their susceptibility to artifacts by demonstrating how changes in seemingly unrelated aspects can affect and modify the visual interpretation. Furthermore, we discuss how comparable plots that visualise the same data and question while avoiding artifacts can be constructed by adhering to the general rules with minor adjustments.
The application of CODA principles on visualization tools aids in interpretation and generalizes to other geochemical questions, encompassing different elements, processes, or settings. Furthermore, certain geochemical plots incorporate principles such as normalization against a reference composition, which could be applicable in other CODA applications.

We hope for this contribution to facilitate mutual understanding between the geochemistry and CODA communities, illustrating how both have cultivated analogous concepts and highlighting shared ideas and potential for learning from each other's approaches. By bridging this understanding, both communities can benefit from the development and refinement of data visualization techniques that accurately reflect the underlying compositional nature of geochemical data.

Keyword

Compositional data, geochemistry, visualitzaion, modelling

Advancing Mineral Characterization Through Integrated Sensor Fusion and Machine Learning: A Preliminary Study

Chryselle Ultima Ortiz MANCENIDO[1]*, University of South Australia
(chryselle_ultima.mancenido@mymail.unisa.edu.au)
William Skinner[2], ARC Training Centre for Integrated Operations for Complex Resources, University of South Australia
Caroline Tiddy[3], MinEx CRC Education and Training Program, University of South Australia

Abstract

Knowing the mineralogy and quantity of ore is a critical concern in the mineral processing industry as it dictates several factors in downstream mineral processing. Spectroscopic techniques are widely used for qualitative and quantitative analyses of materials much like in minerals. Traditional means of characterization are often done by employing several of these techniques independently dictated by the type of information one wants to obtain as there is not one single technique that covers it all (both rock-forming and economic minerals). Moreover, these approaches are frequently subjective and time-inefficient, rooted in human judgment. Approaches adopted concerning the problem include using data fusion and machine learning frameworks.

To address these challenges, this study aims to establish a workflow for fusing data from multiple sensor techniques, with a focus on x-ray fluorescence (XRF) data and infrared reflectance data. Utilizing non-destructive methods such as XRF and infrared reflectance for data collection is advantageous due to their minimal sample preparation requirements. Assisted machine learning will be employed to achieve high-accuracy mineral identification and quantification in drill core samples. The availability of mobile field deployable drill core scanning instruments and sensors makes it a promising avenue to develop methods capable of integrating real-time data and providing valuable insights for timely decision-making. Additionally, these methods offer distinct yet highly complementary datasets, enhancing the comprehensiveness and reliability of the analytical framework. This integration is anticipated to overcome the limitations of separate techniques, particularly in dealing with complex mineral assemblage.

Recent investigations employing machine learning frameworks to classify minerals and quantify their relative abundance across diverse sample media have yielded promising findings. Nevertheless, there remains a gap in thoroughly evaluating the precision of these methods and exploring alternative algorithmic approaches.

The study is in its preliminary stages, having completed data collection, exploration, and initial preprocessing to establish the foundation for developing a baseline classification model. Specific intervals from an openly accessible geoscience drill core dataset, namely the Mineral Systems Drilling Program (MSDP11) provided by the Geological Survey of South Australia (GSSA), have been chosen. Infrared reflectance data from the HyLogger-3 and XRF measurements have been

obtained at corresponding intervals in the drill core, with a resolution of approximately 10 cm. Concurrently, ongoing quality assurance and control processes are underway for the XRF data to ensure its reliability in model development. It's imperative to utilize high-quality data, as unreliable data undermines the effectiveness of the model.

The current study experiments with various data fusion levels and conducts preliminary unsupervised learning to establish training labels. Additionally, dimensionality reduction and feature selection techniques are being evaluated to retain essential information from each data source. This approach aims to enhance model accuracy and interpretability, advancing understanding and predictive capabilities in the application.

Keyword

Data Fusion, Machine Learning, Classification, Mineralogy

Specifying control factors on Ore Chemical Composition of hydrothermal deposits over Japan through Factor Analysis

Michiharu ENATSU[1]*, Kyoto University (jhrc.3594@gmail.com)
Katsuaki Koike[2], Department of Urban Management, Kyoto University

Abstract

Data mining has been applied to economic geology recently. However, most studies of data mining have focused on specific mines or regions. Thus, more general discussion of deposit generation and formation is needed by targeting a wide area. In this study, we analyzed 326 ore samples from the 116 hydrothermal deposits over Japan, which were stored in the Kyoto University Museum and the Mineral Industry Museum of Akita University for elemental concentrations by XRF, ICP-MS, and ICP-AES. Factor analysis was implemented using the analyzed chemical composition data, and we tried to clarify the relationship between geological factors and the chemical composition of the ores. The results of factor analysis indicate that these following factors regulated the chemical composition of ores in the hydrothermal deposits in Japan: "Factor 1: generation of galena and sphalerite", "Factor 2: migration of elements associated with silicate mineral", "Factor 3: generation of pyrite and chalcopyrite ", and "Factor 4: Elements concentrated in Kuroko-type deposits". Clustering of the factor scores from Factor 1 to 4 was used to find features of mineral deposits in each region, which revealed that the Pb-Zn rich deposits are distributed in the Inner Zone of Southwest Japan and the Mo-As-Ba rich deposits and Fe-Cu rich deposits are distributed in the Northwest Japan Arc. Differences between these two regions can be explained by difference of subduction system of the Oceanic plate beneath the ancient Japan Island from the Cretaceous to Neogene period.

Acknowledgement: We wish to express our gratitude to Prof. Yasushi Watanabe of Akita University for providing the ore samples.

Keyword

Hydrothermal deposits, Geochemical composition, Multivariate statistical analysis, Tectonic control

Development of a Software Platform for the Real-Time Hyperspectral Interpretation of Samples from the Vaca Muerta (Argentina) Formation within a Virtual Reality Environment.

Douglas Bazo DE CASTRO[1]*, Universidade Estadual de Campinas (UNICAMP)
(castrodouglasdev@gmail.com)
Diego Fernando Ducart[2], Universidade Estadual de Campinas (UNICAMP)

Abstract

In this project, four samples from the Vaca Muerta formation were chosen, and their hyperspectral images were captured using Hyspex sensor. The Neuquen Basin is situated in the Neuquen Province in Argentina, with its geological history dating from the Late Triassic to the early Cenozoic [1]. The organic-rich sediments of the Vaca Muerta system were deposited during the ocean anoxic event (OAE). [1].

This formation is the most effective source rock interval in the Neuquen Basin, with 2% up to 12% total organic carbon [2]. The Vaca Muerta formation is an important matter inside the oil and gas industry. Reflectance spectroscopy is a significant method for measuring the absorption spectra and other properties of solids. The relevant parameters are wavelength, frequency, and wavenumbers [2].

In this study, the data images collected are processed within the Unreal Engine 5 graphics engine using the C++ language, enabling analysis in virtual reality on a server by multiple users simultaneously. As per Zheng [3], Virtual Reality (VR) is a human-computer interface that produces simulations of realistic virtual environments, allowing users to navigate and interact with the surroundings from various perspectives. Virtual Reality (VR) as a medium enables participants to immerse themselves in an embodied perspective [4]. The samples were additionally scanned with a LiDAR (Light Detection and Ranging) sensor, allowing users to virtually interact with the samples while analyzing the hyperspectral images. This workflow facilitates data sharing for collaborative analysis among multiple users simultaneously, utilizing the virtual reality environment to interact and create a collaborative workspace.

The collaborative aspect of this environment aligns with the principles embraced by technology hubs, enhancing outcomes through the creation of a collaborative workspace. Integrating this collaborative approach into geosciences can enhance data sharing, facilitate brainstorming, and enable real-time information exchange for diverse datasets, including hand samples, images, and spectra.

Another innovative aspect of this project is the seamless sharing of hyperspectral data and hand samples with scientists worldwide, allowing real-time interpretation and collaboration among diverse professionals.

Agência Nacional do Petróleo (ANP)
This project has the support of sponsorship from the Agência Nacional do Petróleo (ANP) through

the Programa de Recursos Humanos em Exploração Petrolífera e Geologia Exploratória (PRH 19.1). The PRH 19.1 is situated in Institute of Geosciences, Unicamp.

[1] Leanza, H., Estudio sobre los cambios faciales de los estratos limítrofes Jurásico - Cretácicos entre Loncopué y Picún Leufú, Prov. del Neuquén, Rep. Argentina.. Revista de la Asociacion Geologica Argentina. volume 28. 97-132, 1973
[2] Uliana, M.A., Legarreta, L., . Hydrocarbons habitat in a Triassic to Cretaceous subAndean setting: neuquen basin, Argentina. J. Petrol. Geol. 16 (Issue 4), 397–420. 1993a
[3] Zheng, J.M. & Chan, K.W. & Gibson, Ian. (1998). Virtual reality. Potentials, IEEE. 17. 20 - 23. 10.1109/45.666641.
[4] Sherman, W. R., and Craig, A. B. Understanding virtual reality: Interface, application, and design. Elsevier, 2002.

Keyword

virtual reality, hyperspectral, Vaca Muerta, geotechnology, lidar

Spatial Estimation of Grain Size Distributions using Compositional Kriging

stephen tyson[1]*, UTB (stephen.tyson@utb.edu.bn)
Ahram Kim[2], UTB

Abstract

Accurate grain size distributions are important to determine the best method to control sand from producing petroleum wells, however, the selection of sands or gravel packs often has to be completed before the well has been drilled due to component lead times. The challenge is to estimate a grain size distribution at an unknown location.

The most common way to display and model grain size distributions appears to be; display as a cumulative distribution curve with grain size decreasing left to right, either on a linear scale of phi values or a log scale of grain size diameters in mm. This would be the default display from a Malvern laser particle size analyser (LPSA), This a normal or log normal distribution is fitter to this cumulative distribution for further modelling. However, when the grain size distribution is plotted as a probability distribution function, it is obvious that, in all the sands we investigated, the distribution is rarely unimodal and the same formation in adjacent wells could have grain size distributions with different modalities.

Current best practice. Is to interpolate the mean and variance of the fitted normal or log normal distribution, usually with some variant of the kriging algorithm, even though this would guarantee a unimodal distribution at any location.

We present an alternative technique using compositional kriging. The grain size distributions are binned if they come from an LPSA , or if they are sieved, the sieve proportions are used directly. By treating the distribution as a mixture of grains of different size categories, it is possible to use compositional kriging. This will honour the spatial model of each category in the composition as well as the spatial relationships between categories. Using this approach we were able to accurately model the changes in grain size distribution modality. This was particularly significant as the selection of sand screen was highly sensitive to some of the categories of grain size.

It may be possible to consider this approach for other spatial variables which are continuously distributed that have significantly different shapes or modalities across the region of interest

Keyword

Geostatistics, Grain Size Distribution, Compositional Data

The evolution of fluid pressure in fault zone and its response to hydrothermal mineralization

Yihui XIONG[1]*, China University of Geosciences (xiongyh426@cug.edu.cn)
Renguang Zuo[2], China University of Geosciences

Abstract

The behavior and evolution trajectory of faulting process, which shows a first-order relationship with hydrothermal mineral deposits, is greatly influenced by fluid flow and fluid pressure. Further investigations are required to achieve an in-depth understanding of the formation and evolution mechanisms behind the link between the fluid pressure development and the occurrence of induced faulting and mineralization processes. Aiming at exploring the effects of fluid pressure development on the behavior of faulting and mineralization, different fluid pressure increase rates are considered as the initial data for the cellular automaton model. The simulated results show that the varying fluid pressure increase rates play a crucial role in determining faulting and mineralization processes. More specifically, as the fluid pressure increase rates increase, the faulting event scales change from a large number of small-scale fault ruptures to a small number of large-scale ruptures. The different behaviors of fluid pressure fluctuations induced by low and high fluid pressure increase rates can promote cyclic mineral precipitation and further form enriched geochemical patterns with strong spatial structure. Besides, the correlation length at the percolation threshold, which is of great significance to the degree and scale of mineralization, increases with the increase of fluid pressure increase rates. It is concluded that grids with high fluid pressure increase rates are much more prone to producing enriched geochemical patterns with strong spatial structure than grids with low fluid pressure increase rate. Therefore, the analysis of the results suggest that the way of fluid pressure development is a key factor to quantify the behavior of faulting and mineralization processes.

Keyword

Cellular automaton, Hydrothermal mineralization, Fluid pressure

Decoding the Dynamic Impact of Clay-Coated Quartz Grains in Sandstone through Multiphase-Field Modeling

AKASH KUMAR[1]*, KIT, Karlsruhe (akash.kumar@kit.edu)
MICHAEL SPÄTH[2], KIT, Karlsruhe
DANIEL SCHNEIDER[3], KIT, Karlsruhe
BENJAMIN BUSCH[4], KIT, Karlsruhe
CHRISTOPH HILGERS[5], KIT, Karlsruhe
BRITTA NESTLER[6], KIT, Karlsruhe

Abstract

The reservoir quality of sandstones hinges significantly on the presence or absence of clay coatings enveloping quartz grain surfaces. Porosity and permeability, pivotal hydraulic and mechanical parameters, exert a profound impact on the storage potential of sandstone reservoirs, encompassing geothermal energy, groundwater, and hydrocarbons. Employing the multiphase-field method, a widely embraced tool in material science, this study ventures into the modelling of interface motion and phase transitions, extending its utility to geological phenomena like mineral cementation.

Through the application of a thermodynamically consistent multiphase-field model, our investigation delves into the intricate influence of clay coatings on quartz grain surfaces, shedding light on the ensuing variations in porosity and permeability across diverse sandstone compositions. A meticulous three-dimensional digital representation of sandstone allows for precise control over quartz grain coating. This
research addresses two primary facets: 1) examining the impact of varying levels of clay coating on quartz overgrowth cement volumes, and 2) scrutinizing the repercussions of quartz grain size on the dynamic evolution of overall porosity and permeability within the reservoir rock.

To assess the evolving sandstone permeability during the precipitation of quartz on partially to completely clay mineral coated quartz grains, computational fluid dynamics analysis is conducted at various stages. Subsequent scrutiny of the amassed data reveals intricate correlations among the grain coating coverage, rock properties, and their collective impact on porosity, permeability, and their interplay during quartz precipitation.

Our computational studies indicate that sandstones boasting a higher grain coating coverage result in lower quartz cement contents, and therefore preserve porosity during diagenesis. These revelations furnish a foundational understanding for more nuanced reservoir quality predictions, with potential applications spanning geothermal energy, water resources, and the storage of carbon and hydrogen.

Keyword

clay-coating, multiphase-field model, quartz, cementation

Optimal drilling for exploration: an iterative approach

Guillaume PIROT[1]*, The University of Western Australia (guillaume.pirot@uwa.edu.au)
Kubra Akbulut[2], The University of Western Australia
Özgür Yedek[3], The University of Western Australia
Mark Jessell[4], The University of Western Australia

Abstract

The mining industry faces various challenges in satisfying the increasing demand for minerals related to clean energy transitions. One of these challenges is the need to improve geological characterization at the stage of undercover exploration. This usually requires costly drilling operations, so raises the challenge of how we can reduce our exploration footprint and costs while also reducing geological uncertainty by developing optimising drilling operations? Here, to address this question, we propose to optimize the design and location of additional drillholes in an iterative way, relying on the information provided by previously drilled holes.

The approach is illustrated by a synthetic reference case, used as ground truth, based on a legacy data set from the Hamersley basin, WA, Australia. In this simplified setting, the stratigraphy is assumed to be known. To mimic the exploration process, we start by initializing a database of vertical and regularly spaced drillholes. From the database, using the implicit geological modelling engine LoopStructural, we generate an ensemble of geological model realizations. From this ensemble, geological uncertainty is estimated by Shannon's entropy. The next optimal drillhole location is then obtained by maximizing an objective function that can be parameterized to account for or ignore the degree of freedom around drilling parameters, such as dip direction and dip, as well as to explore the relationship with Shannon's entropy. The iterative exploration ends when the drilling budget is exhausted. Preliminary results show the importance of defining carefully the objective function in order to maximize the value of current information for the needs of the geological modelling engine and to provide an efficient drilling sequence.

Keyword

geological uncertainty, 3D modelling, optimization

Integrating Multivariate Data in Constructing 3D Geological Structure by Multiple-point statistics Method

Weisheng HOU[1]*, Sun Yat-sen University (houwsh@mail.sysu.edu.cn)
Songhua Yang[2], Sun Yat-sen University
Yanhu Li[3], Sun Yat-sen University
Shuwan Ye[4], Sun Yat-sen University

Abstract

In recent years, the multiple-point statistics (MPS) method has been successfully used to generate 3D complex geological structures. More and more researches showed that, in MPS simulation, integrating multiple data provides much more geological patterns and reduces the uncertainties of simulation results. But, due to the lack of a unified data-driven framework for training image fusion, the multivariate data structure is difficult to integrate from the perspective of the physical significance of the data.

In this study, a multivariate data fusion method in generating the initial model is proposed for the iterative MPS method coupling fully connected neural network (FCN), which three main steps are included: constructing 3D TD, generating the initial model and expectation-maximum (EM)-like iteration process. Here, an intuitive expansion process is carried out to obtain 3D patterns from 2D cross-sections, in which the process is executed from the nodes adjacent to 3D TD layer by layer from top to bottom. For each kind of data, 3D pattern are extracted and reorganized as list Canlist from the 3D TD by the similarity.

The initial model, coupling with a sequential process, is constructed by FCNs based on back propagation (BP) framework. The FCN is used to generate the top Stop(atti) and bottom Sbott(atti) surfaces of each geological block atti, in which the FCN is trained by the elevation of geological contacts in cross-sections. Therefore, each contact surface might be generated twice by different trained FCNs. Then, surfaces of different objects would cross each other, resulting in wrong assignments on a grid with several attributes. Thus, a sequential process with multivariate data fusion is implemented. Here, all profiles of different kinds of data have the same locations and scope. The key steps are: (1) Setting the sequential path, which could be a random path and sequential path. (2) For each variate data, selecting the candidate patterns from Canlist by the similarity with pattern on the node to be simulated of the overlapped area. (3) Calculating the probability of candidate patterns of different variants by the distance vector of the positions of candidate patterns and data event of nodes to be simulated; (4) Integrating probabilities of the multivariate by linear pooling method with cross-entropy weight. (5) The pattern with maximum weighting probability is selected and pasted on the node of to be simulated. Repeating step (2) to (5), the initial model can be obtained. Although the initial model can be treated as a result, an EM-like algorithm is implemented to obtain more reasonable and smooth result.

A concrete example of reconstructing the overthrust model by SEG/EAGE is used to test the proposed method, in which ten profiles of velocity, density and lithology are extracted as data

sources. The simulation results illustrated that: (1) the precision of the simulation result can be improved with multivariate fusion. (2) high similarity of different type of data can be identified by cross-entropy weighting method, leading to the small uncertainty of simulation results. (3) the distance vector constraints can improve the process of choosing candidate pattern.

Keyword

Multiple variants integration, Multiple point statistics, Fully connected neural network, Overthrust model

A comprehensive rapid updating of resource models with complex geology

Sultan ABULKHAIR[1]*, University of Adelaide (sultan.abulkhair@adelaide.edu.au)
Peter Dowd[2], University of Adelaide
Chaoshui Xu[3], University of Adelaide

Abstract

Resource modelling of mining deposits usually involves a comprehensive approach to modelling as many important variables as possible. This includes quantitative (e.g., grades) and qualitative (e.g., geological domains) variables that should be integrated into the block model together. For example, it is common to divide the deposit into geological domains and then to estimate the grades within those domains. However, the major challenge in resource modelling is the uncertainty at locations with no conditional data available. Therefore, it is important to consider integrating massive streams of sensor measurements into the resource models. This work demonstrates a comprehensive rapid resource model updating with real-time sensor observations using a real case study from an iron oxide copper-gold (IOCG) deposit in South Australia. The proposed approach uses an ensemble Kalman filter with multiple data assimilations to integrate sensor observations into the resource model in near real-time. For qualitative variables, a method based on pluri-Gaussian simulation is used to transform geological domains into Gaussian random fields. Rotation based iterative Gaussianisation helps transform grade variables into independent multivariate Gaussian factors. Updating geological domains ensures that the uncertainty around the domain boundaries is reduced to a minimum. Updating grade variables separately within each domain results in more accurate grade prediction.

Keyword

Ensemble Kalman filter, data assimilation, pluri-Gaussian simulation, rotation based iterative Gaussianisation, geological uncertainty

Enhancing Geothermal Resource Assessment: Well-Correlation and Analysis of Depositional Facies in the Szentes Region, Hungary

Catarina C. CASTRO[1]*, Doctoral School of Earth Sciences, University of Pécs
(castrocc@gamma.ttk.pte.hu)
János Geiger[2], GEOCHEM Ltd.
János Kovács[3], Department of Geology and Meteorology, University of Pécs
Ferenc Fedor[4], Department of Geology and Meteorology, University of Pécs

Abstract

The Szentes geothermal field stands out as one of Hungary's most active geothermal (hydrothermal) sites, with a long history of geothermal water production. Its geological background is marked by the evolution of a deltaic system that began during the Late Miocene period. The sedimentary environments changed upward from deep basin through basin slope, delta front to delta plain, resulting in the deposition of sedimentary sequences that present high-porosity and geothermal gradient anomalies creating favorable conditions for the development of medium and low-enthalpy geothermal systems. Despite extensive exploration efforts, the lack of reinjection practices poses a major challenge to the sustainability of its flow system. In order to determine optimal reinjection sites, deep understanding of the past framework of the depositional system within the area and their correlation along the field is a key process. A comprehensive large scale well-correlation analysis is performed using high-resolution well data to identify and characterize different depositional facies and cyclic depositional patterns of the Upper Pannonian sequences in the Szentes geothermal field, Southeastern Hungary. Applying Integrated Predictive Error Filter Analysis (INPEFA) to sixteen Gamma-Ray logs using Cyclolog Software®, this study traces sedimentary discontinuities and grain-size trends in order to determine stratigraphic boundaries. Based on well-correlations, more accurate and realistic dynamic models can be developed for groundwater simulations. This facilitates the assessment of the potential impact of reinjected water on the geothermal flow system, and enables informed decisions in the field of geothermal exploration and production, leading to more efficient resource management.

Keyword

well-logging, correlation, geothermal, reinjection

Automatic Reconstruction of Geological Reservoir Models Based on Conditioning Data Constraints and BicycleGAN

Wenyao FAN[1]*, China University of Geosciences (Wuhan) (fanwy_jlu@163.com)
Gang Liu[2], China University of Geosciences (Wuhan)
Qiyu Chen[3], China University of Geosciences (Wuhan)

Abstract

For geological reservoir units with different sizes of pore spaces and relatively stronger anisotropic heterogeneities, Generative-Adversarial-Network-based (GAN) modeling methods can overcome limitation of numerical-simulation-based ones and support finely representation of nonstationary models. However, due to conditioning data weak constraints, GANs might ignore local detail features, with artifacts and noise during simulation. Some pre-processing strategies are strictly limited by the conditioning data distribution patterns, and corresponding processes should be updated frequently when new data are introduced, with relatively complicated operation. Therefore, the BicycleGAN framework was introduced in this paper. Based on bijective consistency between the latent vector and output, an image-to-image translation task with different dimensions is established, and multiple networks were coupled to realize finely representation of spatial attributes. Specifically, the mapping between conditioning data and output is established through the U-Net architecture, which not only local detail information is considered, but also reduce the impact of conditioning data distribution patterns. Meanwhile, the mapping between latent and actual test time distribution is also established by an encoding function to ensure simulation authenticities. In addition, a joint loss function combined with conditioning loss and prior loss is defined to ensure reconstruction accuracy of different facies types. Four kinds of categorical and continuous training images were selected to verify the network simulation performances. Results show that reconstruction accuracy for facies types of conditioning data is almost consistent with those of the references, keeping similarities in terms of spatial variability, connectivity, structural similarity, and facies type reproductions. Meanwhile, for the saved BicycleGAN, inputting different kinds of conditioning data once only, and a variety of simulations can be obtained rapidly, thereby realizing conditioning reconstruction of geological reservoir models.

Keyword

Geological reservoir modeling, Spatial distribution patterns, Generative Adversarial Networks, Bijective consistency, Conditioning loss

Comparative study of the Hybrid Domaining Framework (HDF) for lithological domain modelling and updating

Yerniyaz ABILDIN[1]*, University of Adelaide | Datarock (yerniyaz.abildin@adelaide.edu.au)
Chaoshui Xu[2], University of Adelaide
Peter Dowd[3], University of Adelaide
Amir Adeli[4], University of Adelaide

Abstract

Identifying zones containing mineralisation is an essential aspect of mineral resource estimation, which involves various techniques such as manual interpretation, implicit modelling, and advanced geostatistical methods. The definition of these zones is based on the concept of domains that can be manually determined or derived from geological information. In geostatistics, categorical domaining approaches such as Indicator Kriging (IK), Sequential Indicator Simulation (SIS), and PluriGaussian Simulation (PGS) can automatically define mineral domains and quantify the associated uncertainty. In addition, the recently developed Hybrid Domaining Framework (HDF) uses machine-learning classification techniques trained on the categorical properties of geological information. This paper presents a comparative study of the domaining approaches of IK, SIS, PGS, and HDF in the case of the acquisition of new data that can be used for the overall model updating or downscaling purposes. The performances of these approaches are evaluated for the assays and geological data obtained from exploration and grade control drillholes. The results indicate that the HDF framework can effectively quantify the uncertainty of the domain boundaries and produce good results on par with the IK, SIS, and PGS methods. However, for better categorical domain modelling HDF depends significantly on the quality and availability of quantitative covariates in the assay data. This suggests that using HDF for only partially available assay data from grade control drilling to update and down-scale the original model may not provide any significant benefit particularly when the partially available data are less important for the trained HDF classifier compared with the unavailable data.

Keyword

domain modelling, machine learning, geostatistical simulation, geological uncertainty, model updating

SA-RelayGANs: A Novel Framework for the Characterization of Complex Geological Structures Based on GANs and Self-Attention Mechanism

Qiyu Chen[1]*, China University of Geosciences (chenqiyu403@163.com)
Zhesi Cui[2], China University of Geosciences
Gang Liu[3], China University of Geosciences

Abstract

Increased availability and quality of surface and subsurface observations provide the chance to improve the perception of geological phenomena. An important factor that hinders our understanding of geological structures is the characterization of heterogeneous patterns with continuous attributes inside the structures (e.g., porosity, permeability, fluid saturation, etc.). Unlike categorical attributes, continuous attributes convey more realistic characteristics but require more computational resources to characterize such complex earth systems. In this work, we propose a novel deep learning approach for the characterization of complex geological realism with continuous attributes based on generative adversarial networks (GANs) and self-attention mechanism, named SA-RelayGANs. To address the complexity of heterogeneous geological structures, we divide the modeling process into two stages: facies construction stage and property reconstruction stage. In the first stage, we employ an improved GAN with self-attention mechanism to construct the heterogeneous structures while adhering to hard conditioning constraints. In the second stage, we utilize another GAN with an attribute enhancement term to reconstruct realizations based on the constructed structures and observations. SA-RelayGANs can successfully predict the statistical distributions of heterogeneous structures with continuous attributes by using limited observations. This study highlights the effectiveness of using GANs to characterize the heterogeneous patterns of geological realism and the application over large geoscience fields.

Keyword

Deep learning, Generative Adversarial Networks, Geomodeling

Three-dimensional stratigraphic modeling via adaptive search strategy-based multiple-point geostatistical simulation

Hongfeng - FANG[1]*, China University of Geosciences (fanghongfeng98@163.com)
Qiyu - Chen[2], chenqiyu403@163.com
Gang - Liu[3], liugang67@163.com

Abstract

3D stratigraphic models provide a visual and quantitative description of complex geological structures and phenomena, which can support subsurface space development and utilization, geological disaster prediction and evaluation, etc. Multiple-point geostatistics (MPS) shows prospects in the automatic characterization of heterogeneous structures and phenomena. But complex geological structures hardly meet the stationarity assumption of MPS. In this work, we present a novel 3D stratigraphic modeling approach via adaptive search strategy-based MPS simulation, named AS3DR. A horizontal search range is preferentially set to prominent geospatial correlation in the adaptive search strategy. A search range in the vertical direction can be obtained by projecting the node to different adjacent cross-sections. The intersection of horizontal and vertical search ranges is taken as the training image of the current node in MPS simulation. A unique aggregation function fuses multiple statistics in different directions to a combined probability distribution. Various synthetic experiments and a real application are performed to verify the performance of AS3DR. Multiple experiments show that AS3DR adaptive selects and fuses training images from adjacent cross-sections to capture and reproduce multiple-point patterns accurately in the 3D reconstruction of complex stratigraphic structures. It mitigates the negative influence of the strong non-stationarity of complex geological structures in MPS methods to extend the application scope of MPS to 3D stratigraphic modeling.

Keyword

3D stratigraphic modeling, Multiple-point geostatistics, Non-stationarity, Adaptive search, Probability aggregation

GEOFRAC-based 3D fracture modeling combined with borehole investigation data for groundwater and hydrothermal fluid flow systems

Taiki KUBO[1]*, Kyoto University (kubo.taiki.3n@kyoto-u.ac.jp)
Jacek Scibek[2], RWTH Aachen University
Katsuaki Koike[3], Kyoto University

Abstract

Clarifying a hydraulic property of geologic media is an important problem common to various fields in geosciences. In this research, we selected the Tono area situated in central Japan for a case study of such hydraulic characterization. This area is covered by Cretaceous granite and many geological investigations had been carried out by JAEA to understand the deep underground properties. The permeability of crystalline rock is primarily influenced by the facture structure. However, when the stability on the very long-time scale is considered, such as a case to evaluate the safety of geological disposal of radioactive waste, the properties of the rock matrix and the altered part also affect hydraulic structure. In this study, we applied GEOFRAC (GEOstatistical FRACture simulation method; Koike et al., 2015), to simulate the regional fracture system. GEOFRAC is a geostatistics-based method which can incorporate fracture density, strike, and dip into geometrical fracture simulation. The GEOFRAC model covering the study area of 12 km (E-W) by 8 km (N-S), with a depth range of 1.5 km was constructed from the fracture observation data by borehole television. The model revealed the existence of a two-layered distribution of low-angle fracture dense zones, and integration with hydraulic test data suggested the influence of major faults on groundwater flow systems. In addition, physical property measurement for over 100 borehole core samples were carried out using non-destructive measurement devices, a probe permeability meter (permeameter; Scibek and Annesley, 2021) and 3D scanner to identify changes in permeability within rock matrices and small alteration zones, which are difficult to extract in hydraulic tests using a borehole. In addition, detailed observations using a microscope revealed the characteristics of rock properties and their distribution, which have a significant effect on permeability besides fractures. Permeameter measurements unveiled that a granite region with numerous voids, known as the episyenite zone, had high permeability. From the integration of GEOFRAC model and measurement results, the spatial variation of hydraulic conductivity obtained in hydraulic tests was improved to a more detailed one. GEOFRAC was furthermore applied to modeling a fracture system in a geothermal field, Wayang Windu, west Java, Indonesia with producing 227 MW power generation. Fractures parallel to main faults and connected fractures to form fluid paths were detected, which contributes to estimating upflow patterns from the reservoir.

Acknowledgment:
This work was supported by the Japan Science and Technology Agency and Japan International Cooperation Agency through “Science and Technology Research Partnership for Sustainable

Development” (SATREPS) [grant number JPMJSA1401] and the Ministry of Economy, Trade and Industry (METI) of Japan.

References:

Koike, K., Kubo, T., Liu, C., Masoud, A., Amano, K., Kurihara, A., Matsuoka, T., Lanyon, B. (2015) 3D geostatistical modeling of fracture system in a granitic massif to characterize hydraulic properties and fracture distribution. Tectonophysics. 660, 1-16. https://doi.org/10.1016/j.tecto.2015.06.008

Scibek, J., Annesley, I. R. (2021) Permeability testing of drill core from basement rocks in the fault-hosted gryphon U deposit (Eastern Athabasca Basin, Canada): Insights into fluid–rock interactions related to deposit formation and fedistribution. Natural Resources Research. vol. 30, 2909-2956. https://doi.org/10.6084/m9.figshare.12365984.v2

Keyword

geostatistics, geothermal, permiability, groundw water flow, 3D model

Ab-initio calculations and molecular dynamics simulations of In and Cu repalceing Zn in ZnS with different structures: implications for In enrichment in Pb-Zn mineralization

Zongcong HE[1]*, Sun Yat-Sen University (hezc3@mail2.sysu.edu.cn)
Fan XIAO[2], Sun Yat-Sen University

Abstract

Indium (In) is a critical metal with strategic resource significance, which plays an increasingly important role in the global economic landscape. In is a rare metal, with extremely low abundance in the crust, usually occurring as an associated mineral. Due to its sulfur philic property, In mainly accumulates in zinc sulfides (ZnS) of sulfide deposits through isomorphous substitution. ZnS crystallises in close-packed structures, the most common of which are sphalerite with cubic 3C structures and its polymorph wurtzite with hexagonal 2H structures. The enrichment of In in crystal structures exhibits a selective hyper-enrichment mechanism, with In being concentrated at higher levels in sphalerite, while its concentration is lower in wurtzite. However, there is still little known about physicochemical constrains on these two crystal structure, which hinders the understanding of In mineralization. Understanding the controlling role of crystal structure in the enrichment mechanism of In enter ZnS is crucial. In this contribution, the ab-initio calculations and molecular dynamics simulations were used to calculate the thermodynamic properties and electronic structure of In entering sphalerite and wurtzite in the isomorphic replacement mechanism under the metallogenic conditions of skarn deposits. The calculation results show that: (1) The distinction between the two different structures of In-bearing ZnS primarily manifests in their thermodynamic characteristics, while their electronic structures differ little; (2) In enters sphalerite via the isomorphic substitution mechanism, which is relatively stable compared to wurtzite; (3) Temperature plays a crucial role in governing the incorporation of In into the lattice of ZnS. The optimal temperature for In to enter sphalerite through the isomorphic substitution mechanism is 275°C-300°C, while the optimal temperature for In to enter wurtzite through this mechanism is 225°C-250°C. This study not only provides atomic or/and molecular simulation insights for understanding the related processes of In formation in zinc ores, but also provides a scientific theoretical basis for further exploring the genesis mechanism of In deposits.

Keyword

Indium, Enrichment mechanism, Ab-initio calculations, Molecular dynamics simulations

A training image-free direct mulitpoint algorithm based on Artificial Neural Networks

Raimon TOLOSANA-DELGADO[1]*, Helmholtz Institute Freiberg/HZDR (r.tolosana@hzdr.de)
Enayatollah Ranjineh KHOJASTEH[2], Faculty of Mining Engineering, Sahand University of Technology, Tabriz, Iran
K. Gerald VAN DEN BOOGAART[3], Helmholtz Institute Freiberg/HZDR

Abstract

Multipoint simulation (MPS) algorithms exploit the dependence structure of the target variable at a series of k-nearest points around each simulation location. Most of the algorithms require the usage of a training image (TI) to either estimate and draw realisations from the conditional distribution of the target variable at an unsampled location, or else directly draw from the TI at the earliest occurrence of a sufficiently similar pattern as the conditioning one. The innovation from the TI (i.e. the ability to produce patterns not strictly found in it) happens because of a certain tolerance embedded into these algorithms.

We present an MPS that can be trained on extensive conditioning data as well as on a TI. The method has three steps. In a first step, the training data is so to say "folded"" in a pre-specified series of ways to produce long lists of patterns containing (k+1)-tuples of nearest and near observations to each sample location: not just tuples of the target variable are created, but also information about the constellation of the corresponding (k+1) locations of these tuples is added to the patterns. In a second step, the folded dataset is fed into the training of an artificial neural network (ANN) to predict the target variable at the reference point conditional on the surrounding k-point pattern. Once the ANN is trained, in the third step we follow a random path through the simulation grid, each time finding the k-nearest data points and using the trained ANN to predict the conditional target value at each grid node.

In this contribution, we discuss the details of the proposed algorith with an illustration example and discuss its properties and applicability.

Keyword

geostatistics, simulation, multipoint, Artificial neural networks

Prospectivity mapping in complex geological settings using Machine Learning and Multiple Criteria Decision Analysis: application to British Columbia (Western Canada)

Antoine BOUZIAT[1]*, IFP Energies nouvelles (antoine.bouziat@ifpen.fr)
Thibaut LEIBEL[2], OCTO Technology
Renaud DIVIES[3], IFP Energies nouvelles
Vanessa TELES[4], IFP Energies nouvelles
Kaveh DEHGHAN[5], TotalEnergies
Olivier SICCARDI[6], TotalEnergies

Abstract

Play-based and Common Risk Segment (CRS) methodologies, classically used in the Oil and Gas industry, can also serve exploration activities for emerging subsurface applications, such as carbon storage, geothermal energy, natural hydrogen or lithium resources production. However, as these applications usually correspond to lower financial margins, extra efficiency in the process appear critical. One solution is then to leverage data science and Machine Learning capabilities to facilitate data integration and digitally assist the workflow execution.

Nevertheless, adjusting classical prospectivity mapping methodologies to new applications and Machine Learning is far from straightforward, notably in complex geological settings. Indeed, the input data are often simultaneously scattered, very heterogeneous (in nature, dimension, scale, resolution, quality or extension), and strongly dependent from subject matter knowledge, with inherent biases, uncertainties and interdependencies. Besides, the notion of prospectivity in emerging subsurface businesses remain fuzzy, case-dependent and multi-factor. Finally, quantitative risk assessment and explainability appear as key elements to foster the adoption of the resulting technologies by operational geoscientists.

In this context, the ideal prospectivity mapping methodology integrates the available data and knowledge, is digitally assisted while remaining expertise-driven, and is relatively simple to deploy while remaining explainable and collaborative. To address these ambitious objectives, we propose a strategy based on the following components: (1) formalization of the existing subject matter knowledge, for instance with conceptual graphs or ontologies, (2) data integration with Machine Learning, possibly using knowledge-infusion techniques in the statistical models, (3) Multiple Criteria Decision Analysis (MCDA) procedures, to combine human inputs and mathematical rigor in weighting the various factors impacting prospectivity, and (4) uncertainty propagation and Shapley Additive Explanations (SHAP) to ensure risk appraisal and explainability in the process.

The promises of the presented methodology are illustrated with a real-life case study, consisting in mapping the geothermal potential of the British Columbia region (Western Canada). A challenge

is to consider the peculiarly varied geology of the area, divided in sedimentary, volcanic, intrusive, ultramafic and metamorphic domains, with different assets regarding to geothermal energy production. The results highlight the power of Machine Learning to extract multiscale and multivariate correlations in the data, but also the benefits of the MCDA approach to introduce subject matter knowledge. In particular, the geological environment is used as an over-arching factor delineating several subregions, where different MCDA procedures are run independently. More generally, this work confirms the interest of hybrid methodologies in mathematical geosciences, blending data-driven approaches and more knowledge-driven ones.

Keyword

Data integration, Knowledge infusion, Machine Learning, Multiple Criteria Decision Analysis, British Columbia

Numerical estimation of fracture network permeability based on GEOFRAC model for groundwater modeling in a tin mine

Lei LYU[1]*, Yunnan University of Finance and Economics (leilyu@ynufe.edu.cn)
Chunxue LIU[2], Yunnan University of Finance and Economics
Chen GANG[3], Kunming University of Science and Technology
Liang GUO[4], Yunnan Provincial Geological Prospecting Engineering Corp.

Abstract

Numerous geological research studies and mining operations have proved that fracture is one of the important factors controlling groundwater flow, mineralization and ore distribution in metallic deposits. most current approaches for groundwater flow simulation of naturally fractured media rely on the calculation of equivalent permeability tensors from a discrete fracture network. Simulating a discrete fracture network (DFN) in a mine area is therefore crucial to mine water inrush accidents and disasters prevention, resource exploration and underground mining safety. This study aimed to construct a plausible two-dimensional DFN using GEOstatistical FRACture simulation method (GEOFRAC), a geostatistical method of conditioning directions (strikes and dips) and locations of sample fractures, by selecting the northern part of the Gejiu tin district, southwest China, and using 3724 outcrop fractures sampled on the ground of mountain Gaosong. Geographically, the mining area is located in the southern part of the middle-Dian Plateau, an alpine hilly area. The mountains in the area are continuous, heavy and overlapping, and there is no obvious trend; they are mostly blocky mountains. The mountainous area accounts for 86% of the total area of the region. The Gaosong mine is situated in the northern part of the tin mine in Gejiu, which is restricted by the Gejiu and Jiajieshan Faults in a north–south direction and the Gesong and Beiyinshan Faults in an east–west direction, and is covered mainly by dolomite and dolomitic limestone of the middle Triassic with dispersed distribution of Tertiary mudstone and Quaternary residual deposits. The study area was a rectangular area of 17 km by 9 km that covered the Gaosong mining area Key parameters of this DFN are density, direction, and connective condition of discs that form a fracture plane. The simulated fractures were verified in that their directions corresponded well with those of the sample fractures. The permeability tensor of each modeling grid is then calculated based on the fracture network constructed.

The study planned to build a rational DFN in a metallic mining area by selecting the Gaosong mine in southwestern China to depict the relationship between fracture distribution and permeability tensor. The GEOFRAC method was validated by the consistency of major tendencies in simulated fractures' directions with those of outcrop sample data and positional agreement of the continuous fractures with the actual faults. GEOFRAC is confirmed as a convincing tool to generate a rational DFN that can describe restrictions of fractures on the groundwater flow path and contribute to preventing mine water inrush accidents. The calculated permeability shows consistency with the main fractures and faults in the study area. Future works could reduce bias in sampled fractures direction, consider fractures widths for modeling more plausible DFN and

generate a more general fracture network with both ground network and underground network. By using such systematic fracture networks with calculated permeability, groundwater flow can be simulated in this tin mining area.

Keyword

Discrete fracture network, geostatistics, permeability tensor, groundwater flow, fault distribution

The joint modeling of correlated gold grades and rock types using the geostatistical multivariate method and the machine learning method in Xincheng gold deposit, China

Xiaoning LIU[1]*, China University of Geoscience(Beijing) (3001210118@email.cugb.edu.cn)
Gongwen Wang[2], China University of Geoscience(Beijing)
Yongming Peng[3], Xincheng Gold Limited Company of Shandong Gold Group, China
Xianyong Zhao[4], Xincheng Gold Limited Company of Shandong Gold Group, China

Abstract

In the mining industry, various geostatistical multivariate modeling methods are employed for the estimation and simulation of interest attributes. They can be broadly categorized into two streams: co-simulation techniques based on co-kriging methods and independent multi-Gaussian simulation techniques based on decorrelation transformation. However, these methods are typically applied to gaussian continuous variables and fail to directly handle categorical variables. In the case of altered rock type gold deposits, a correlation relationship between alteration rock type and gold content is evident. The main focus of this study is to integrate the complex relationship between multivariate variables into the deposit model to reproduce representative statistics and maintain the correlation relationship. Pluri-Gaussian methods offer a promising approach by facilitating the application of numerous well-established continuous variable modeling techniques to categorical variables. This is achieved through the reconstruction of categorical variables on the Gaussian distribution. To illustrate and compare the practical performances of different methods combining continuous and categorical variables, we employ geostatistical multivariate modeling methods and neural-network (NN) based methods. The unequally sampled measured data from the Xincheng deposit in the Jiaoxibei gold field, China were taken the demonstration dataset, including lithology and grade data from drillholes, and grade data from trenches. Furthermore, this paper presents the merit and limitation of each method.

Keyword

Geostatistical multivariate modeling, Pluri-gaussian modeling, Machine learning, Altered type gold deposit, Xincheng deposit

Assessment of Theoretical CO2 Storage Capacity in Gas Field and Its Uncertainty Using Integrated Three-Dimensional Structural and Petrophysical Modeling

Syed Yasir Ali SHAH[1], Central South University, China
Linze DU[2], Central South University, China
Baoyi ZHANG[3]*, Central South University, China (zhangbaoyi@csu.edu.cn)

Abstract

This study presents a pioneering effort to assess the theoretical carbon dioxide (CO2) storage capacity of the faulted reservoir between the G and E sands of the Lower Goru formation in the Kadanwari Gas Field, the Middle Indus Basin, Pakistan. An innovative integrated three-dimensional (3D) structural and petrophysical modeling approach is employed. Seismic interpretation revealed a complex faulted reservoir system with NW-SE trending normal faults, influencing reservoir compartmentalization and potential CO2 migration pathways. 3D structural modeling unveiled intricate structural features, including horsts, grabens, and half-grabens, resulting from multiple phases of deformation. The petrophysical modeling demonstrated favorable reservoir properties, with good porosity and permeability in the target intervals. Sequential Gaussian simulation (SGS) was used to generate 3D property models, capturing the spatial distribution of petrophysical parameters, including porosity, permeability, shale volume, and water saturation. Geological uncertainties were incorporated through variogram parameterization, enabling the estimation of pore volume distribution and its associated uncertainty. A novel formulation, tailored to the site-specific characteristics, was introduced to estimate the theoretical CO2 storage capacity in the Kadanwari Gas Field. The results indicate a theoretical storage capacity ranging from 7.54 million tons (P10) to 85.14 million tons (P90), with a mean capacity of 42.83 million tons (P50). This study establishes a comprehensive workflow for evaluating CO2 storage capacity in complex geological settings, addressing the critical gap in the literature related to carbon neutrality initiatives in Pakistan. The findings lay the foundation for future CO2 geological sequestration projects in the Middle Indus Basin and contribute to the country's efforts to mitigate its carbon footprint.

Keyword

Carbon dioxide geological sequestration, Three-dimensional geological modeling, Carbon neutrality, Unertainty, Petrophysical parameter

Unveiling Spatial Correlation between Heat-Affected Coal and Igneous Intrusions: A Probabilistic Analysis Using Indicator Kriging

Mohamad Nur Nur Heriawan[1]*, Bandung Institute of Technology (heriawan@itb.ac.id)
Tomy Alvin Rivai[2], Bandung Institute of Technology
Mirza Dian Rifaldi[3], Bandung Institute of Technology
Agus Haris Widayat[4], Bandung Institute of Technology
Komang Anggayana[5], Bandung Institute of Technology

Abstract

The formation of heat-affected coal (HAC) occurs as a consequence of the thermal metamorphism of coal seams in situ, typically induced by proximity to or contact with igneous intrusions (IGN). This transformative process alters both the physical and chemical properties of coal seams, often leading to challenges in distinguishing HAC from visually similar coaly shale in core samples. Consequently, there exists a disparity wherein HAC is sometimes found in correspondence with the presence of IGN, while in other instances, no such correlation is observed. While traditional methods such as aeromagnetic mapping can effectively correlate with the spatial distribution of IGN, they fail to capture the distribution of HAC. To address this discrepancy, this study proposes an innovative approach to elucidate the spatial correlation between HAC and IGN through the generation of a probability map employing the Indicator Kriging (IK) method. Indicator data for both HAC and IGN were meticulously curated based on drillhole and geophysical logging data, specifically targeting areas where HAC and IGN were encountered. Subsequently, variograms were constructed for the indicator data sets to discern spatial correlation patterns. Utilizing kriging estimation techniques, a probability map was generated, indicating the likelihood of HAC occurrence across the study area. To establish a meaningful threshold, a probability value of 0.5 was adopted, delineating regions of high probability where the occurrence of HAC coincided with IGN. The proposed methodology was applied to a coal prospecting area located in Central Kalimantan, Indonesia. By employing Indicator Kriging, the study aimed to unveil the intricate spatial relationships between HAC and IGN within this specific geological context. Through the delineation of high probability zones on the generated map, insights into the potential co-occurrence of HAC and IGN were gleaned, offering valuable guidance for future exploration endeavors in the region. The utilization of Indicator Kriging represents a novel approach in elucidating the spatial correlation between HAC and IGN, offering significant advantages over traditional methods. By integrating drillhole and geophysical logging data, this methodology allows for a more refined analysis, enabling the identification of subtle spatial patterns that might otherwise be overlooked. The application of this approach in the Central Kalimantan coal prospecting area underscores its potential as a valuable tool for geological exploration and resource assessment, facilitating informed decision-making processes. In conclusion, the study presents a pioneering methodology for investigating the spatial correlation between HAC and IGN, leveraging the capabilities of Indicator Kriging to generate probability maps indicative of their co-occurrence. The application of this approach in a real-world setting demonstrates its

efficacy in delineating regions of interest for further exploration and resource assessment. Moving forward, the integration of advanced spatial analysis techniques such as Indicator Kriging holds promise for enhancing our understanding of complex geological phenomena, thereby informing more effective resource management strategies.

Keyword

heat affected coal, igneous intrusion, probability map, indicator kriging, resource management

Enhancing lithological classification in high-resolution CT scan data using Convolutional Neural Networks for domain allocation

Milena Nasretdinova[1]*, The University of Adelaide (milena.nasretdinova@adelaide.edu.au)
Peter Dowd[2], The University of Adelaide
Chaoshui Xu[3], The University of Adelaide

Abstract

Identifying lithological domains is a fundamental component of the mining process and plays a crucial role in determining the composition and distribution of rocks, minerals, and ores. Accurate lithological classification improves decision-making in exploration, resource assessment, extraction, processing, and environmental management. Geologists mostly use direct visual inspections to describe cores, but this method is time-consuming and susceptible to subjective interpretations in facies classification. Rapid and automated core classification, coupled with associated core analysis, is crucial for optimising the return on investments and refining decision-making processes. X-ray computed tomography (CT) imaging is a highly effective non-destructive technique for meticulously inspecting cores. Digital images from X-ray CT scans provide valuable insights into core composition and internal structure, facilitating automated core classification. Integrating millimetre-scale accurate data enhances lithology classification workflows, enabling high-resolution lithology descriptions. Recent advances in CT scanning and reconstruction algorithms, together with progress in computing power and image analysis, provide new opportunities for extracting more information from entire cores. This research is devoted to developing an algorithm that primarily uses 2D core CT scan image slices to train a Convolutional Neural Network (CNN) followed by the formation of lithological domains.

In the work presented here, the aim is to allocate domains within a real copper-gold-molybdenum deposit using an automated approach for lithology prediction. The methodology involves pre-processing X-ray CT scans before training and automatically identifying and eliminating undesirable artefacts. Following this step, lithology labels are determined by employing a geological core description provided by the user, which considers factors such as grain size, texture, and the depositional environment. The labelled images are then augmented by these factors and used as inputs for training a CNN classifier. The trained classifier undergoes validation on a set of unseen images to predict lithology classes. Subsequently, the classifier is used to predict lithology on a set of previously unseen test images, with the results revealing distinct classes that exhibit sufficiently high recall. As the result of the previous steps is a set of lithological classes, the next step is to reduce the dimension of the dataset and find the relationships between the variables. In this study, Principal Component Analysis (PCA) is used to do this. After identifying the principal components and their interrelationships, the dataset is divided into groups to obtain the estimation domains. The last step in constructing a resource model based on spatially distributed geological data is to define the spatial domains. When the dataset is large and includes multiple variables, as is the case presented here, machine learning

methods are used to infer these lithological domains. Geostatistical Hierarchical Clustering (GHC) is an unsupervised machine learning method that is used to determine the domains. The results of the study show that the use of CNN for the automatic classification of lithology demonstrates a high responsiveness but requires a large amount of data for training. Domain allocation based on GHC allows for the identification of areas associated with various complex geological phenomena.

Keyword

Image classification, X-ray Computed Tomography, Convolutional Neural Networks, Principal Component Analysis, Geostatistical Hierarchical Clustering

Mining-induced Soil Contamination Mapping using a Combined Model of Random Forest and Ordinary Kriging

Hosang Han[1]*, Kangwon National University (qkfehr@gmail.com)
Jangwon SUH[2], Kangwon National University

Abstract

This study employed a model combining machine learning and geostatistical techniques to predict the spatial distribution of soil contamination in abandoned mine areas. Data were collected from 40 points of abandoned metal mines in Gijang-gun, Busan, Korea. The characteristics of the collected data were analyzed using exploratory data analysis, which formed the framework of the study. Random Forest (RF) and Ordinary Kriging (OK) were used to identify the optimal options and parameters of each model using GridSearchCV, a type of hyperparameter tuning. The RF residuals were calculated by subtracting the predicted values from the actual values of 40 sampling points. The residuals were then spatialized using the OK method. The prediction map of the RF-OK model was generated by summing the RF prediction map and the OK interpolation of RF prediction residuals. The evaluation criteria used to verify the predicted values were root mean squared error (RMSE) and coefficient of determination (R^2). The prediction models were validated using k-Fold cross validation. As a results, The RMSE (mg/kg) values for the RF, OK, and RF-OK interpolation models were calculated to be 66.214, 65.101, and 52.884, respectively, and the R^2 values were calculated to be 0.867, 0.871, and 0.915. These results suggest that the combined model outperformed the single RF and OK models. The study demonstrates that hyperparameter tuning enabled the optimization results to be obtained with minimum RMSE and maximum R^2, and confirms that the developed combined RF-OK model has better predictive performance than the single model in soil contamination mapping. It is also believed that this will provide a more reliable determination of contamination levels in areas requiring environmental monitoring, contributing to effective prevention and remediation efforts.

This work was supported by the Energy & Mineral Resources Development Association of Korea (EMRD) grant funded by the Korean government (MOTIE) (2021060001, Data science-based oil/gas exploration consortium)

Keyword

soil contaminant, interpolation, machine learning, geostatistics

Research on multi-parameter warning threshold and discriminant model of landslide disaster

Yi DONG[1]*, China Coal Aerial Survey and Remote Sensing Group Co., LTD.
(yiyddong@126.com)

Abstract

Landslide is a common natural geological disaster. It has the characteristics of fast occurrence and great destructiveness, which seriously threatens the life and property safety of mountain residents. Early perception and early warning of landslides are important safeguard measures to prevent and reduce losses caused by landslide disasters. At present, the landslide warning model generally adopts threshold warning, that is, by setting a reasonable monitoring parameter threshold, it is associated with the warning level, so as to achieve the purpose of landslide disaster threshold warning. However, different monitoring parameters have great differences in landslide characterization, and single parameter landslide disaster warning leads to high false alarm rate. In order to improve the accuracy of landslide monitoring and early warning, different landslide parameters in several effective landslide early warning cases are analyzed in depth, and three monitoring parameters with obvious characterization in the process of landslide occurrence, GNSS horizontal displacement, dip angle and crack, are selected. On the basis of filtering the data, the above three parameters are normalized respectively, and then the K-means clustering function is used to obtain the four centroid values of each parameter as the basis for setting the landslide warning threshold. According to this, each parameter is divided into five intervals, corresponding to five levels of landslide disaster warning. The three selected parameters are combined to establish a multi-parameter early warning sample database, so that the warning level of the multi-parameter after the intersection is consistent with the highest level of any single parameter warning. BP neural network is used to train 150,000 multi-parameter samples to obtain a multi-parameter intelligent early warning model of landslide, and then the remaining 10,000 multi-parameter samples are trained and re-estimated, with an accuracy rate of 92.5 %. The research shows that the threshold setting of multi-parameter early warning of landslide disaster is reasonable, and the established multi-parameter early warning model can be used in landslide disaster early warning.

Keyword

Landslide, multi-parameter, warning threshold, warning model

Density Estimation in Mineral Deposits: Tracing the Evolution from Archimedes to Contemporary Methods

Joao Felipe Coimbra Leite Costa[1]*, UFRGS (jfelipe@ufrgs.br)
Wilmer Emilio Moreno[2], UFRGS
Marcel Antonio Arcari Bassani[3], UFRGS

Abstract

This work discusses the intricacies of density estimation in mineral deposits. Beyond the inherent correlation between economic viability and ore abundance within a deposit, the study accentuates the role of density in shaping grade-tonnage curves, thereby influencing resource quantification. Despite recent strides in enhancing density estimation through quality manuals and standardization efforts, this review emphasizes the persistent disparities in Quality Assurance and Quality Control (QA/QC) procedures used for density and grades. While grades are usually estimated in a block model, the same does not occur for density. Specifically, only 20% of mining companies estimate density in a block model. The prevailing approach, performed in 60% of companies, is to use the global average density for the entire domain. This approach assumes that the density is constant in the space. On top of that, 18% of the technical reports analyzed did not have any discussion regarding density. Considering the importance of density for mineral resources, the mining industry should move towards more rigorous estimation practices for density.

As a part of state-of-the-art, it is important to trace the historical evolution of density measurement. This paper starts by highlighting Archimedes' foundational contributions, 250 years before Christ, mentioning the evolution of measurement tools, including the areometer from Pappus of Alexandria, a pycnometer by Abu Raihan Biruni, reaching the Lane-Wells gamma-gamma density measurement tool. Next, it discusses density derived from chemical grades, which initially was proposed following the Bowen series, giving the name of normative mineralogy calculation.

Moreover, the paper also discusses the use of seismic and gravimetric inversion to obtain 3D density block models. These techniques are crucial when hard data is not abundant.. This comprehensive review extensively covers passive seismic methods, introducing a discussion on Horizontal-to-Vertical Spectral Ratio (HVSR). While primarily designed for seismic risk assessment in urban settings, HVSR's recent applications in identifying mineral deposits showcase its potential in the mining sector, having diverse examples of coal mines.

In conclusion, this paper provides a panoramic view of the current state-of-the-art in mineral deposit density estimation and contributes with novel perspectives based on geophysical-geostatistical inversion as the possible solution to an old problem.

Keyword

geostatistics, mineral resources estimation, density

Genetics and statistical topology of holy stones

Tamas JASKO[1]*, Jasko & Jasko (tamas.jasko@jasko.info)

Abstract

Holy stones (hag stones, adderstanes, Hühnergötter) are stones with naturally occurring holes, believed to have magical powers that occupy an important place in the folklore of Baltic peoples, but their genetic classification and topological form is almost ignored in petrology.

Our study of holy stones involved two populations, the one consisting of prominent examples featuring in illustrated literature, or typical specimens exhibited in museums and public places. The other group consisted of accessible specimens in a number of collections, allowing precise measurements and systematic comparisons.

The material composition of 485 holy stones is as follows: flint 446 (92%), quartzite 23 (5%), limestone 7 (1%), volcanics 3 (1%), other and uncertain 6 (1%).

It is generally assumed that pure mechanical erosion will never produce holy stones, their form is due to a combination of a pre-existing inhomogeneity, chemical weathering and mechanical erosion.

The inhomogeneity in flint and limestone holy stones are biogenic determined either as concretions, or surviving hollows in fossil structures. In (meta) quartzite the hole is the void left by chemical erosion of a needle like mineral shaped during metamorphosis. In volcanics the hole probably originated as a fluid filled void (bubble). In the „other" category we find some sandstone, which originate probably as concretions, and also an iron meteorite.

Topology of holy stones is studied by counting the holes i.e. classifying by topological genus. Distribution by genus is as follows: G1 (1 hole) 75%, G2 (2 holes) 17%, G3 (3 holes) 6 %, G4-G7 (4 or more holes) 2%. Statistical tests were carried out to decide if these topological classes are independent. As a null hypothesis it was assumed that the number of holes in holy stones follows the zero-truncated-Poisson (ZTP) distribution law. A separate study found the overall frequency of holy stones to be about 0.2 % in flint gravel, which is the most prolific source of holy stones.

Size distribution of holy stones was studied for finding the contribution of genetic classes to differences of shape and to such parameters as the mean weight, axis lengths and ratios. Two of the ratio parameters are particularly important for characterisation: the c/a projection sphericity and the h/b hole diameter ratio.

Keyword

holy stones, topology, probability distributions, diagenesis, erosion

The role of mathematical geoscience in exploring the complexity of human-environment-climate relations: The IAMG 2024 Krumbein Medal.

Jennifer M MCKINLEY[1]*, Queen's University Belfast (j.mckinley@qub.ac.uk)

Abstract

Our changing climate poses one of the greatest risks to human, society and planetary health. However, the impacts will vary spatially and at different scales. Evidence shows that the most disadvantaged and those with existing conditions will be disproportionately affected. The World Health Organisation (WHO) estimates that almost a third of all global deaths are linked to the environment, whether naturally occurring (geogenic) or formed through human activities such as industrial practices (historical and modern), atmospheric air pollution or traffic pollution. The question posed is how can geoscientists use spatial data analysis, informatics and statistics to explore the impacts on the environment and human health? The complexity of human-environmental and climate change relations is explored through examples from two funded research project examples. The UKRI ESRC funded SPACE (Supporting Environments for Physical and Social Activity Healthy Ageing and Cognitive Health) project explores how the local environment and pollutants synergistically affect our cognitive health outcomes. The EU Horizon 2020 UPSURGE project explores regenerating cities with the power of nature to mitigate against air pollution and its health effects. The role of mathematical geosciences and the importance of spatial thinking are explored to gain a greater understanding of the link between human health and our environment, the potential impacts of air and traffic pollution and the value of green space and nature-based solutions. The approaches presented acknowledge the multivariate compositional nature of the integrated environmental and health related data.

Keyword

Climate change, air pollution, environment, compositional data analysis, human health

Optimizing Geothermal Operations While Mitigating Induced Seismicity Risks: An AI-based Framework for Decision-Making Under Uncertainty

Sofia Mantilla Salas[1]*, Stanford University (sofiams@stanford.edu)
Markus Zechner[2], Stanford University
Mansur Arief[3], Stanford University
Jihui Ding[4], Stanford University
Anthony Corso[5], Stanford University
Jef Caers[6], Stanford University

Abstract

Geothermal energy stands at the forefront of the renewable energy transition, offering an abundant, low-carbon solution to our increasing energy needs. Unlike wind or solar, geothermal systems provide a constant energy source independent of weather conditions. Low-enthalpy geothermal systems, particularly, are appealing for supplying heating and cooling demands of populated residential areas with poor weather conditions for other renewable energy sources. Despite the multiple benefits of geothermal energy, induced seismicity poses a safety hazard that hinders the social acceptance of this energy source at the scale and pace needed for an effective energy transition. Planning for multiple, long-term sequential engineering decisions in geothermal operations to supply energy demands while rigorously managing the risk of induced seismicity represents a highly complex, time-consuming, and costly challenge for humans.

The work presented here is part of a large, multidisciplinary project that develops a decision-making under uncertainty framework using a Partially Observable Markov Decision Process (POMDP) tailored to a real-world low-enthalpy geothermal system. This project is located near a populated area that aims to replace fossil fuels for essential heating and cooling needs. The POMDP model seeks to strike the intricate balance between revenue maximization and induced seismicity risk management and mitigation. It incorporates various sources of uncertainty, including subsurface structure and geomechanics parameters, water injection and extraction pressure propagation, and total energy extraction. The model builds a belief representation based on stochastic observations, enabling online tree search to determine the optimal actions and timings to meet local energy demands while mitigating safety risks. Additionally, it offers detailed guidance on the strategic acquisition of monitoring data, highlighting the value of future observations to effectively update the beliefs and decrease uncertainties inherent in this geothermal system.

This research evaluates the suitability for AI-based planning of various earthquake safety-focused models and data sources, including induced seismicity and seismic hazard maps forecasting models and seismicity monitoring data. The smooth integration of the models and data gave us a comprehensive understanding of their complex interplay. It allowed us to accurately quantify and simulate the tradeoffs when planning between this project's safety and economic objectives. By

harnessing the power of AI to refine complex planning strategies for real-world applications, this research illuminates a pathway toward rendering geothermal projects economically sustainable and intrinsically safer for communities. This innovative approach represents a significant stride in reconciling the demands of renewable energy production with the imperative of public safety, setting a new standard for developing geothermal energy as a cornerstone of a sustainable future.

Keyword

Geothermal Energy, Induced Seismicity, AI, Safety, Energy Transition

A Mathematical Model of Early Earth Magma Ocean Differentiation

SEEMA KUMARI[1]*, 1. University of Muenster, Germany; 2. Indian Institute of Science, Bangalore, India (seema091089@gmail.com)
Ramananda Chakrabarti[2], Indian Institute of Science, Bangalore, India

Abstract

We present a mathematical multi-reservoir open-system model, which probes the evolution of the terrestrial magma ocean using the short-lived Hf-W isotope system (t1/2 = 8.9 Myr). Several aspects related to Earth's magma ocean differentiation have remained unknown, such as the amount (and depth) of the magma ocean and the extent (amount and timescale) of crystallization and formation of late-stage denser residues and preservation deep within the mantle.

We quantitatively evaluate magma ocean differentiation to interpret the origin of large low shear velocity provinces (LLSVPs). A series of differential equations describing the changing mass and abundance of 182Hf, 182W, and 184W nuclides in each reservoir (magma ocean crystals and magma ocean melt/residue reservoirs) are solved numerically at 0.1 Myr time steps for the initial 200 Myr of Earth's history. If the rising mantle plumes from the core-mantle boundary sample the LLSVPs (McNamara, 2019) and erupt to form OIBs, and if a significant part of the LLSVPs comprises the late-stage magma ocean residue, then a successful model solution should reproduce a similar compositional constraint (Hf and W concentrations and isotopic ratio, $\mu^{182}W$, is ppm deviation in 182W/184W relative to the present terrestrial standard) observed in the OIB-source in our modeled magma ocean residue reservoir.

Our model-derived successful solutions indicate the existence of a magma ocean comprising 38-70% of the total mantle mass right after the core formation (30-45 Myr), which continued to crystallize for another ~45 Myr leaving behind a residual material (mRES) of ~2-10%. These results indicate the presence of magma ocean within the first 100 Myr of solar system formation when the Hf-W system was extant, resulting in a distinct and characteristic $\mu^{182}W_{RES} \leq 0$ (and up to ~ -23 observed for some OIBs). Our results support the plausibility that the late-stage products (denser than ambient mantle) that remained after the crystallization of magma ocean could have sequestered very early and preserved until today, representing the present-day LLSVPs.

References: McNamara, A.K., 2019. A review of large low shear velocity provinces and ultra low velocity zone. Techtonophysics 760, 199–220.

Keyword

182Hf-182W isotope system, Core Formation, Magma Ocean, Magma Ocean crystallization, LLSVP

A Geologically Variational Autoencoder for Geochemical Anomaly Detection by Ad-Hoc and Post-Hoc Interpretability Algorithms

Zijing LUO[1]*, China University of Geosciences (1201911208@cug.edu.cn)
Renguang ZUO[2], zrguang@cug.edu.cn

Abstract

Deep learning algorithms (DLAs) are emerging as prominent tools for processing geochemical survey data in support of mineral exploration. Nevertheless, the inherent complexity of the internal structure and parameters of DLAs renders their operational mechanisms and decision behaviors challenging to comprehend accurately. In the field of geochemical exploration, the interpretability of predictive outcomes from DLAs is of paramount significance. It directly influences the subsequent deployment of mineral exploration efforts. Moreover, functioning as a purely data-driven model, DLAs merely learn latent patterns from training data. This may potentially result in inconsistencies between the DLA's predictions and the studied mineral deposit model. Thus, the construction of a reliable and interpretable DLA has become a focus in geoscience discovery. Additionally, due to the intricate interrelationships among geochemical elements, determining which elements can furnish valuable information for the detection of concealed mineral deposits poses a challenging task. Therefore, this study employed the SHapley Additive exPlanations (SHAP) framework, a widely employed post-hoc interpretability analysis method, in conjunction with a variational autoencoder (VAE). Through this integration, this study explores the contribution of geochemical elements to the identification of multivariate geochemical anomalies. Utilizing the SHAP tool for element importance ranking offers a novel perspective for the selection of a suitable elemental association related to mineralization. In order to make the geochemical anomalies identified by DLA more consistent with geological cognition, this study, based on the mineral deposit model in the southeastern Hubei Province of China, constructed a geologically VAE model using an ad-hoc interpretable modeling technique, with selected elemental associations related to mineralization as inputs. The interpretability of the model in identifying the abnormal distribution of the element associations can be improved by constructing a hidden layer and loss function containing metallogenic regularity and key metallogenic factors. The highly anomalous areas identified by the metallogenic-factor VAE model not only contain most of the known Au deposits, but also can reasonably identify geochemical anomalies related to ore-forming processes under the guidance of the metallogenic regularity. Various pieces of evidence suggest that this comprehensive approach aids in discerning geological anomalies indicative of potential mineral deposits within intricate geochemical datasets, thereby providing more robust guidance for mineral exploration.

Keyword

Geochemical anomalies, Interpretable deep learning, Variational autoencoder, Geological

constraints

Geoscience model assessment

Jeff BOISVERT[1]*, University of Alberta (jbb@ualberta.ca)

Abstract

The current state of geoscience model assessment is reviewed, a new method is presented, and views from geology, geophysics, mining, petroleum, and environmental fields are explored. Model assessment (a.k.a. checking or validation or confirmation or verification or reconciliation) is a critical but often overlooked step in geoscience modeling. First, to explore the current state of the art, views from the diverse fields of geology, geostatistics, mining, petroleum, and geophysics are compared. The main finding here is that different fields have access to different types/quantities of data and the modeling goals often differ, leading to different views on model assessment. Second, the often-used cross validation, leave-n-out, and k-fold validation methods are compared. The main finding here is that cross validation is nearly always preferred if the task is to quantify the performance of a modeling method. Finally, a new proposed workflow is presented where an ensemble of exhaustive models/datasets is used as a test bed for algorithm performance and assessment. This method is not helpful for individual model assessment, rather, it is the recommended method of algorithm assessment; that is, how different candidate modeling techniques should be compared.

Researchers are often focused on generating the next best algorithm, while practitioners are often focused on ‘making reconciliation work’ or generating the next model on a deadline. For both researchers and practitioners, it is commonly understood that considerable time should be spent on data QAQC, with some rules of thumb placing this at 70% of the total time dedicated to a given project; however, model QAQC is more often overlooked and should, perhaps, be taking up a larger share of a projects time. We are past the point where the excuse of ‘we do not know the truth’ can be used to justify poor model assessment practices and procedures; in fact, this is simply an argument for the quantification and checking of uncertainty in all geoscience models.

Keyword

Geostatistic, modeling, estimation, simulation

Effect of the mesh size near the fault on finite source inversion: 3-D finite element earthquake modeling

Minsu KIM[1]*, Kangwon National University (minsu@kangwon.ac.kr)
Byung-dal So[2], Kangwon National University

Abstract

Three-dimensional finite element models, which can handle the stress perturbations caused by subsurface mechanical heterogeneities and fault interactions, have been combined with finite source inversion to estimate the coseismic slip distribution over the fault plane. However, the mesh structure used to discretize the governing equations in the numerical model significantly affects the numerical accuracy. In this study, we performed kinematic finite source inversion with idealized (regular observation point array) and regional (GEONET, GPS Earthquake Observation Network System stations in Japan) models with different mesh sizes to quantitatively analyze the effect of the mesh size around the fault plane on the estimated fault slip distribution. Synthetic observational data vectors obtained from the finest models are compared with those from the coarser models, which were used to construct the Green's function matrix. We found that the coarser mesh models derived a smaller surface displacement, leading to a decrease in the norm of the Green's function matrix, which in turn influenced the fault slip magnitude from the finite source inversion. Finally, we performed the finite source inversion for the fault slip distribution of the 2011 Mw 9.0 Tohoku-Oki earthquake using the coseismic surface displacements recorded at the GEONET and seafloor stations and finite element modeling. By reducing the mesh size on the fault, we confirmed that the estimated magnitude of fault slip converged to about 80 m, which is consistent with the range of fault slip magnitudes from previous studies based on the Okada model. At least 0.88 million total domain elements and a mesh size of 6.7 km2 on the fault plane with an area of 240 × 720 km2 are required for the convergence of fault slip. Furthermore, we found that the location of the maximum fault slip is less sensitive to mesh size, implying that source inversion based on a coarse mesh model can quickly provide the rough fault slip distribution.

Keyword

finite source inversion, earthquake modeling, slip distribution, slip distribution

Source apportionment of heavy metal contamination in urban-agricultural-aquacultural soils near the Bohai Bay Coast based on cokriging and land-use classification

Ling Zeng[1]*, Chengdu University of Technology (lineezeng@126.com)

Abstract

Heavy metal concentrations of Cd, As, Pb, Cu, Cr, and Hg were investigated for 86 soil samples in Jinzhou near the Bohai Sea in China, in order to identify what anthropological activities influenced their distribution levels. Ordinary cokriging (OCK) was utilized to map six heavy-metal distributions by incorporating their main environmental influencers. The resultant p values for the six OCK mapping models of 0–2.78% indicated good statistical significance of the models, and the relative mean absolute errors of 4.82–12.53% and relative root mean square errors of 6.23–18.21% indicated allowable predication precision for their concentrations. The contamination distributions by OCK mapping were then graded based on the standards of the China National Environmental Monitoring Center and the Chinese Environmental Protection Administration, which showed that Cu and As contaminations in parts of this area were over the natural level but not polluted, Cr contamination was omnipresent over the natural level in this area and even reached the polluted level in parts of this area. The graded contamination maps that were overlapped with land-use maps and Google satellite maps, as well as the verifications reported in literatures, enabled correlations of the different contamination levels of As, Cu, and Cr with human activities. Resultantly, it indicated that As and Cu contamination over the natural level may be related to agricultural planting and aquacultural activities along the coast of Bohai Bay, with the contaminants transported via watercourses; Cr contamination over the natural level may have been due to vehicle emissions; and, Cr pollution may have been from steel manufacturing and geochemical factories

Keyword

Soil heavy metal contamination, Cokrging, Source apportionment, Land-use classification, Bohai Bay

Geochemical characteristics and Exploration implications of the Shangyi region, Zhangjiakou City

Lujia PAN[1]*, Hebei Normal University (peter205834@hebtu.edu.cn)
Lujia Pan[2], Hebei Normal University

Abstract

Zhangjiakou Shangyi is located in the North China Craton (Sino Korean paraplatform) across the northern Inner Mongolia axis (Inner Mongolia anteklise) and Yanshan Taiwan two two fold belt tectonic units. The structures in the area are mainly faulted structures, mainly divided into two groups: the North West and the East-West direction. The tectonic movement is one of the main reasons for the formation of mineral resources in the study area, through the cracks of various properties of magmatic activity and the formation of motion control and fault control the ore body shape, size and distribution, resulting in the formation of mineral resources is conducive to all kinds of structural forms. The metamorphism of the crust since the Archean has provided the help for the formation of mineral resources.

The study area exposed strata are mainly ancient Archean Sanggan group, Archean HONGQIYINGZI group, Proterozoic metamorphic rocks of the Great Wall Changzhou ditch group and Gaoyuzhuang group, Mesozoic lower Jurassic Xiahuayuan formation, Middle Jurassic Tuchengzi Formation and Cenozoic Oligocene Miocene Hannuoba formation, new world new the Shixia group and the Quaternary overburden layer.

By geochemical exploration of 1:50000 in the study area, the anomalous characteristics and distribution of 16 kinds of single elements and four sets of combined elements were analyzed and summarized. The key anomalies of AS-5, AS-24, AS-15, AS-33 and AS-35 were explained and evaluated.

This article from the stream sediment geochemical characteristics of ore-forming elements in the distribution, correlation analysis, R cluster analysis based on the distribution of elements, discusses the distribution characteristics of elements assemblage characteristics, combined with the geological condition of mineralization, and the mineralization anomaly verification results existing information for metallogenic prediction. The authors believe that the study area has the potential to find polymetallic deposits or ore bodies dominated by two back silver sand back Au, Ag, W, Mo and Bi, and the research results have important theoretical and practical significance for guiding the prospecting in this area.

Keyword

stream sediments, geochemistry, anomaly interpretation, prospecting direction, Zhangjiakou

Lithology mapping based on machine learning: a case study of the Eastern Tianshan Mountains

Huaqing Yang[1]*, SUN YAT-SEN UNIVERSITY (yanghq36@mail2.sysu.edu.cn)
fan XIAO[2], SUN YAT-SEN UNIVERSITY

Abstract

The East Tianshan area harbors significant mineral resources and exhibits a complex structural evolution, necessitating precise geological mapping for effective mineral exploration and structural analysis. However, conventional geological mapping faces challenges due to the extensive coverage area in the East Tianshan Mountains. Consequently, this study employs machine learning methods to swiftly and economically conduct regional mapping by integrating multi-source data including ground, object, chemical, and remote sensing imagery. Geophysical, geochemical, and remote sensing image data serve as predictive variables, with the utilization of random forest and artificial neural network algorithms to predict the spatial distribution and lithology of buried rock masses in the covered area of the East Tianshan Mountains. To address the issue of uneven distribution of lithologic sample data, oversampling techniques are introduced, and the optimal prediction model is attained through hyperparameter grid search. The results reveal that the optimal parameters for the random forest model are as follows: EN=1600, Dmax=200, Fmax='sqrt', SSmin=2, SLmin=1, achieving an overall average accuracy of 98.18%. For the artificial neural network model, the optimal parameter combination entails three hidden layers with the optimal number of nodes [450, 650, 650], resulting in an overall average accuracy of 90.39%. Comparative analysis demonstrates the superiority of the random forest model (98.18%) over the artificial neural network model (90.39%), thus establishing the former as the representative model for lithology mapping (prediction and recognition) in this experiment. Additionally, this study contributes to augmenting prior research outcomes concerning the distribution of magmatic rocks in the eastern Tianshan Mountains.

Keyword

machine learning, multi-source data, lithological identification, random forest, artificial neural network